*City of Carlsbad*

# Climate Change Vulnerability Assessment

City of Carlsbad

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*Prepared by*

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# Table of Contents



## Tables



## Figures

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# Executive Summary

The City of Carlsbad Climate Change Vulnerability Assessment evaluates how climate change may impact vulnerable community members, natural resources, critical facilities, buildings, services, and infrastructure in Carlsbad. This report will inform Carlsbad of potential climate change impacts and help prepare the required climate adaptation goals, policies, and implementation programs for the Public Safety Element as part of the City's General Plan Update.

Climate change is a global phenomenon that can impact local health, natural resources, infrastructure, emergency response, and many other aspects of society through changes in climate conditions. In Carlsbad, temperature and precipitation are expected to change in the following ways:

- **Increasing temperatures.** Average maximum temperatures in Carlsbad are expected to rise between 3.2° Fahrenheit (F) and 4.0°F by 2050, and between 4.2°F and 7.2°F by 2100.
- **Increasing intensity of precipitation events and longer dry periods.** It is projected that the wettest day every year will increase from 10-30% by the end of the century with more precipitation occurring during extreme events.

Changes in temperature and precipitation are expected to influence the frequency, duration, and magnitude of a variety of climate hazards. Climate change models indicate that Carlsbad is expected to experience the following by the end of the century:

- **Extreme Heat.** Carlsbad is projected to experience an increase in the annual number of extreme heat days in the coming decades. In Carlsbad, an extreme heat day occurs when the maximum temperature is above 92.5°F. The annual number of extreme heat days is projected to increase by as much as 22 days and the annual number of warm nights is projected to increase by as much as 73 nights. Both are qualified as days or nights in which the temperature exceeds the 98th percentile of historically observed temperatures (CEC 2021).
- **Drought.** The City is projected to experience increases in the length of dry spells.
- **Wildfire.** The City is projected to experience an increase in high wildfire risk days, frequency, and potential area burned from wildfires.
- **Landslides.** Susceptibility of landslides in Carlsbad is projected to increase as precipitation variability increase and wildfires increase in frequency, area, and severity.
- **Riverine and Stormwater Flooding.** Riverine flooding occurs when rivers or streams break their banks and flood surrounding land. Climate change may cause changes in precipitation patterns, leaving low-lying areas throughout Carlsbad to experience more frequent flooding and could increase the extent of 100-year floods.
- **Air Quality.** Air Quality within the San Diego Region is projected to worsen because of an increase in wildfires and average maximum temperature. Longer periods of drought will also contribute to worsening air quality.
- **Sea Level Rise.** The City is projected to experience up to 6.6 feet of sea level rise by 2100 with impacts creating vulnerabilities to multiple assets.

# Report Organization

The report is composed of the following six parts:

1. **Introduction** describes the methodology and key data sources used to prepare the Climate Change Vulnerability Assessment.
2. **Exposure to Climate Hazards** outlines climate drivers, relevant climate hazards, historical hazards events, how hazards are expected to change, and includes figures mapping climate hazards spatially across Carlsbad.
3. **Sensitivity** identifies populations and assets most at risk to climate change.
4. **Adaptive Capacity** summarizes plans, policies, and programs that help Carlsbad cope with climate hazard events.
5. **Vulnerability Analysis** describes potential impacts for each hazard based on sensitive community, natural, and built assets, with consideration given to their adaptive capacity. The chapter includes vulnerability scores of low, medium, or high for each population group and asset. See Vulnerability Scoring Methodology section below for more detail.
6. **Conclusion** presents the key findings of this report.

# Populations, Assets, and Services at Risk

Projected changes in climate drivers and hazards will adversely impact community members, natural resources, critical facilities, buildings, services, and infrastructure in Carlsbad. The Carlsbad Climate Change Vulnerability Assessment describes the impacts climate change is expected to have on the following populations and assets:

## Vulnerable Populations

Vulnerable populations were grouped based on potential exposure to climate hazards, access to resources to prepare, cope with, or recover from climate hazards, whether individuals face societal disadvantages, or if individuals have heath conditions or health sensitivities that leave them vulnerable to climate hazards. Often individuals have characteristics that make them vulnerable in a variety of ways; however, for the purpose of this assessment, they were grouped based on the sensitivity that increases their risk the most.

- Individuals with high outdoor exposure
- Under-resourced individuals
- Individuals facing societal barriers
- Individuals with chronic health conditions or health related sensitivities

## Natural and Recreational Resources

Municipal parks

Open spaces

Ocean and beaches

Lagoons

Waterways

Hillsides

Urban Forest

Critical habitat

Rivers and streams

Vernal Pools

Wetlands

### Buildings and Facilities

Municipal buildings

Educational facilities

Medical facilities

Residential and commercial development

Roadways and transportation facilities

Active transportation routes

Fire stations

Police stations

Entertainment and Hospitality

Airport

### Infrastructure and Critical Services

Water services

Wastewater

Storm drainage and flood protection

Solid and hazardous waste and recycling

Fire services

Emergency services

Medical services

Utilities and major utility corridors

Communication networks

Public transportation

## Adaptive Capacity

Adaptive capacity is the ability to adjust to the consequences of climate change. Types of adaptive capacity include adjustments in behavior, resources, processes, and technologies. Carlsbad has actively taken steps to increase the City's adaptive capacity by relying on existing policies, plans, programs, and institutions that increase the City's resilience to climate change. There are existing plans, programs, and policies in place to mitigate impacts of wildfire, flooding, sea level rise, and drought on the City's buildings, facilities, infrastructure, and critical services, as well as to mitigate impacts of extreme heat, drought, sea level rise, and wildfire on the City's vulnerable populations.

## Vulnerability Analysis

Climate change is expected to impact public health, natural resources, buildings and facilities, and infrastructure and critical facilities. Understanding local climate risks and impacts allows communities to prepare for the future and increase their resilience. Population groups and asset categories with high vulnerability scores are described below.

### Vulnerable Populations

- **Extreme Heat.** Increased number of extreme heat days will result in increased public health risks, particularly to vulnerable populations, through heat-impacted diseases and air quality degradation. Individuals with high outdoor exposure, under-resourced individuals, individuals

facing societal barriers, and individuals with chronic health conditions are all vulnerable to extreme heat.

- **Drought.** Individuals with high outdoor exposure are particularly at risk to drought conditions. During prolonged drought conditions, people experiencing homelessness may have difficulty accessing clean and affordable drinking water.
- **Wildfire.** Individuals with high outdoor exposure, individuals with chronic health conditions, under resourced individuals, and individuals facing societal barriers are all at risk to wildfire impacts. The associated risks are mortality, structural damage and loss to their place of residence, smoke-caused health complications, and exacerbation of social vulnerabilities.
- **Riverine and Stormwater Flooding.** Outdoor workers may be exposed to hazardous work conditions during riverine and/or stormwater flooding events and therefore are vulnerable to health impacts. People experiencing homelessness are disproportionately at risk to health impacts during flood events because they often live in flood hazard areas and do not have access to transportation or resources needed to evacuate inundated areas.
- **Air Quality.** Individuals with high outdoor exposure and individuals with chronic health conditions are particularly vulnerable to poor air quality. Outdoor workers and people experiencing homelessness are disproportionally vulnerable to poor air quality because they are outdoors and are directly exposed to outdoor air pollutants. Individuals with chronic health conditions or health related sensitivities are at risk of developing or experiencing exacerbated health impacts from poor air quality. Children are extremely vulnerable to health impacts from poor air quality because their respiratory system has not fully developed yet. Older adults, military veterans, and pollution burdened individuals are vulnerable to health impacts from poor air quality because they are more likely to have underlying respiratory and/or cardiovascular conditions. Individuals with cardiovascular disease and individuals with asthma may experience severe health impacts if exposed to poor air quality.
- **Sea Level Rise.** People who live in inundation zones may need to retrofit homes to adapt to sea level rise and associated impacts such as mold. This activity is particularly difficult for those with limited access to resources, including individuals who are unemployed, and low-income individuals. Linguistically isolated individuals may not have access to non-English versions of sea-level-rise preparedness guidance and therefore may not be able to prepare for and cope with sea-level-rise.

## Natural and Recreational Resources

- **Extreme Heat.** Wildlife under these conditions face impacts of heat stress and heat related illness as well as disrupted reproductive cycles. Plants are more likely to experience heat stress and drying, species' habitat ranges may shift and be replaced with invasive species. Natural resources are highly exposed to extreme heat and warm nights. Both mid- and end- of century projections depict dramatic increases in extreme heat days
- **Drought.** Impacts from drought involve risks associated with water scarcity and availability for reliant natural resources. Drought will disrupt habitats and wildlife abilities to survive from dehydration and reliable food sources. There is a risk of generally stressed natural resources and unsupportable conditions for consistent stream flow.
- **Wildfire.** The largest direct impacts to natural resources are caused by wildfires. There is direct mortality and loss of

resources and wildlife from wildfire as well as indirect mortality due to uninhabitable areas, loss of available food sources and seed bank. The severity and frequency of wildfires can exacerbate these impacts further through habitat conversions resulting in vegetation communities that no longer supports the species using that habitat.

- **Riverine and Stormwater Flooding.** Riverine and stormwater flooding will mostly affect sensitive species of plants and wildlife that are not upland based. Other impacts include damage from inundation within storm flooded areas such as habitats and lands around streams and waterbodies in the City. Additionally, stormwater flooding can reduce overall water quality through algae blooms causing water quality issues within wetlands.
- **Air Quality.** The direct effects of air quality declines on natural resources relates to plant and wildlife health as increased air pollutants causes stress and mortality. Impacts from air quality can further impact natural resources since air quality declines correspond with other hazards, compounding risks.
- **Sea Level Rise.** Coastal inundation affects habitats, wildlife, and plants throughout Carlsbad. Environmentally sensitive lands such as lagoons and wetlands are most affected by sea level rise and show limitations in ability to shift habitat location.

## Buildings and Facilities

- **Extreme Heat**. Extreme heat could impact occupants of buildings and facilities that are not adequately weatherized for increased temperatures.
- **Sea Level Rise.** The structures and buildings that occupy sea level rise flood and inundation hazard zones in Carlsbad are at risk of structural damage from sea level rise. There are several critical facilities in the City's sea level rise zones.

## Infrastructure and Critical Facilities

- **Extreme Heat.** Extreme heat affects roadways, active transportation routes, and railroads creating vulnerabilities to damages through sustained heat. Electrical infrastructure is also at risk to grid overload through increased power demand.
- **Drought.** Drought can impact water reliability and water infrastructure. All emergency services depend on water, particularly firefighters who require adequate water supply for fire suppression. Drought vulnerability can create service strain for emergency and medical services.
- **Riverine and Stormwater Flooding.** Impervious surfaces can impede the absorption of water and augment stormwater flooding in areas of Carlsbad. There is risk of damage from increased extreme precipitation events including erosion, washouts, and sinkholes. Storm drainage and flood protection services for the City may be impacted by these events.
- **Air Quality** Higher incidence of unsafe air quality generated by increased smog, dust and wildfire smoke can create general strain on existing infrastructure and critical services through increased rates of hospitalization and emergency and medical services.
- **Sea Level Rise.** The impacts Carlsbad is expected to experience related to services and infrastructure are moderate when presented together. Per the 2017 Carlsbad Sea Level Rise Vulnerability Assessment, there are 8 parcels of critical infrastructure, 5.8 miles of transportation routes, and 7.3 miles of lateral public access ways impacted by sea level rise through 2100

# Key Findings

The Climate Change Vulnerability Assessment identifies the community members, natural resources, critical facilities, buildings, services, and infrastructure most vulnerable to climate change hazards in Carlsbad. Although the City has policies and programs in place to prepare for climate related hazards, gaps remain as summarized in the Climate Change Vulnerability Assessment. This assessment is a starting point for establishing an adaptation policies and programs in the Carlsbad Public Safety Element.

# 1 Introduction

## 1.1 Background on Climate Change

This report evaluates how climate change may impact vulnerable community members, natural resources, buildings and facilities, and services and infrastructure in Carlsbad. This report is consistent with Government Code § 65302 (as amended by Senate Bill (SB) 379) which requires cities, counties, and unincorporated areas across California to prepare a Climate Change Vulnerability Assessment to inform updates to the Public Safety Element of the General Plan. Understanding Carlsbad's vulnerabilities to climate change provides a foundation to develop required climate adaptation goals, policies, and implementation programs for the City's Public Safety Element.

### Causes of Climate Change

Climate change is caused by the addition of excess greenhouse gases (GHGs) to the atmosphere, which traps heat near the earth's surface raising global average temperatures in what is referred to as the greenhouse effect. This increase in average temperatures across the globe affects sea level rise, precipitation patterns, the severity of wildfires, the prevalence of extreme heat events, water supply, and ocean temperatures and chemistry (NASA 2022). According to the Intergovernmental Panel on Climate Change (IPCC), GHGs are now higher than they have been in the past 400,000 years, raising carbon dioxide levels from 280 parts per million to 410 parts per million in the last 150 years (IPCC, 2021). The dramatic increase in GHGs is attributed to human activities beginning with the industrial revolution in the 1800s, which represented a shift from an agrarian and handicraft-based economy to one dominated by industry and machine manufacturing (NASA 2022).

## 1.2 Carlsbad Snapshot

Carlsbad is a coastal community located 30 miles north of San Diego. The City borders the Pacific Ocean to the west, Encinitas to the south, Vista and San Marcos to the east and Oceanside to the north. Since being incorporated as a City in 1952 there has been a steady rate of growth with the current population of Carlsbad at approximately 115,585 full-time residents (Cal DOF 2022).

## 1.3 Lexicon

Several words and phrases are used throughout the plan to illustrate climate vulnerabilities within Carlsbad.

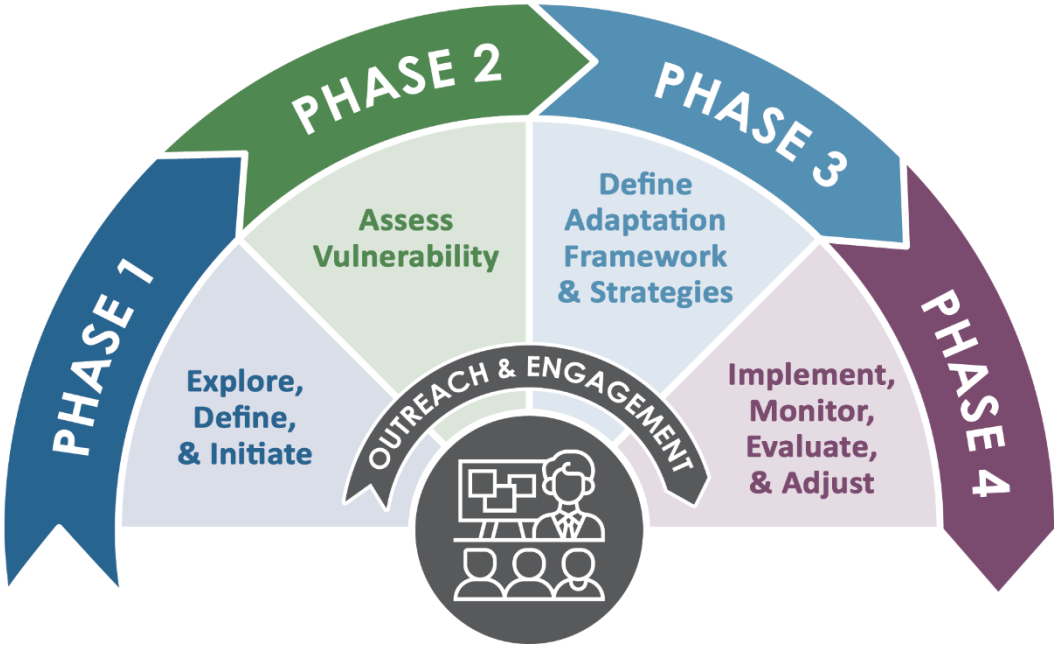
- **Adaptation.** The process of adjustment to actual or expected climate and its effects, either to minimize harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate (IPCC, 2012).
- **Adaptive Capacity.** Carlsbad's ability to cope with and adjust to the impacts of climate change (Cal OES 2020).
- **Asset.** Referential to a resource, structure, facility or service that is relied on by a community.
- **Cascading Impact.** Climate hazard caused impacts that compromise infrastructure or disrupt critical services (i.e., power supply or water conveyance) broadening the scope of impact past a singular subject to reliant subsystems and populations (Collins et al. 2019).
- **Climate Driver.** A change in the climate which acts as the main source of change for subsequent climate hazards. Climate drivers relevant to the city and discussed in this report are temperature and precipitation.
- **Climate Hazard**. A dangerous or potentially dangerous condition created by the effects of the local climate (Cal OES 2020). Climate hazards of concern for Carlsbad are extreme heat, warm nights, chill hours, drought, wildfire, landslides, tule fog, riverine and stormwater flooding, and air quality.
- **Compounding Risk.** When two or more extreme events or average events occur simultaneously and increase the scope of impact or severity of the event; an additional risk brought about by increased frequency of events from climate change (Seneviratne et al. 2012).
- **Exposure.** The presence of people, infrastructure, natural systems, and economic, cultural, and social resources in areas are subject to harm (Kalansky et al. 2018).
- **Impact.** Effects on natural and human systems including effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate hazards and the vulnerabilities of the system or asset effected (IPCC 2012).
- **Mitigation.** An act or sustained actions to reduce, eliminate, or avoid negative impacts or effects (Cal OES 2020).
- **Resilience.** The capacity of an entity (an individual a community, an organization, or a natural system) to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience (Cal OES 2020)
- **Sensitivities**. The degree to which a species, natural system, community, asset, or other associated system would be affected by changing climate conditions (Cal OES 2020).
- **Vulnerable Populations.** Vulnerable populations are the communities most impacted by climate change and climate disasters. Vulnerable populations may experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts (Cal OES 2020)
- **Vulnerability.** The propensity or predisposition to be adversely affected (IPCC 2012).

## 1.4 Vulnerability Assessment Methodology

The following section details state guidance, methods, and sources used in the production of this report.

### California Adaptation Planning Guide Phases

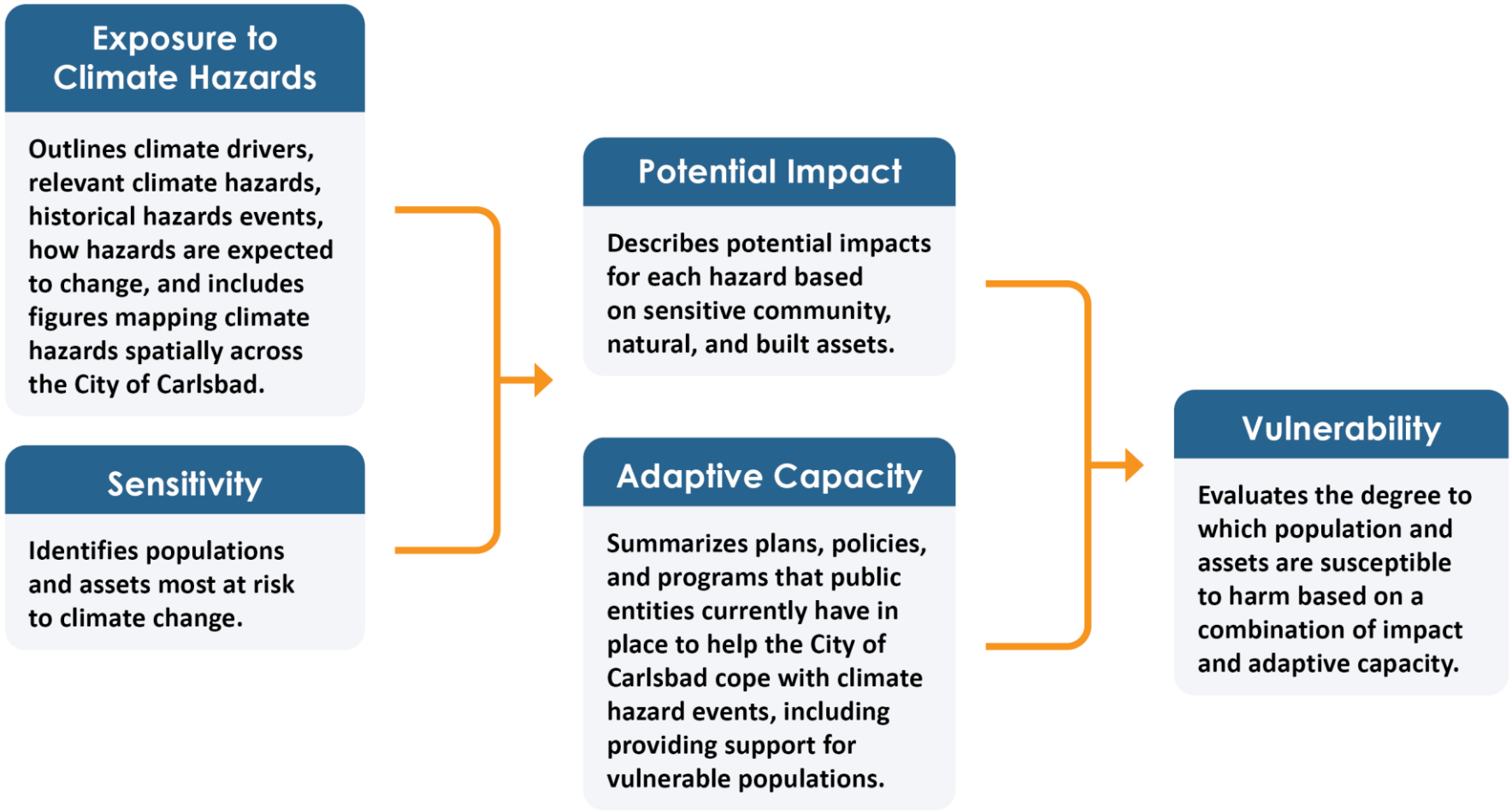
The Carlsbad Climate Change Vulnerability Assessment follows the vulnerability assessment process recommended by the California Governor's Office of Emergency Services, as documented in the 2020 California Adaptation Planning Guide (Cal APG). The adaptation planning process outlined by the Cal APG consists of four phases, illustrated in the graphic below, with Phase 2 detailing the vulnerability assessment process (Cal OES, 2020).




Source: 2020 California Adaptation Planning Guide

The Carlsbad Climate Change Vulnerability Assessment is prepared consistent with Phase 2 of the Cal APG and is composed of the following parts found in Figure 1.

**Figure 1 Vulnerability Assessment Flow Diagram**



## Key Data Sources

The following data sources and tools, many of which are recommended within the Cal APG, were used in preparation of this report. Additional plans were consulted to inform the adaptive capacity analysis which are provided in Section 4.

- **U.S. Census, 2015-2019 American Community Survey (ACS)** presents demographic data by census tract and was used to supplement the HPI percentile score. 2020 U.S. Census data was used to identify the percentage of the Carlsbad population that corresponds to each vulnerable group
- **Cal-Adapt** is an online tool that presents historic and modeled projections based on 10 different global climate models. The tool was developed and is maintained by the University of California with oversight from the California Energy Commission (CEC). This tool is used to present projection data related to minimum and maximum temperature, precipitation, extreme heat, warm nights, drought, and wildfire.
- **California's Fourth Climate Change Assessment** was developed by the CEC and other State of California coordinating agencies to present up-to-date climate science, projections and potential impacts associated with climate change. The CEC and coordinating agencies developed nine regional reports to provide regional-scale climate information to support local planning and action. The San Diego Region Summary Report (2018) presents an overview of climate science, regional projections, 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 San Diego Region Summary Report was used to understand regional changes that may affect Carlsbad both directly and indirectly.
- **The California Healthy Places Index (HPI)** is an online mapping tool that reports on community conditions that are known to predict health outcomes and life expectancy. The tool was prepared by the Public Health Alliance of Southern California, a collaborative of local health departments in Southern California. HPI displays 25 community characteristics at various legislative boundaries, including census tracts and city and county boundaries. The community characteristics relate to the following identified Policy Action Areas: economic, education, housing, health care access, neighborhood, clean environment, transportation, and social factors. HPI applies a relative percentile score across all census tracts in California using statistical modeling techniques based on the relationship of the Policy Action Areas to life expectancy at birth. Low percentile scores reflect unhealthy conditions. HPI was used to prepare the social sensitivity index score as described in more detail below. HPI is a useful in providing both big picture and localized insights into community health. The limitation of this tool is the data behind the measurements and percentile scores is based on US Census information from 2014. Though much of the community health indicators have remained constant the tool was supplemented with additional information from **CalEnviroScreen** to ensure that the best available data is used in this report.
- **CalEnviroScreen4.0** uses a variety of statewide indicators to characterize pollution burden (the average of exposures and environmental effects) and population characteristics (the average of sensitive populations and socioeconomic factors). The model scores each of the indicators using percentiles and combines the scores to determine a CalEnviroScreen score for a given census tract relative to others in the state. Designated disadvantaged communities are those communities that scored within the highest 25 percent of census tracts across California

(CalEnviroScreen percentile scores of 75 or higher), in addition to other parameters relating to income status.

- **San Diego County Multi-Jurisdictional Hazard Mitigation Plan** presents information on existing processes and plans in place that address the County and Carlsbad's ability to prepare for climate change impacts and informed the adaptive capacity discussion of this report. The Multi-Jurisdictional Hazard Mitigation Plan (2018) was also used to identify recent historical events.
- **2017 Carlsbad Sea Level Rise Vulnerability Assessment** is a California Coastal Commission approved vulnerability assessment that presents information on different coastal flood scenarios anticipated to occur as a result of climate change for the years 2050 and 2100. The City of Carlsbad prepared the Sea Level Rise Vulnerability Assessment consistent with 2015 California Coastal Commission Sea Level Rise Policy Guidance, the 2012 California Adaptation Planning Guide, and the 2007 ICLEI-Local Governments for Sustainability Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. This assessment was completed using CoSMoS (an online tool developed by the United States Geological Survey) that depicts sea-level rise projections under a variety of emissions scenarios. The 2050 and 2100 sea level rise scenarios were overlayed with 7 different asset categories to determine overall vulnerability across three separate zones along the Carlsbad coastline. Information from the Carlsbad Sea Level Rise Vulnerability Assessment is used throughout this report to supplement climate hazard information, impacts, and adaptive capacity. The sea level rise projections used in the Carlsbad Sea Level Rise Vulnerability Assessment are 1.6 ft by 2050 and 6.6 ft by 2100. The assessment was conducted spatially using three separate planning zones. From north to south, Planning Zone 1 encompasses Buena Vista Lagoon to Tamarack Avenue. Planning Zone 2 continues south to just below Palomar Airport Road including the Agua Hedionda Lagoon. Planning Zone 3 extends to the southern limits of Carlsbad on the south side of the Batiquitos Lagoon.

## Data Limitations

The limitations of this report and analysis stem from gaps in data availability and completeness of data methods. Census data can miss portions of the population (e.g., undocumented individuals) and general demographic information may not fully identify the full extent of populations vulnerable to climate change (Cantwell 2021). Federal Emergency Management Agency (FEMA) 100-year and 500-year flood plains do not account for climate change projections, zones are instead based on historical information. The California Department of Forestry and Fire Protection (CalFire) very high fire hazard severity zones are based on vegetation, fire history, and terrain but also has similar limitations in not projecting fire zones into the future (OSFM 2022). Extrapolating landslides and air quality hazard exposure data in the context of climate change is difficult and the estimates of exposure to these hazards are likely to be underestimated.

The 2017 Carlsbad Sea Level Rise Vulnerability Assessment presents information based on best available guidance. Since being produced, the Ocean Protection Council and California Coastal Commission guidance of scenarios has changed, and the scope of impacts has subsequently changed as well. Framed as a living document, the Sea Level Rise Vulnerability Assessment is intended to be regularly updated with best available science to yield a more accurate discussion of vulnerability.

The data presented in **Cal-Adapt** tools are projections, or estimates, of future climate. The limitation in these projections is that the long-term behavior of the atmosphere is expressed in averages – for

example, average annual temperature, average monthly rainfall, or average water equivalent of mountain snowpack at a given time of year. The averages discussed often downplay the extremes by which daily weather events occur and when presented as an average, only show moderate changes within the climate. What is often lost in averages is that the frequency of extremes, like atmospheric rivers, may increase while low-moderate intensity weather events decrease through the end of the century. In instances of modeled precipitation projections, it maintains an average similar to historic levels which does not account for anticipated fluctuations in extremes (CEC 2021).

## Vulnerability Scoring Methodology

Vulnerability scoring is a valuable step in the climate vulnerability assessment process because it identifies which assets and populations face the highest threat to climate hazards. This can aid in the prioritization of adaptation actions. The vulnerability score is a combination of the impact and adaptive capacity score. The impact and adaptive capacity scores are developed using a qualitative methodology outlined in the Cal APG, as seen in Table 1. Impact and adaptive capacity scores are identified for each asset and population for each climate hazard. The vulnerability score is prepared by combining the two scores as demonstrated in

### Table 1 Impact and Adaptive Capacity Scoring Rubric

| Score | Impact | Adaptive Capacity |
|---|---|---|
| Low | Impact is unlikely based on projected exposure; would result in minor consequences to public health, safety, and/or other metrics of concern. | Asset managers lack adopted policies or established programs that help the community or the assets they manage to manage for change; major changes would be required. |
| Medium | Impact is somewhat likely based on projected exposure; would result in some consequences to public health, safety, and/or other metrics of concern. | Asset managers have some adopted policies or established programs that help the community or the assets they manage to manage climate impact; some changes would be required. |
| High | Impact is highly likely based on projected exposure; consequences to public health, safety, and/or other metrics of concern. | Asset managers have many adopted policies or established programs that help the community or the assets they manage to manage climate impact; minimal to no changes are required. |

Source: Cal OES 2020

The impact and adaptive capacity scores are combined to form the vulnerability score based on the approach presented in Table 2. The range of potential impacts spans 1 through 5 with 4-5 being at highest vulnerability, which is consistent with methodology from Cal APG.

### Table 2 Vulnerability Score Matrix

| | | | | |
|---|---|---|---|---|
| **Potential Impacts** | **High** | 3 | 4 | 5 |
| | **Medium** | 2 | 3 | 4 |
| | **Low** | 1 | 2 | 3 |
| | | **High** | **Medium** | **Low** |
| | | **Adaptive Capacity** | | |

Source: Cal OES 2020

# 2 Exposure to Climate Hazards

Climate change is a global phenomenon that can impact local health, natural resources, infrastructure, emergency response, and many other aspects of society. Projected changes to the climate are dependent on location. The Cal-Adapt tool provides climate data from global scale models that have been localized (downscaled) to 3.7 mile by 3.7-mile grids (CEC 2021). The data in Cal-Adapt is consistent with information from the California Fourth Climate Change Assessment to model future changes in specific types of hazards within this assessment. Projections throughout this section are outlined by two separate Representative Concentration Pathways (RCP) (CEC 2021).

- RCP 4.5 is a medium emissions scenario where global emissions peak by the year 2040
- RCP 8.5 is a high emissions scenario in which global emissions continue to rise through the end of the 21st century.

Additionally, projections are forecasted to mid-century (2035-2064) and end-century (2070-2099) as 30-year averages to be compared to a modeled historical baseline (1961-1990) (CEC 2021).

This section presents information on temperature and precipitation, which are characterized as climate drivers. The section then provides information on projected changes to natural hazards, including extreme heat, drought, wildfire, landslides, riverine and stormwater flooding, air quality, sea level rise, and groundwater which result from changes to climate drivers.

## 2.1 Climate Drivers

In Carlsbad, the climate drivers of concern include Temperature and Precipitation. All projections are pulled from the Cal-Adapt Local Climate Change Snapshot tool and supplemented with the San Diego regional information found in the California Fourth Climate Change Assessment (CEC 2021, Kalansky et al. 2018).

### Temperature

Carlsbad has an average maximum temperature of 73.4°F and an average minimum temperature of 51.9°F (CEC 2021). The average maximum and minimum temperatures are expected to increase in Carlsbad with mid-century projections showing a 3°F (RCP 4.5) to 4°F (RCP 8.5) increase in temperature maximum and minimums (CEC 2021). End-Century projections show a 4°F (RCP 4.5) to 7°F (RCP 8.5) increase in Carlsbad and generally throughout the San Diego region a 5°F to 10°F increase (CEC 2021, Kalansky et al. 2018). Temperature increases affects extreme heat and warm nights, drought, wildfire, and air quality. Global temperature increases cause ocean temperatures to rise which expands ocean waters. Glaciers, ice caps, and ice sheets melt from rising temperatures which further contribute to sea level rise (Kalansky et al. 2018).

### Precipitation

Currently the amount of precipitation received by San Diego County is not sufficient in addressing the population or infrastructure needs and is supplemented by external sources such as the Colorado River Basin and the Carlsbad Desalination Plant (Kalansky et al. 2018).

Carlsbad precipitation projections under RCP 8.5 demonstrate a 0.6-inch decrease by mid-century and 1-inch decrease by end-century in annual precipitation totals (CEC, 2021). However, as already observed in recent decades precipitation changes are largely observed as more extreme variability with intensely wet years followed by extreme droughts (Kalansky Et al. 2018). It is projected that the wettest day every year will increase from 10-30% by the end of the century in the San Diego Region (Kalansky Et al. 2018). There will be more dry periods punctuated by increased precipitation intensities of the largest storms or wet periods, producing little net change in precipitation totals but more extreme conditions (Kalansky Et al. 2018). Precipitation changes are expected to affect wildfire, drought, landslides, riverine stormwater flooding, and air quality.

**Historical Precipitation Extremes**

Precipitation volatility similar to what has been projected within the California Fourth Climate Change Assessment can be observed over the last two decades where wet years in 2005, 2011, and 2017 have been offset by extended droughts in 2001-2004, 2007-2010, 2012-2015, and 2018 to present (Kalansky Et al. 2018).

## 2.2 Hazards

This section outlines projected changes for the following climate hazards:


Extreme Heat


Drought


Wildfire


Landslides

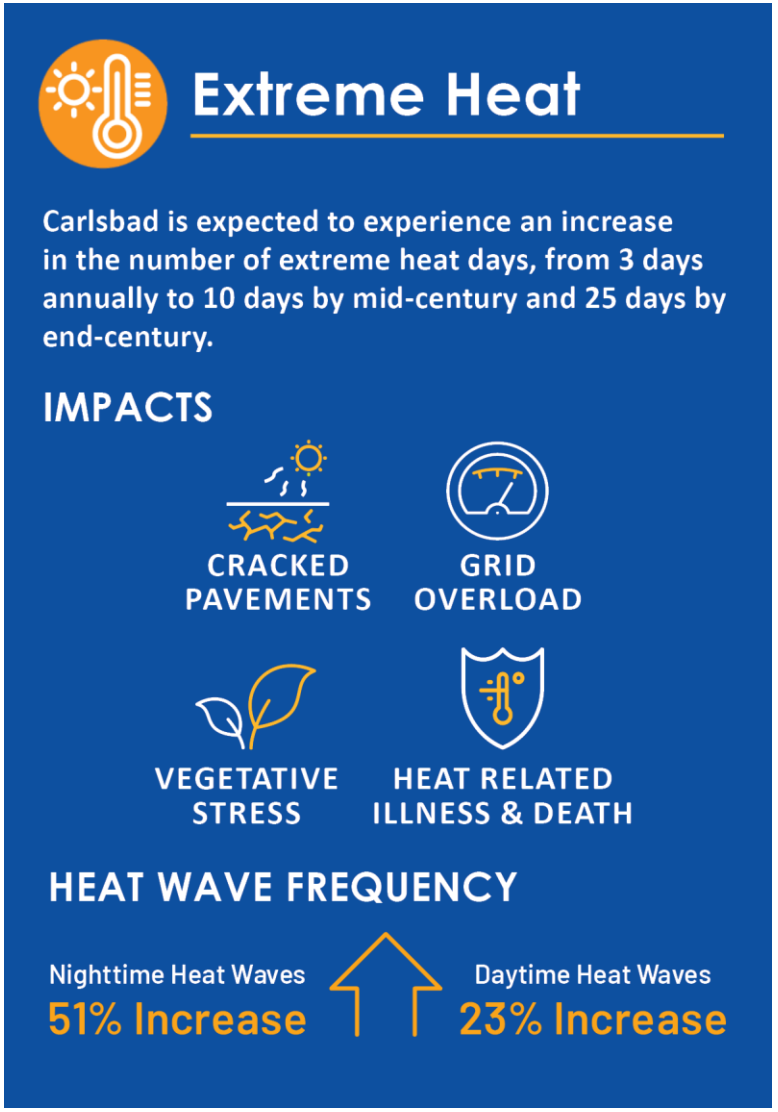

Riverine and Stormwater Flooding


Air Quality


Sea Level Rise

## Extreme Heat

Extreme heat waves are defined as multiple days in which the daily maximum temperature exceeds the 98thpercentile value of the historical average (CEC 2021). For Carlsbad, the threshold temperature is 92.5°F (CEC 2021). Increased frequency of individual extreme heat days and extended duration of extreme heat waves can result in increased public health risks, particularly to vulnerable populations like older adults, young children, and individuals with underlying chronic diseases, through heat-related illnesses and increased vector-borne illnesses. Warm nights can further exacerbate the risk of heat illness because they affect the body's ability to cool after a day of heightened temperatures. Carlsbad has historically experienced 4 warm nights a year and is projected to experience a mid-century total of 32 nights (RCP 8.5) and an end-century total of 33 (RCP 4.5) to 77 nights (RCP 8.5) (CEC 2021). Extreme heat events and warm nights are expected to occur across more heat wave events as well (CEC 2021). Extreme heat can also damage roadways, overload electrical grid systems, and result in vegetation die-off or stress.

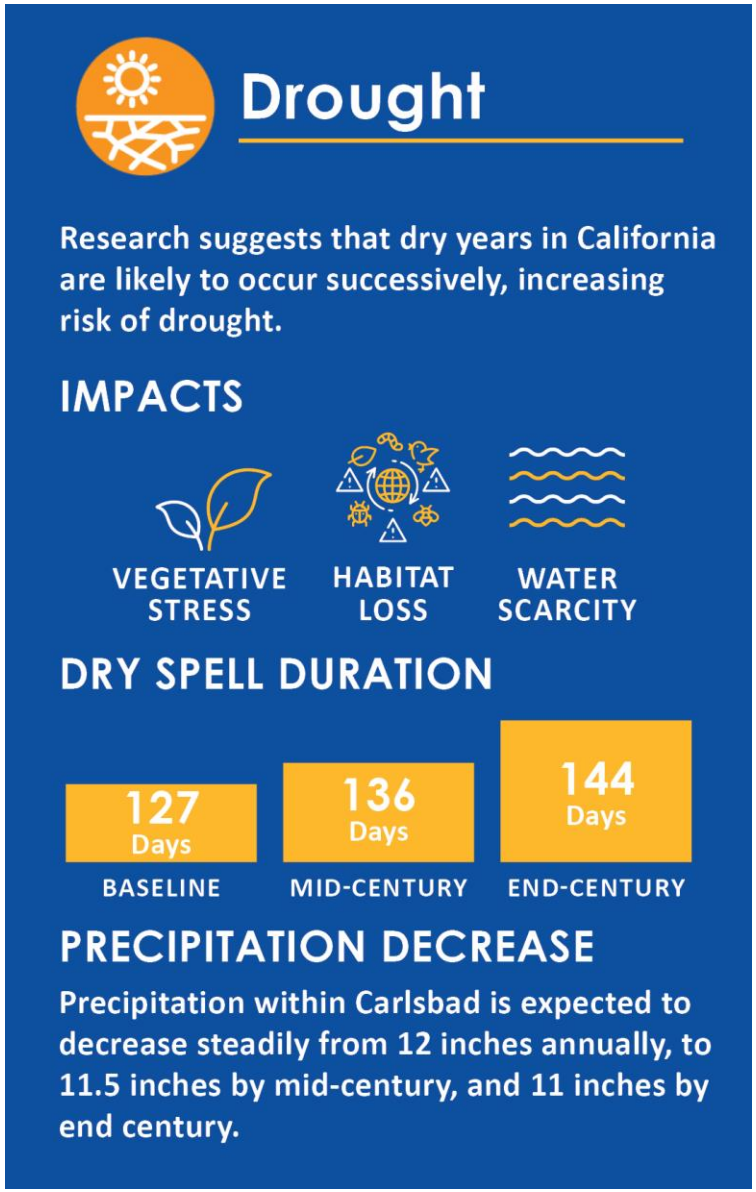


## Drought

Climate change will increase the likelihood that low-precipitation years will coincide with above-average temperature years. Warming temperatures increase seasonal dryness and the likelihood of drought due to decreased supply of moisture and increased atmospheric demand for moisture as evaporation from bare soils and evapotranspiration from plants increases. The increased moisture loss from soils and vegetation amplifies dryness during periods without precipitation. In California's highly variable climate setting, climate models project less frequent but more extreme daily precipitation, with year-to-year precipitation becoming more volatile and the number of dry years increasing (Kalansky et al. 2018).

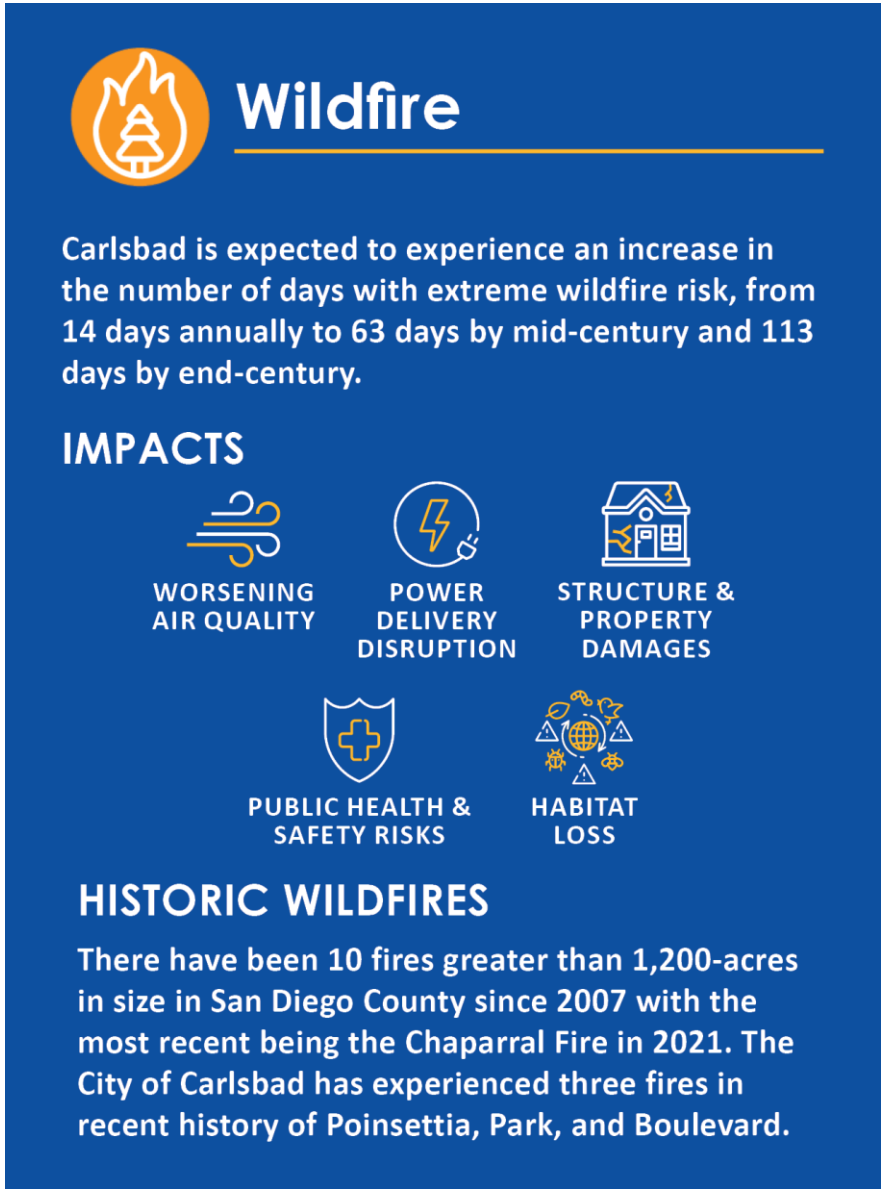
The duration of dry spells is projected to vary based on emissions scenario. Like patterns in precipitation some of the annual variability is obscured within 30-year averages. Despite this, the clear trend is for maximum lengths of dry spells to increase through the end of century (CEC 2021).

Drought can affect vulnerable populations as well as economic productivity throughout Carlsbad. Vulnerabilities for natural resources can include stressed vegetation and habitat depletion while populations may be more vulnerable to heat stress and dehydration (Kalansky et al. 2018).

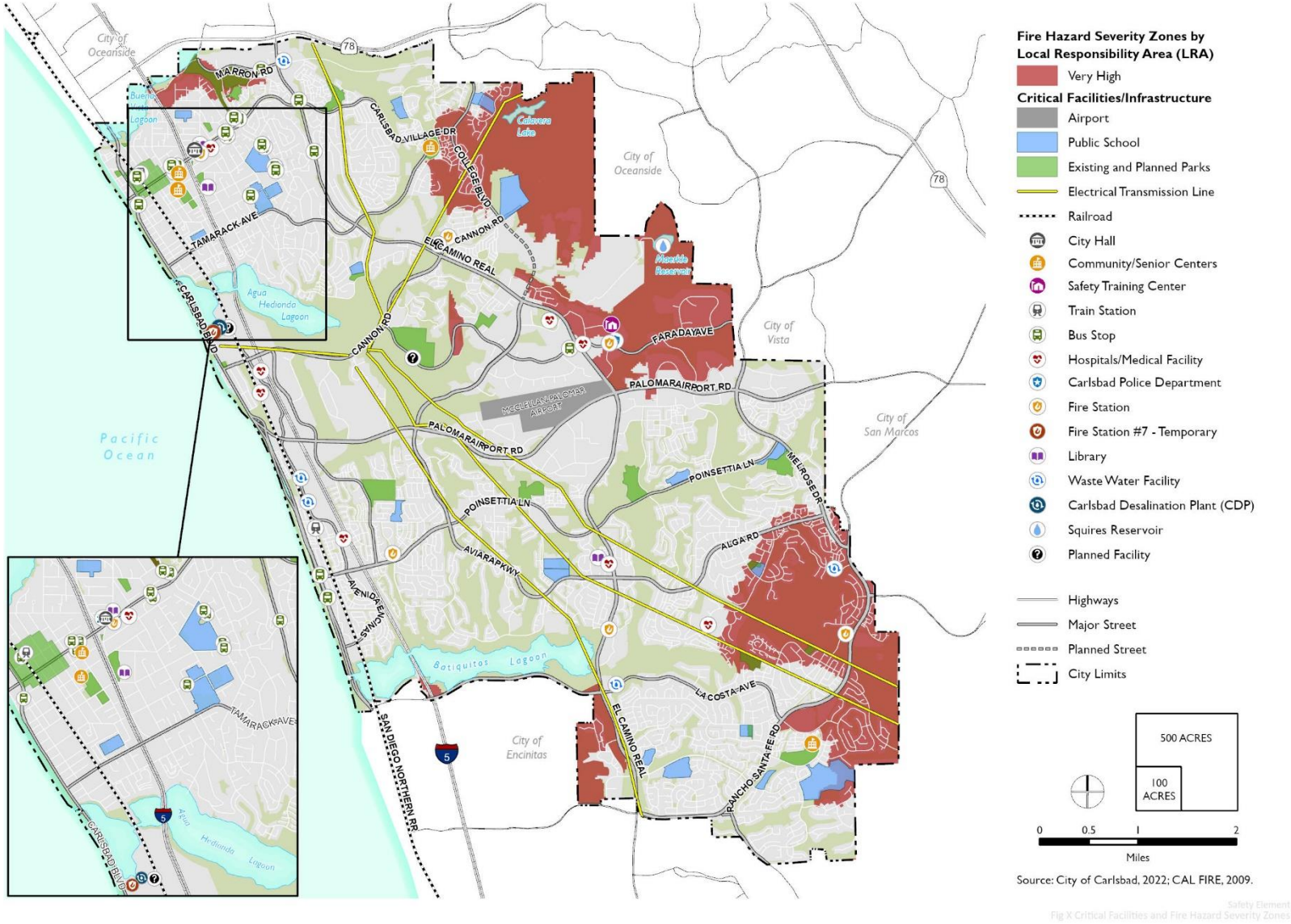


## Wildfire

The occurrences of wildfires have increased significantly within California in frequency, area, and severity over the past two decades (Kalansky et al. 2018). Fires occurring in city limits occurred in January 2022, January 2021, and May 2014. For Carlsbad this trend is projected to follow through mid and end-century projections (CEC 2021). Wildfire events are a product of temperature increases compounded with precipitation declines creating wildfire prone conditions. San Diego County's wildfires are influenced by Santa Ana Winds, downed power lines, and fuel availability (Kalansky et al. 2018). Most areas in Carlsbad face significant wildfire risk. These areas are categorized as CAL FIRE very high fire hazard severity zones (VHFHSZ), shown in Figure 2. There are several critical facilities within the VHFHSZ including 4 parks, 3 schools, 2 fire stations, the police department, and the wastewater treatment facility. Several roads and residential areas are also located within the City's fire zone. Several fires have afflicted the boundaries of Carlsbad including the Boulevard, Park, and Poinsettia fires. Wildfires can create risk of injury, death, or financial hardship if personal property is damaged as well as physical damage to all other assets creating cascading risks for vulnerable populations when infrastructure is damaged or off-line including communications infrastructure.

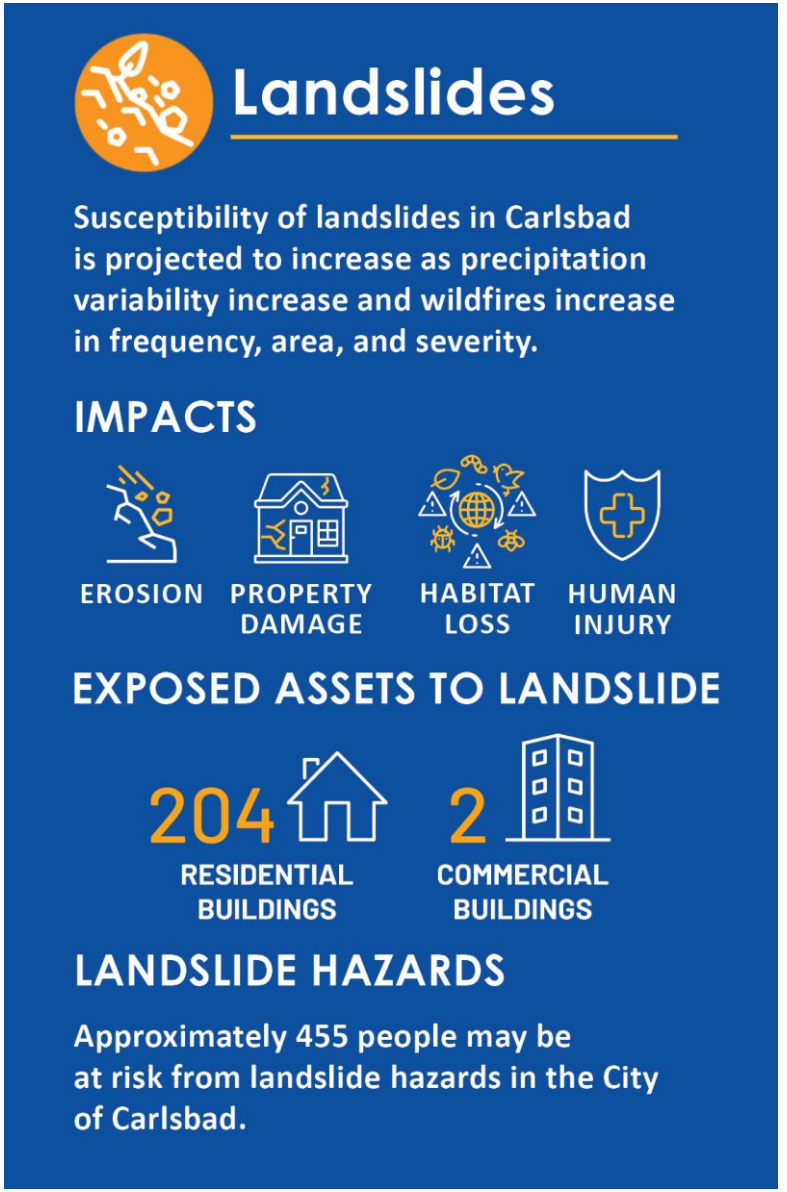


## Figure 2 Wildfire Hazard Severity Zones in Carlsbad



## Landslides

Triggered by extreme bouts of precipitation on wildfire burn scars, the susceptibility of the larger San Diego region to landslides is projected to increase as precipitation variability increases and wildfires increase in frequency, area, and severity (Kalansky et al. 2018). The San Diego Region is projected to experience increases to wildfire and precipitation and subsequently landslide-prone conditions(CEC 2021). Landslides for the City occupy regions that overlap with wildfire zones, and along sloped areas in the Carlsbad hills (CDOC 2021). The San Diego County Multi-Jurisdictional Hazard Mitigation Plan exposure assessment details specific assets at risk within Carlsbad to landslides as well as the afflicted population total for the City.



## Riverine and Stormwater Flooding

Climate change may cause low-lying areas throughout Carlsbad to experience more frequent flooding and could increase the extent of 100-year floods. Riverine flooding is projected to increase as precipitation extremes increases (CEC, 2021). Figure 3 maps the 100- and 500-year floodplains within Carlsbad. Stormwater systems may be overwhelmed more frequently as more extreme rain events occur, causing localized flooding which could impact properties and close streets. While no critical facilities or infrastructure occupy 100-year or 500-year floodplains in Carlsbad, the community of Rancho Carlsbad is located within the 100-year floodplain. Several parks, fire stations, schools, wastewater facilities, and electric power facilities aborder existing floodplains.

Flooding impacts directly create physical damages from inundation (Kalansky et al. 2018). Flooding can also cascade into power, wastewater, and storm drainage infrastructure, exacerbating public health concerns.

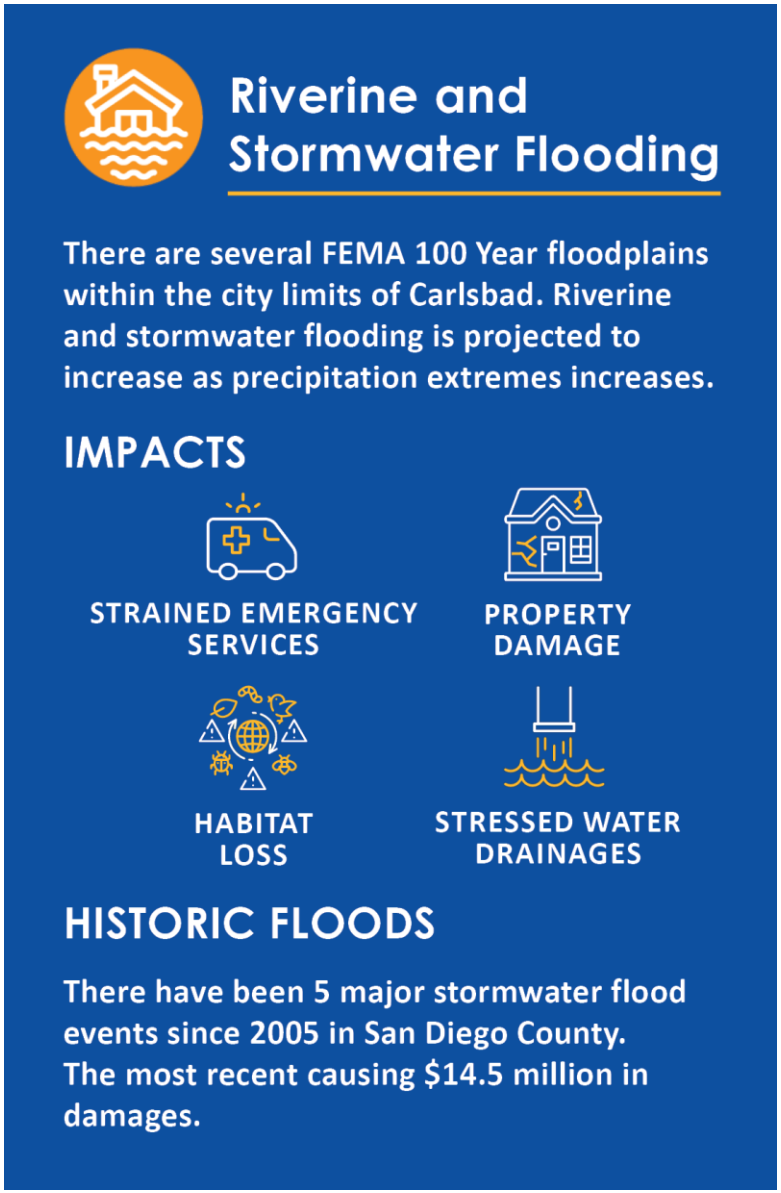
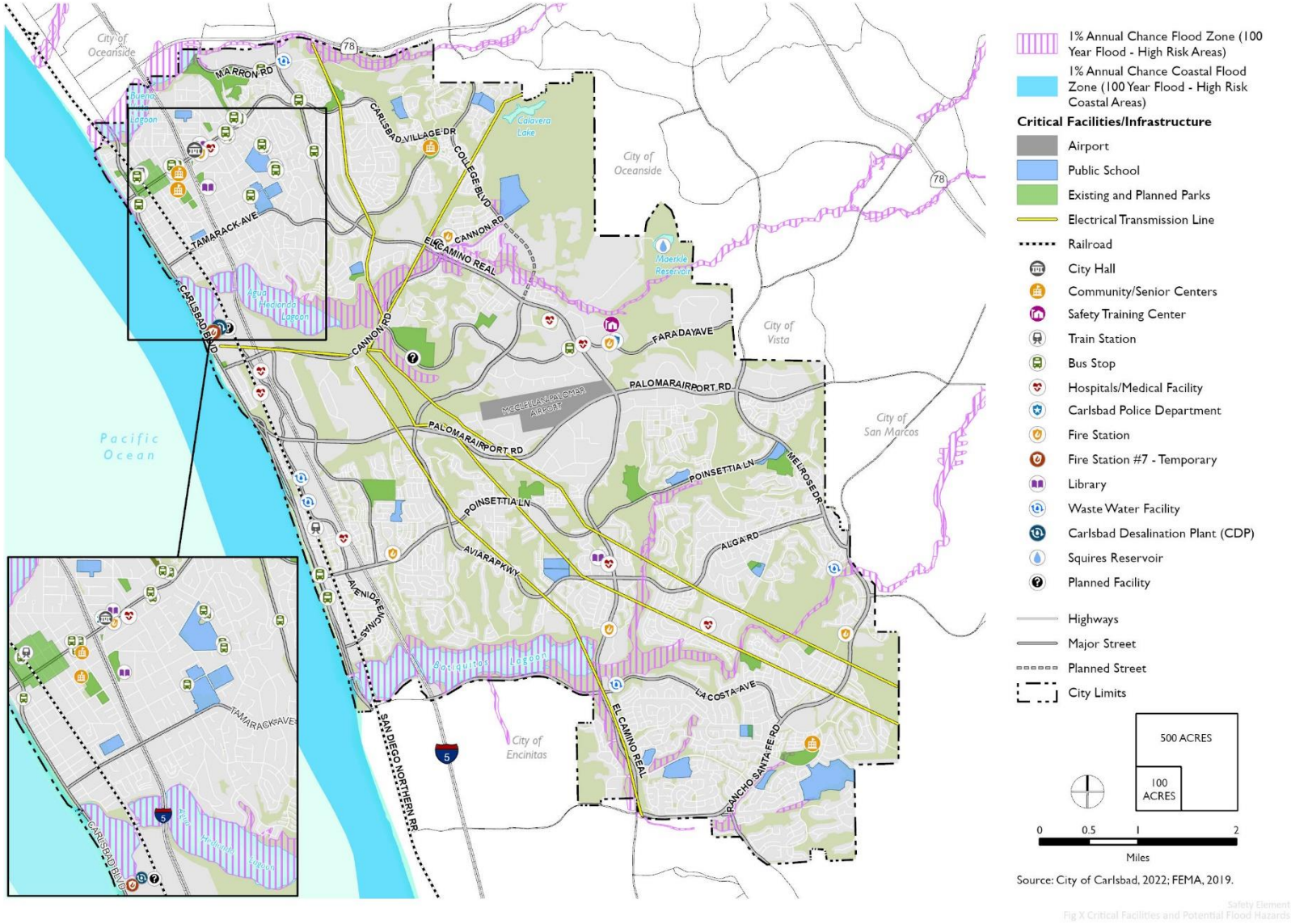


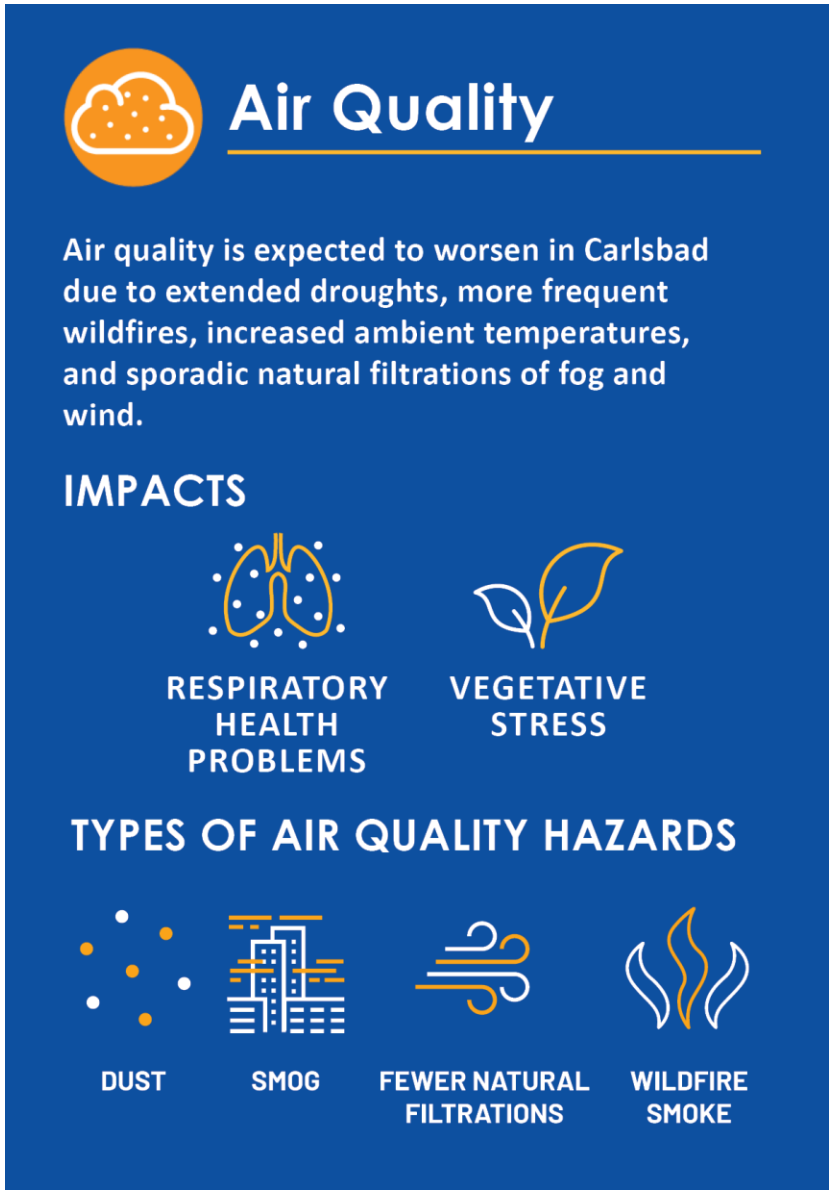
**Figure 3 100 and 500 Year Floodplain in Carlsbad**



## Air Quality

Worsening air quality due to climate change can create respiratory issues for vulnerable populations and impact indoor areas without adequate air filtration systems. There are several types of air quality decline sources found below:

- **Dust.** Increased temperature leads to dry, dusty conditions also associated with drought (Kalansky et al. 2018).
- **Smog.** Increases in ambient temperature can lead to higher rates of smog also referred to as ozone. Ground-level ozone specifically will be experienced at higher rates leading to raised cardiovascular and respiratory morbidity and mortality rates (CDPH, 2014). Ground-level ozone has also been shown to have particularly disproportionate adverse impacts on populations experiencing homelessness and lower median income (PNAS, 2021). Carlsbad will experience increases in ozone concentrations in parallel to temperature increases.
- **Fewer Natural Filtrations.** Precipitation variability and long periods of dry spells lead to less reliable air quality for the entire region. Moisture in the air can filter pollutants and provide for overall improved conditions.
- **Wildfire Smoke.** Temperature, severe wildfire conditions, and the area burned by wildfires throughout the state has increased and will continue to increase. Higher temperatures accompanied by an increase in the incidence and extent of large wildfires will lead to increased wildfire smoke and associated toxins and air pollution (Kalansky et. al 2018).



## Sea Level Rise

Sea level rise (SLR) can negatively impact the coastal area of Carlsbad through regular tidal inundation, erosion, and storm flooding. Climate change is expected to increase the rate of sea level rise dependent on the extent of warming temperatures. The Carlsbad Sea Level Rise Vulnerability Assessment evaluated 1.6 feet of sea level rise by 2050 and 6.6 feet of sea level rise by 2100. Groundwater inundation brought about by Sea Level Rise was determined to have little effect on the community (Wood et al. 2020). See Figure 4 for areas potentially tidally inundated and overlaid with critical facilities. There are 5 hazard zones outlined within the Carlsbad Sea Level Rise Vulnerability Assessment found below.

- Coastal Inundation Hazard Zone
- Lagoon Inundation Hazard Zone
- Bluff Hazard Zone
- Coastal Flood Hazard Zone
- Lagoon Flood Hazard Zone

Each of these hazard zones are based on modeling conducted to analyze impacts of sea level rise. The zones were used to better understand which assets would be affected. Additional, qualitative assessments were provided onimpacts of sea level rise on visual resources, cultural resources, saltwater intrusion, and lifeguard services.Impacts were characterize as none to moderate (Carlsbad 2017).

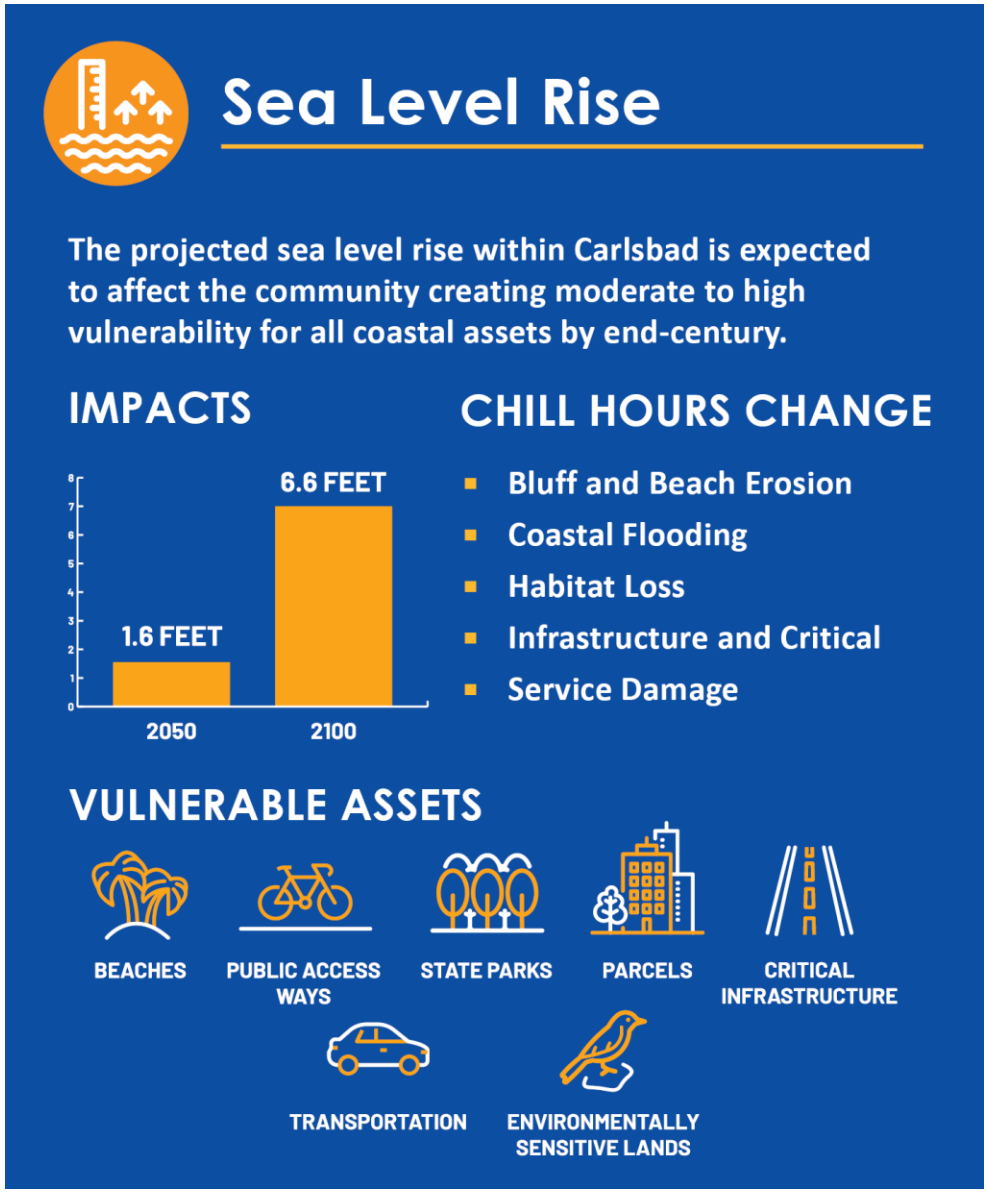
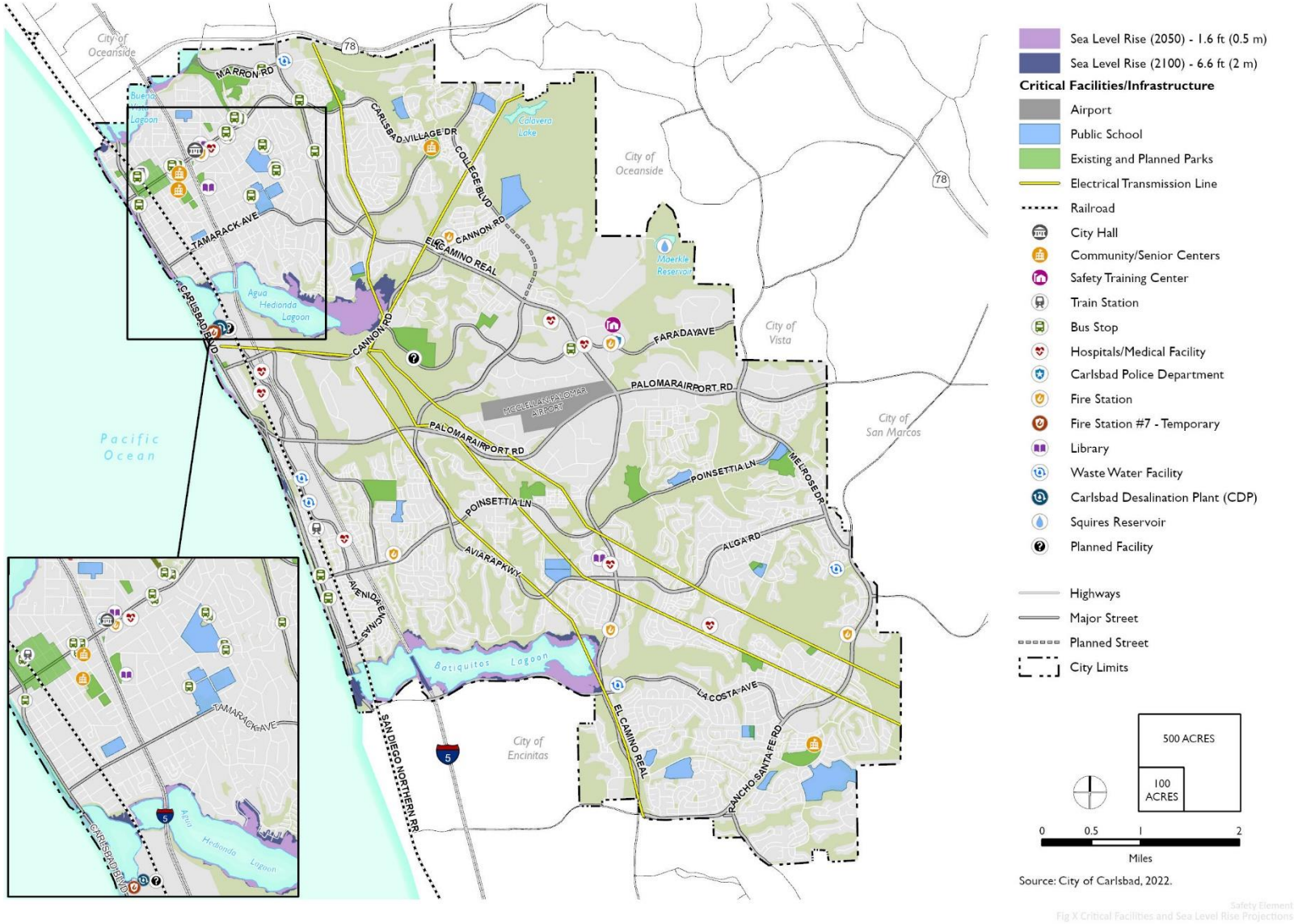


**Figure 4 Sea Level Rise in Carlsbad Through 2050 and 2100**



# 3 Sensitivity

Populations and assets are affected by climate change depending on their sensitivity to climate hazards. Sensitivity is the degree to which a species, natural system, community, asset, or other associated system would be affected by changing climate conditions (Cal OES 2020). This section identifies sensitive populations and assets within Carlsbad. Potential impacts from the climate hazards of concern on sensitive populations and assets are presented in the Vulnerability Analysis section. Assets are grouped in the following manner:


Vulnerable Populations


Natural and Recreational Resources


Buildings and Facilities


Infrastructure and Critical Services

## 3.1 Vulnerable Populations

While all people in a community will experience climate change, some may be more affected than others. For example, older adults and young children may be more at-risk to heat illness during an extreme heat event. Several factors influence sensitivity to climate hazards including an individual's health, age, and ability, societal disadvantages, inequities in access to health care, economic opportunity, education and other resources, and inequities found in basic needs and exposure to environmental stressors (Cal OES 2020). Vulnerable populations experience heightened risk to climate change and have fewer resources to adapt and recover from climate change impacts. Following guidance from the Southern California Adaptation Planning Guide, vulnerable population groups were identified for the City (SCAG 2020). Carlsbad has several vulnerable populations that will disproportionately experience climate change listed in Table 3 below.

## Table 3 Vulnerable Populations in Carlsbad

| Population | Population Description | Total Number, Percentage of Population or Households |
|---|---|---|
| Individuals with education attainment less than 4 years of college | Percent of people over age 25 without a bachelor's education or higher | 41% |
| Renters | Housing units that are renter occupied | 35% |
| Non-white Communities | All individuals that do not identify as white | 27% |
| Older adults | Individuals 65 years or older | 17% |
| Individuals with Asthma | Percent of people with Asthma | 8% |
| Low Income | Individuals below the federal poverty level | 7% |
| Individuals with no health insurance | Individuals aged 18 to 64 years old currently uninsured | 6% |
| Households without broadband internet | Households without access to broadband internet. | 6% |
| Individuals with disabilities | Individuals with access and functional needs (physical and mental) | 5% |
| Children | Individuals 5 years and younger | 5% |
| Miliary Veterans | Individuals who have served but are not currently serving in the US Armed Forces | 5% |
| Unemployed | Percentage of population aged 25-64 who are unemployed | 4% |
| Households without a computer | Households without access to a computer. | 3% |
| Linguistically Isolated | Households with individuals who are non or limited English-speaking | 3% |
| Outdoor Workers | Individuals who are employed, 16 and older, and work outdoors | 2% |
| Isolated Individuals | Households without access to a vehicle | 2% |
| People experiencing homelessness | Individuals who currently lack fixed, regular, and adequate housing | 147 |
| Individuals with Cardiovascular Disease | Age-adjusted rate of emergency department visits for heart attacks per 10,000. | 9 |

Source: The percentages used in this table were acquired from the California Healthy Places Index 3.0, U.S. Census, 2015-2019 American Community Survey (ACS), and CalEnviroScreen

Vulnerable populations were grouped based on potential exposure to climate hazards, access to resources to prepare, cope with, or recover from climate hazards, whether individuals face societal disadvantages, or if individuals have heath conditions or health sensitivities that leave them vulnerable to climate hazards. Often individuals have characteristics that make them vulnerable in a variety of ways; however, for the purpose of this assessment, they were grouped based on the sensitivity that increases their risk the most. Vulnerable populations are grouped below:

- **Individuals with High Outdoor Exposure.** Outdoor workers, and people experiencing homelessness.
- **Under-Resourced Individuals.** Low-income, unemployed, individuals with no health insurance, households without a computer, households without a broadband internet, renters, isolated individuals, individuals with educational attainment of less than 4 years of college
- **Individuals Facing Societal Barriers.** Non-white communities, linguistically isolated, American Native and Native Alaskan, and Undocumented individuals.
- **Individuals with Chronic Health Conditions or Health Related Sensitivities.** Older adults, children, Individuals with disabilities, individuals with asthma, individuals with cardiovascular disease, and Military Veterans.

## 3.2 Natural and Recreational Resources

Natural and recreational resources within Carlsbad as detailed in the Open Space Element of the General Plan include the ocean and beaches, coastal public accessways, three lagoons (Agua Hedionda, Batiquitos and Buena Vista, California's first ecological reserve), waterways, parks, hillsides, and the urban forest. These various resources provide habitat, sources of community resilience, recreation, and economic productivity to the City. These resources are spread throughout the City and face various levels of exposure to climate hazards.

## 3.3 Buildings and Facilities

Climate change is expected to amplify extreme weather and climate hazards in Carlsbad. A jurisdiction's vulnerability increases when buildings and facilities are not designed, operated, and/or maintained to function effectively under extreme weather conditions or can be damaged by extreme weather conditions. The following buildings and facilities would be particularly sensitive to climate change: municipal and public buildings, educational facilities, hospitals, residential, commercial, and industrial development, roadways and transportation facilities, active transportation routes, fire stations, police stations, and entertainment and hospitality.

## 3.4 Infrastructure and Critical Services

Within Carlsbad there is a large array of infrastructure and critical services that are vulnerable to climate change. Assets within this category include water services, wastewater, the desalination plant, storm drainage and flood protection, solid and hazardous waste and recycling, fire services, emergency services, medical services, utilities and major utility corridors, public transportation, roadways, communication infrastructure, and active transportation routes (bike paths and walkways). This asset group is sensitive to climate change as the impacts of hazards can affect the service line ability to provide

resources and the infrastructure in place may not be adequately prepared to sustain increasing and compounding hazards.

# 4 Adaptive Capacity

Adaptive capacity is the ability to adjust to the consequences of climate change. This section summarizes the ways in which asset managers, including the City and other agencies and utilities, currently manage for the negative impacts of climate change. Types of adaptive capacity include adjustments in behavior, resources, and technologies. The City of Carlsbad and other asset managers have actively taken steps to increase the adaptive capacity of assets and the community in Carlsbad. Existing policies, plans, programs, and institutions that increase the city's resilience to climate change impacts are organized by climate hazard and listed in Table 4, Table 5, Table 6, and Table 7.

## 4.1 Extreme Heat and Warm Nights

Table 4 lists programs, plans, and policies that help communities become more resilient to an increase in extreme heat and warm nights.

**Table 4 Program, Plans, and Policies to Manage Impacts of Extreme Heat and Warm Nights**

| Existing and Planned Programs, Plans, and Policies | Objectives |
|---|---|
| San Diego County Aging and Independence Services (AIS) Cool Zones and Fan Program | This program is a partnership between San Diego County Aging and Independence Services and SDG&E to maintain designated cooling centers for county residents especially those more susceptible to heat related illness. The program also provides electric fans free of charge to seniors and other vulnerable groups without access to air conditioning. |
| San Diego County Excessive Heat Response Plan (County of San Diego Health and Human Services Agency 2021) | The San Diego County Health and Human Services Agency maintains an internal and external Excessive Heat Response Plan. The Internal plan coordinates public health resources in response to extreme heat events. The external plan ("Consumer Version") is a public facing document which provides resident guidance and strategies for mitigating heat related hazards. |
| Carlsbad Cool Zone Program | The City of Carlsbad maintains cooling centers for residents during periods of extreme heat. The sites provide free air-conditioning and conserve energy for the whole community. |
| San Diego Gas & Electric (SDG&E) Medical Baseline Allowance Program (SDG&E 2021) | SDG&E provides additional electricity at discounted rates to customers with a qualifying medical need. This program often allows heat sensitive individuals to continue operating space cooling equipment more consistently. |

# 4.2 Riverine & Stormwater Flooding, Droughts, & Sea Level Rise

Table 5 lists programs, plans, and policies that help increase the community's resilience to riverine and stormwater flooding, droughts, and sea level rise.

**Table 5 Programs, Plans, and Policies to Manage Riverine and Stormwater Flooding, Droughts, and Sea Level Rise Impacts**

| Existing and Planned Programs, Plans, and Policies | Objectives |
|---|---|
| Carlsbad Municipal Water District (CMWD) Urban Water Management Plan (Carlsbad Municipal Water District 2020) | The Carlsbad Municipal Water District (CMWD) Urban Water Management Plan includes descriptions of CMWD's water supply sources, projected water demands, and supply reliability during normal water years, single dry years, and five consecutive dry years. The plan includes a discussion of the impacts of climate change on the system in a vulnerability analysis as well as strategies for mitigation and adaptation. |
| Claude "Bud" Lewis Carlsbad Desalination Plant | Beginning operation in 2015, the Claude "Bud" Lewis Carlsbad Desalination Plant provides a "drought-proof" source of drinking water to water utilities throughout the San Diego region. |
| Olivenhain Municipal Water District (OMWD) Urban Water Management Plan (Olivenhain Municipal Water District 2020) | The Olivenhain Municipal Water District (OMWD) Urban Water Management Plan includes descriptions of OMWD's water supply sources, projected water demands, and supply reliability during normal water years and periods of drought. The plan includes a discussion of the impacts of climate change on the system. |
| Olivenhain Municipal Water District (OMWD) Potable Water and Recycled Water Master Plan (Olivenhain Municipal Water District 2015) | The OMWD Potable Water and Recycled Water Master Plan forecasts potable water demand through 2050 as well as outlines the planned expansion of the water districts potable and recycled water systems. The plan incorporated the findings of San Diego County Water Authority's 2013 climate change analysis to inform water demand projections. |
| North San Diego Water Reuse Coalition (NSDWRC) | The NSDWRC is a collaborative program between northern San Diego County water and wastewater agencies. The agencies are taking inventory of where there is a supply of wastewater and a demand for recycled water. This program will provide the region with a drought-proof source of water and reduce discharge of wastewater to the ocean. |
| San Diego Integrated Regional Water Management Plan: Integrated Flood Management Planning Report (County of San Diego 2013) | This regional study serves as a guidance document to facilitate an integrated water resources approach to flood management. It includes information to perform planning level risk analysis and defines general strategies and approaches to guide flood management decision making. The report highlights the need for floodplain management systems to be flexible and resilient to changing conditions like climate change and population growth applied towards stormwater flooding. |
| City of Carlsbad Local Coastal Program Land Use Plan 2019 (Carlsbad 2019). | The 2019 Local Coastal Plan for the City of Carlsbad, supported by the 2017 Sea Level Rise Vulnerability Assessment, provides several land use policies that support sea level rise adaptation efforts. Policies of LCP-7-P.28 through LCP-7-P.36 build on the sea level rise vulnerability assessment to incorporate findings and recommendations into the local coastal plan including land use and mitigation actions. |

| Existing and Planned Programs, Plans, and Policies | Objectives |
|---|---|
| Agua Hedionda Watershed Management Plan (City of Vista 2008) | The 2008 Agua Hedionda Waterhed Management Plan describes water quality, habitat, erosion, and hazard concerns within the Agua Hedionda Watershed. The City of Carlsbad assisted in the development of the Plan. The Plan acknowledges the long-term challenges that climate change will pose on the watershed's wildlife and overall watershed function. A variety of management actions are recommended including preservation of riparian buffer and wetlands restoration and stormwater retrofit projects. Considerations of predicted impacts from climate change are not described in relation to the proposed management actions. |
| City of Carlsbad Local Coastal Program (Draft) | The City of Carlsbad Local Coastal Plan, approved by the City Council on October 12, 2021, identifies coastal areas that are most susceptible to damage from a climate change driven increase in the sea level. The assessment projects potential hazards through 2050 and 2100. It compares the relative risks and vulnerabilities of different areas and resources. The report also describes possible adaptation strategies the City can implement to prevent future coastal flooding and erosion. The LCP is considered "draft" as it is subject to the review and approval of the California Coastal Commission. The document is currently under review by the Commission. |
| SANDAG Regional Beach Sand Project | The Project placed 1.5 million cubic yards of beach quality sand on regional beaches in the fall of 2021. Around 140,000 cubic yards were placed in South Carlsbad and about 218,000 cubic yards of sand were placed in North Carlsbad. |
| The Carlsbad Opportunistic Sand Program | The Carlsbad Opportunistic Sand Program was launched in 2006 to leads the City's sand acquisition effort. Under the program, Carlsbad can accept up to 150,000 cubic yards a year. |

# 4.3 Wildfires

Table 6 lists programs, plans, and policies that help increase the community's resilience to wildfires. There are no policies or programs in place that specifically address landslides or air quality related hazards.

**Table 6 Programs, Plans, and Policies to Manage Wildfire Impacts**

| Existing and Planned Programs, Plans, and Policies | Objectives |
|---|---|
| Carlsbad Hazard Reduction Program | The Carlsbad Hazard Reduction Program is managed by the Carlsbad Fire Department in order to comply with AB 38 which requires real estate sales of property within a High or Very High Fire Severity Zone to involve an inspection by local fire authorities to demonstrate compliance with state and local laws regarding defensible space and vegetation management. |
| Carlsbad Fire Department's Fire Prevention Bureau (Carlsbad Fire Department 2022) | The Carlsbad Fire Department's Fire Prevention Bureau works to mitigate risks within the community by providing education about the benefits of proper safety practices and reduction of all types of hazardous conditions. The Bureau's responsibilities include fire code enforcement, Hazard reduction inspections in the Wildland Urban Interface, and public education. |
| SDG&E Wildfire Mitigation Plan (SDG&E 2021) | The SDG&E Wildfire Mitigation Plan details the various mitigation efforts the utility is making to reduce the risk of and increase resilience to wildfire. These efforts include risk assessment and mapping, situational awareness and forecasting, public safety power shutoffs, grid hardening, vegetation monitoring and management, grid operations and protocols, and emergency preparedness. |
| San Diego County Resilience Review Report: Wildland Fire (County of San Diego 2019) | The Wildfire Resilience Review Report is part of the larger San Diego County Resilience Program and is intended to identify gaps in San Diego County's approach to reducing the community risk from wildfire. The report makes recommendations to support risk mitigation before a wildfire, functional capacity in response to wildfire, and strategies to recover from a wildfire. Task G.2 states to establish a Memorandum of Agreement with Carlsbad Fire, San Marcos Fire, and Escondido Fire to create a Joint County Technical Rescue Team (County of San Diego 2019). |
| San Diego Gas & Electric (SDG&E) Public Safety Power Shutoff (PSPS) Notifications and Supportive Services (SDG&E 2021) | SDG&E operates a notification system to alert customers of Public Safety Power Shutoff during periods of elevated wildfire risk. During a PSPS, SDG&E provides various supportive services to customers with qualifying needs including hotel stays, accessible transportation, food support, welfare checks, and backup power systems. |

## 4.4 Multiple Climate Hazards

Table 7 lists programs, plans, and policies that help increase the community's resilience to multiple climate hazards.

**Table 7 Programs, Plans, and Policies to Manage Multiple Climate Hazard Impacts**

| Existing and Planned Programs, Plans, and Policies | Objectives |
|---|---|
| San Diego County Multi-Jurisdictional Hazard Mitigation Plan (County of San Diego 2018) | The Plan assesses hazards within the County including Carlsbad and identifies mitigation strategies that reduce or eliminate long-term risks to people and property from those hazards. Climate hazards planned for include drought, flood, landslides, extreme heat, winter storms, and wildfire. The Plan outlines goals and objective to mitigate risk to vulnerable populations and physical assets across San Diego County including Carlsbad. |
| San Diego County Emergency Operations Plan (EOP) (County of San Diego 2018) | The County EOP summarizes a comprehensive emergency management system which enables a planned response to a wide variety of disaster situations. The high-level goals of the EOP are 1) to provide a system for the effective management of emergency situations; 2) to identify lines of authority and relationships; 3) to assign tasks and responsibilities; 4) to ensure adequate maintenance of facilities, services, and resources; and 5) to provide a framework for adequate resources for recovery operations. While the plan does not address climate change directly, it establishes a framework of response to multiple hazards exacerbated by climate change including flooding, drought, wildfire, and landslides. |
| Carlsbad You Are Not Alone (YANA) Program | The YANA program is a free service for Carlsbad seniors who live alone and would benefit from a daily check. YANA clients are called each morning Tuesday through Saturday. If the client does not respond, a welfare check is conducted. |
| City of Carlsbad Emergency Operations Plan (City of Carlsbad 2021) | Carlsbad's Emergency Operations Plan details protocols to prevent, protect, mitigate, respond, and recover from the effects of disasters. The plan provides a system for the effective management of emergency situations and identifies lines of authority and responsibility. The plan reviews the hazards most likely to impact the City, especially those exacerbated by climate change including drought, extreme heat, wildfire, flooding, and severe winter storms. |
| Ready Carlsbad Business Alliance (RCBA) | The RCBA is a program that promotes business emergency preparedness and supports the continuity of operations and community recovery. The program is a collaborative effort between the Carlsbad Chamber of Commerce, local businesses, and the City of Carlsbad. |
| Carlsbad Emergency Response Team (CERT) Program | The CERT program trains volunteers in basic first aid, light search and rescue, and small fire suppression, and are closely associated with Carlsbad's Fire Department. CERT volunteers may assist neighbors and other emergency personnel in times of emergency, and support evacuations along with other responsibilities. |
| Carlsbad Emergency Operations Center (EOC) | The EOC provides a common location to coordinate resource support for fire, police, public works, and other response agencies as well as coordinate general public emergency notifications, evacuations and sheltering in the event of a large-scale emergency. |

| Existing and Planned Programs, Plans, and Policies | Objectives |
|---|---|
| Habitat Management Plan for Natural Communities in the City of Carlsbad (City of Carlsbad 2004) | The Plan outlines a citywide effort to identify opportunities for the City to work collaboratively with federal and state wildlife agencies to preserve the diversity of habitat and sensitive biological resources within the City. The Plan discusses impacts of and management strategies for wildfire, flood, landslide, and air quality. However, it does not include content around climate change and the relationship between climate change and habitat and wildlife within the City. |
| Alert San Diego Emergency Notification System (County of San Diego 2022) | The County of San Diego uses a regional notification system to send telephone notifications to residents and businesses within the County impacted by an emergency or disaster. The Alert San Diego system is used by emergency response personnel to notify those homes and businesses at risk with information on the event including, but not limited to evacuation and shelter in place orders. The systems usage rates for Carlsbad are not publicly available. |
| Carlsbad General Plan Public Safety Element | The Carlsbad General Plan Public Safety Element provides policy direction that supports laws and regulation of future development that will minimize the risk of personal injury, loss of life, property damage, and environmental damage associated with natural and human-caused hazards. The Public Safety Element includes goals related to climate adaptation and resilience, and policies that will support the community's capacity to better withstand the impacts associated with climate change. These policies include promoting design decisions that improve community resilience and protect vulnerable populations, protecting critical transportation, energy and water infrastructure, and ensuring emergency services have adequate capacity to address increase needs due to climate change-related impacts. |

# 5 Vulnerability Analysis

This section describes the impacts each climate hazard has on community assets and services described in the Sensitivity section. Existing plans, policies, and programs that contribute to the adaptive capacity are summarized throughout. An impact score and an adaptive capacity score is identified for each asset by climate hazard, along with an overall vulnerability score consistent with the scoring methodology described in Vulnerability Assessment Methodology.

There are 7 groups of assets evaluated in the Sea Level Rise Vulnerability Assessment which are also addressed in this report. The information Table 8 within section 5.2 presents the assets projected to be impacted, along with the time horizon and vulnerability ratings in the Carlsbad Sea Level Rise Vulnerability Assessment which is used where relevant in this section.

## 5.1 Vulnerable Populations

**Individuals with High Outdoor Exposure** including outdoor workers and people experiencing homelessness, face disproportionate direct exposure to climate hazards, causing them to be extremely vulnerable to the effects of climate change.

**Under-resourced individuals** often do not have access or the ability to afford resources needed to prepare for, cope with, and recover from climate change impacts. Individuals who are unemployed or are low-income often face financial barriers when preparing for and recovering from climate change hazards. Individuals in these groups often live in homes that are less protected against climate hazards. Low-income individuals may not be able to take time off work to address health concerns either caused by or exacerbated by climate hazards. Individuals with educational attainment of less than 4 years of college usually have lower earning potential than those with a 4-year college degree. As defined by the U.S. Census Bureau, this population group does not include individuals who have attended trade schools, apprentice program, or who have attained associates degrees. Individuals with 4-year degrees are half as likely to be unemployed than those who only have a high school degree (Association of Public and Land-Grant Universities N.d). Individuals in this group are less likely to have access to transportation, healthcare, and other basic needs. Under-resourced individuals often lack the financial resources to evacuate from a climate hazard and/or find an affordable place to evacuate to.

**Individuals Facing Societal Barriers** also face additional impacts of climate change. Non-white individuals are more likely to live in high hazard risk areas and less likely to be homeowners, which leaves them vulnerable to climate hazards. If evacuation and/or advisory notices, hazard preparedness material, or governmental guidance is not provided in non-English versions, linguistically isolated individuals may not be able to prepare for, cope with, or recover from a climate hazard (Gamble et al. 2016).

**Individuals with chronic health conditions or health related sensitivities** are socially and physiologically vulnerable to climate change impacts and hazards. Older adults and individuals with disabilities may have limited or reduced mobility, mental function, or communication abilities, making it difficult to evacuate during or prepare for a climate hazard event (CDPH 2020). They may also

have medical needs for electricity which may be impacted during a public safety power shutoff or climate hazard event. There are several senior facilities in Carlsbad in La Costa Glen and other smaller facilities as well such as Carlsbad by the Sea. Individuals in these groups are more likely to have pre-existing medical conditions or chronic illnesses that may exacerbate the risk of illnesses and medical problems from climate hazards. Similarly, individuals with asthma and individuals with cardiovascular disease are more likely to experience health impacts from climate hazards because of their pre-existing conditions or diseases (PHASoCal 2022). Children are socially and physiologically vulnerable to climate hazards with limited understandings of climate hazards and insufficient resources to independently prepare for and safely respond during a climate hazard event. Children, especially young ones, are reliant on their parental figures to ensure their health, safety, and wellbeing (CDPH 2020). Children also have vulnerable physical characteristics because they have not fully physiologically developed and are therefore more vulnerable to health effects of climate change impacts (Kenny et al. 2014). Military veterans are more likely to have chronic health complications as well as experiencing low-income or homelessness after their service, which also makes them vulnerable to preparing and responding to climate hazards (Olenick et at. 2015).

## Potential Impacts

### *Extreme Heat*

Outdoor workers and people experiencing homelessness are at risk to health impacts from extreme heat. Outdoor workers, including construction workers, roofers, and landscapers, are often subject to strenuous work conditions and are vulnerable during extreme heat events. People experiencing homelessness are exposed to health-related impacts associated extreme heat because they have limited access to shelter and air conditioning. The primary health impacts to these populations are heat-related illnesses, such as heat stress, heat stroke, and dehydration, which can be life-threatening (CDPH 2020).

Under-resourced individuals may not be able to pay for adequate air conditioning or fans, increasing their exposure to extreme heat. Isolated individuals don't have access to a vehicle to travel to cooling centers or move to temporary shelters during extreme heat event (Cooley et al. 2012). Under-resourced individuals are less likely to receive medical care for illnesses triggered or exacerbated by extreme heat. Households without a computer or broadband internet may not receive heat advisory warnings or governmental guidance, causing them to experience health impacts from extreme heat exposure (CDPH 2017).

Non-white communities often live in housing with insufficient protection from extreme heat events and limited or no affordable air conditioning. Linguistically isolated individuals may not to be able to read heat advisory warnings or governmental guidance, potentially causing them to experience greater exposure to extreme heat (Gamble et al. 2016). The primary health impacts to these populations are heat-related illnesses, such as heat stress, heat stroke, and dehydration, which can be life-threatening (CDPH 2020). These populations may not have access to medical services to treat heat-related illnesses.

Individuals with chronic health conditions or health related sensitivities are particularly at risk to heat related illnesses during extreme heat events. Individuals with disabilities, older adults, and children may have difficulty turning on air conditioning or traveling to cooling centers during extreme heat events. Extreme heat conditions can exacerbate asthma, cardiovascular disease, certain disabilities, and other respiratory and cardiovascular conditions, potentially causing heat-related illnesses such as heat stress, heat

stroke and dehydrations, which can be-life threatening (CDPH 2020). Children are still physiologically developing which means that they are less able to regulate their bodies during extreme heat events (Kenny et al. 2014).

### *Drought*

Outdoor workers and people experiencing homelessness are at risk to drought conditions and associated cascading impacts. During prolonged drought conditions, people experiencing homelessness may have difficulty accessing clean and affordable drinking water (Gamble et al. 2016).

During periods of prolonged drought, under-resourced individuals are more likely to experience the cost burden associated with increased water rates (Feinstein et al. 2017). These individuals may struggle to access clean and affordable drinking water which may cause dehydration and/or exacerbate underlying health conditions and illnesses (Gamble et al. 2016).

Non-white communities are at risk to drought conditions and associated cascading impacts. Individuals in these groups may face systemic and/or cultural barriers when seeking to access affordable and clean drinking water, which may cause dehydration and/or exacerbate underlying health conditions and illnesses (Gamble et al. 2016).

Individuals with chronic health conditions or health related sensitivities are at risk to drought conditions and associated cascading impacts. Prolonged drought conditions can lead to water scarcity and individuals may need to rely on poor quality water supplies. Individuals with chronic health conditions or health related sensitives may experience negative health impacts if they become dehydrated. Children and older adults are especially at risk to dehydration as their bodies are not able to regulate as well (Kenny et al. 2014). Dehydration may exacerbate underlying health conditions and illnesses. (California Department of Public Health 2017).

### *Wildfire*

Outdoor workers may be exposed to hazardous work conditions during wildfire events and may become injured from smoke inhalation or burns. People experiencing homelessness are particularly at-risk during wildfire events as they often suffer from respiratory conditions, mental illness, and chronic health conditions that may be exacerbated from physical contact with wildfire or smoke inhalation. People experiencing homeless have limited access to shelter and do not have access to transportation to evacuate from burning areas. They may also have their personal belongings destroyed or damaged during a wildfire event (CDPH 2017).

Under-resourced individuals may experience injuries or death from smoke inhalation or burns and are less likely to receive medical treatment (CDPH 2017). These individuals may have their belongings and homes damaged by a wildfire. If this occurs, under-resourced individuals are likely to suffer from the cost burden associated with losses or damage. Households without a computer or internet may not receive communications and evacuations to safely evacuate from hazard areas. Isolated individuals are vulnerable during wildfires because they no do have access to a vehicle to evacuate. Renters have limited control over home hardening and improvements that may protect against fire and smoke. Subsequently, they may experience economic and health impacts and a greater loss of belongings than homeowners (Gamble et al. 2016).

Non-white communities are more likely to live in wildfire hazard zones and in housing with insufficient protection against wildfire.

Linguistically isolated individuals may not be able to read wildfire or smoke advisory warnings or governmental guidance, potentially causing them to experience greater exposure to smoke and/or wildfire. Individuals in these groups have may face systematic and/or cultural barriers to access resources to safely evacuate hazard areas (Gamble et al. 2016). Individuals in these groups may experience injuries or death from smoke inhalation or burns (CDPH 2017).

Individuals with chronic health conditions or health related sensitivities may experience injuries or death from smoke inhalation or burns (CDPH 2017). Older adults, military veterans, and pollution burdened individuals are vulnerable to health impacts from wildfire smoke pollutants because they are more likely to have underlying respiratory and/or cardiovascular conditions and illnesses. Children may experience respiratory health impacts from wildfire smoke because their respiratory systems are not fully developed and are sensitive to stressors. Individuals with cardiovascular disease may experience severe cardiovascular health impacts if exposed to wildfire smoke pollutants. Individuals with asthma may experience severe respiratory health impacts such as difficulty breathing if exposed to wildfire smoke pollutants. Individuals with disabilities, children, and older adults may have difficulty evacuating from wildfires, increasing the risk of health impacts from wildfire smoke inhalation or fire burns (EPA 2022).

### *Landslides*

There is limited exposure for vulnerable populations to the impacts of landslides. As listed within the San Diego County Multi-Jurisdictional Hazard Mitigation Plan, there are 206 exposed buildings creating vulnerabilities for only the occupants of these areas.

### *Riverine and Stormwater Flooding*

Outdoor workers may be exposed to hazardous work conditions during riverine and/or stormwater flooding events and therefore are vulnerable to health impacts (CDPH 2020). People experiencing homelessness are disproportionately at risk to health impacts during flood events because they often live in flood hazard areas and do not have access to transportation to evacuate inundated areas. They may also have their personal belongings destroyed or damaged during a flood event. (Ramin & Svoboda 2009).

Under-resourced individuals may experience injuries or death from high velocity flooding and are less likely to receive medical treatment (CDPH 2017). Individuals in these groups may experience cost burdens if their belongings and homes are damaged from floodwater inundation. Isolated individuals have limited or no access to a vehicle to evacuate flood hazard areas. Households without a computer or internet may not receive communications and emergency alerts to safely evacuate from hazard areas (CDPH 2020). Renters have limited control over home improvements that may protect against flood damage. Subsequently, they may experience economic and health impacts and a greater loss of belongings than homeowners (Gamble et. al 2016).

Non-white communities are more likely to live in flood hazard areas and in housing with insufficient protection against riverine and stormwater flooding. Linguistically isolated individuals may not be able to read flood warning or governmental guidance, potentially causing them to experience greater exposure to flooding. Individuals in these groups may face systematic and/or cultural barriers when seeking to access resources needed to safely evacuate hazard areas (Gamble et al. 2016).

Older people and children are particularly at risk to injury and/or death from high velocity flooding (CDPH 2017). Riverine and stormwater flooding may also limit access to transportation systems, healthcare centers, and emergency response to those that are injured or in need or consistent medical care, such as those with chronic health conditions or illnesses. Children, older adults, individuals with disabilities, and individuals with chronic health conditions or illnesses may not be able to safely evacuate floodwater hazard areas.

### *Air Quality*

Outdoor workers and people experiencing homelessness are disproportionally vulnerable to poor air quality because they are outdoors and are directly exposed to air pollutants (CDPH 2017).

Under-resourced individuals may be disproportionally impacted by poor air quality because their housing lack sufficient air filtration and they may not be able to afford supplemental air filtration equipment (Gamble et al. 2016). Individuals in these groups may experience the development or exacerbation of respiratory illnesses and are less likely to receive medical treatment (California Department of Public Health 2017).

Non-white communities are vulnerable to health impacts associated with poor air quality because their housing may lack sufficient air filtration and they may not be able to afford supplemental air filtration equipment (Gamble et al. 2016). Linguistically isolated individuals may not be able to read air quality advisory warnings or governmental guidance that are in English, potentially causing them to experience greater exposure to extreme heat (CDPH 2017).

Individuals with chronic health conditions or health related sensitivities are at risk of developing or experiencing exacerbated health impacts from poor air quality. Children are extremely vulnerable to health impacts from poor air quality because their respiratory system has not fully developed yet (CDPH 2017). Older adults, military veterans, and pollution burdened individuals are vulnerable to health impacts from poor air quality because they are more likely to have underlying respiratory and/or cardiovascular conditions. Individuals with cardiovascular disease and individuals with asthma may experience severe health impacts if exposed to poor air quality (EPA 2022).

### *Sea Level Rise*

People who live in inundation zones may need to retrofit homes to adapt to sea level rise and associated impacts such as mold. This activity is particularly difficult for those with limited access to resources, including individuals who are unemployed, and low-income individuals. Linguistically isolated individuals may not have access to non-English versions of sea-level-rise preparedness guidance and therefore may not be able to prepare for and cope with sea-level-rise. (Cooley 2012).

## Adaptive Capacity

Carlsbad has plans, policies and programs in place that protect vulnerable populations across all climate hazards. The level of enforceability, implementation, and efficacy varies based on the hazard type.

San Diego County AIS Cool Zones and Fan Program benefits the elderly in addressing extreme heat concerns.

Plans concerning stormwater flooding and drought mainly address infrastructure resilience and water reliability and drainage, in turn helping vulnerable populations. Plans like the Carlsbad Municipal Water District UWMP and the OMWD Potable Water, Recycled

Water, and Sewer Master Plans, can serve as a platform of water assurance for vulnerable populations. Additionally, the desalination plant serves as a source of water resilience in the face of drought benefiting vulnerable populations.

The Local Coastal Plan has little mention of the human impact SLR poses to vulnerable population. However, this document does make mention of many adaption strategies that benefit vulnerable populations afflicted by SLR.

### *Vulnerability Score*

The following table includes vulnerability scores for Vulnerable Populations in Carlsbad. Vulnerability scores are a combination of the impact and adaptive capacity score. The impact and adaptive capacity scores are developed using a qualitative methodology outlined in the Cal APG, as seen in Table 1.

| Climate Hazard | Impact Score | Adaptive Capacity Score | Vulnerability Score |
|---|---|---|---|
| Extreme Heat | High | Medium | **4-High** |
| Drought | High | Medium | **4-High** |
| Wildfire | High | Medium | **4-High** |
| Landslides | Low | Low | **3-Medium** |
| Riverine and Stormwater Flooding | Medium | Low | **4-High** |
| Air Quality | High | Low | **5-High** |
| Sea Level Rise | High | Medium | **4-High** |

## 5.2 Natural and Recreational Resources

Primary vulnerabilities for natural resources are associated with climate hazard-caused stress and physical damage to resource types within this asset group. Compounding climate hazards stress natural ecosystems past their ability to absorb individual climate hazards. Wildlife will seek out more conducive habitats during climate hazards such as extreme heat or drought which tend to be where people recreate (USDA 2020). Recreational areas are also placed under increased risk via climate projections creating additional stress and competing needs for safe habitats. Impacts related to habitat shifts are exacerbated compared to rural communities as densely populated and isolated open space areas have limited opportunities for re-seeding or re-habitation from adjacent areas. Natural resources are highly vulnerable to the effects of climate change in Carlsbad.

### Potential Impacts

*Extreme Heat*

The impacts under extreme heat and warm nights are similar to impacts experienced by vulnerable populations. Wildlife under these conditions face impacts of heat stress and heat related illness as well as disrupted reproductive cycles, and compounding risks associated with early and extended seasonal temperature increases (Backlund 2008). Because it is seasonally warmer earlier in the year species can emerge early with no food source and potentially face a delayed cold front which increases mortality rates. Timing of seasonal warmth may not overlap with food sources and extreme heat may stress dependent vegetation communities and wildlife (Dale, 1997, Hamerlynck 1995, Maclean 2011). Plants are more likely to experience heat stress and drying, species' habitat ranges may shift and be replaced with invasive species including urban forestry. Some pests can proliferate more easily with warmer temperatures (Hamerlynck 1995), and some plants and animals ill-suited to the new warmer conditions may suffer increased mortality rates (CA, 2022). Natural resources are highly exposed to extreme heat and warm nights. Both mid- and end- of century projections depict dramatic increases in extreme heat days (CEC 2021).

*Drought*

Impacts from drought involve risks associated with water scarcity and availability for reliant natural resources. Drought will disrupt habitats and wildlife abilities to survive from dehydration and reliable food sources. The City supports a number of sensitive plant and wildlife species dependent on wetland and tidal habitats. Extended or variable drought conditions effect the amount and duration water is available in ephemeral and permanent waters sources, impacting plants and wildlife dependent on those aquatic resources (Burkett 2000). This includes unsupportable urban forestry as well as lagoons.

*Wildfire*

The largest direct impacts to natural resources are caused by wildfires. There is direct mortality and loss of resources and wildlife from wildfire as well as indirect mortality due to uninhabitable areas, loss of available food sources and seed bank (Backlund 2008). The severity and frequency of wildfires can exacerbate these impacts further through habitat conversions resulting in vegetation communities that no longer supports the species using that habitat and the landscape providing minimal alternative habitats (Bell et.al 1999, Stephenson et.al 1999, Coop et.

al 2020). As discussed with the Exposure to Climate Hazards section, extreme wildfire risk days are projected to increase through the end of the century (CEC 2021). Figure 2 depicts the spread of VHFHSZ's bordering and fully encompassing areas with natural resources.

### *Landslides*

Landslide susceptibility is limited and the likelihood of landslides occurring is determined by precipitation and wildfire occurring sequentially (CA, 2022). In the event of a landslide there is potential for loss of lands, habitat, and disruption of waterbodies in areas of debris flow. The susceptibility of natural resource lands in Carlsbad to landslides is less than other hazards such as wildfire but the risks around loss of topsoil and habitat conversions can increase the scope of impact. Wildlife and plants face a compounding risk when presented with landslide events.

### *Riverine and Stormwater Flooding*

Flooding impacts are mainly caused by associated erosion and the detrimental effects flooding can have on water quality, especially to aquatic and fish species dependent on water quality for survival (Talbot 2018). Riverine and stormwater flooding will mostly affect sensitive species of plants and wildlife that are not upland based. Other impacts include damage from inundation within storm flooded areas such as habitats and lands around streams and waterbodies in the City. Additionally, stormwater flooding can reduce overall water quality through algae blooms causing water quality issues within wetlands (EPA 2022).

### *Air Quality*

The direct effects of air quality declines on natural resources relates to plant and wildlife health as increased air pollutants causes stress and mortality. Impacts from air quality can further impact natural resources since air quality declines correspond with other hazards, compounding risks.

### *Sea Level Rise*

Impacts to natural resources are summarized in Table 8. The extent to which coastal inundation affects habitats, wildlife, and plants is large within Carlsbad. Environmentally sensitive lands such as wetlands, riparian areas, and woodlands are most affected by sea level rise and show limitations in ability to shift habitat location (Carlsbad 2017). Vulnerability determined within the Carlsbad Sea Level Rise Vulnerability Assessment outlines moderate to high ratings for natural resources through the end of the century.

**Table 8 City-Wide Sea Level Rise Vulnerability Summary**

| Asset Category | Horizon | Impacted Assets | Overall Vulnerability Rating (Low-High) |
|---|---|---|---|
| Beaches | 2050 | 27 acres | Moderate |
| | 2100 | 146 acres | High |
| State Parks | 2050 | 6 Parcels | Moderate - High |
| | 2100 | 6 Parcels | Moderate - High |
| Environmentally Sensitive Lands | 2050 | 1,088 acres | Moderate |
| | 2100 | 1,164 acres | High |

Source: City of Carlsbad 2017 Sea Level Rise Vulnerability Assessment

## Plans and Programs in Place to Alleviate Climate Impacts on Natural Resources (Adaptive Capacity)

There are no relevant plans programs or policies directly increasing the adaptive capacity of Carlsbad natural resources to the climate hazard of extreme heat. As one of the few cities with an adopted Local Coastal Plan (LCP) and a Habitat Management Plan there is a

fair amount of existing capacity to manage the natural resources unique to the community. Since the Habitat Management Plan's approval in 2004 understanding of the hazards has increased around insights to how climate change can create vulnerabilities for natural resources. The LCP which is supported by the Carlsbad Sea Level Rise Vulnerability Assessment does offer insights on how sea level rise will impact natural resources as well as adaptation strategies in relation to climate change.

Related to wildfire, there are existing programs and plans on vegetation management found in Table 6 and Table 7.

Indirect planning exists around adaption for natural resources around flooding and drought including the San Diego Integrated Regional Water Management Plan: Integrated Flood Management Planning Report, Carlsbad Municipal Water District (CMWD) Urban Water Management Plan, the OMWD Potable Water and Recycled Water Master Plan, and the Vallecitos Water District Water, Wastewater, and Recycled Water Master Plan.

### *Vulnerability Score for Natural Resources*

The following table incudes vulnerability scores for Natural Resources in Carlsbad. Vulnerability scores are a combination of the impact and adaptive capacity score. The impact and adaptive capacity scores are developed using a qualitative methodology outlined in the Cal APG, as seen in Table 1.

| Climate Hazard | Impact Score | Adaptive Capacity Score | Vulnerability Score |
|---|---|---|---|
| Extreme Heat/Warm Nights | High | Low | **5-High** |
| Drought | High | Low | **5-High** |
| Wildfire | High | Medium | **4-High** |
| Landslides | Low | Low | **3-Medium** |
| Riverine and Stormwater Flooding | High | Medium | **4-High** |
| Air Quality | Medium | Low | **4-High** |
| Sea Level Rise | High | Medium | **4-High** |

## 5.3 Buildings and Facilities

Vulnerabilities within this asset category primarily concern physical exposure and damages related to climate hazards. Impacts to buildings and facilities related to hospitality and entertainment such as Legoland and hotels may have cascading impacts across economic productivity and viability. Impacts associated with operations of critical services are discussed under Infrastructure and Critical Services.

### Potential Impacts

*Extreme Heat and Warm Nights*

Extreme heat could impact occupants of buildings and facilities that are not adequately weatherized for increased temperatures.

*Drought*

Drought will have minimal impact on the physical structures of buildings and facilities across Carlsbad.

*Wildfire*

The structures and buildings that occupy wildfire hazard zones are at risk of structural damage from wildfires. There are several critical facilities in the City's wildfire hazard zones shown in Figure 2.

*Landslides*

Landslide susceptibility for Carlsbad overlaps with sloped wildfire hazard zones (CDOC 2021). Impacts to buildings and facilities as outlined in the multi-jurisdiction hazard mitigation plan encompass 2 commercial buildings and 204 residential buildings.

*Riverine and Stormwater Flooding*

There is minimal risk to the physical structures outlined under this asset category to riverine and stormwater flooding. The location of floodplains in Figure 3 show only a slight risk of impact based on current flood conditions.

*Air Quality*

The impact of reduced air quality will have a similar effect as extreme heat for buildings and facilities. The ability to filter air will greatly affect the reliant subsystems, services, and populations reliant on the buildings and facilities. The direct impact on structures is low.

*Sea Level Rise*

As outlined in Table 9 there is a large scope of end-century impacted assets to sea level rise with 657 parcels of residential and commercially zoned areas being inundated (Carlsbad 2017). Physical damages brought about by coastal flooding are mainly related to coastal flooding as it causes structural damages. The actual likelihood of buildings and facilities being flooded due to sea level rise is low, however due to the high value of the structure's vulnerability was listed as moderate (Carlsbad 2017).

Findings from the Sea Level Rise Vulnerability Assessment were sorted into three planning zones with different vulnerability scores associated with levels of impact and adaptive capacity. Within Planning Zone 1 there was a listed moderate vulnerability by 2050 and a high vulnerability by 2100 with affected areas in the northern

portion of the Village Planning Area and the Buena Vista Lagoon. Planning Zone 2 has a high vulnerability score with affected structures of the residential parcels along Terramar Point, the northern shoreline of Agua Hedionda Lagoon, Hubbs Sea World Research Institute, the Carlsbad AquaFarm, and the YMCA facility. Planning Zone 3 has a moderate vulnerability rating with undeveloped lands and a golf course on the north side of the Batiquitos Lagoon. Collectively the community's buildings and facilities are rated as low to moderately vulnerable to sea level rise by 2050 and moderately to highly vulnerable by 2100 (Carlsbad 2017).

**Table 9 City-Wide Sea Level Rise Vulnerability Summary**

| Asset Category | Horizon | Impacted Assets | Overall Vulnerability Rating (Low-High) |
|---|---|---|---|
| Parcels | 2050 | 564 Parcels | Moderate |
| | 2100 | 657 Parcels | High |
| Critical Infrastructure | 2050 | 0 Parcels | Low |
| | 2100 | 8 Parcels | Moderate |

Source: City of Carlsbad 2017 Sea Level Rise Vulnerability Assessment

## Plans and Programs in Place to Alleviate Climate Impacts on Buildings and Facilities (Adaptive Capacity)

Carlsbad has minimal existing adaptive capacity to increase the weatherization of buildings and facilities throughout the city. SDG&E wildfire mitigation plan and the Carlsbad Public Safety element are the only plans and policies with mention of structure hardening. The City of Carlsbad Local Coastal Program Land Use Plan does offer adaptive capacity for the City in the form of best practice land use for development exposed to sea level rise.

### *Vulnerability Score for Buildings and Facilities*

The following table incudes vulnerability scores for Buildings and Facilities in Carlsbad. Vulnerability scores are a combination of the impact and adaptive capacity score. The impact and adaptive capacity scores are developed using a qualitative methodology outlined in the Cal APG, as seen in Table 1.

| Climate Hazard | Impact Score | Adaptive Capacity Score | Vulnerability Score |
|---|---|---|---|
| Extreme Heat/Warm Nights | Medium | Low | **4-High** |
| Drought | Low | Medium | **2-Medium** |
| Wildfire | Medium | Medium | **3-Medium** |
| Landslides | Low | Low | **3-Medium** |
| Riverine and Stormwater Flooding | Low | Low | **3-Medium** |
| Air Quality | Low | Low | **3-Medium** |
| Sea Level Rise | Medium | Low | **4-High** |

# 5.4 Infrastructure and Critical Services

Overall vulnerabilities associated with this asset category involve structural preparedness and service reliability in the face of climate change. This section is mainly concerned with the cascading impacts physical damages to buildings and facilities can have on services and infrastructure.

## Potential Impacts

### *Extreme Heat and Warm Nights*

As temperatures increase, roadways, active transportation routes, and railroads are vulnerable to damages through sustained heat such as buckled railroad ties and cracked surfaces (Kalansky et al. 2018). Additional impacts from extreme heat are associated with increased emergency service calls which may strain medical services. Electrical infrastructure could be overwhelmed by demand and result in blackouts or energy providers could conduct power safety shutoffs to avoid impacts to electrical facilities. Power outages have significant impacts on communication networks, water conveyance, and vulnerable populations. Emergency service providers may not be able to fully function if systems they rely upon experience power outages (e.g., telecommunication network, EOC facilities, etc.).

### *Drought*

Drought can impact water reliability and water infrastructure. All emergency services depend on water, particularly firefighters who require adequate water supply for fire suppression. Water providers within the City will encounter increased difficulty as drought impacts general service reliability. Drought impacts can create service strain for emergency and medical services. Cracked pavements from drought compounded with extreme heat affects roadways and transportation routes.

### *Wildfire*

There are some facilities located in the VHFHSZ's as shown in Figure 2. Additionally, utility lines have the potential to be damaged in high-risk locations, resulting in oil and gas leaks and power outages. Utility lines under certain high wind conditions can also trigger wildfires through downed power lines (Kalansky et al. 2018). Power safety shut offs in response to wildfire risk can affect service reliability of power. Increased frequency of wildfires can place strain on fire and emergency services. Evacuation routes could be disrupted during a wildfire event limiting emergency responders and ability for people to evacuate as well. Post-wildfire there are additional issues of displacement and needs for temporary shelters for uprooted communities.

### *Landslides*

There is no projected impact of landslide to services and infrastructure within Carlsbad.

### *Riverine and Stormwater Flooding*

Impervious surfaces can impede the absorption of water and augment stormwater flooding in areas of Carlsbad. There is risk of damage from increased extreme precipitation events including erosion, washouts, and sinkholes. Storm drainage and flood protection services for the City may be impacted by these events. Water supply for fire suppression as well as wildfire-caused declines in water quality are additional cascading impacts.

### *Air Quality*

Higher incidence of unsafe air quality generated by increased smog, dust and wildfire smoke can create general strain on existing infrastructure and critical services through increased rates of hospitalization and emergency and medical services (CDPH, 2020).

### *Sea Level Rise*

The impacts Carlsbad is expected to experience related to services and infrastructure are moderate when presented together. There are 8 parcels of critical infrastructure, 5.8 miles of transportation routes, and 7.3 miles of lateral public access ways impacted by sea level rise through 2100 found in Table 10 (Carlsbad 2017). Part of a sewer pump station is expected to be inundated by the 2100 horizon and negatively impact the community through service disruption and sewer spills (Carlsbad 2017). The Carlsbad Boulevard crossing of Buena Vista Lagoon is considered highly vulnerable to sea level rise by 2100 (Carlsbad 2017).

**Table 10 City-Wide Sea Level Rise Vulnerability Summary**

| Asset Category | Horizon | Impacted Assets | Overall Vulnerability Rating (Low-High) |
|---|---|---|---|
| Public Access Ways | 2050 | 26 beach access ways<br>2.6 miles of lateral access ways | Moderate |
| | 2100 | 37 beach access ways<br>7.3 miles of lateral access ways | Moderate |
| Transportation | 2050 | 1.6 Miles | High |
| | 2100 | 5.8 Miles | High |

Source: City of Carlsbad 2017 Sea Level Rise Vulnerability Assessment

## Plans and Programs in Place to Alleviate Climate Impacts on Services and Infrastructure (Adaptive Capacity)

The relevant existing plans, policies, and programs for Carlsbad are mainly multi-hazard based. All multi-hazard plans, programs and systems are designed to address service and infrastructure failings and contingencies. Existing planning covers mainly wildfire with some mention of flood hazards. Relevant plans and systems in place are found below:

- San Diego County Multi-Jurisdictional Hazard Mitigation Plan (County of San Diego 2018)
- San Diego County Emergency Operations Plan (EOP) (County of San Diego 2018)
- City of Carlsbad Emergency Operations Plan (City of Carlsbad 2021)
- Carlsbad Emergency Response Team (CERT) Program
- Carlsbad Emergency Operations Center (EOC)
- San Diego County Resilience Program (County of San Diego 2020)
- Alert San Diego Emergency Notification System (County of San Diego 2022)
- Carlsbad General Plan Public Safety Element
- Claude “Bud” Lewis Carlsbad Desalination Plant
- San Diego Gas & Electric (SDG&E) Public Safety Power Shutoff (PSPS) Notifications and Supportive Services (SDG&E 2021)

Cascading risks of services and power dependencies are addressed in relation to wildfire throughout these plans and programs.

### *Vulnerability Score for Services and Infrastructure*

The following table incudes vulnerability scores for Services and Infrastructure in Carlsbad. Vulnerability scores are a combination of the impact and adaptive capacity score. The impact and adaptive capacity scores are developed using a qualitative methodology outlined in the Cal APG, as seen in Table 1.

| Climate Hazard | Impact Score | Adaptive Capacity Score | Vulnerability Score |
|---|---|---|---|
| Extreme Heat | High | Low | **5-High** |
| Drought | High | Medium | **4-High** |
| Wildfire | High | High | **3-Medium** |
| Landslides | Low | Low | **3- Medium** |
| Riverine and Stormwater Flooding | High | Low | **5-High** |
| Air Quality | High | Low | **5-High** |
| Sea Level Rise | Medium | Low | **4-High** |

# 6 Conclusion

This report evaluates how climate change may impact vulnerable community members, natural resources, critical facilities, buildings, services, and infrastructure in Carlsbad. The report provides a prioritized list of vulnerable population groups and assets for which adaptation policies and programs should be developed and implemented to increase community resilience.

The City of Carlsbad's **Exposure to Climate Hazards** was analyzed through projections from the Cal-Adapt Local Climate Change Snapshot tool and regional context presented in the California Fourth Climate Change Assessment San Diego region report. A list of asset categories with high vulnerability scores is provided on the next page. The City's exposure to wildfire was mapped in Figure 2. FEMA classified floodplains were also mapped across the city showing 100-year and 500-year floodplains occupying regions closest to the ocean and lagoons within city limits in Figure 3. Figure 4 presents 1.6-foot and 6.6-foot projections of sea level rise through the years of 2050 and 2100 respectively, consistent with the 2017 Carlsbad Sea Level Rise Vulnerability Assessment.

The City's asset groups explored in the **Sensitivity** section outlined vulnerable populations listed in Table 3, natural and recreational resources, buildings and facilities, and infrastructure and critical services.

The **Adaptive Capacity** section outlined the existing programs, plans, and policies that help the city of Carlsbad become more resilient to increased exposure to climate hazards. The vulnerability score is a combination of the impact and adaptive capacity score. In the **Vulnerability Analysis** section the impact and adaptive capacity scores are developed using a qualitative methodology outlined in the Cal APG, as seen in Table 1 and Table 2.Impact and adaptive capacity scores for each climate hazard are identified for each sensitivity. A complete list of the population groups and asset categories with high-vulnerability scores is provided below along with the following summary points.

- All sensitive population groups identified are highly vulnerable to extreme heat, with many population groups also vulnerable to air quality, wildfires, flooding, and sea level rise.
- Natural resources are highly vulnerable to extreme heat, drought, wildfire, flooding, and sea level rise. Vulnerability for natural resources is focused on habitat conversions and damage, mortality, and scarcity of resources for plants and wildlife.
- Buildings and facilities in the City are highly vulnerable to sea level rise. Buildings and facilities located in inundation zones are at risk of structural damage from sea level rise.
- Infrastructure and critical facilities are highly vulnerable to extreme heat, flooding, air quality, and sea level rise. Several facilities are in the wildfire hazard severity zones of Carlsbad. These buildings and facilities are at risk of structural damage from wildfire. Infrastructure and dependent populations experience additional cascading impacts around power outages from downed utility lines, power safety shut offs and grid overload. All forms of power outages can affect how critical services are able to perform their needed functions during a hazard.

| Climate Hazard | Impact Score | Adaptive Capacity Score | Vulnerability Score |
|---|---|---|---|
| **Vulnerable Populations** | | | |
| Extreme Heat | High | Medium | **4-High** |
| Drought | High | Medium | **4-High** |
| Wildfire | High | Medium | **4-High** |
| Riverine and Stormwater Flooding | Medium | Low | **4-High** |
| Air Quality | High | Low | **5-High** |
| Sea Level Rise | High | Medium | **4-High** |
| **Natural and Recreational Resources** | | | |
| Extreme Heat/Warm Nights | High | Low | **5-High** |
| Drought | High | Low | **5-High** |
| Wildfire | High | Medium | **4-High** |
| Riverine and Stormwater Flooding | High | Medium | **4-High** |
| Air Quality | Medium | Low | **4-High** |
| Sea Level Rise | High | Medium | **4-High** |
| **Buildings and Facilities** | | | |
| Extreme Heat/Warm Nights | Medium | Low | **4-High** |
| Sea Level Rise | Medium | Low | **4-High** |
| **Infrastructure and Critical Facilities** | | | |
| Extreme Heat | High | Low | **5-High** |
| Drought | High | Medium | **4-High** |
| Riverine and Stormwater Flooding | High | Low | **5-High** |
| Air Quality | High | Low | **5-High** |
| Sea Level Rise | Medium | Low | **4-High** |

The Carlsbad Public Safety Element will include policies and programs to increase the resilience of the population groups and asset categories with the highest vulnerability to climate change, as presented in this report.

# 7 References

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