# CITY OF IRVINE

## CLIMATE VULNERABILITY ASSESSMENT



February 2023

# ORGANIZATION

This document includes the following chapters:

## Chapter 1- Introduction

This chapter describes climate adaptation planning and the applicable State requirements as they relate to this Vulnerability Assessment and Adaptation Framework.

## Chapter 2 – Community Profile

This chapter provides a description of the City's general environment and demographics. Special emphasis is made to reveal disadvantaged communities and vulnerable populations.

## Chapter 3 – Vulnerability Assessment

This chapter includes forecasts of each of the five climate-related hazards. It also maps where those hazards are most likely to affect the City of Irvine and which areas are most vulnerable to these changes.

This chapter evaluates the City's current capacity to address the five climate-related hazards. This includes an assessment of the City's current policies and programs and how they address the ability to respond to hazard events.

## Chapter 4 – Adaptation Framework: Recommendations to Improve Resilience

This chapter includes potential strategies and policy recommendations to increase the City's ability to adapt to hazards and meet the needs of its vulnerable communities.

# CONTENTS

# ACRONYMS

ACS = United States Census American Community Survey

APG 2.0 = California Adaptation Planning Guide 2.0

CEC = California Energy Commission

CAL FIRE = California Department of Forestry and Fire Protection

CF = Critical Facilities

CNRA = California Natural Resources Agency

CalOES = California Office of Emergency Services

CoSMoS = Coastal Storm Modeling System

FEMA = Federal Emergency Management Act

FHSZ = Fire Hazard Severity Zones

FOC = Facilities of Concern

IRWD = Irvine Ranch Water District

LHMP = Local Hazard Mitigation Plan

MWD = Metropolitan Water District

NOAA = National Oceanic and Atmospheric Administration

OCFA = Orange County Fire Authority

OCTA = Orange County Transportation Authority

OCWD = Orange County Water District

OEHHA = California Office of Environmental Health Hazard Assessment

OPC = Ocean Protection Council

OPR = Office of Planning & Research

SCAG = Southern California Association of Governments

USGS = United States Geological Service

UHI = Urban Heat Island

UHIE = Urban Heat Island Effect

UHII = Urban Heat Island Index

UWMP = Urban Water Management Plan

VHFHSZ = Very High Fire Hazard Severity Zones

# CHAPTER 1. INTRODUCTION

According to the State of California's Legislative Analyst's Office:

> *"Addressing the widespread impacts of climate change represents a significant challenge for the state. A changing climate presents California with five key climate hazards: (1) higher temperatures and extreme heat events, (2) more severe wildfires, (3) more frequent and intense droughts, (4) flooding due to extreme precipitation events, and (5) coastal flooding and erosion from sea-level rise. These hazards will threaten public health, safety, and well-being—including from life-threatening events, damage to public and private property and infrastructure, and impaired natural resources."*[1]

To address the potential impacts from these hazardous events on the community, the City of Irvine is expanding upon their climate action and hazard mitigation planning efforts to focus on climate change adaptation by understanding the community's vulnerabilities to climate hazards and explore strategies to reduce the vulnerability to projected climate change effects, increase the local capacity to adapt, and build resilience.

This vulnerability assessment and adaptation framework follow goals outlined in the City of Irvine's Safety Element and Local Hazard Mitigation Plan (LHMP) that correspond with climate adaptation planning, specifically:

### Safety Element (2015)

"Minimize the danger to life and property from manmade and natural hazards, including fire hazards, flood hazards, non-seismic geologic hazards and air hazards."

### City of Irvine Local Hazard Mitigation Plan (2020)

The City's Local Hazard Mitigation Plan (LHMP) was developed to broadly increase resilience in Irvine. The following key goals were developed for the City's LHMP:

- Protect against threats from natural hazards to life, injury, and property damage for Irvine residents and visitors.
- Increase public awareness of potential hazard events.
- Preserve critical services and functions by protecting key facilities and infrastructure.
- Protect natural systems from current and future hazard conditions.
- Coordinate mitigation activities among City departments, neighboring jurisdictions, and with federal agencies, and
- Prepare for long-term change in hazard regimes.

The purpose of this effort is to expand upon the City's previous work to provide more detail regarding community assets and vulnerable population impacted by climate change and lays the groundwork to form policies and programs to support climate resilience.



[1] Legislative Analyst's Office (LAO). 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.

## Regulatory Drivers and Guidance for Climate Adaptation Planning

The report includes a Vulnerability Assessment and Adaptation Framework, which could be incorporated into the City's General Plan Safety Element, in compliance with SB 379, Government Code section 65302(g)(4)[2] and the Office of Planning & Research's (OPR) General Plan Guidelines.

According to SB 379, general plan safety elements must address climate change vulnerability, adaptation strategies, and emergency response strategies. SB 379 states:

> *"This bill would, upon the next revision of a local hazard mitigation plan on or after January 1, 2017, or, if the local jurisdiction has not adopted a local hazard mitigation plan, beginning on or before January 1, 2022, require the safety element to be reviewed and updated as necessary to address climate adaptation and resiliency strategies applicable to that city or county. The bill would require the update to include a set of goals, policies, and objectives based on a vulnerability assessment, identifying the risks that climate change poses to the local jurisdiction and the geographic areas at risk from climate change impacts, and specified information from federal, state, regional, and local agencies."*

As specified in Government Code section 65302(g)(4)(A) vulnerability assessments must identify the risks that climate change poses to the local jurisdiction and the geographic areas at risk from climate change impacts, utilizing federal, state, regional, and local climate vulnerability documentation such as APG 2.0 and the Cal-Adapt climate tool created by the California Energy Commission (CEC) and University of California, Berkeley Geospatial Innovation Facility. Other sources of information include data from local agencies regarding their adaptive capacity and historical data on natural events and hazards. Per Government Code section 65302(g)(4)(B), adaptation policies, goals, and objectives are to be developed based on findings from the vulnerability assessment. Additionally, Government Code section 65302(g)(4)(C) requires jurisdictions to create a set of feasible implementation measures to reduce climate change impacts on new or proposed land uses.

### Assembly Bill 162 (2007)

Assembly Bill 162 requires that, upon the next revision of the housing element on or after January 1, 2009, cities and counties address flood hazards and safety in the land use, conservation, safety, and housing elements of their general plans.

### Senate Bill 1241 (2012)

Senate Bill 1241 revised the safety element requirements to require all cities and counties whose planning area is within the state responsibility area (SRA) or very high fire hazard severity zones (VHFHSZs), as defined by CAL FIRE, to address and incorporate specific information regarding wildfire hazards and risk, and policies and programs to address and reduce unreasonable risks associated with wildfire. Upon the next revision of the housing element on or after January 1, 2014, the bill requires those cities and counties to review and update the safety element to consider the advice in the Office of Planning and Research's most recent publication of "Fire Hazard Planning, General Plan Technical Advice Series" as well as: information regarding fire hazards, a set of goals, policies, and objectives

[2] SB 379 was enacted to integrate climate change adaptation into California's general plan process.

based on identified fire hazards, and a set of feasible implementation measures designed to carry out those goals, policies, and objectives.

### Senate Bill 1035 (2018)

Senate Bill 1035 requires regular updates to the safety element chapter of the general plan. New information regarding flood and fire hazards must be included and climate change adaptation and resilience must be addressed as part of the update. After 2022, safety elements must be updated upon each revision of the housing element or local hazard mitigation plan, but no less often than once every 8 years. Housing element revisions are typically on 4–8-year cycles and LHMP revisions are on 5-year cycles.

### Senate Bill 99 (2019)

Senate Bill 99 requires that, upon the next revision of the housing element on or after January 1, 2020, the safety element must be updated to include information identifying residential developments in hazard areas that do not have at least two emergency evacuation routes (i.e., points of ingress and egress).

### Senate Bill 747 (2019)

Senate Bill 747 requires that, upon the next revision of a LHMP on or after January 1, 2022, or beginning on or before January 1, 2022, if a local jurisdiction has not adopted a LHMP, the safety element must be reviewed and updated as necessary to identify evacuation routes and their capacity, safety, and viability under a range of emergency scenarios. If a LHMP, emergency operations plan, or other document that fulfills commensurate goals and objectives, a local agency may use that information in the safety element to comply with this requirement by summarizing and incorporating by reference such a plan or other document into the safety element.

Consistent with Government Code 65302(g)(4)(A), the following vulnerability assessment and adaptation framework also takes guidance from:

### California's Fourth Climate Assessment (2018)

California Natural Resources Agency (CNRA), OPR, and CEC prepared California's Fourth Climate Assessment in 2018. The Climate Assessment was designed to presents findings in the context of existing climate science, including strategies to adapt to climate impacts and key research gaps needed to spur additional progress on safeguarding California from climate change.

### Safeguarding California Plan (2018)

CNRA released an update to the Safeguarding California Plan in 2018, providing a roadmap for State government action to build climate resiliency. The Safeguarding California Plan presents overarching strategies and outlines ongoing actions and cost-effective and achievable next steps to make California more resilient to climate change.

### Ocean Protection Council State Sea Level Rise Guidance (2018)

Between 2017 and 2018, the Ocean Protection Council (OPC) released two reports that update their understanding of sea level rise science and best practices for planning and addressing anticipated

impacts. The reports synthesize recent evolving research on sea level rise science and provides higher level recommendations for how to plan for and address sea level rise impacts, notably including a set of projections recommended for use in planning, permitting, investment, and other decisions.[3]

### California Adaptation Planning Guide (2020)

The California Office of Emergency Services (Cal OES) released the second version of the Adaptation Planning Guide in 2020 - APG 2.0 - which includes updated guidance, an increased focus on equity and outreach, and best practices. The APG is designed to help local government, regional entities, and climate organizations incorporate best practices and current science and research into their adaptation plans.[4]

### LOCAL AND REGIONAL CLIMATE PLANNING

This vulnerability assessment and adaptation framework also draws upon existing efforts in the region to address climate change. These documents include, but are not limited to:

- City of Irvine General Plan Safety Element (Amended 2015)
- City of Irvine Local Hazard Mitigation Plan (2020)
- California Department of Transportation (Caltrans) Climate Change Vulnerability Assessment District 12 Technical Report (2019)
- Southern California Adaptation Planning Guide (APG) (2020)
- Southern California Association of Governments (SCAG) Climate South California Climate Adaptation Framework SB379 Compliance Curriculum for Local Jurisdictions (2021)
- Southern California Association of Governments (SCAG) Climate Risk & Vulnerability Assessment Tool for SB 379 Safety Element Updates
- Office of Planning and Research Defining Vulnerable Communities in the Context of Climate Adaptation (2018)

## Methodology and Planning Process

The APG 2.0 provides a four-step process that communities can use to plan for climate change. The APG is designed to be flexible and guide communities in adaptation planning.



[3] Ocean Protection Council (OPC). 2018. State of California Sea-Level Rise Guidance: 2018 Update.
[4] California Governor's Office of Emergency Services (Cal OES). California Adaptation Planning Guide. June 2020.


Source: California Governor's Office of Emergency Services, 2020.

Phases of the Adaptation Planning Process include:

- Phase 1, Explore, Define, and Initiate:

  This phase includes scoping the process and project, such as identifying the potential climate change effects and important physical, social, and natural assets in the community.

- Phase 2, Assess Vulnerability:

  This phase includes analysis of exposure to, sensitivity of, and adaptive capacity to respond to climate effect to determine physical and social vulnerability.

- Phase 3, Define Adaptation Framework and Strategies:

  This phase focuses on creating an adaptation framework and developing adaptation strategies based on the results of the vulnerability assessment. The adaptation strategies are the community's potential response to the vulnerability assessment.

- Phase 4, Implement, Monitor, Evaluate, and Adjust:

  In this phase, the adaptation framework is implemented, consistently monitored, and evaluated, and adjusted based on continual learning, feedback, and/or triggers.

The purpose of this report is to document Step 1 through Step 3. The vulnerability assessment and development of adaptation measures follows the approach recommended by APG 2.0.

The vulnerability assessment identifies projected climate change exposures for the city at mid- to late-century timeframes. In addition to identifying the City's exposure to the effects of climate change, the vulnerability assessment evaluates the sensitivity of key population groups and major community elements to climate change and associated hazards.

# CHAPTER 2. COMMUNITY PROFILE

The City of Irvine is located in southern Orange County, adjacent to the cities of Newport Beach, Lake Forest, Tustin, Santa Ana, Laguna Hills, Laguna Woods, and Laguna Beach. Situated at the foothills of the Santa Ana Mountains to the east, the San Joaquin Hills to the west and south, and the low-lying flatlands of central Orange County to the north, the City has a diverse geographic setting. Located approximately five miles south of the City of Santa Ana (Orange County Seat), the City is in a key job center for both Orange County and southern California.[5]

According to the US Census American Community Survey (ACS), in 2019 the City of Irvine had a population of almost 263,000. **Table 2-1: Demographics** displays the demographics in the City of Irvine and Orange County from 2019[6]. As shown in the table, the median household income for City residents is 13 percent greater than that for the region. Even with a greater median household income, compared with the region, a larger percentage of residences rent their home, and more are living below the poverty level. The number of households with a person living with a disability is 37 percent less for Irvine residences as compared to Orange County.

**Table 2-1: Demographics**

| | Irvine | Orange County |
|---|---|---|
| Total Population[1] | 262,665 | 3,168,044 |
| Percent of residents that are children (less than 10 years)[2] | 10.4% | 11.7% |
| Percent of households that have people 65+ years[1] | 20.6% | 29.8% |
| Percentage of households with at least one person living with a disability[1] | 12.3% | 19.6% |
| Median age[2] | 34.0 | 36.2 |
| Total households[1] | 94,490 | 1,037,492 |
| Median household income[2] | $113,097 | $97,972 |
| Percent of rental households[2] | 48.7% | 40.7% |
| Percent of household income below poverty level[1] | 13.1% | 9.9% |

Note: Percentage values rounded to nearest tenth decimal.
Source: US Census Bureau, ACS 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2]



## Vulnerable Communities

Compared to the region, the City's population age distribution skews slightly younger than the region. (**See Table 2-2: Age Distribution Comparison**). This may be partially due to the large educational institution population. 12.6 percent of the population is aged 65 years and older, although 20.6 percent of Irvine households have a resident that is aged 65 years and older.

[5] City of Irvine. 2015a. General Plan Safety Element.
[6] Data for vulnerable populations was extracted from a combination of US Census Bureau American Community Survey 2015 – 2019 estimates and ESRI's Business Analyst 2021 forecasts. Data sources have been noted in each demographic table.

Table 2-2: Age Distribution Comparison

| | Irvine | Orange County |
|---|---|---|
| Under 5 | 5.1% | 5.7% |
| 5 - 14 | 13.0% | 12.4% |
| 15 - 24 | 15.7% | 12.9% |
| 25 - 34 | 17.0% | 15.1% |
| 35 - 44 | 14.5% | 13.3% |
| 45 - 54 | 12.7% | 12.7% |
| 55 - 64 | 11.4% | 12.3% |
| Over 65 | 12.6% | 15.6% |

Note: Percentage values rounded to nearest tenth decimal.
Source: US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021.

In California, those persons of retirement age (i.e., 65 years and older) are expected to grow more than twice as fast as the total population and this growth will vary by region. This means that people are living longer, and the number of older persons is increasing. This trend is also evident in Irvine, where the percent of the population aged 65 years and older grew by 43 percent from 2010 to 2021.

The racial and ethnic composition of a population may affect housing needs because of cultural preferences associated with different racial/ethnic groups. Cultural influences may reflect preference for a specific type of housing and household structure. Research has shown that number and share of Americans living in multigenerational family households have continued to rise. In 2016, a record 64 million people, or 20 percent of the U.S. population, lived with multiple generations under one roof. The Asian and Hispanic populations are more likely than whites to live in multigenerational family households.[7]

Table 2-3: Race and Ethnicity shows that, according to the 2015-2019 ACS, the ethnic distribution of the Irvine's population was predominantly White, not Hispanic or Latino, and Asian Alone with each group representing approximately 44 percent of the population. Approximately 11.6 percent of the city's population was of Hispanic origin. While Orange County has larger percentage of the population identifying as White, not Hispanic or Latino (55.6 percent), it also has a much larger share of the population identifying as Hispanic or Latino origin (34.2 percent).

Table 2-3: Race and Ethnicity

| | Irvine | Orange County |
|---|---|---|
| White Alone (Not Hispanic or Latino) | 44.7% | 55.6% |
| Black Alone (Not Hispanic or Latino) | 2.2% | 1.9% |
| American Indian Alone (Not Hispanic or Latino) | 0.2% | 0.6% |
| Asian Alone (Not Hispanic or Latino) | 43.6% | 21.9% |
| Pacific Islander Alone (Not Hispanic or Latino) | 0.2% | 0.3% |
| Some Other Race Alone (Not Hispanic or Latino) | 3.1% | 14.8% |
| Two or More Races (Not Hispanic or Latino) | 6.0% | 4.9% |
| Hispanic Origin (Any Race) | 11.6% | 34.2% |

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021.

[7] Cohn, D'Vera and Jeffrey S. Passel. 2018. *A record 64 million Americans live in multigenerational households.* Pew Research Center. April 5, 2018. https://www.pewresearch.org/fact-tank/2018/04/05/a-record-64-million-americans-live-in-multigenerational-households. Accessed April 28, 2022.

The Irvine community is diverse with multiple languages spoken. As shown in **Table 2-4: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - Irvine**, the majority of residents aged 5 years and older are fluent in English. However, over 16,000 residents or about 6.5 percent of the population are not fluent in English. In response, the City implements programs intended to communicate information to the diverse community of residents and workers with different backgrounds. The City of Irvine's website offers translation for 81 languages to provide information for the diverse community members.[8] The Irvine Police Department's Policy 345 provides guidance to members when communicating with individuals with limited English proficiency (LEP) to reasonably ensure that LEP individuals have meaningful access to law enforcement services, programs, and activities, while not imposing undue burdens on its members.[9]

**Table 2-4: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - Irvine**

| | Number of Speakers | Percent Not Fluent in English |
|---|---|---|
| English Only | 122,128 | - |
| Spanish | 15,502 | 5.9% |
| Indo-European Languages | 27,602 | 9.7% |
| Asian and Pacific Island Languages | 74,197 | 15.9% |
| Other Languages | 7,094 | 13.2% |

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022



## 2.1 VULNERABLE POPULATIONS

Climate change disproportionately affects those with existing disadvantages. Low-income communities and communities of color often live in areas with conditions that expose them to more severe hazards, such as higher temperatures and worse air quality. These communities also have fewer financial resources to adapt to these hazards. For instance, low-income populations are already disproportionately burdened by energy bills and may reduce air conditioning usage out of concerns about cost. People with chronic medical conditions are often more physiologically susceptible to negative health impacts from extreme heat and poor air quality, and those with mobility issues are particularly at risk. Many of the above risk factors are often present in older adults, who are more likely to have a limited income, chronic health conditions, and mobility limitations, and are more likely to experience social isolation.[10]

Factors such as age, physical and mental condition, socioeconomic status, access to key services, and other factors affect the ability of people to prepare for and protect themselves and their property from a climate-related event. Even though hazard events may impact all parts of the city with equal severity, individuals may experience the effects differently.

[8] City of Irvine. 2022a. Home Page. https://www.cityofirvine.org/. Accessed May 3, 2022.

[9] City or Irvine. n.d. Policy 345. Limited English Proficiency Services.

[10] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

## Disadvantaged Communities

According to the California Office of Environmental Health Hazard Assessment (OEHHA) a community is considered disadvantaged based on its pollution burden and sensitive populations. OEHHA provides the CalEnviroScreen tool to evaluate and map disadvantaged communities. The dataset helps identify California communities that are most affected by specific sources of pollution, and where people are often especially vulnerable to pollution's effects. The dataset uses environmental, health, and socioeconomic information to produce scores for every census tract in the state that are mapped using a scale based on the pollution burden of the location. The higher the percentage, the greater the burden and the higher likelihood of environmental justice concerns.

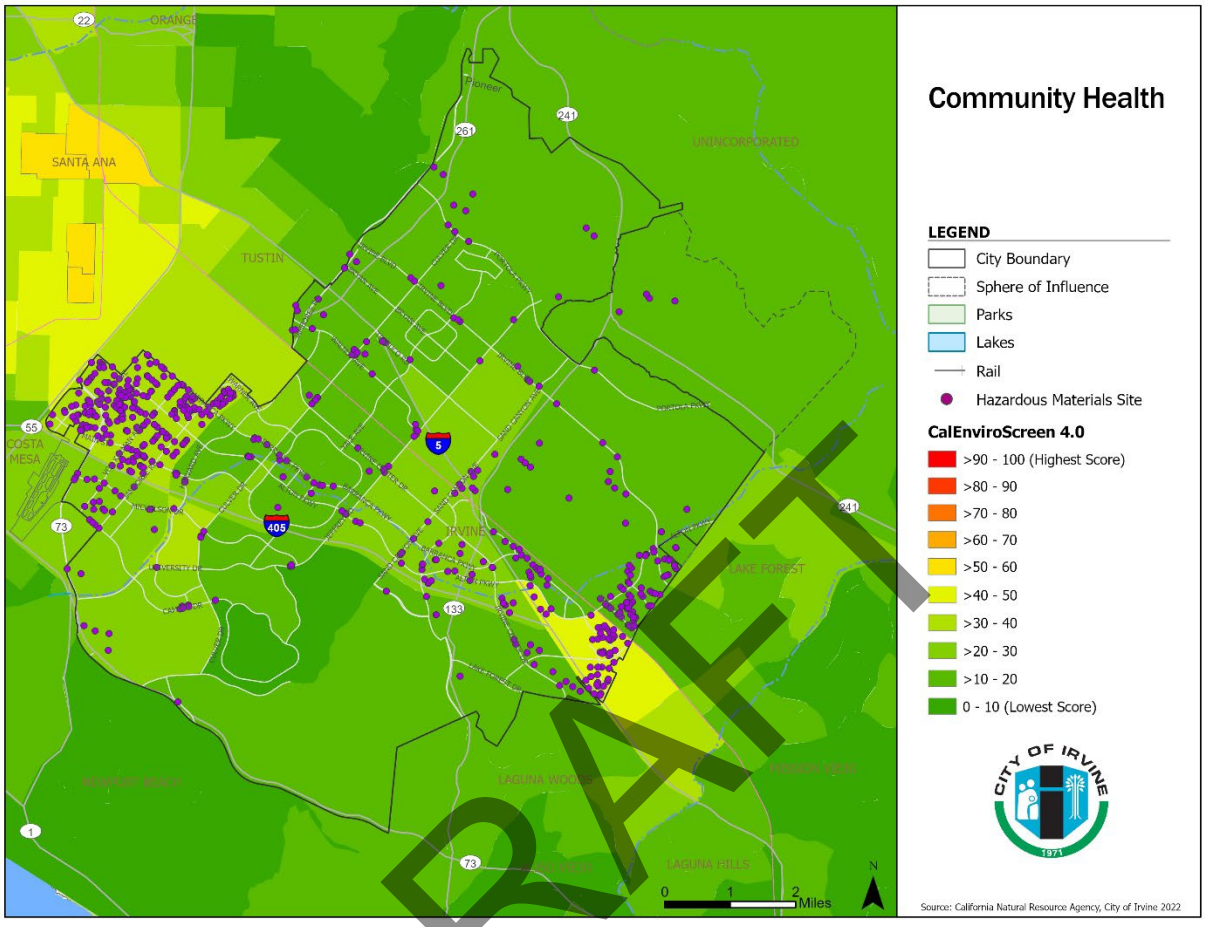
CalEnviroScreen calculates scores for two groups of indicators: Pollution Burden (e.g., PM2.5 concentrations, diesel PM emissions, adjacency to solid waste sites) and Population Characteristics (e.g., asthma emergency department visits, linguistic isolation, low-income households). **Figure 2-1: CalEnviroScreen 4.0** shows the combined Pollution Burden scores, which is made up of indicators from the Exposures and Environmental Effects components of the CalEnviroScreen model. Pollution Burden represents the potential exposures to pollutants and the adverse environmental conditions caused by pollution. Compared to all census tracts in the state, those tracts in Irvine are all in the bottom half, meaning the population of Irvine has lower pollution burden compared to other areas in the state. As a result, OEHHA does not identify any census tract in the City as containing disadvantaged communities.

While the City does not have state-defined disadvantaged communities, the City still has populations that are vulnerable to climate hazard events. Each section covering a different climate hazard within the Vulnerability Assessment contains an analysis of social sensitivity using the following criteria to assess the potential impact to vulnerable populations:

- Disability status: Persons with disabilities may often have reduced mobility and experience difficulties living independently. As a result, they may have little or no ability to prepare for and mitigate hazard conditions without assistance from others. An estimated 12.3 percent of Irvine households contain at least one person with a disability.
- Income levels: Lower-income households are less likely to have the financial resources to implement mitigation activities on their residences. They may also struggle with having the necessary time to find and access educational resources discussing hazard mitigation strategies. Furthermore, lower-income households are less likely to be able to afford moving to areas that are safer or less at risk of being impacted by a hazard. The national poverty limit standard for the U.S. for a four-person family is an income of $26,200 or less. In Irvine, between 2015 and 2019, an estimated 13.1 percent of households had an income that was considered below the poverty level. An estimated, 2.6 percent of households received food stamps or qualified for the Supplemental Nutrition Assistance Program (SNAP).[11]
- Seniors (individuals at least 65 years of age): Seniors are more likely to have reduced mobility, physical and/or mental disabilities, and lower income levels, all of which may decrease their ability to prepare for and mitigate a hazard event.

[11] United States Census Bureau (US Census). 2010. 2010 Summary File 1, ESRI Forecasts 2021. Accessed May 5, 2022.

Figure 2-1: CalEnviroScreen 4.0






## Homeless Population

The homeless are highly susceptible to impacts from direct and indirect climate effects including extreme heat events, air pollution from wildfires, and precipitation-driven or coastal flooding. Throughout Orange County, homelessness has become a substantial issue. Previous factors contributing to the rise in people experiencing homelessness included the general lack of housing affordable to lower-income people, increases in the number of people whose incomes fall below the poverty level, reductions in public subsidies, the de-institutionalization of those with mental illness, and increasing substance abuse issues. The increase in the number of layoffs and the loss of employment during the COVID-19 pandemic have likely contributed to an increase in this population because these effects resulted in the inability to afford housing. The impact of the COVID-19 on homelessness in Orange County will likely continue when eviction moratoriums are lifted, which could result in a further increase in people experiencing homelessness. According to the SCAG pre-certified data, 130 individuals are experiencing homelessness in Irvine, with three individuals (2 percent) who are sheltered and 127 individuals (or 98 percent) who are unsheltered.[12]

[12] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.

In Orange County, homelessness is addressed regionally by the Orange County Continuum of Care (COC), an umbrella organization that brings together government agencies and community-based nonprofit organizations in a coordinated effort to meet the urgent needs of people experiencing homelessness or that are in imminent danger of experiencing homelessness. The County of Orange Health Care Agency is the collaborative applicant, and 2-1-1 OC is the Homeless Management Information System lead agency.

Both Irvine and Orange County currently have a number of existing programs to assist individuals experiencing homelessness, including shelters, provided by Orange County.

## 2.2 MAJOR COMMUNITY ELEMENTS

The City provides the educational, employment, recreational, and cultural opportunities of a large city and, since its incorporation in 1971, has grown to include strong, diverse residential and business communities. At 50 years old, Irvine is a relatively young city; however, it is continuing its history of master planning through redevelopment of the former El Toro Marine Corps Air Station into the Great Park Neighborhoods and through the redevelopment of underutilized commercial and industrial uses into much needed housing.[13]

The identification of assets potentially affected by climate change related events follows FEMA's LHMP Guidance categorizing community elements as follows:

### Essential Services

#### Fire and Emergency Services

The City contracts with the Orange County Fire Authority (OCFA) to provide fire protection and emergency services in the community. OCFA is a regional fire service agency that serves 23 Orange County cities and all unincorporated areas and protects over 1.6 million residents from its 71 fire stations located throughout the county.[14]

There are eleven (11) strategically located fire stations in the City of Irvine, which allow firefighters and paramedics to provide timely responses to emergencies and to efficiently respond to volume demand.[15]

#### Police Services

The Irvine Police Department is comprised of six (6) distinct Divisions which operate under the direction and management of the Chief of Police. Each Division contains unique and specialized Bureaus, Units, and Sections responsible for overseeing and maintaining the programs of the Department. The Divisions are as follows:

- Administration, including the Office of the Chief of Police, public information officer and support services.
- Business Services, including budget/grant office, communications (9-1-1 dispatch), technology support, regulatory affairs, technical services, property, and custody.
- Operations, including patrol and criminal investigations.

[13] City of Irvine. 2022a. https://www.cityofirvine.org/. Accessed May 3, 2022.
[14] City of Irvine. 2022e. Public Safety. https://www.cityofirvine.org/irvine-gives/public-safety. Accessed May 2, 2022.
[15] Orange County Fire Authority (OCFA). 2022b. https://ocfa.org/AboutUs/FireStations.aspx. Accessed May 2, 2022.

- Support Services, including emergency management, traffic/special events, and community outreach.
- Office of Professional Development, including Academy and POST training section, firearms and range section and recruitment, personnel, and hiring section.
- Office of Professional Standards, including Internal Affairs, risk management. and worker's compensation.[16]

## Transportation Systems

The City of Irvine is served by multiple modes of transportation including bus, light rail, train, biking, and walking. The Street & Right-of-Way Maintenance Division maintains 470 centerline miles of roadway, over 1,155 linear miles of curb and gutter, 900 miles of sidewalk, approximately 5,600 catch basins well as access ramps, traffic signs, pavement markings, and street striping (Irvine 2022f). Partners like the Orange County Transportation Authority (OCTA), Amtrak, iShuttle, Spectrumotion all work together to provide the transportation network in the City of Irvine.

### Active Transportation Options

- Biking. The City of Irvine provides a system of 113.24 miles of off-street bikeway trails and 286.42 lane miles of on-street bikeways.[17]
- The iShuttle, operated and managed by the OCTA, serves residents, employees and employers in the Irvine Spectrum Area and the Irvine Business Complex by taking commuters and residents to and from work and home.
- ACCESS is OCTA's shared-ride service for people who are unable to use the regular, fixed-route bus service because of functional limitations caused by a disability. These passengers must be certified by OCTA to use the ACCESS system by meeting the Americans with Disabilities Act (ADA) eligibility criteria.
- The Irvine Station, located in the Spectrum area of the City, is a growing transportation hub in South Orange County.
- The Irvine Transportation Network is a "one-stop shop" for transportation information for anyone living in, working in, or traveling through the Irvine Business Complex (IBC).
- TRIPS is a transportation service available to Irvine residents (18 and older) who are unable to drive due to permanent physical and/ or cognitive disability.
- Amtrak is an intercity rail system throughout the nation with several stops throughout Orange County and Southern California.
- Metrolink is a commuter rail system throughout Southern California linking communities to employment and activity centers. It provides reliable transportation and mobility for the entire region while creating less congested roadways and more livable communities.
- Spectrumotion helps Irvine Spectrum employees find the best possible way to commute to work.
- Mobility Guide: The City of Irvine offers a variety of transportation options for seniors and special needs population.



[16] City of Irvine. 2022b. Police. https://www.cityofirvine.org/ipd-divisions-bureaus-units. Accessed May 2, 2022.
[17] Transportation. https://www.cityofirvine.org/work/transportation. Accessed May 2, 2022.

## Lifeline Utility systems

Infrastructure plays a vital role in mitigating the effects of hazard events. When infrastructure fails, it can exacerbate the extent of certain hazards or create complications for rescue workers trying to reach victims. For example, fallen utility poles, because of high winds or seismic activity, can obstruct roadways and prevent emergency vehicles from reaching affected areas. The following are brief descriptions of major infrastructure in the city that may be affected by climate-related hazards:

### Electricity

Irvine receives its electrical supply from Southern California Edison. There are seven substations located within the City connecting 220kV and 66 kV powerlines that run both east to west and north to south. These lines bring power to Irvine and the surrounding cities and provide connection to other regional power sources as well.13 These connections help Irvine access auxiliary electricity sources, should any of its immediate infrastructure fail. However, a larger and more regional failure of the power grid would likely disrupt power transmission to Irvine for an extended time period until power can be restored.[18]

### Water Supply

Approximately 35 percent of Irvine's drinking water is purchased from the Metropolitan Water District (MWD) of Southern California. This imported water comes from the Colorado River via the Colorado River Aqueduct and from Northern California via the State Water Project. The remaining 65 percent of Irvine's drinking water supply comes from Irvine Ranch Water District's (IRWD) local groundwater wells in the Orange County Groundwater Basin, managed by the Orange County Water District (OCWD). These wells range in depth from 400 to 2,000 feet and extract high quality water. The blend of imported and groundwater vary according to the time of year and the customer's geographical location within the District.[19]

### Wastewater Capacity

The City of Irvine's wastewater conveyance and treatment is provided by IRWD. IRWD conveys all of sewage from the City of Irvine to their Michelson Water Recycle Plant (MWRP) and Los Alisos Water Recycle Plant except for the small area known as the Irvine Business Complex, which is conveyed to Orange County Sanitary District. The Irvine Business Complex is roughly bounded by San Diego Creek to the east, CA-78 to the south, Warner Ave. the north, and the City of Irvine's boundary to the west. IRWD is actively planning to address conveyance and treatment issues over the planning period and has laid out a progressive and comprehensive plan.[20]

### Stormwater Management

The Public Drainage Program is responsible for the maintenance and upkeep of City public drainage facilities. The Program's responsibilities include the annual inspection and cleaning of all City storm drains and catch basins, erosion control of slopes along City open channels and other City drainage facilities, cleaning of debris and clearance of drainage systems after storm events and the prevention of standing water issues/concerns in City right-of-way areas. The Clean Water Program has two goals: maintain water quality and protect beaches, lagoons and creeks from illicit discharges, sewage spills and other pollutants.[21]



[18] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[19] City of Irvine. 2022. https://www.cityofirvine.org/community-development/water-quality. Accessed May 2, 2022.
[20] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.
[21] City of Irvine. 2022. https://www.cityofirvine.org/public-works-department/public-drainage. Accessed May 2, 2022.

## Waste Management

Waste Management of Orange County provides all residential/multi-family refuse, recycling, and green waste service as well as bulky item and Christmas tree collection.

## Hazardous Materials

The threat that hazardous materials pose to human health depends on the type of material, frequency, and duration of exposure, and whether chemicals are inhaled, penetrate skin, or are ingested, among other factors. Exposure to hazardous materials can result in short- or long-term effects, including major damage to organs and systems in the body, or death. Hazardous waste is any material with properties that make it dangerous or potentially harmful to human health or the environment. Hazardous materials can also cause health risks if they contaminate soil, groundwater, and air, potentially posing a threat long after the initial release.[22]

Hazardous materials can cause damage to physical assets in Irvine if they are released into the environment. Corrosive hazardous materials can damage the exteriors of any buildings or structures designated as a critical facility or facility of concern by the city. Flammable hazardous materials can potentially start fires and may cause any nearby critical facilities to flashover. Sites that are closer to the origin for the release of the hazardous materials are more at threat than those that are further away. Figure 2-2: Critical Facilities and Hazardous Materials Sites shows hazardous materials sites identified in the city.

## Economic Elements

### Irvine Spectrum

The Irvine Spectrum is one of the City of Irvine's two major business centers. It is comprised of 5,000 acres, 38 million square feet of commercial space, and 3,500 companies that employ nearly 80,000 people. The City's major retail center, the Irvine Spectrum Center, is comprised of 1.2 million square feet and more than 130 stores, restaurants, and entertainment venues.11 This location is major attraction in the City due to its convenient location between I-5 and I-405 and draws a significant amount of visitors and employees from outside the City.

### Irvine Business Complex

The Irvine Business Complex is a 2,800-acre area in the western part of the City containing industrial, commercial office, and residential uses. The zoning in this part of the City allows for over 15,000 base residential units, non-residential uses (commercial, office, industrial), and hospitality uses. This area of the City is a major economic hub as a significant of amount of people enter the City every day to work in the businesses within this complex.[23]

## Natural Resource Areas

The City features 20 developed community park sites totaling over 387 acres and six special facilities totaling 55.1 acres. In total, 39 public neighborhood parks and vista points totaling 178.6 acres and many private neighborhood parks are in Irvine. Moreover, the City has off-street bicycle trails totaling over 63 miles. In addition to parks, the City is in a league of its own when it comes to trails and preserved open spaces.

[22] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[23] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

The Jeffrey Open Space Trail, Bommer Canyon, and Quail Hill are a few of the treasured areas that have been preserved in connection with Irvine's historic Open Space Initiative and are examples of the extraordinary recreational opportunities available to residents. Among these community park facilities, the Orange County Great Park, currently being developed, will consist of over 1,300 acres of parkland, and will serve the residents of Irvine and the region with significant amenities, open space, and passive and active recreational facilities and enhance the living environment surrounding residences in the area.[24]

### Institutional Uses

Several higher education institutions are in the City, including the University of California, Irvine; Concordia University; Irvine Valley College; University of Southern California (Orange County Center); and campuses of University of La Verne and Pepperdine University.[25] Combined enrollment for these schools is over 41,000 students, which can greatly increase the City's daytime population, impact roadways, and community services.[26]

## CRITICAL FACILITIES AND FACILITIES OF CONCERN

Essential Facilities are further categorized as Critical Facilities (CF) and Facilities of Concern (FOC) and consist of properties and structures that play important roles in government operations and the services they provide to the community. Examples of CFs and COFs include local government offices and yards, community centers, public safety buildings like police and fire stations, schools, and any other properties a city has deemed essential for its operations. CFs may also serve dual roles if a city designates them as points of public assembly during an emergency. CFs are often owned by the City, but many are also owned and operated privately, such as some utilities and telecommunication infrastructure.

The Hazard Mitigation Planning Committee for the 2020 LHMP Update identified 213 CFs or FOC in Irvine that fall into 6 different categories based on their function or characteristics. Table 2.5: Critical Facilities and Facilities of Concern shows the number of CFs and FOC in each category, the total estimated value of the facilities in each category, and examples of the facilities in each. Appendix D of the LHMP has a complete list of the CFs and FOC. Figure 2-2: Critical Facilities and Hazardous Materials Sites shows the locations of CFs and FOC (and hazardous materials sites) in Irvine that were mapped. Some facilities were not mapped due to security concerns.

The potential loss value is the total insured value of the CFs that fall within the hazard zone. It is intended to provide the ballpark estimate of the cost of replacement if the property is completely or severely damaged. Actual costs of repair could be smaller or larger than the provided estimate. The data was provided by the City's Property Schedule and therefore, information for facilities not owned by the City are not shown (e.g., bridges, private buildings). In some instances, replacement cost information was not made available. Where this occurs "N/A" has been used within the table.



[24] City of Irvine, 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.
[25] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.
[26] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

Table 2.5: Critical Facilities and Facilities of Concern

| Category | Number of Facilities | | Examples | Potential Loss*,[27] |
|---|---|---|---|---|
| | Critical | Concern | | |
| City Vital Operations | 4 | 1 | City Hall, Police Station, Operations Support | $99,520,918 |
| City Community Centers | 12 | 0 | Community Centers | $32,171,675 |
| City Resident Services | 4 | 5 | Senior Centers, Animal Shelter, Daycare, Other Community Facilities | $13,173,434 |
| City Recreation Support | 0 | 21 | Parks, Recreation Amenities, Sports Complexes, and support facilities | $56,969,379 |
| Bridges | 120 | 0 | Overpasses and underpasses | $166,687,247 |
| Schools | 0 | 46 | Irvine Unified School District and Tustin Unified School District Facilities | N/A |
| **Total** | **140** | **73** | | **$368,522,653** |

* Based on the City of Irvine insured replacement values

## City of Irvine Adaptive Capacity to Climate-Related Hazards

The City of Irvine has implemented programs or partnered with external agencies to prepare, respond, and help the community recover from manmade and natural hazards, including those that are climate related. The following programs improve the overall adaptive capacity of the City:

### Prepare Irvine

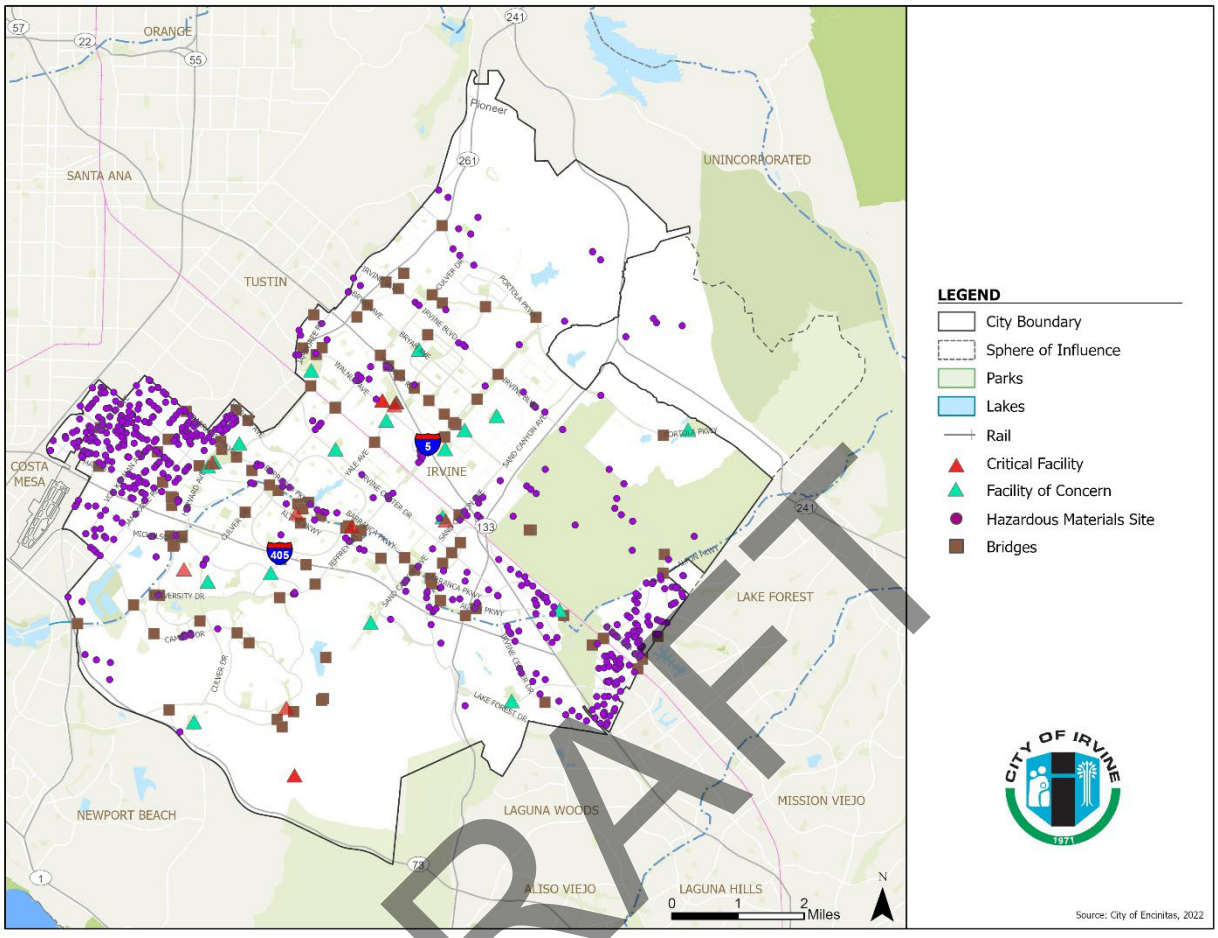
The Irvine Police Department Office of Emergency Management mobilizes local first responders for hazardous events but recognizes that they cannot reach everyone in our City right away. In times of disaster, a trained and informed public is better prepared to protect themselves, their families, their workplace, and their neighbors.[28]



[27] City of Irvine. October 2019. 2018-2019 Statement of Values

[28] City of Irvine. 2022. Prepare Irvine. https://www.cityofirvine.org/prepare. Accessed May 3, 2022.

Figure 2-2: Critical Facilities and Hazardous Materials Sites






## AlertOC

AlertOC is a mass notification system designed to keep Orange County informed of emergencies that may require immediate lifesaving actions. Time-sensitive voice and text messages from the City of Irvine will be sent to city residents and workers warning of hazardous events, including wildfire.[29]

## AB 38

As of July 1, 2021, a seller of a property that is located in a high or very high fire hazard severity zone as identified by the Director of Forestry and Fire Protection must provide to the buyer documentation stating that the property is in compliance with local vegetation management ordinances.[30]

[29] AlertOC. 2022. https://member.everbridge.net/453003085613900/login. Accessed May 3, 2022.
[30] State of California. 2019. AB38, Wood. Fire safety: low-cost retrofits: regional capacity review: wildfire mitigation. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB38. Accessed May 3, 2022.

### CERT

Irvine's Community Emergency Response Team (CERT) is a program designed to prepare citizens to help themselves, their families, and their neighbors in the event of a catastrophic disaster. Because professional emergency service personnel will not be able to help everyone immediately, CERT training can make a difference in saving lives and protecting property in our community. The training includes the basic skills important in disaster response, such as disaster medical operations, fire suppression, and light search and rescue.[31]

### IDEC

The Irvine Disaster Emergency Communications (IDEC) is an organized team of over 60 experienced, trained and dedicated amateur radio operators (Hams). Members routinely volunteer their time and extensive radio communication skills to augment normal methods of communications used by the Irvine Police Department in times of emergencies or major disasters.

### Translation Services

The City of Irvine's website offers translation for 81 languages to provide information for the diverse community members.[32]



[31] City of Irvine. 2022. https://www.cityofirvine.org/irvine-gives/public-safety. Accessed May 2, 2022.
[32] City of Irvine. 2022. https://www.cityofirvine.org/. Accessed May 3, 2022.

# CHAPTER 3. VULNERABILITY ASSESSMENT

Addressing the widespread impacts of climate change represents a significant challenge for the state. A changing climate presents California with five key climate hazards: (1) higher temperatures and extreme heat events, (2) more severe wildfires, (3) more frequent and intense droughts, (4) flooding due to extreme precipitation events, and (5) coastal flooding and erosion from sea-level rise. These hazards will threaten public health, safety, and well-being—including from life-threatening events, damage to public and private property and infrastructure, and impaired natural resources.[33]

Follow state guidance, this report provides an assessment of the city's vulnerabilities to climate change. It identifies and describes the climate hazards and other climate effects that may affect the city in the future. The vulnerability assessment follows the process outlined in Phase 2 of APG 2.0 and is composed of the following three steps:

- Exposure: The purpose of this step is to understand is to characterize the city's exposure to current and projected climate hazards. Existing hazards that can be worsened by the effects of climate change are identified and described, based on historical data, including the City's LHMP. Climate data are used to develop projections for how existing hazards are expected to change by mid- and late century from future climate change.

- Sensitivity: This step will characterize potential future climate impacts to community populations and assets. Using historical data, research from regional and state reports on climate impacts, this step explores how sensitive vulnerable populations and assets may be affected by the projected impacts of climate change hazards.

- Adaptive Capacity: The City and its supporting agencies, and countywide organizations have already taken steps to build resilience and protect sensitive populations and assets from hazards. Thus, the purpose of this step is to characterize to characterize Irvine's current capability to cope with the projected impacts from climate hazards to vulnerable populations and assets. The adaptive capacity of the City to adapt to each of the identified climate impacts is determined through a review of existing plans and programs.



## 3.1 EXISTING HAZARDS

The LHMP provides a comprehensive understanding of hazards, including those worsened by climate change. It evaluates emerging climate risks, sea-level rise, coastal storms, erosion, floods, landslides, wildfires, extreme heat, and drought/water supply hazards. Three major existing hazards that are anticipated to become more frequent or severe because of climate change are wildfires, landslides, and flooding.

[33] California Legislative Analyst's Office (LAO). 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.

### 3.1.1 FLOODING

Historical documents show that damaging floods occurred in the Los Angeles Basin in 1884, 1916, 1927, 1937, 1938, 1969, and 1997. The last one included the inundation of the lowlands in the Santiago Hills, EL Toro, San Joaquin Marsh, and Upper Newport Bay areas. It is expected that future developments will be protected from 100-year floods by the continuation of measures which alleviate flood hazards, such as channels, retention basins, and drains.[34]

### 3.1.2 WILDFIRES AND SMOKE

The topography of the foothills of the Santa Ana Mountains and San Joaquin Hills in Irvine is extremely conducive to wildfires. The community is bordered by natural, undeveloped hillsides/ mountains to the northeast and open space areas to the southwest. In between these two areas is most the City's developed areas. Over the past two decades, Irvine has been impacted by fires in or adjacent to the city such as the Santiago Fire in 2007, Freeway Complex Fire in 2008, the Canyon Fire in 2017, and the Silverado Fire in 2020.

### 3.1.3 GEOLOGIC AND SEISMIC HAZARDS

Liquefaction occurs when seismic energy shakes an area with low-density, fine grain soil, like sand or silt, is also saturated with water. When the shaking motion reaches these areas, it can cause these loosely packed soils to suddenly compact, making the waterlogged sediment behave more like a liquid than solid ground. During liquefaction events, the liquified soil can lose its stability which can cause damage to buildings and infrastructure built upon it. In severe cases, buildings may completely collapse. Pipelines or other utility lines running through a liquefaction zone can be breached during an event, potentially leading to flooding or release of hazardous materials.

Although earthquakes are not explicitly a climate hazard, climate change could potentially cause them to become more destructive because of an increased risk of liquefaction—the process by which semi-saturated or saturated sediment loses structural competency under intense shaking.[35] Rising groundwater associated with sea level rise can increase the amount of saturated sediment and the risk of liquefaction.

Landslides occur when earth on slopes become destabilized, typically after heavy rains, when the precipitation saturates the soil and makes it less stable, or when significant erosion from rainfall destabilizes the ground. Slopes that have recently burned face a greater risk from rain-induced landslides, as the fires burn up many of the trees, brush, and other vegetation that help stabilize the earth. Earthquakes may also be a source of landslides as the shaking can destabilize already loosened soils.

Major landslides have occurred throughout the Southern California region. For example, landslides were set off by the 1971 San Fernando and 1994 Northridge earthquakes. As a master planned community, the City of Irvine has taken numerous steps to mitigate landslide hazards as part of the development process. As a result, the City has not experienced significant landslide events.[36]



[34] City of Irvine. 2015a. General Plan Safety Element.
[35] USGS. (n.d.-b). *Natural hazards: What is liquefaction?* https://www.usgs.gov/faqs/what-liquefaction. Accessed March 2022.
[36] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

## 3.2 ANALYZING CLIMATE CHANGE

Climate change effects are categorized as direct or indirect. Direct effects are caused by the initial impacts of increased greenhouse gas (GHG) emissions, while indirect effects occur because of the direct effect(s). The direct climate change effects include changes in temperature and precipitation. The indirect effects, which can occur because of isolated changes or a combination of changes in the direct effects (e.g., temperature or temperature plus precipitation), include extreme heat events drought, wildfires, onshore flooding associated with large precipitation events, landslides, and coastal flooding and inundation resulting from sea level rise.

To assess the potential direct and indirect effects from climate change, APG 2.0 recommends using Cal-Adapt, a global climate simulation model data. Cal-Adapt addresses uncertainty surrounding potential GHG emissions with the use of Representative Concentration Pathways. The RCPs in this vulnerability assessment rely upon two future emissions scenarios: RCP 4.5 and RCP 8.5. RCP 4.5 represents a medium emissions scenario of GHG emissions and assumes emissions will rise, then even out near the middle of the century, and decrease to below 1990 levels by the end of the 21st century. RCP 8.5 is a high emissions scenario where GHG emissions continue to increase through the end of the 21st century.[37]

Cal-Adapt also includes ten global climate models, downscaled to local and regional resolution using the Localized Constructed Analogs statistical technique. Four of these models were selected by California's Climate Action Team Research Working Group as priority models for research contributing to California's Fourth Climate Change Assessment2. Projected future climate from these four models can be described as producing:

- A warm/dry simulation (HadGEM2-ES),
- A cooler/wetter simulation (CNRM-CM5),
- An average simulation (CanESM2), and
- The model simulation that is most unlike the first three for the best coverage of different possibilities (MIROC5).

### 3.2.1 DIRECT EFFECTS OF CLIMATE CHANGE

There are two primary direct effects of climate change: changes to temperature and changes to precipitation. These changes include increases or decreases in temperature and precipitation. They also include changes in the frequency, duration, and intensity of changes to these patterns.

#### CHANGES IN TEMPERATURE

Observations over the past century indicate that temperature has increased across southern California. Based on 1896-2015 temperature records for the California South Coast NOAA Climate Division, which encompasses the City of Irvine, California's Fourth Climate Change assessment for the Los Angeles region reports significant trends in annual average, maximum, and minimum temperature around 0.16°C per decade.

[37] Bedsworth et al. 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. Publication number: SUMCCCA4-2018-013.

Every month has experienced significant positive trends in monthly average, maximum, and minimum temperature. Monthly average and minimum temperatures have increased the most in September and monthly maximum temperatures have increased the most in January, with each trend exceeding 0.2°C per decade.[38]

According to Cal-Adapt, the historic, observed (1961-1990) annual average maximum temperature for the Irvine was 72.0°F, and the historic, observed annual average minimum temperature was 50.5°F. As shown in **Table 3-1: Change in Annual Average Temperature**, both are projected to increase by mid-century and further increase by the end of the century. The annual average maximum temperature in the city is projected to be 75.7°F by mid-century and 76.4°F by the end of the century under the medium emissions scenario. Under the high emissions scenario, the annual average maximum temperature in the study area is projected to be 76.6°F by mid-century and 79.6°F by the end of the century. This equates to an increase in temperatures of 4.4°F to 7.6°F by the end of the 21st century, according to the medium or high emissions scenario.[39]

Table 3-1: Change in Annual Average Temperature

| Annual Average Temperature | Historic Annual Average Temperature (1961 - 1990) | Medium Emissions (RCP 4.5) | | High Emissions (RCP 8.5) | |
|---|---|---|---|---|---|
| | | Mid-Century | End-Century | Mid-Century | End-Century |
| Maximum | 72.0 | 75.7 | 76.4 | 76.6 | 79.6 |
| Minimum | 50.5 | 53.8 | 54.7 | 54.9 | 57.9 |
| F = degrees Fahrenheit | | | | | |

California Energy Commission. 2022. CalAdapt. Local Climate Change Snapshot for Irvine: Annual Average Maximum and Minimum Temperature. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

### Annual Average Minimum Temperature

According to Cal-Adapt, the annual average minimum temperature is projected to increase in Irvine (Table 3-1. Change in Annual Average Temperature), consistent with the projected trend of overall warming for the region. Under the RCP 4.5 scenario, average minimum temperatures are projected to increase by approximately 4.2°F by 2100. Under the RCP 8.5 scenario, an increase of approximately 7.4°F for average minimum temperatures by 2100 is projected. With increasing minimum temperatures, it is anticipated that the city will experience warmer conditions throughout the year; however, this does not preclude severe winter weather events from occurring.

## Changes in Precipitation

Precipitation over the Los Angeles region, including the City of Irvine is highly variable from year to year and only about five storms each year make up 50 percent of the annual precipitation total according to California's Fourth Climate Change assessment for the Los Angeles region. Natural climate variability phenomena, such as the El Niño-Southern Oscillation, can influence the amount of precipitation that the region receives, but there are no clear trends in historical precipitation for this region.[40]



[38] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.
[39] California Energy Commission. 2022. Cal-Adapt Data Download Tool: LOCA Downscaled CMIP5 Climate Projections. https://cal-adapt.org/data/download/. Accessed April 28, 2022.
[40] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles

### Annual Average Precipitation Levels

According to Cal-Adapt, annual projected precipitation levels in the city are expected to experience modest change by the end of the century. **Table 3-2: Change in Annual Average Precipitation** identifies estimated annual average precipitation levels. The results of these projections suggest that during average years, precipitation levels will be similar to conditions currently experienced within the city, with a potential increase in average annual rain at the end of the century under the RCP 8.5 scenario.

**Table 3-2: Change in Annual Average Precipitation**

| Historic Annual Average Precipitation (1961 - 1990) | Medium Emissions (RCP 4.5) | | High Emissions (RCP 8.5) | |
|---|---|---|---|---|
| | Mid-Century | End-Century | Mid-Century | End-Century |
| 13.3 | 13.2 | 13.2 | 13.0 | 14.5 |

CalAdapt. Local Climate Change Snapshot for Irvine: Annual Average Precipitation. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed May 2, 2022.

## 3.2.2 INDIRECT EFFECTS OF CLIMATE CHANGE

This analysis addresses five indirect effects of the projected changes to temperature and changes to precipitation: Extreme heat events, drought, wildfire and smoke, flooding, and liquefaction.

### Mental Health

Before focusing on the indirect effects of changes in temperature and precipitation, it is important to note that the impacts from climate change such as fires and floods can have acute mental health impacts. As reported in the state's 4th Climate Change Assessment, there are potential links between extreme weather events and anxiety and depression, post-traumatic stress disorder, and suicide.[41]

### 3.2.2.1 EXTREME HEAT EVENTS

Extreme heat events are a period when temperatures are abnormally high relative to a designated location's normal temperature range. Extreme heat events are one of the leading weather-related causes of death in the United States—from 1999 through 2009, extreme heat exposure caused more than 7,800 deaths.[42] There are generally three types of extreme heat events:

- Extreme Heat Days: a day during which the maximum temperature surpasses 98 percent of all historic high temperatures for the area, using the time between April and October from 1961 to 1990 as the baseline.
- Warm Nights: a day between April to October when the minimum temperature exceeds 98 percent of all historic minimum daytime temperatures observed between 1961 to 1990.
- Extreme Heat Waves: a successive series of extreme heat days and warm nights where extreme temperatures do not abate. While no universally accepted minimum length of time for a heat wave event exists, Cal-Adapt considers four, successive extreme heat days and warm nights to be the minimum threshold for an extreme heat wave.



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Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

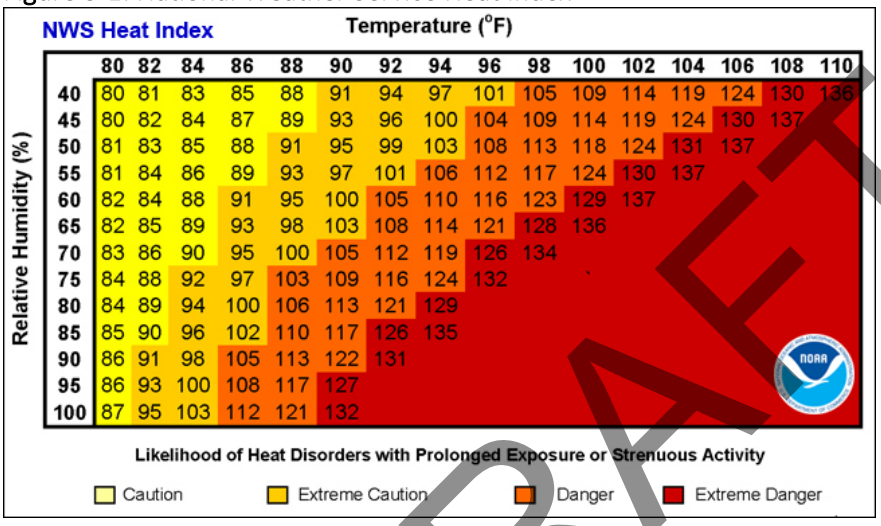
[41] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles
Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

[42] United States Global Change Research Program, 2016: The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. A. Crimmins, J. Balbus, J. L. Gamble, C. B. Beard, J. E. Bell, D. Dodgen, R. J. Eisen, N. Fann, M. D. Hawkins, S. C. Herring, L. Jantarasami, D. M. Mills, S. Saha, M. C. Sarofim, J. Trtanj, and L. Ziska, Eds.

Extreme heat events will feel different from region to region since different areas have different historic high temperatures. For example, an extreme heat day on the coast will feel different than an extreme heat day in the High Desert. The reason for this is how humidity plays a factor in the perceived heat that people feel. Humid conditions will make a day feel hotter than non-humid conditions, even though the temperature may be the same. The difference between the perceived temperature and the actual temperature is known as the "heat index."

To illustrate the effect of the heat index, a 90-degree day with 50 percent humidity feels like 95°F whereas a 90°F day with 90 percent humidity feels like 122°F. **Figure 3-1: National Weather Service Heat Index** shows National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service Heat Index.[43]

**Figure 3-1: National Weather Service Heat Index**




Source: National Oceanic and Atmospheric Administration National Weather Service Heat Index.

## Historical Extreme Heat Events

Local data from within Irvine is generally available using the Tustin Irvine Ranch National Weather Service Cooperative Network station. The data indicates that the average maximum temperature for the area from all years between 1902 and 2003 is 85.2°F, occurring in the month of August.[44] Given that the minimum threshold for an extreme heat day in Irvine is 93.2°F, it is rare that the temperature exceeds this threshold on a regular basis. Still, extreme heat events have occurred in the region which occasionally impact the City as well. Some significant historic extreme heat events include:

- September 1963, the temperature reached 113°F at the now defunct El Toro Air Force Base and the surrounding region was hot as well, including coastal areas. Temperatures in Carlsbad and Oceanside reached 108°F. School children and employees were sent home due to the heat and some agricultural crops were destroyed.

[43] National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service Heat Index. https://www.weather.gov/safety/heat-index. Accessed March 31, 2022.
[44] Western Regional Climate Center. 2020. Tustin Irvine Ranch, California (049087). https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca9087. Accessed May 3, 2022.

- April 1989, daily high temperature records were set for all weather monitoring stations in Southern California. Los Angeles and Riverside set records at 106°F and 104°F respectively.[45]

More recent extreme heat events have also affected the greater region surrounding Irvine:

- On October 23, 2017, Southern California experienced two extreme heat days. The weather monitoring station at Long Beach Airport indicated that temperatures reached 105°F that day.[46]
- Throughout July 2018, extreme heat waves occurred throughout Southern California, including Irvine. The hottest day of the heat waves occurred on July 6 when temperatures reached 114°F in Santa Ana, CA. A second but less intense extreme heat wave occurred on July 25 where regional temperatures went above 100°F in places like Burbank. While local temperature data for Irvine is not available the weather monitoring station at nearby Long Beach Airport indicates that the temperature reached 95°F that day.[47]
- On Sunday, September 6, 2020, the temperature at John Wayne Airport Station measured 104°F.[48]
- For two consecutive days, on April 7-8, 2022, the temperature at John Wayne Airport Station measured 100°F.[49]

Unusually hot days and multi-day heat waves are a natural part of day-to-day variation in weather. As the Earth's climate warms, however, hotter-than-usual days and nights are becoming more common and heat waves are expected to become more frequent and intense. Increases in these extreme heat events can lead to more heat-related illnesses and deaths, especially if people and communities do not take steps to adapt.[50]

## Vulnerability to Extreme Heat Events

### Exposure

The Fourth Assessment indicates that Southern California can expect longer and hotter heat wave, with continued future warming over the region.[51] Annual mean maximum temperature could increase by 7.6°F by 2100 (see **Table 3-1: Change in Annual Average Temperature**).[52] As illustrated in **Table 3-3: Change in Number of Extreme Heat Days** the annual number of extreme heat days (over 92.1°F) in the City could increase up to 19 days by 2100.[53]



[45] National Oceanic and Atmospheric Administration. May 2017. "A History of Significant Weather Events in Southern California." https://www.weather.gov/media/sgx/documents/weatherhistory.pdf

[46] Weather Underground. 2019. Long Beach Airport, California – October 2017. https://www.wunderground.com/history/monthly/us/ca/long-beach/KLGB/date/2017-10. Accessed May 3, 2022.

[47] Climate Signals. December 2018. Southern California Heat Wave July 2018. https://www.climatesignals.org/events/southern-california-heat-wave-july-2018. Accessed May 3, 2022.

[48] Weather Underground. 2020. John Wayne Airport, California – September 6, 2020. https://www.wunderground.com/history/monthly/us/ca/costa-mesa/KSNA/date/2020-9. Accessed May 3, 2022.

[49] Weather Underground. 2020. John Wayne Airport, California – April 7 - 8, 2022-4. Accessed May 3, 2022.

[50] Sarofim, M.C., S. Saha, M.D. Hawkins, D.M. Mills, J. Hess, R. Horton, P. Kinney, J. Schwartz, and A. St. Juliana. 2016. Chapter 2: Temperature-related death and illness. In: The impacts of climate change on human health in the United States: A scientific assessment. U.S. Global Change Research Program.

[51] Southern California Association of Governments. Southern California Climate Adaptation Planning Guide. October 2020.

[52] California Energy Commission. 2022. CalAdapt. Local Climate Change Snapshot for Irvine: Annual Average Maximum Temperature. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

[53] California Energy Commission. 2022. CalAdapt. Local Climate Change Snapshot for Irvine: Extreme Heat Days. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

Table 3-3: Change in Number of Extreme Heat Days

| Number of Extreme Heat Days* | Historic Annual Average Extreme Heat Days (1961 - 1990) | Medium Emissions (RCP 4.5) | | High Emissions (RCP 8.5) | |
|---|---|---|---|---|---|
| | | Mid-Century | End-Century | Mid-Century | End-Century |
| | 4 | 8 | 10 | 10 | 23 |

*Number of days in a year when daily maximum temperature is above a threshold temperature of 92.1 °F.
Note: Threshold temperature used in this tool is location specific. It is defined as the 98th percentile value of historical daily maximum/minimum temperatures (from 1961–1990, between April and October) observed at a location.

Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Extreme Heat Days. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

## Warm Nights

An atmospheric Urban Heat Island (UHI) is defined as warmer air in urban areas than in the surrounding areas and may be small and non-existent during the day and most intense at night and during the winter due to the slow release of heat from urban infrastructures. Atmospheric UHI causes human discomfort during the night and like surface UHI (See Extreme Heat Events, Sensitivity: Social), can have negative public health impacts.[54]

Warm night temperatures affect the ability of a community and its residents to effectively cool down from extreme heat days. If temperatures remain higher than normal during the night, the compounding impacts from high daytime temperatures can be highly detrimental to public health.

According to Cal-Adapt, a warm night event in Irvine is a night when the evening temperature exceeds 65.5°F. Table 3-4: Change in Number of Warm Nights identifies the projected average number of warm nights that would occur each year under the RCP 4.5 and RCP 8.5 scenarios. By 2100, an estimated 35 to 72 warm nights (RCP 4.5 and RCP 8.5, respectively) could be experienced (compared to only four days annually based on observed historical conditions). Based on these projections, the city can anticipate increased demand - towards the end of the century - for cooling centers and calls for service from vulnerable populations, which are expected to be disproportionately impacted by extreme heat conditions.



Table 3-4: Change in Number of Warm Nights

| Number of Warm Nights* | Historic Annual Average Warm Nights (1961 - 1990) | Medium Emissions (RCP 4.5) | | High Emissions (RCP 8.5) | |
|---|---|---|---|---|---|
| | | Mid-Century | End-Century | Mid-Century | End-Century |
| | 4 | 25 | 35 | 34 | 72 |

*Number of days in a year when daily minimum temperature is above a threshold temperature of 65.5 °F.
Note: Threshold temperature used in this tool is location specific. It is defined as the 98th percentile value of historical daily maximum/minimum temperatures (from 1961–1990, between April and October) observed at a location.

Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Warm Nights. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

[54] Southern California Association of Governments. Southern California Climate Adaptation Planning Guide. October 2020.

## Sensitivity: Major Community Elements

The impacts of extreme heat events will be most severely felt in highly developed areas of the city that are intensely paved and surrounded by buildings constructed of dark (heat absorbing) materials without the cooling benefits of tree shade. Urbanized areas can experience higher temperatures, greater pollution, and negative health effects, especially during summer months than rural communities. This phenomenon is known as the Urban Heat Island Effect (UHIE). Urban heat islands are created by a combination of heat-absorptive surfaces (e.g., dark pavement and roofing), heat-generating activities (e.g., automobile engines and industrial generators), and the absence of "green spaces" (vegetative surfaces that provide evaporative cooling). During extreme heat days and heatwaves, asphalt and darker surfaces reduce nighttime cooling (as retained heat is released from these surfaces). The UHIE is known to intensify extreme heat days and heatwaves.

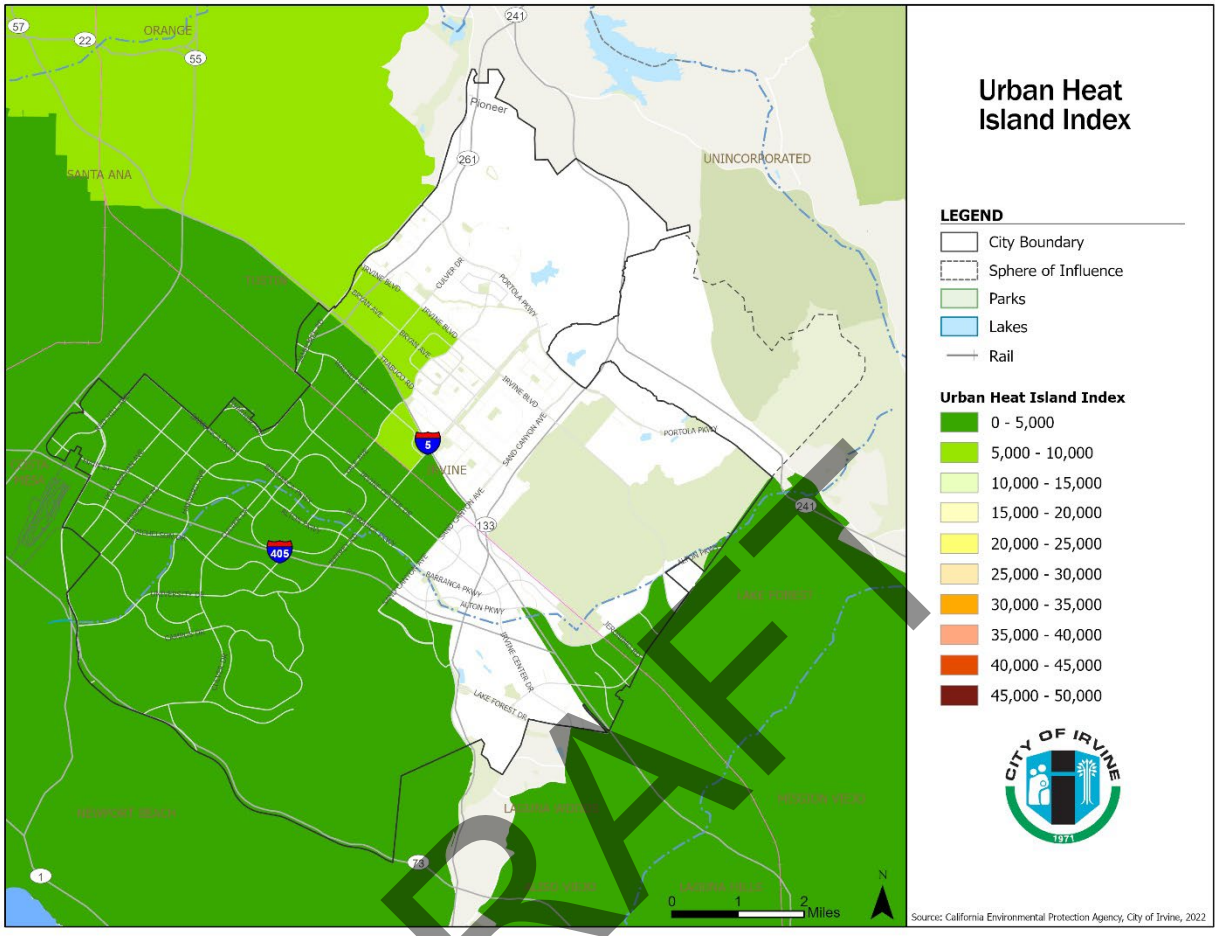
An Urban Heat Island Index (UHII) can be calculated by atmospheric modeling, as a temperature differential over time between an urban census tract and nearby upwind rural reference points at a height of two meters above ground level, where people experience heat. The modeling covered 182 warm season days from 2006 and 2013, with one-hour timesteps, so the UHII is the sum of 24 * 182 = 4,368 hourly temperature differences. Since 2020, the index is also reported in degree-hours per day on a Celsius scale – a measure of heat intensity over time, calculated by dividing the UHII by 182 days. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period.[55]

As illustrated in **Figure 3-2: Urban Heat Island Index**, the city is not severely impacted by the UHIE that may intensify extreme heat days and heatwaves. However, even without a large UHIE, the city is still projected to have extreme heat days and many types of infrastructure are affected by extreme heat, including roads and rails.



[55] California Environmental Protection Agency. 2022. Urban Heat Island Interactive Maps. https://calepa.ca.gov/urban-heat-island-interactive-maps-2. Accessed April 12, 2022.

Figure 3-2: Urban Heat Island Index




Source: California Environmental Protection Agency. 2022

## Sensitivity: Major Community Elements

### Transportation Systems

High temperatures increase the risk of pavement deterioration, depending on the paving materials and the traffic load of a given road.[56,57] The type of pavement used is typically based on historical climate conditions; the increasing occurrence of frequent and prolonged extreme heat outside of historical norms will present challenges to the roadway system.[58]



[56] Daniel, J.S., J.M. Jacobs, E. Douglas, R.B. Mallick, and K. Hayhoe. 2014. Impact of climate change on pavement performance: Preliminary lessons learned through the Infrastructure and Climate Network (IC Net). dot:10.1061/9780784413326.001.
[57] Rowan, E., C. Evans, M. Riley-Gilbert, R. Hyman, R. Kafalenos, B. Beucler, B. Rodehorst, A. Choate, and P. Schultz. 2013. Assessing the sensitivity of transportation assets to extreme weather events and climate change. Transportation Research Record: Journal of the Transportation Research Board 2326(1):16—23. doi:10.3141/2326-03.
[58] Holsinger, H. 2017. Preparing for change. FITWA-HRT-17-002. Public Roads 80(4). McLean, VA: Office of Research, Development, and Technology, Federal High Administration. https://highways.dot.gov/public-roads/januaryfebruary-2017/preparing-change. Accessed April 11, 2022.

Extreme heat may also cause pavement heave and damage to transportation infrastructure and functioning.[59] Extreme heat is also problematic for rail systems, as railroad tracks exposed to high temperatures are at risk of warping or buckling.[60]

### Lifeline Utility Systems

As heat waves worsen, energy systema will need to adapt to help communities and businesses cope with rising temperatures. Access to air conditioning will be vital for vulnerable populations, even life saving for the elderly, young children, and those with pre-existing health conditions. However, increased cooling needs for both air conditioning and refrigeration will place significant stress on the power system during periods of extreme heat. And if that power comes from fossil-fired power plants, there may also be an increase in soot, smog, and other forms of air pollution with the associated public health consequences.[61] Impacts on electricity resources from climate hazards can include stress and physical damage to the electricity generation, transmission, and distribution system.

Transmission facilities face increasing climate change-related risks because of increased frequency of wildfires, severe wind, and the extreme heat. Extreme heat and drought can add stress to transmission systems, resulting in system failure. Electrical infrastructure may fail due to increased electrical loads and stress from longer periods of increased operation. A 2011 study found that just one extra day with temperatures above 90 F increases annual household energy use by 0.4 percent.[62]

Higher temperatures can reduce the water supply in California from reduced precipitation and snowpack and earlier snowmelt.[63]

### Economic Elements

Laborers in weather-exposed industries such as construction and agriculture are the most prone to extreme heat impacts, even if they work fewer hours when it is hotter. Workers are less productive when it's hotter out.[64] Exposure to high temperatures may affect worker safety by increasing rates of workplace injuries[65] and it may also affect the performance and productivity of workers.[66] Higher temperatures tend to reduce growth in many industries that involve substantial indoor work, including retail, services, and finance.



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[59] Guo Y, Gasparrini A, Li S, Sera F, Vicedo-Cabrera AM, de Sousa Zanotti Stagliorio Coelho M, et al. (2018) Quantifying excess deaths related to heatwaves under climate change scenarios: A multicountry time series modelling study. PLoS Med 15(7): e1002629.

[60] Magill, B. 2014. "Sun kinks" in railways join the list of climate change's toll. Scientific American, June 2. www.scientificamerican.com/article/sun-links-in-railways-Join-the-list-of-climate-change-s-toll. Accessed April 11, 2022.

[61] Abel, D.W., T. Holloway, M. Harkey, P. Meter, D. Ahl, V.S. Limaye, and J.A. Patz. 2018. Air-quality-related health impacts from climate change and from adaptation of cooling demand for buildings in the eastern United States: An interdisciplinary modeling study. PLOS Medicine 15(7):1—27.dot:10.1371/journal.pmed.1002599.

[62] Deschênes, Olivier and Michael Greenstone. 2011. Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the US. American Economic Journal: Applied Economics Vol. 3 No. 4 October 2011

[63] U.S. Environmental Protection Agency. 2016. What Climate Change Means for California. https://www.epa.gov/sites/production/files/2016-09/documents/climate-change-ca.pdf

[64] Lemione, Derek. 2021. 4 ways extreme heat hurts the economy. Cornell University Alliance for Science. August 3. https://allianceforscience.cornell.edu/blog/2021/08/4-ways-extreme-heat-hurts-the-economy. Accessed May 6, 2022.

[65] Park, J., Pankratz, N., & Behrer, A. (2021). Temperature, Workplace Safety, and Labor Market Inequality. IZA Discussion Paper No. 14560

[66] Cui, W., Cao, G., Park, J. H., Ouyang, Q., & Zhu, Y. 2013. Influence of indoor air temperature on human thermal comfort, motivation and performance. Building and environment, 68, 114-122.

An 1°F increase in the average summer temperature is associated with a reduction in the annual growth rate of state-level output of 0.15 to 0.25 percentage points and rising temperatures could reduce U.S. economic growth by up to one-third over the next century.[67]

This increase in electricity use on hot days stresses electric grids right when people depend on them most, as seen in California during recent heat waves. Blackouts can be quite costly for the economy, as inventories of food and other goods can spoil and many businesses either have to run generators or shut down. For instance, the 2019 California blackouts cost an estimated $10 billion.[68]

### Natural Resource Areas

Extreme temperatures — as opposed to warmer average temperatures — are the catalyst for a growing number of extinctions. In 2002, researchers looked at 538 plant and animal species at 581 sites around the world that had been previously surveyed. The goal was to understand what aspect of climate change was the most serious threat to biodiversity. They found that 44 percent of the species at the sites had gone locally extinct, and that the culprit was an increase in the temperature of the hottest days of the year.[69]

Birds suffer more than other animals as they are diurnal and exposed to the hottest part of the day. Small mammals live underground and are generally nocturnal. Insects are small and can take advantage of smaller habitat niche although some insects have taken a heat hit as well. A recent study found that the number of areas that native bumblebees occupy has plummeted 46 percent in North America and 17 percent in Europe compared to surveys taken from 1901 to 1974. Those bee-less areas were also places with a high degree of climate variation, especially higher temperatures. "Climate change is related to the growing extinction risk that animals are facing around the world," lead author Peter Soroye said, because of "hotter and more frequent extremes in temperatures."[70]

Water stress induced mortality processes such as hydraulic failure or carbon starvation are caused by extreme heat (and drought). Many trees operate at or near their tolerance limit for water stress and may not be able to acclimate or acclimate fast enough to keep pace with the changing climate.[71] Even if such stresses do not directly kill trees themselves, they can increase vulnerability to mortality from pests as witnessed by the large-scale forest dieback from bark beetle outbreaks taking place across North America.[72]



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[67] Colacito, Riccardo; Bridget Hoffmann, Toan Phan. 2018. Temperature and Growth: A Panel Analysis of the United States. Journal of Money, Credit, and Banking. December 3. https://doi.org/10.1111/jmcb.12574. Accessed May 6, 2022.
[68] Wara, Michael. 2019. Impacts of Wildfire on Electric Grid Reliability. Senate Energy and Natural Resources Committee Testimony. December 19.
[69] Roman-Palacios, Cristian and John J Wiens. 2020. Recent responses to climate change reveal the drivers of species extinction and survival. Proceedings of the National Academy of Sciences. February 10. https://doi.org/10.1073/pnas.1913007117
[70] Soroye, Peter. Tim Newbold, Jeremy Kerr. 2020. Climate change contributes to widespread declines among bumble bees across continents. Science. February 7. Pp. 685-688. DOI: 10.1126/science.aax8591.
[71] Williams I N, Torn M S, Riley W J and Wehner M F 2014 Impacts of climate extremes on gross primary production under global warming Environ. Res. Lett
[72] Hicke J A, Meddens A J H, Allen C D and Kolden C A 2013 Carbon stocks of trees killed by bark beetles and wildfire in the western United States Environ. Res. Lett.

## Sensitivity: Vulnerable Populations

Higher temperatures and extreme heat can lead to heat cramps, heat exhaustion, heat stroke, respiratory illness, and increase the risk of heat-related mortality in addition to expansion of vector-borne disease.[73] Whereas a heat event can be relatively harmless for those with a reliable means for staying hydrated and cool, it can be deadly for others. Young children, the elderly, or people suffering from serious medical conditions are physiologically more vulnerable to heatstroke. Some senior citizens also take medicines that can make it harder for their bodies to maintain a safe internal temperature, creating an additional threat from extreme heat events. Young children may not be aware of the signs of dehydration or ways of protecting themselves from heatstroke.

Surface UHI can cause urban surface areas to become 50 to 90 degrees Fahrenheit warmer than the air temperature and is present at all hours of the day and the night, but is most intense during the day and in the summer. Due to changes in the sun's intensity, its magnitude varies with seasons. Surface UHI contributes to human discomfort during the day and an increase in energy demand for air conditioning. If a person does not have access to air conditioning, the daytime heat can lead to heat-related illnesses.[74]

Sudden spikes in heat can catch people by surprise. Stores can rapidly sell out of fans, air-conditioning units, or drinking water during a heatwave. Lower-income households or those with limited mobility may be unable to acquire enough insulation or cooling devices without significant advance preparations. This can be further compounded by the threat of Public Safety Power Shutoff events. During these events, extreme heat impacts may affect larger portions of the City and populations that wouldn't be viewed as vulnerable under normal circumstances.[75]

Figure 3-3: Heat Health Action Index displays the Heat Health Action Index from the California Natural Resources Agency's California Heat Assessment Tool (CHAT). CHAT uses a dataset that was designed to investigate how the frequency of HHEs will change throughout the 21st century. The HHAI is a statistically weighted result of social (e.g., education, income, linguistic isolation), health (e.g., asthma, percent low birth weight), and environmental (e.g., pollution, tree canopy) indicators and is intended to represent overall heat vulnerability. Represented by US Census Tract, the range is from 0 to 100, with lower scores representing less heat vulnerability. All census tracts are projected to have low vulnerability to heat which corresponds to Cal-Adapts projections for the number of Extreme Heat Days through the end of the century (see Table 3-3: Change in Number of Extreme Heat Days).

While the general population may be less vulnerable to extreme heat events, people have unique and individual thresholds. Extreme heat events including heat waves can lead to illness and death, particularly among older adults, the very young, and other vulnerable populations. People living in homelessness are at a high risk of health complications during heat waves, especially if they are unsheltered. According to data counts by the OC Health Care Agency, in 2017, there were approximately 4,800 individuals experiencing homelessness in the county, with over 50 percent unsheltered, approximately 25 percent in emergency shelters, and 20 percent in transitional shelters.[76] During a heat wave, these people are very vulnerable to heatstroke, especially if they are unable to reach a cooling center.

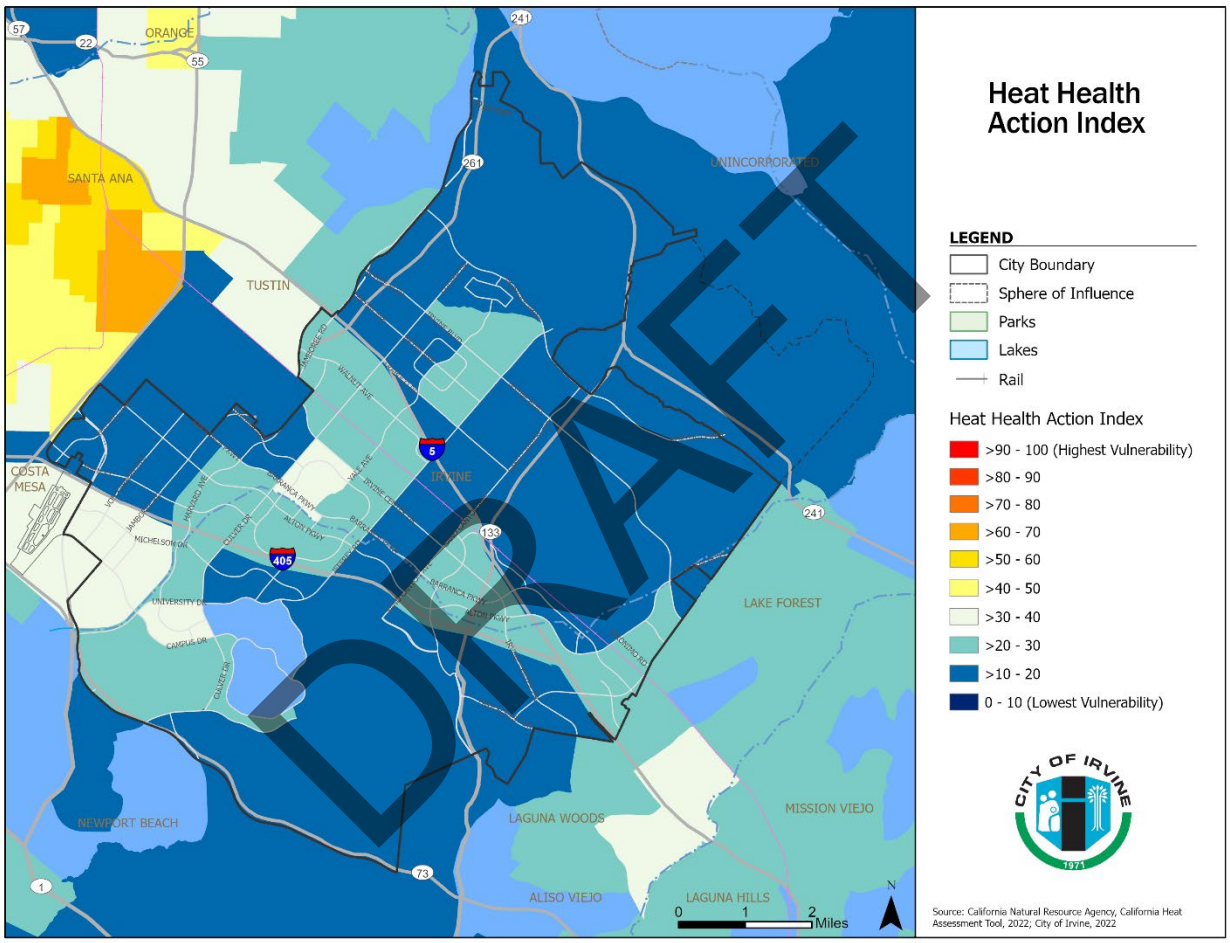


[73] Southern California Association of Governments. 2020. Extreme Heat & Public Health Report. September.
[74] Southern California Association of Governments. 2020. Extreme Heat & Public Health Report. September.
[75] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[76] OCGov. 2017. Orange County Point in Time Count 2017: Homelessness in Orange County. http://www.ocgov.com/civicax/filebank/blobdload.aspx?BlobID=64596

## Adaptive Capacity

Current research indicates that most people can adapt biologically and physically to incremental increases in average normal temperatures. children, pregnant women, and older adults are more susceptible to adverse effects because they are less able to regulate their body temperatures. Other at-risk groups include individuals working outdoors, outdoor athletes, the socially isolated and those with incomes below the federal poverty level, as well as communities of color. Continuous exposure to increased heat over time will impact how individuals are able to work and play both now and in the future.[77]

### Figure 3-3: Heat Health Action Index




## Regulation and Planning

California is dedicated to addressing the climate change impacts on transportation infrastructure, including funding and research initiatives as well as department- and agency-led projects to assess climate-related vulnerabilities and plan for more climate-resilient transportation infrastructure.

[77] National Institute of Heath, National Institute of Environmental Health Sciences. 2022. *Temperature-related Death and Illness*. https://www.niehs.nih.gov/research/programs/climatechange/health_impacts/heat/index.cfm#footnote1 Accessed April 7, 2022.

- Chapter 5 of 2017 (SB 1, Beall) Provided $20 Million for Climate Adaptation Planning Grants to prepare for and reduce damage from climate change impacts on transportation infrastructure.
- Chapter 118 of 2016 (AB 2800, Quirk) Established the Climate-Safe Infrastructure Working Group to convene a working group consisting of engineers, scientists, and architects to examine how to incorporate climate change impact data into state infrastructure planning, design, construction, operations, and maintenance.
- Agency (CalSTA) Developed Climate Action Plan for Transportation Infrastructure. Developed in response to Executive Order N-19-19, which called for CalSTA to leverage discretionary state transportation funds to reduce GHG emissions in the transportation sector and adapt to climate change.

Renewable energy and electricity storage technologies can add flexibility to the electricity grid. Together with microgrids, renewables can support increased grid resilience and reliability in the face of extreme weather. Electricity storage also has the potential to replace fossil-fired "peaking" power plants, which are called upon in times of high demand for electricity such as during extreme heat events.[78]

The City has addressed extreme heat in planning documents such as their Local Hazard Mitigation Plan, Urban Forestry Policy, and Cool Blocks Program. The City also has regulations and programs in place that are beneficial during extreme heat events by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

### City of Irvine Local Hazard Mitigation Plan (2020)

The 2020 LHMP included mitigation actions to decrease the risks associated with extreme heat, including:

- Notify residents through public service announcements a couple of days in advance of a severe weather event. Focus on media methods that target vulnerable populations, such as elderly, sick, lower-income, or persons with limited mobility to better ensure they have adequate time to prepare.
- Implement a tree-planting program to diversify tree age and increase shaded areas in the City to reduce the effects of the urban heat island effect.
- Expand use of public facilities (libraries, community centers, etc.) as warming/cooling centers for vulnerable populations during extreme weather events, and assess facility needs in order to automatically open these facilities as extreme weather centers when conditions require.
- Promote passive cooling design (brise soleil, long roof overhangs, locating windows away from southern facades, etc.) in new developments during the design review process.
- Upgrade HVAC within City facilities to more efficient systems that may include split systems or decentralized systems that allow for heating and cooling the spaces needed, not entire buildings.
- Evaluate the long-term capacity of designated cooling centers and shelters in the City to provide enough relief from extreme heat. Assess the need to expand services as the frequency, length, and severity of future heatwaves potentially change as a result of climate change.

[78] Abel, D.W., T. Holloway, M. Harkey, P. Meter, D. Ahl, V.S. Limaye, and J.A. Patz. 2018. Air-quality-related health impacts from climate change and from adaptation of cooling demand for buildings in the eastern United States: An interdisciplinary modeling study. PLOS Medicine 15(7):1—27. dot:10.1371/journal.pmed.1002599.

### Urban Forestry Policy (2009)

Trees are a source of shade, air conditioning and other environmental benefits, and yield both a high quality of life and economic benefits to the community, including enhanced property values. An urban forest is an integral part of the city's infrastructure providing significant ecological, social, and economic benefits including improved air quality, reduced erosion and stormwater runoff, energy conservation, improved health, and enhanced livability. The Irvine Public Works Department's Landscape Maintenance Division is guided by an Urban Forestry Policy (2009) to provide for orderly inventorying, inspection, trimming, removal, and planting to promote the health and safety of the community.[79]

### Cool Block Program (2021)

Developed and funded by the Empowerment Institute, the Cool City Challenge (CCC) initiative is a $1 million grant competition among California cities to develop the most innovative pathways to carbon neutrality, including the Cool Block program which requires recruitment of 200 Cool Block team leaders to lead their neighbors through a shared learning program to improve sustainability and quality of life in their own neighborhoods, with an eye toward rapid expansion across the city.

The Cool Block program also reduces climate emissions and utility bills while building resiliency and local emergency preparedness against climate disasters such as extreme heat, floods, wildfires, and extreme storm events that are already worsening considerably worldwide. The strategy developed through the CCC will identify and incentivize innovative climate solutions, create bottom-up change from the demand side (consumers) and connect it to top-down change from the supply-side (business, technology, and policy adoption). The resultant community synergy can empower social, environmental, and economic outcomes not previously imagined possible.[80]

## 3.2.2.2 DROUGHT + WATER SUPPLY

Warmer temperatures also contribute to more frequent and intense droughts by leading to a decline in and faster melting of winter snowpack, greater rates of evaporation, and drier soils. These conditions decrease the amount of spring and early summer snowmelt runoff upon which the state historically has depended for its annual water supply, while they increase the demand for irrigation water in both agricultural and urban settings. The period of 2012 through 2015 represents the state's four driest consecutive years on record in terms of statewide precipitation, and 2021 was the third driest single year. Moreover, 2022 already experienced the driest consecutive January and February in the Sierra Nevada, based on records dating back over one hundred years.

Drought may lead to water-related problems. When rainfall is less than normal for weeks, months, or years, the flow of streams and rivers declines, water levels in lakes and reservoirs fall, and the depth to water in wells increases. If dry weather persists and water-supply problems develop, the dry period can become a drought.[81]



[79] City of Irvine. 2009. Public Works Department Urban Forestry Policy. March 17.
[80] City of Irvine. 2021. https://www.cityofirvine.org/cool-block-program. Accessed May 2, 2022.
[81] United States Geological Survey. 2022. California Water Sciences Center. California Drought. https://ca.water.usgs.gov/california-drought/what-is-drought.html. Accessed April 12, 2022.

As a result, droughts have widespread impacts across the state, including mandatory water use restrictions, reductions in agricultural crop production, over-pumping of groundwater which damages infrastructure from land sinking and dries up domestic well and degraded habitats for fish and wildlife.[82]

### Historical Drought Events

The 2007–2011 California drought marked the beginning of increased restrictions on State Water Project (SWP) pumping from the Bay-Delta due to environmental considerations. In April 2007, MWD notified its member agencies that it expected challenges in meeting demands due to insufficient imported water supplies from the SWP and the Colorado River. To meet demands, MWD announced that it would implement shortage-related actions consistent with its Water Surplus and Drought Management Plan.

In January 2014, Governor Brown proclaimed a state of emergency throughout California, calling for increased conservation across the state.

On March 1, 2022, the California Department of Water Resources reported, "Statewide, the snowpack is 63 percent of average for this date. With only one month left in California's wet season and no major storms in the forecast, Californians should plan for a third year of drought conditions."[83]

## Vulnerability to Drought

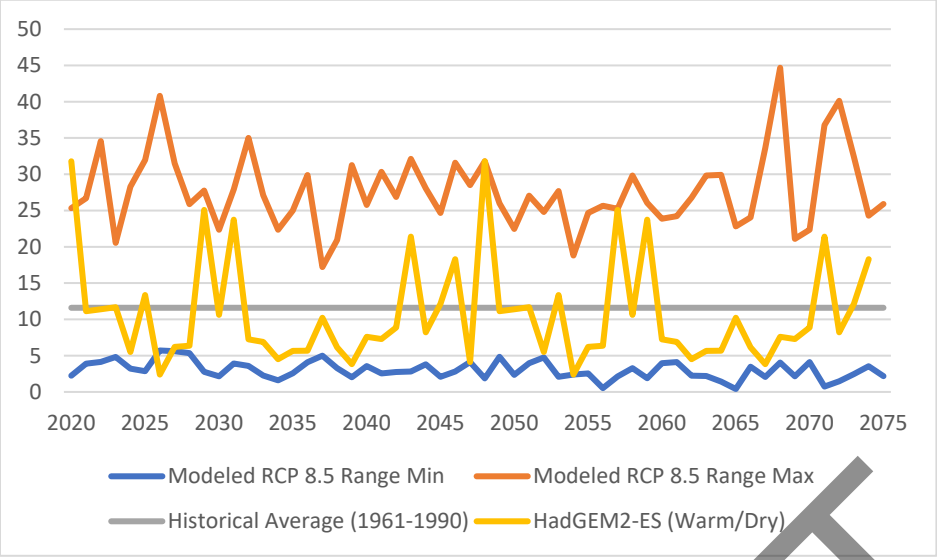
### Exposure

As shown in Table 3-2:  Change in Annual Average Precipitation, under both the medium and high emissions scenarios, Irvine is not expected to experience significant changes in average precipitation. California, and by default the City, has been experiencing prolonged periods of drought. Recent research suggests that extended drought occurrence (a "mega-drought") could become more pervasive in future decades. An extended drought scenario is predicted for all of California from 2025 to 2075 under the HadGEM2-ES simulation and high emissions scenario. The extended drought scenario is based on the average annual precipitation between 1961 and 1990 of 10.9 inches. As shown in **Figure 3-4: Projected Drought Conditions**, under the projected drought scenario between 2025 and 2075, Irvine's precipitation would decrease by 2.7 inches; with the variability in annual precipitation would be between 2.4 and 25.1 inches for the HadGEM 2-ES model.[84]



[82] State of California, Legislative Analyst's Office. 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.
[83] California Department of Water Resources. 2022. Statewide Snowpack Falls Well Below Average Following Consecutive Dry Months. March 1, 2022. https://water.ca.gov/News/News-Releases/2022/March-22/March-2022-Snow-Survey. Accessed April 12, 2022.
[84] California Energy Commission. Cal-Adapt. 2022. Extended Drought Scenarios, Precipitation by Water Year for Irvine. https://cal-adapt.org/tools/extended-drought/#lat=33.0450&lng=-117.2539&boundary=place&climvar=Wildfire. Accessed April 28, 2022.

Figure 3-4: Projected Drought Conditions




Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Extended Drought Scenarios. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

## Sensitivity: Major Community Elements

Drought will continue to be a foreseeable event in the future of California, including Irvine. Since most droughts are almost entirely contingent on global weather phenomena, which vary from year to year, it is impossible to predict either the frequency or severity of future drought events in Irvine. Droughts that result from infrastructure failure are equally impossible to predict since the circumstances that lead to infrastructure failure are unique to each situation.[85]

As vegetation changes because of drought conditions, the animal species that depend on certain plant communities for food supply and habitat may be affected. The projected increase in the duration of droughts through the end of the century may threaten ecosystems as species become weak due to limited access to water and become susceptible to disease, pest, and decay.[86]

Climate change is anticipated to abate drought in certain situations but, on the other hand, could also intensify and exacerbate it in other cases. In some cases, climate change-intensified weather patterns, like El Niño-Southern Oscillation (ENSO), may bring more rain to California and Irvine which would abate drought conditions. In other years, climate change may also prolong the *La Niña* phase of ENSO which could lead to longer periods with no precipitation in California.

### Lifeline Utility Systems

Climate change is also expected to increase the average temperature and cause more frequent and prolonged heat waves in California and Irvine. During these events, water supplies may be diverted for cooling functions in the City.

[85] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[86] California Natural Resources agency, Governor's Office of Planning and Research, and California Energy Commission. 2019. California's Fourth Climate Change Assessment; San Diego Region Report. Available: https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-009_SanDiego_ADA.pdf. Accessed April 12, 2022.

Hotter temperatures may also lead to increased surface water evaporation which could lead to greater water consumption. If a drought were to occur during a future heat wave, it could place the water supply under strain.

From a regional perspective, warmer overall temperatures in California are anticipated to lead to a reduction in statewide water supplies. Much of California's water comes from melted snow in the High Sierra. As the average temperature grows warmer with climate change, the amount of precipitation that falls as snow is expected to shift towards rain. As less snow falls, the amount of melted water from the snowpack in the Sierra Nevada will decrease, reducing the water that will flow into the reservoirs and aqueducts that supply Southern California. This could place strain on the City's imported water supply, leading to greater reliance on Orange County's local groundwater. If regional water agencies, like OCWD, do not account for increased groundwater withdrawal, Irvine and the greater Orange County region could experience subsidence as a result.

### Economic Elements

The water sector is central to public health and the economy. Water utilities ensure a reliable supply of clean water to communities and ecosystems and contribute significantly to the resilience of many other sectors, including agriculture, energy, and manufacturing. Drought can result in impacts to water utility operations, including:

- Loss of water pressure and water supply
- Poor water quality from the source that may require additional treatment to meet drinking water standards
- Inability to access alternative and supplementary water sources because of high demand by and competition from other users
- Increased customer demand
- Increased costs and reduced revenues related to responding to drought impacts.

Within Irvine, approximately 1,323 acres of land are designated for agricultural use, which is scattered throughout the City (Irvine 2020). These farmers may be impacted in future drought conditions by increased cost for water, lower water quality, and the introduction of potential pests that may expand during a drought.

Drought, as well as recreationists' negative perceptions of drought, fire bans, or wildfires, may result in decreased visitations, cancellations in hotel stays, a reduction in booked holidays, or reduced merchandise sales. Reduced revenues in the sector can negatively impact the livelihood of small outdoor recreation businesses that have limited resources to manage the financial burden of drought. This, in turn, impacts the mental health of small business owners, staff, and communities. [87] A continued drought combined with elevated temperatures could impact the operations of the Great Park's Farm + Food Lab and Farmer's Market.

### Natural Resource Areas

When a drought occurs, the existing pressures on the ecosystem's natural water supplies are amplified. If the ecosystem's water needs aren't considered in water allocation decisions, then this already vulnerable ecosystem may be pushed beyond the threshold at which it can recover.

[87] National Integrated Drought Information Systems. Water Utilities. https://www.drought.gov/sectors/water-utilities. Accessed May 5, 2022.

The ecosystem will begin to function differently, leading to a loss in the critical services it once provided humans—such as purifying water and air, preventing erosion, and providing recreation opportunities.[88] An exceptionally severe drought could dramatically reduce the amount of water available for landscaping in Irvine and deprive trees of the irrigation they require for their survival (Irvine 2020).

Droughts can also lead to the expansion of territory for existing pests and introduction of new pests. Pests that are currently afflicting trees in Orange County include the following:

- Asian Citrus Psyllid: Carries a plant disease known as Huanglongbing, or citrus-greening disease, which kills citrus trees. Parts of the City of Irvine are in the quarantine area for this pest.
- Gold Spotted Oak Borer: Burrow into oak trees which kills the tree over time.
- Invasive Shot Hole Borer: Burrow into all kinds of native trees in all kinds of settings, including urban areas. These insects carry the Fusarium Dieback fungus which kills the tree.[89]

Any tree has the potential to be infested by pests that could result in the tree's death. This means all areas of Irvine that are landscaped with trees could experience tree mortality. These areas include parks, landscaped parkways and street medians, schools, as well as private homes or businesses.[90]

## Sensitivity: Vulnerable Populations

Droughts are unlikely to cause serious social threats to households in Irvine, though residents and business owners in the City may experience financial costs associated with water conservation efforts. Those who have less access to financial resources, such as low-income households or seniors, may be harder hit if higher water fees are imposed during a severe drought event.[91]

## Adaptive Capacity

The city's reliance on various in internal and regional water resources, including the IRWD and the OCWD, will remain a critical issue for the city's resilience to drought periods.

### City of Irvine

The City has addressed drought in planning documents such as their LHMP, Water Management Program, and Urban Water Master Plan. The City also has regulations and programs in place that are beneficial during drought events by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

<u>City of Irvine Local Hazard Mitigation Plan (2020)</u>

The 2020 LHMP included mitigation actions to decrease the risks associated with drought, including:

- Coordinate closely with IRWD on water use and water conservation efforts throughout the City.

[88] National Integrated Drought Information Systems. Ecosystems. https://www.drought.gov/sectors/ecosystems. Accessed May 5, 2022.
[89] Orange County Fire Authority. 2018. Ready, Set, Go, Newsflash! https://www.ocfa.org/Uploads/SafetyPrograms/OCFA%20Newsflash_Tree%20Pests_3-Page%20Version.pdf
[90] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[91] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

- Update "Division 7 - Sustainability in Landscaping "of the Irvine Municipal Code of Ordinances and the Master Streetscape & Landscape Design Manual to reflect the latest advances in best practices in landscape design that reduce water use within the City.
- Encourage drought tolerant native landscaping, low-flow water fixtures beyond the state minimum code, and daytime watering restrictions on properties throughout the city to reduce water consumption.
- Use drought-tolerant plants when installing new or retrofitting City-owned landscapes. Limit turf that is not drought tolerant to recreational fields and lawns, and only in instances where no feasible drought-tolerant alternatives exist.

City of Irvine Water Management Program (2009)

The Irvine Public Works Department's Landscape Maintenance Division is guided by a Water Management Program (2009). The policy directs City staff to use smart controller technology, crop coefficients, weather data, and field observations to accurately water the landscape. with the purpose of "apply[ing] the least amount of water necessary to maintain healthy plant material."[92]

City of Irvine Water Quality Ordinance

The Water Quality Ordinance (No. 10-06) gives the City of Irvine adequate legal authority as may be necessary to carry out the requirements of the NPDES Permit and accomplish the requirements of the Clean Water Act.[93]

### Irvine Ranch Water District

To manage the water supply for Irvine, the IRWD is guided by the following plans and programs:

Urban Water Management Plan (Draft 2020)

IRWD's Urban Water Management Plan (UWMP) identifies imported and local water supplies needed to meet future demands, including groundwater recovery and water recycling, as well as IRWD's current and planned conservation measures. This helps to ensure that IRWD can provide the service area with a reliable supply of high-quality water to meet current and future demands. The UWMP is updated every five years and submitted to the California Department of Water Resources. The prior 2015 UWMP was adopted by IRWD's Board in 2016.

Water Shortage Contingency Plan (2021)

IRWD's Water Shortage Contingency Plan provides a series of response actions that IRWD may implement in the event of a water shortage due to drought or emergency. It assumes that under a Climate Change scenario, that the anticipated Water Bank Usage would be 7,300 to 11,500 acre feet per year.

The District obtains a majority of its water through groundwater (52 percent) and imported water (14 percent). To ensure a reliable water supply during times of drought, regulatory constraints and other emergencies, the District maintains a diverse water supply portfolio that also includes the following:



[92] City of Irvine. 2009. Public Works Department Water Management Program. March 17.
[93] City or Irvine. 2010. City Council Ordinance No. 10-06. Water Quality. July 13.

Recycled Water

IRWD produces about a quarter of our supply by capturing water that normally would run out to sea, treating it, and reusing it for irrigation and other non-potable, or non-drinking, uses. We also supplement our supplies by cleaning non-potable groundwater to make it suitable for irrigation. Every gallon of recycled water and cleaned groundwater we use saves a gallon of drinking water.

Water Banking

*Strand Ranch Water Banking Project*

Located in Kern County, the Strand Ranch Water Banking Project improves IRWD's water supply reliability by capturing low-cost water available during wet years for use during periods of drought or critical need. Using a system of 502 acres of constructed groundwater recharge ponds on Strand Ranch, IRWD can store up to 50,000 acre-feet in the Water Bank and may recharge or recover up to 17,500 acre-feet in any single year.

*Kern Fan Groundwater Storage Project*

IRWD is partnering with Rosedale-Rio Bravo Water Storage District in the development of the Kern Fan Groundwater Storage Project, which will provide substantial water supply reliability benefits to the agencies. IRWD and Rosedale are actively pursuing both State and Federal funding for the project. Following are links to important documents related to securing State of California Water Storage Investment Program funding and Federal Water Infrastructure Improvements for the Nation (WIIN) Act Funding.

Water Storage Investment Program

On July 24, 2018, the California Water Commission voted to conditionally award the Kern Fan Project $67.5 million. IRWD and Rosedale are now working to complete additional requirements outlined in the program regulations in order to execute a final funding agreement and receive funds.

Water Supply Reliability Program

IRWD has purchased property in Riverside County that is located within the Palo Verde Irrigation District. Ownership of this land will eventually become another element of IRWD's long-term program to increase water supply reliability for its customers during droughts and other potential water supply interruptions. This land is currently farmed by a tenant farmer; IRWD expects to continue with the practice.

## Orange County Water District

OCWD believes the best way to mitigate drought is to increase water supply. Examples of how OCWD is increasing local water supplies and securing long-term water reliability, include expansion of the groundwater replenishment system, a forecast-informed reservoir operation, sustainable management of the groundwater basin, implementation of a Santa Ana River conservation and conjunctive use program, and exploration of ocean desalination.[94]

[94] Orange County Water District. 2022. Drought in California. https://www.ocwd.com/learning-center/drought/. Accessed May 4, 2022.

### Metropolitan Water District

*Water Surplus and Drought Management (WSDM) Plan*

Diversifying the region's water supplies and developing adequate and healthy water storage reserves have proven to be the backstop for water supply reliability. These actions have also contributed to improved seismic resilience for the region. Stored water reserves provide certainty for meeting the needs of the region's vast service area when traditional sources of supply are challenged by drought, climate change, seismic events, and other risks. It is critical that these storage resources be developed, managed, and enhanced.

MWD's WSDM Plan, which defines a regional water management strategy for MWD and its member agencies, has focused on using storage to manage water supplies and enhance reliability since 1999. The WSDM Plan includes the following guiding principle: MWD will encourage storage of water during periods of surplus and work jointly with its member agencies to minimize the impacts of water shortages on the region's retail consumers and economy during periods of shortage.

*Water Supply Allocation Plan*

When continued drought, earthquakes, or other natural disasters lead to shortages of supplies, MWD distributes a limited amount of water through its Water Supply Allocation Plan (WSAP). First developed in 2008, Metropolitan's WSAP takes a basic premise --to fairly distribute a limited amount of water supply-- and applies it through a detailed methodology to reflect a range of local conditions and needs of the region's retail water consumers. In particular, under severe drought conditions or a potential seismic event that impacts imported conveyance systems, it may be necessary and prudent to call for greater reductions in the use of limited water supplies and to reduce reliance on storage reserves. The WSAP has 10 levels of water supply allocations, each corresponding to a five percent reduction of supply. A Level 2 allocation, for example, represents a reduction of approximately 10 percent in overall water supply available to each member agency. The level of WSAP reduction implemented would correlate to the severity of the seismic event.



#### 3.2.2.3 WILDFIRE + SMOKE

Wildfire in southern California is influenced by a multitude of factors: a dry and warm Mediterranean climate with periodic episodes of Santa Ana winds and droughts, the type and spatial distribution of vegetation (along with dead/ dry vegetation caused by pests), varying topography, large urban-wildland interfaces, past fire suppression attempts, and human activities.[95]

According to the state's Fourth Climate Change Assessment, by 2100, the frequency of extreme wildfires burning over 25,000 acres could increase by nearly 50 percent. As with other climate hazards, the state already is beginning to experience an increase in severe wildfires. Most of California's largest and most destructive wildfires have occurred in recent decades. This pattern has been particularly notable in the last few years, which have seen some of the worst wildfires in the state's recorded history. Five of the twenty most destructive wildfires in the state's history occurred in 2020 alone, with an additional two in 2021. [96]

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[95] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

[96] State of California, Legislative Analyst's Office. 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.

Not only do high-severity wildfires take lives and level homes, businesses, and community infrastructure, they also destroy fish and wildlife habitats. Moreover, intense wildfires can also impair air quality throughout the state. The Los Angeles Region Report as part of the to the state's Fourth Climate Change Assessment describes how the LA-Long Beach region already has some of the worst air quality in the country, ranking as the most polluted region in the United States for ozone and among the top 10 most polluted cities for year-round and short-term particle pollution. And, while air quality in the region has improved in recent decades, climate change threatens to reverse this trend. Higher future temperatures are likely to increase the production of ground-level ozone, a respiratory irritant that is a component of smog. Ground-level ozone is associated with various negative health outcomes, including reduced lung function, pneumonia, asthma, cardiovascular-related morbidity, and premature death.[97]

The City is composed of relatively flat land and hillsides along its northern and southern borders. The hillsides are an integral part of the community's image and identity, providing a visual backdrop, an environmental preserve, and a recreational resource. There are several open space areas within the city, characterized by shrubs and native trees. During the dry months, the wildfire risk in these open, vegetated areas can increase when exacerbated by occasional Santa Ana winds and elevated temperatures. Additionally, extreme weather conditions, such as high temperature, low humidity, and/or winds of extraordinary force, may cause an ordinary, localized fire to expand into a more intense and difficult to control wildfire. Currently, many homes within the city are in the urban-wildland interface, which is characterized by zones of transition between wildland and developed areas and often include heavy fuel loads that increase wildfire risk.

### Historical Wildfire Events

- Freeway Complex Fire – a 2008 wildfire that burned parts of Yorba Linda, Anaheim, Brea, Chino Hills, and Diamond Bar. Over 30,000 acres were burned destroying 314 homes, 43 outbuildings, and 4 commercial structures. No fatalities were reported during this event (CAL FIRE 2018)
- Santiago Fire – Began on October 21, 2007, in the foothills north of Irvine and east of the City of Orange. Over 28,000 acres were burned, resulting in the destruction of 14 homes and 24 outbuildings. No fatalities were reported during this event.
- Canyon Fire – a 2017 wildfire that burned in the Anaheim Hills area of Orange County. In total the fire burned 9,217 acres, destroyed 25 structures, and damaged another 55. In total, 16,570 people were evacuated from their homes in Anaheim, Orange, and Tustin.[98]
- Silverado Fire starting on October 26, 2020, resulted in the evacuation of over one-third of the City's population.[99]

## Vulnerability to Wildfire

Climate change will result in changes in precipitation patterns, increased temperature, and drought conditions. Wetter months may lead to increased vegetative growth while following periods of drought will allow for the vegetative growth to dry up creating greater amounts of fuel for fires. Climate change will also worsen existing severe wind events, which fuel the spread and intensity of

[97] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.
[98] Graham, Jordan. 2017. "Canyon Fire 2 now 90 percent contained, full containment expected Tuesday". OC Register. Retrieved February 5, 2020.
[99] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.

wildfires. Santa Ana wind events blow in an offshore direction in parts of Southern California and are caused by the formation of large high-pressure systems over eastern California, Nevada, and Utah, producing winds that are strong and extremely dry. Santa Ana winds have caused some of the region's most damaging wildfires and account for some of the worst extreme heat events. While future wind events are predicted to decrease, the intensity of a severe wind event over a shorter amount of time is predicted to increase.[100]

Future projections indicate that southern California may experience a larger number of wildfires and burned area by the mid-21st century under RCP8.5. Overall burned area is projected to increase over 60 percent for Santa Ana-based fires and over 75 percent for non-Santa Ana fires.[101]

## Exposure

The potential for wildland fires represents a hazard where development is adjacent to open space or within proximity to wildland fuels. Steep hillsides and varied topography within portions of the city also contribute to the risk of wildland fires.

Wildfires are not measured on a specific scale and are usually classified by size (e.g., acres burned) or impact (buildings destroyed or damaged, injuries or deaths, cost of damage, etc.). The risk of wildfire is classified on a three-tier scale of fire hazard severity zones (FHSZs): very high, high, and moderate. These classes do not correspond to a specific risk or intensity of fire but are qualitative terms that consider many factors. Fire-prone areas are also classified by the agency responsible for fire protection. Federal Responsibility Areas (FRAs) fall to federal agencies such as the US Forest Service, the Bureau of Land Management, and the National Park Service. State Responsibilities Areas (SRAs) fall to the California Department of Forestry and Fire Protection (CAL FIRE), and Local Responsibility Areas (LRAs) fall to local governments.

CAL FIRE data was used to identify Very High Fire Hazard Severity Zones (VHFHSZ) in the city that are included in the LRA (See **Figure 3-5: Fire Hazard Severity Zones**) identifies the City's Critical Facilities and Facilities of Concern. All structures located within this fire zone are at an elevated risk to wildfire impacts.

Fire hazards are probable in the City due to large quantities of combustible vegetation, poor access to fire hazard areas, and lack of water supply for fire protection in fire hazard areas. Development within these zones is regulated through the Uniform Building Code and Uniform Fire Code. Requirements imposed as part of the development review process include fire lanes, fuel modification zones, fire retardant building materials, smoke detectors and automatic sprinkler systems, depending on the size and type of development. Special fire protection consideration is given to industries handling hazardous materials, multi-story buildings with high occupant levels, and large built-up areas with combustible roof coverings. High hazard areas are predominantly in the hilly portions of the City with volatile chaparral as the fuel source.[102]

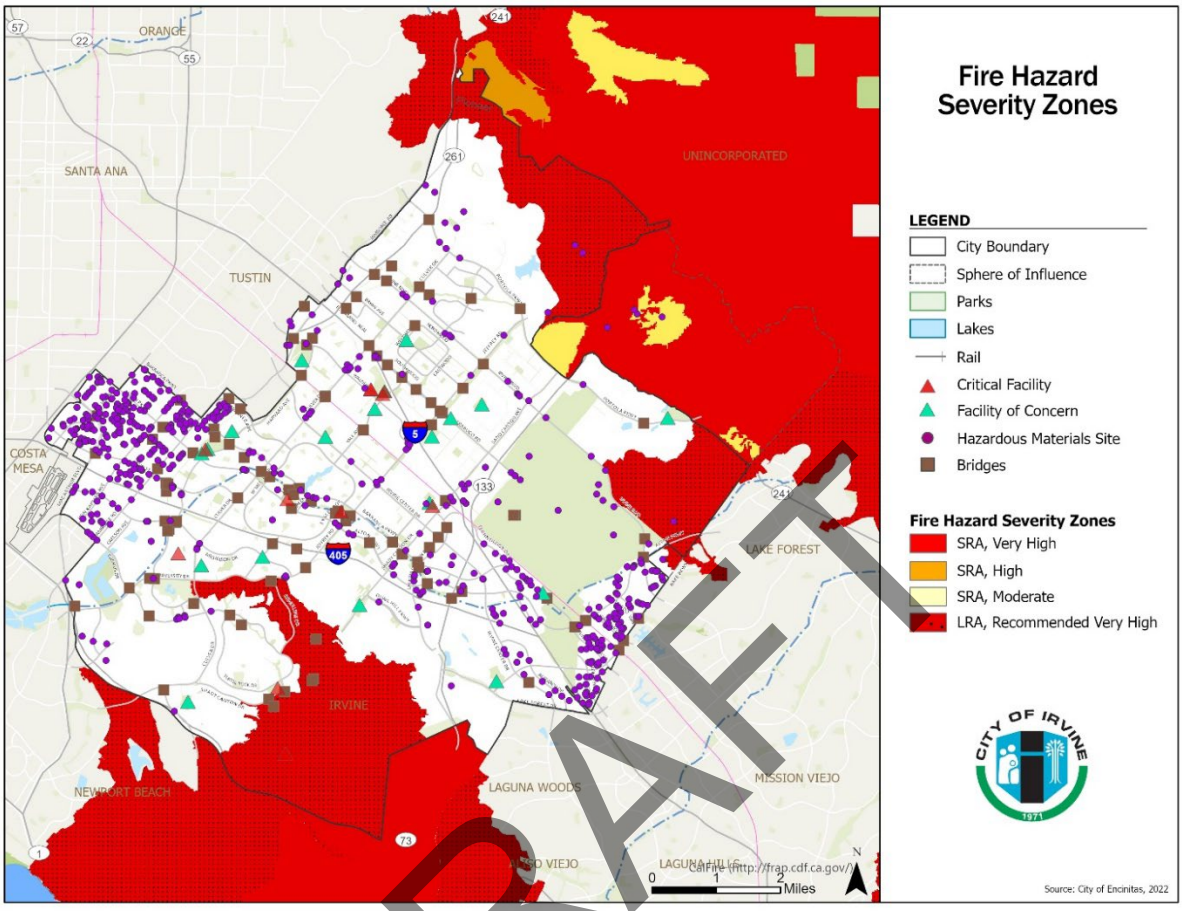


[100] California Natural Resources agency, Governor's Office of Planning and Research, and California Energy Commission. 2019. California's Fourth Climate Change Assessment; San Diego Region Report. Available: https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-009_SanDiego_ADA.pdf. Accessed April 12, 2022.

[101] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

[102] City of Irvine. 2015a. General Plan Safety Element.

Figure 3-5: Fire Hazard Severity Zones






## Essential Facilities

**Table 3-5: Critical Facilities and Facilities of Concern (Fire Hazard Severity Zone)** identifies six Critical Facilities and one Facility of Concern within this zone, which could result in a potential loss of approximately $1.4 million. While these areas have a high degree of vulnerability to wildfire, other areas of the City may also be susceptible due to ember cast. These areas typically referred to as the Wildland Urban Interface (WUI) are vulnerable if the right conditions exist. Typically, the WUI is impacted if adequate fuels are combined with dry conditions and strong winds. Sometime the ignition of a wildfire may occur as a result if power lines located around overgrown trees cause a spark and catch the tree on fire. These types of incidents are the main impetus for the newly established Public Safety Power Shutoff (PSPS) program that is occurring throughout the State. The City of Irvine currently has 11 circuits that could be affected by future PSPS events.

Table 3-5: Critical Facilities and Facilities of Concern (Fire Hazard Severity Zone)

| Category | Number of Facilities | | Examples | Potential Loss* |
|---|---|---|---|---|
| | Critical | Concern | | |
| City Vital Operations | - | - | City Hall, Police Station, Operations Support | $0 |
| City Community Centers | - | - | Community Centers | $0 |
| City Resident Services | - | - | Senior Centers, Animal Shelter, Daycare, Other Community Facilities | $0 |
| City Recreation Support | - | 1 | Parks, Recreation Amenities, Sports Complexes, and support facilities | $168,300 |
| Bridges | 6 | - | Overpasses and underpasses within the City | $1,256,640 |
| Schools** | - | - | Irvine Unified School District and Tustin Unified School District Facilities | N/A |
| **Total** | **6** | **1** | | **$1,424,940** |

* Based on the City of Irvine insured replacement values

**Replacement Values unavailable



As the frequency, severity and impacts of wildfire are sensitive to climate change as well as other factors, including development patterns, temperature increases, wind patterns, precipitation change and pest infestations, it is difficult to project exactly where and how fires will burn. Instead, climate models estimate increased risk to wildfires. The Keetch-Byram Drought Index (KBDI) represents a simplified proxy for favorability of occurrence and spread of wildfire but is not itself a predictor of fire. As shown in Table 3-6: City of Irvine KBDI > 600 (days), The city's risk to wildfire is projected to substantially increase by end of the century compared with the historic baseline. This will lead to an increased risk for areas in Irvine susceptible to wildfire and corresponding smoke.

Table 3-6: City of Irvine KBDI > 600 (days)

| KBDI > 600 (days) | Historic KBDI > 600 (days) (1961 - 1990) | Medium Emissions (RCP 4.5) | | High Emissions (RCP 8.5) | |
|---|---|---|---|---|---|
| | | Mid-Century | End-Century | Mid-Century | End-Century |
| | 15 | 51 | 61 | 61 | 108 |

Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Wildfire KBDI. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

KBDI is cumulative. The KBDI values increase on dry and warm days and decrease during rainy periods. In California we would expect KBDI to increase from the end of the wet season (spring) into the dry season (summer & fall). The list below explains what values of KBDI represent:

| | |
|---|---|
| 0–200 | Soil moisture and fuel moistures are high, low wildfire risk. |
| 200– | Soil and fuels start to dry, average wildfire risk. |
| 400– | Onset of drought with moderate to serious wildfire risk. |
| 600– | Severe drought, extreme wildfire risk and increased wildfire occurrence. |

Climate change is expected to cause an increase in temperatures as well as more frequent and intense drought conditions. This will likely increase the amount of dry plant matter available for fuel, increasing the risk of wildfire statewide. In the foothills of the Santa Ana Mountains and San Joaquin Hills, which are already highly prone to wildfires, climate change is expected to increase the number of acres burned annually. Based on the RCP 8.5 scenario, with the CanESM2 model, the annual average of area burned could increase to an average of 212.5 hectares by the end of the century, which is an increase of 35 hectares from the annual mean for 1961-1990.[103] However, increases in fuel supplies could cause wildfires to move faster or spread into more-developed areas, which could increase the threat to Irvine.

These are unique challenges for the City as 29 percent of households in the Fire Hazard Severity Zone have at least one individual age 65 years and older. Additionally, almost 15 percent of households have at least one person living with a disability. Challenges that these populations face include potential inability to access emergency supplies, evacuate, or receive and understand emergency information. The effects of climate change hazards can result in infrastructure disruptions including power outages. Such events could result in additional health hazards for the elderly or persons with disabilities who rely on power to sustain medical equipment/assistive technology use.

According to **Table 3-7: Fire Hazard Severity Zone Vulnerable Populations,** residents living in the VHFHSZ have a median income that is approximately $23,000 higher than the city-wide figure, more households with at least one person living with a disability, and fewer residents living under the poverty limit. Compared to citywide households, there is a substantially larger number of households in the fire hazard zone with a resident aged 65 years and older.

**Table 3-7: Fire Hazard Severity Zone Vulnerable Populations**

| | FHSZ | Irvine |
|---|---|---|
| Total Population[1] | 7,641 | 262,665 |
| Percent of residents that are children (less than 10 years)[2] | 11.5% | 10.4% |
| Percent of households that have people 65+ years[1] | 29.0% | 20.6% |
| Percentage of households with at least one person living with a disability[1] | 14.9% | 12.3% |
| Median age[2] | 36.9 | 34.0 |
| Total households[1] | 3,491 | 94,490 |
| Median household income[2] | $136,305 | $113,097 |
| Percent of rental households[2] | 46.1% | 48.7% |
| Percent of household income below poverty level[1] | 9.4% | 13.1% |

Source: US Census Bureau, American Community Survey (ACS) 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2]

As shown in **Table 3-8: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - FHSZ**, the majority of the estimated 7.231 residents in the Very High Fire Hazard Severity Zone aged 5 years and older are fluent in English. 4.2 percent of the population residing in the VHFHSZ are not fluent in English.

[103] Cal-Adapt. 2022. Modeled Annual Area Burned under a High Emissions (RCP 8.5) Scenario and Central Population Growth scenario: Irvine, California. https://cal-adapt.org/tools/wildfire. Accessed May 5, 2022.

Table 3-8: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - FHSZ

| | Number of Speakers | Percent Not Fluent in English |
|---|---|---|
| English Only | 4,263 | - |
| Spanish | 339 | 5.6% |
| Indo-European Languages | 464 | 4.1% |
| Asian and Pacific Island Languages | 2,023 | 13.1% |
| Other Languages | 142 | 0% |

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

## Sensitivity: Major Community Elements

### Transportation Systems

Wildfire could damage roads in several ways. Unsafe conditions and damage could lead to road closures. Typical asphalt mixtures could ignite or melt/excessively soften. Debris from fires and subsequent landslides could block roads.[104,105] Most major roads have sidewalks that create a small defensible space as well as development of the surrounding areas. Roads can be damaged by increased traffic of heavy vehicles, and vehicles that exceed weight limits, used during emergency response or recovery efforts. Costs associated with transportation infrastructure losses include repair costs, clean-up costs, and costs related to service disruptions.[106]

### Lifeline Utility Systems

Additionally, wildfire can cause direct and indirect damage to electrical infrastructure. Direct exposure to fire can sever transmission lines, and heat and smoke can affect transmission capacity. Other impacts of climate change also threaten electricity infrastructure, including wildfires that can destroy poles and towers carrying transmission lines.[107]

Wildfire events can physically damage water infrastructure including pipes, water meters, dams, spillways, and other structures and equipment. Costs associated with water infrastructure losses include repair costs, clean-up costs, and costs related to service disruptions.



[104] Carvel, R., & Torero, J. (2006). The Contribution of Asphalt Road Surfaces to Fire Risk in Tunnel Fires: Preliminary Findings. Proceedings of the International Conference on Risk and Fire Engineering for Tunnels, Stations, and Linked Underground Spaces (pp. 83-87). Hong Kong: Tunnel Management International.

[105] Cannon, S., & DeGraff, J. (2009). The Increasing Wildfire and Post-Fire Debris-Flow Threat in Western USA, and Implications for Consequences of Climate Change. In K. Sassa, & P. Canuti, Landslides - Disaster Risk Reduction (pp. 177-190). Verlag Berlin Heidelberg: Springer.

[106] Feo, Teresa J., Amber J. Mace, Sarah E. Brady, and Brie Lindsey. 2020. The Costs of Wildfire in California An Independent Review of Scientific and Technical Information. California Council on Science and Technology. ISBN Number: 978-1-930117-66-2.

[107] Davis, M., and S. Clemmer. 2014. Power failure: How climate change puts our electricity at risk—and what we can do. Cambridge, MA: Union of Concerned Scientists. https://www.ucsusa.org/sites/default/files/2019-10/Power-Failure-How-Climate-Change-Puts-Our-Electricity-at-Risk-and-What-We-Can-Do.pdf. Accessed April 11, 2022.

Mitigation actions specifically to reduce water infrastructure losses primarily include infrastructure hardening and defensible space. Water infrastructure damage can also cause contamination of drinking water supplies that can pose a risk to public health.[108]

Wildfires can damage or destroy gas, electric, and telecommunications infrastructure including poles, towers, lines, pipes, and other physical assets.[109] Damage is primarily caused by direct exposure to the flames and heat from the fire, but carbon build-up and particulate matter from wildfire smoke can also damage components used to deliver electricity.[110] Furthermore, flame retardants and firefighting techniques used to suppress fires can also damage utility infrastructure.[111]

### Economic Elements

Wildfire can lead to the loss of buildings and infrastructure that may need to be repaired from damage or replaced if destroyed. Additional economic losses include the value of personal property or inventory that was damaged along with the home or commercial building, costs associated with temporary accommodations or service disruptions, and costs related to toxic material and debris cleanup. When infrastructure losses cause service disruptions, the costs can be borne by customers and communities far from the perimeter of the wildfire.[112]

### Natural Resource Areas

Furthermore, because of historical forest management trends over the past century, increased temperatures, and more frequent drought, California wildfires are characteristically hotter and more intense as compared to naturally occurring fire regimes. As such, soil structure and moisture retention are damaged leading to increased susceptibility to erosion or landscapes. If Irvine's foothills become covered with dry, overgrown vegetation because of drought condition, extreme heat events and high winds increase the threat of wildfires.

Beyond direct damage to physical property and harmful effects on public safety, wildfires also result in secondary impacts: a major consequence of wildfires is post-fire flooding and debris flow. The risk of floods and debris flows after fires increases due to vegetation loss and soil exposure. These flows are a risk to life because they can occur with little warning and can exert great force on objects in their path.

Wildfires could alter hydrology by changing vegetation, increasing runoff, and resulting in more sediment that could block drainage and damage structures.[113] This impact would be caused by upstream factors; wildfires are unlikely to directly burn and/or damage outfalls themselves due to construction materials and placement near bodies of water.



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[108] Feo, Teresa J., Amber J. Mace, Sarah E. Brady, and Brie Lindsey. 2020. The Costs of Wildfire in California An Independent Review of Scientific and Technical Information. California Council on Science and Technology. ISBN Number: 978-1-930117-66-2.

[109] California Governor's Office of Emergency Services (Cal OES) 2018. California State Hazard Mitigation Plan.https://www.caloes.ca.gov/HazardMitigationSite/Documents/002-2018%20SHMP_FINAL_ ENTIRE%20PLAN.pdf

[110] Aspen Environmental Group. (2008). Sunrise Powerlink Project Attachment 1A: Effect of Wildfires on Transmission Line Reliability. Retrieved from https://www.cpuc.ca.gov/Environment/info/aspen/sunrise/deir/apps/a01/App%201%20ASR%20z_Attm%201A-Fire%20Report.pdf

[111] Sathaye, J., Dale, L., Larsen, P., Fitts, G., Koy, K., Lewis, S., & Lucena, A. (2011). Estimating Risk To California Energy Infrastructure From Projected Climate Change. LBNL-4967E, 1026811. https://doi.org/10.2172/1026811

[112] Feo, Teresa J., Amber J. Mace, Sarah E. Brady, and Brie Lindsey. 2020. The Costs of Wildfire in California An Independent Review of Scientific and Technical Information. California Council on Science and Technology. ISBN Number: 978-1-930117-66-2.

[113] U.S. DOT. 2018. Transportation Climate Change Sensitivity Matrix. U.S. Department of Transportation. Retrieved from https://toolkit.climate.gov/tool/transportation-climate-change-sensitivity-matrix

Conservation areas and open space in the city provide crucial ecosystem services such as the provisioning of clean air and water and climate regulation. If conservation areas are damaged, endangered species could be at increased risk species survival. If habitats of sensitive species are subject to frequent disturbance or destruction, resources may be needed to conserve these species. In addition, in the event of damage, more insects, pests, or invasive species.

Community parks are used for recreation, exercise, as gathering spaces, and sites of natural, historical, tribal cultural, and archaeological resources. Loss of or damage to community parks would interfere with their ability to serve these various functions.

### Sensitivity: Vulnerable Populations

Wildfires are major public health concern as they can cause immediate health impacts through burns, injuries, and heat stress. However, a wildfire can influence the health outcomes of an area larger than the burn area because the associated smoke can travel long distances and worsen the air quality for extended periods. Wildfires can be a significant contributor to air pollution in both urban and rural areas and have the potential to significantly impact public health through particulates and volatile organic compounds in smoke plumes. Wildfires are a major source of particulate matter, which is an air pollutant that increases one's risk for respiratory illnesses, cardiovascular disease, negative birth outcomes, and premature death.[114] Wildfire smoke contains numerous primary and secondary pollutants, including particulates, polycyclic aromatic hydrocarbons, carbon monoxide, aldehydes, organic compounds, gases, and inorganic materials with toxicological hazard potentials.[115] Wildfire smoke also increases exposure to ground level ozone and toxic chemicals (e.g., pesticides, plastics, and paints) released from burned building and other man-made materials. Individuals sheltering in place are also at risk of exposure to hazardous air quality because wildfire smoke penetrates homes, particularly older homes.[116] Beyond these immediate health impacts, the stress, displacement, and loss of home and community from wildfires can cause significant mental health impacts, such as anxiety, depression, and post-traumatic stress disorder.[117]

Outside of the property owners directly impacted by a wildfire event, wildfires can also impact seniors and persons with disabilities. During hazard events such as wildfires, flooding, or extreme storms, the elderly, and other vulnerable populations such as persons with disabilities may require additional assistance to adequately respond. These groups may have limited mobility, be immuno-compromised, and/or not receive notifications regarding current conditions and evacuation requirements. For example, a senior who lives alone may not be aware that a wildfire is burning close to their residence and they have been ordered to evacuate if those notifications were sent in manner that doesn't reach them.



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[114] Bell, J.E., S.C. Herring, L. Jantarasami, C. Adrianopoli, K. Benedict, K. Conlon, V. Escobar, J. Hess, J. Luvall, C.P. Garcia-Pando, D. Quattrochi, J. Runkle, and C.J. Schreck, III, 2016: Ch. 4: Impacts of Extreme Events on Human Health. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC, 99–128.

[115] Künzli, N. et al. 2006. Health effects of the 2003 Southern California wildfires on children. Am J Respir Crit Care Med. 174:1221-8.

[116] Rudolph, L., Harrison, C., Buckley, L. & North, S. (2018). Climate Change, Health, and Equity: A Guide for Local Health Departments. Oakland, CA and Washington D.C., Public Health Institute and American Public Health Association.

[117] Hanigan, Ivan C., Colin D. Butler, Philip N. Kokic, and Michael F. Hutchinson. 2012. "Suicide and Drought in New South Wales, Australia, 1970–2007." Proceedings of the National Academy of Sciences of the United States of America 109 (35): 13950–55.

Persons with disabilities may require special mobility devices or caregiver assistance to go outside which may not arrive as quickly as needed. Other groups with increased threat levels include people with lower-incomes, renters, and the homeless. These groups may not possess enough financial resources to rebuild their homes or search for new homes in the aftermath of a fire.[118]

As shown in Table 3-8: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - FHSZ, the majority of the estimated 7.231 residents in the Very High Fire Hazard Severity Zone aged 5 years and older are fluent in English. While 4.2 percent of the population residing in the VHFHSZ are not fluent in English, the City implements programs intended to communicate information to the diverse community of residents and workers with different backgrounds including the City of Irvine's website offers translation for 81 languages[119] and the Irvine Police Department is prepared to communicate with individuals with limited English proficiency[120]

## Adaptive Capacity

The City has addressed wildfire in planning documents such as their Local Hazard Mitigation Plan, Emergency Management Plan, and Evacuation Plan (Annex XIII). The City also has regulations and programs in place that are beneficial during wildfires by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

### City of Irvine Local Hazard Mitigation Plan (2020)

The 2020 LHMP included mitigation actions to decrease the risks associated with wildfires, including:

- Promote the proper maintenance and separation of power lines and efficient response to fallen power lines.
- Remove highly flammable vegetation in Very High, High, and Moderate Fire Hazard Severity Zones and replant with fire-adapted specimens.
- Create a hillside weed abatement pilot program using goats or other livestock to reduce fuel loads in fire-prone areas.
- Routinely participate in the update of the Orange County Community Wildfire Preparedness Plan for areas within the Very High, High, and Moderate Fire Hazard Severity Zones.
- Create a rapid response plan from among Irvine's and Orange County's first responders to secure hospital, nursing, and assisted living facilities, especially those located within fire hazard severity zones.
- Reinforce and regularly inspect fire retardant infrastructure such as sprinklers, fire hose terminals, and fire suppression systems in City facilities.
- Coordinate with partners to clear dead vegetation in flood control facility footprints, railroad rights-of-way, parks, and open spaces, especially during and after a drought episode.
- Expand the fire hazard prevention awareness campaign to residents in the High and Very High Fire Hazard Severity Zones.
- Work with OCFA on home preparedness assessments to assist more residents in understanding and addressing their wildfire risk.



[118] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[119] City of Irvine. 2022. https://www.cityofirvine.org/. Accessed May 3, 2022.
[120] City of Irvine. n.d. Policy 345. Limited English Proficiency Services.

- Require all new development in Very High, High, and Moderate Fire Hazard Severity Zones to use noncombustible building materials such as masonry, brick, stucco, concrete, steel, or others as appropriate. Establish zones of defensible space around homes in Very High, High, and Moderate Fire Hazard Severity Zones.[121]

### Orange County Fire Authority

For urban areas within the City, the OCFA is able to satisfy fire and basic life safety goals by having a first due unit on scene within a five-minute response time 80 percent of the time. Advanced life support response goals are within eight minutes 80 percent of the time. The service demand for areas considered suburban, rural, or undeveloped typically can expect increased response time goals of up to 15-20 minutes. In order to mitigate the impact of longer response times in these areas, certain building and fire codes are applied at time of development. Some of these may include automatic fire sprinklers, fire retardant building materials, and other special response enhancements unique to the development.[122]

### Orange County Fire Authority – Ready, Set, Go Program

The City of Irvine participates in the CAL FIRE/OCFA "Ready, Set, Go!" program to help property owners property prepare well in advance of a wildfire to increase safety and protect property. This program provides comprehensive information on how to improve structure resistance to wildfires and prepare people to be ready to leave early in a safe manner.[123]

## 3.3.2.4 FLOODING

A flood occurs when land that does not normally have bodies of water becomes suddenly inundated with water. Flooding can occur after periods of heavy rainfall, whether it occurs as a single extreme episode or as a series of storms. Drainages and stream courses may flood their banks and shores if their capacity is exceeded by rainwater. When heavy rainfall hits an area where the ground is already saturated, the risk of flooding is high. In developed areas, the presence of pavement and other impervious surfaces means that the ground is less able to absorb water. As a result, rainwater must be carried away in storm channels or waterways.[124]

Floods pose several threats to communities and public safety. Flooding can cause property damage, destroy homes, and carry away vehicles or other large debris. Topsoil and vegetation can be swept away by floodwaters, leading to erosion. Floodwaters may impede the movement of victims fleeing a flood or of first responders attempting to reach people in need of help.[125]

Climate models predict that California will experience less frequent but more intense storm patterns in the coming decades, including the state's precipitation more frequently falling as rain rather than snow compared to historical trends. Additionally, the state's streams and rivers will swell more in some years from earlier and faster spring snowmelt caused by higher temperatures.



[121] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[122] City of Irvine. 2015a. General Plan Safety Element.
[123] Orange County Fire Authority. 2022. Ready, Set, Go. https://www.ocfa.org/RSG/Ready. Accessed May 3, 2022.
[124] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[125] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

Scientists suggest the combination of these factors could lead to a 50 percent increase in runoff in future years, challenging the capacity of the state's existing reservoirs, canals, levees, and other flood control systems, and increasing the risk of inland flooding. Floods cause significant risk to human life, and damage roads, buildings, and other infrastructure.[126]

## FLOODING

Increases in temperature and precipitation can lead to extreme precipitation events and sea level rise that could lead to flooding in the City. In the context of climate change for Irvine, this analysis categorizes flood types according to climate effect: Onshore flooding caused by precipitation-driven events and coastal flooding. The following describes the types of floods within each category.

### Onshore Flooding from Precipitation-Driven Events

- **Inland flooding** occurs when moderate precipitation accumulates over several days, intense precipitation falls over a brief period, or a river overflow because of an ice or debris jam or dam or levee failure.
- A **flash flood** is caused by heavy or excessive rainfall in a brief period, generally less than six hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through riverbeds, urban streets, or mountain canyons. They can occur within minutes or a few hours of excessive rainfall.

### Coastal Flooding

- A **coastal flood**, or chronic inundation of land areas along the coast, is caused by higher-than-average high tide and worsened by heavy rainfall and onshore winds (i.e., wind blowing landward from the ocean).
- **Storm surge** is an abnormal rise in water level in coastal areas, over and above the regular astronomical tide, caused by forces generated from a severe storm's wind, waves, and low atmospheric pressure.[127]

The following analyses describe onshore flooding and coastal flooding vulnerabilities resulting from projected climate change for the city of Irvine.

### Onshore Flooding from Precipitation Events

Variability in the climate is likely to result in changes to the frequency, intensity, and duration of precipitation events causing heavy rainfall, thunderstorms, and hail. Like other California regions, the high year-to-year variability of precipitation in Irvine is severely affected by extreme precipitation events (days having precipitation at or exceeding the 95th percentile), which accounts for 80 percent of the year-to-year variability.[128]



[126] State of California, Legislative Analyst's Office. 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.
[127] NOAA National Severe Storms Laboratory. *Severe Weather 101.* https://www.nssl.noaa.gov/education/svrwx101/floods/types. Accessed April 6, 2022.
[128] Jennings, M.K., D. Cayan, J. Kalansky, A.D. Pairis, D.M. Lawson, A.D. Syphard, U. Abeysekera, R.E.S. Clemesha, A. Gershunov, K. Guirguis, J.M. Randall, E.D. Stein, S. Vanderplank. (San Diego State University). 2018. San Diego County Ecosystems: Ecological Impacts of Climate Change on A Biodiversity Hotspot. California's Fourth Climate Change Assessment, California Energy Commission. Publication number: CCCA4- EXT-2018-010.

Most of the heaviest events occur during winter. While days with measurable precipitation become less frequent in Southern California, extreme precipitation events are anticipated to intensify. It is predicted that the state will experience prolonged periods of drought followed by extreme precipitation (See Section 3.2.2.2: Drought).

For Irvine, projections show only a slight change in average annual rainfall through the end of the century (Table 3-2: Change in Annual Average Precipitation). Globally, climate change is anticipated to lead to more variability in the intensity of rainfall events from year to year and longer transitions between droughts and deluges.[129] Historically, the City has experienced an average of about 1.5 extreme precipitation events per year. Under the medium emissions scenario, the city is still expected to experience 1.5 extreme precipitation events per year through the end of the century. Under the high emissions scenario, the City is expected to experience a little over 1.5 extreme precipitation events per year by mid-century and the late century.[130]

The primary concern for precipitation-driven hazards is flooding. Areas of Irvine already experiencing flooding when there are heavy rainfall events could find that flooding increases in the future. However, the forecasted changes in Maximum 1-Day Precipitation, the greatest amount of daily rain or snow (over a 24-hour period) for each year, are not anticipated to be substantially differ from historic records (see **Table 3-9. Change in Maximum 1-Day Precipitation**). Therefore, impacts from flooding caused by the largest precipitation-driven events should not be dramatically different than what the community currently experiences.

**Table 3-9. Change in Maximum 1-Day Precipitation**

| Maximum 1-Day Precipitation | Historic Maximum 1-Day Precipitation (1961 - 1990) | Medium Emissions (RCP 4.5) | | High Emissions (RCP 8.5) | |
|---|---|---|---|---|---|
| | | Mid-Century | End-Century | Mid-Century | End-Century |
| | 1.387 | 1.505 | 1.542 | 1.584 | 1.605 |

Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Maximum 1-Day Precipitation. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

## Historical Onshore Flooding Events

- February 6 – 8, 1998. Heavy rain. Up to 3" rainfall over all of Southern California. Catastrophic and widespread flooding, especially in Newport Beach and Irvine. Lots of property damage in southern Orange County. Evacuations and swift water rescues. Landslides, mud slides, and sink holes. Roads, bridges, and railroads damaged.[131]
- April 21, 2001. Mud, rockslides, and minor flooding occurred over highways and Interstates along and through the mountains and foothills. At elevations above 4000 feet, 2-4 inches of snow fell. [132]
- In January 2011, California received a Presidential Declaration for the Severe Winter Storms, Flooding, and Debris and Mud Flows that occurred over a nearly three-week period. During this incident, the State of California incurred well over $75 million in damages, of which over $36 million occurred within Orange County. Much of the damage impacted private and public property, as well as critical infrastructure.

[129] Swain, D. L. (2018). Increasing precipitation volatility in twenty-first-century California. Nature Climate Change.
[130] California Energy Commission. Cal-Adapt Extreme Precipitation Events Tool. Available: https://cal-adapt.org/tools/extremeprecipitation/. Accessed April 28, 2022.
[131] National Weather Service. 2017. A History of Significant Weather Events in Southern California.
[132] NCEI. Storm Events Database. https://www.ncdc.noaa.gov/stormevents/. Accessed May 2, 2022.

- In 2014 heavy rains affecting most of Southern California caused flooding on a section of Bastanchury Road that was nearly a foot deep. Nearby weather stations reported that more than an inch of rain had fallen in a span of three hours.
- In September 2015, flooding of roadways caused severe traffic congestion across Southern California, including Orange County. In the City of Los Angeles, 7,300 people lost power for most of the day, and there more than 500 traffic collisions across the entire region as a result of the road conditions.
- 2017 Winter Storms[66] included three storms over six days inundating southern California. Heavy rains, combined with already saturated soil, produced flash flooding across much of Orange County. Streets flooded with 1 to 3 feet of water in Huntington Beach, Santa Ana, and Newport Beach (Irvine 2020).

## Exposure

Flood zones are geographic areas that the Federal Emergency Management Act (FEMA) has defined according to varying levels of flood risk. These zones are depicted on a community's Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area. In Irvine the 100-year and 500-year floodplains are not contiguous areas but consist instead of various pockets across the city. Most of these areas fall within the major drainages within the City, which include:

- San Diego Creek
- Serrano Creek
- Borrego Canyon Wash
- Agua Chinon Wash
- Bee Canyon Wash
- Peters Canyon Wash
- Sand Canyon Wash

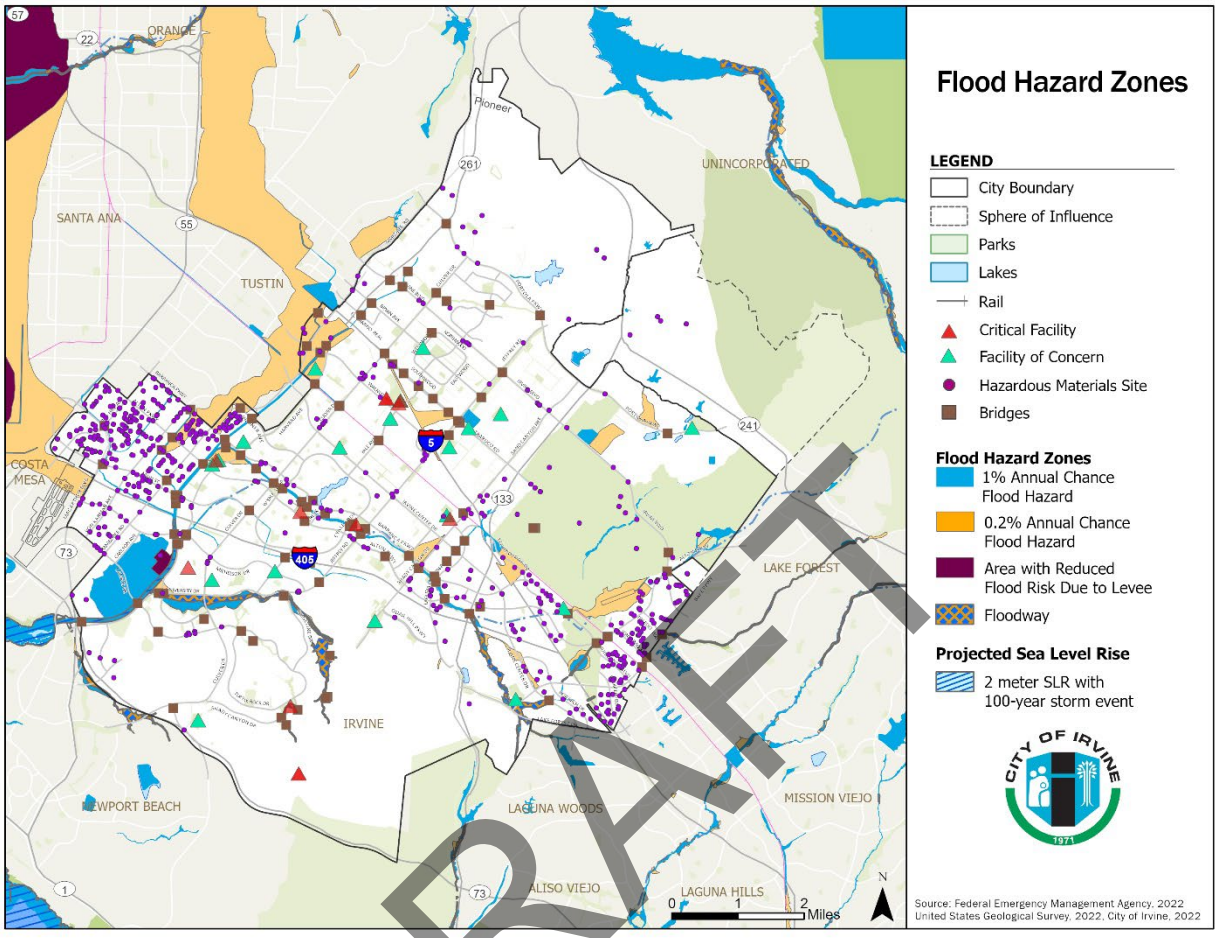
Figure 3-6: Flood Hazard Zones shows the mapped flood hazard zones for 100-year and 500-year flood events in Irvine. This map also depicts the 1-meter sea level rise data, which suggests that sea level rise may affect drainage along San Diego creek. To prevent potential flooding, Irvine has more than a dozen detention or retarding basins, generally located on, or adjacent to drainages within the City. Use of these facilities is intended to reduce downstream erosion by storing water for a limited period. These strategies can also assist with dam inundation impacts.

Floodplain mapping studies are provided by the National Flood Insurance Program. Irvine participates in the program by adopting FEMA-approved floodplain studies, maps, and regulations. These studies may be funded through federal grants; state, city, and regional agencies; and private parties. The program is designed for flood insurance and floodplain management applications.[133]



[133] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

Figure 3-6: Flood Hazard Zones






Portions of the City are located within the 100-year flood zone (1.0 percent Annual Chance of Flooding) and the 500-year flood zone (0.2 percent Annual Chance of Flooding). Any physical assets located within these mapped boundaries can expect to be inundated if enough precipitation were to fall exceeding the storm drain infrastructure design capacity in these areas. Electronic or mechanical equipment on the ground could become waterlogged and nonfunctional. The City has several key underpasses beneath major freeways and rail lines, that if flooded could impact circulation throughout the City.

In addition, the City has key locations along Sand Canyon Avenue, Jamboree Road, Culver Drive, and Jeffrey Road that require pump stations to ensure these underpasses do not fill with water. **Figure 3-6: Flood Hazard Zones** identifies the 100-year and 500-year FEMA flood zone designations. **Table 3-10: Critical Facilities and Facilities of Concern (100-Year Flood)** identifies the physical assets in Irvine located within the 100-year flood zone. Assets include 55 bridges and three City Recreation Support facilities. Potential losses associated with this flood zone could amount to over $130 million. This estimate also includes three assets that have the potential to be impacted by 1 meter of sea level rise. These three bridges are located along San Diego Creek and have a replacement value of over $40 million. In addition, **Table 3-11: Critical Facilities and Facilities of Concern (500-Year Flood)** identifies the additional assets located within the 500-year flood zone, which account for six CFs and two FOC that account for over $12.5 million in additional assets exposed to flooding within the City.

Table 3-10: Critical Facilities and Facilities of Concern (100-Year Flood)

| Category | Number of Facilities | | Examples | Potential Loss* |
|---|---|---|---|---|
| | Critical | Concern | | |
| City Vital Operations | - | - | City Hall, Police Station, Operations Support | $0 |
| City Community Centers | - | - | Community Centers | $0 |
| City Resident Services | - | - | Senior Centers, Animal Shelter, Daycare, Other Community Facilities | $0 |
| City Recreation Support | - | 3 | Parks, Recreation Amenities, Sports Complexes, and support facilities | $17,390,145 |
| Bridges | 55 | - | Overpasses and underpasses within the City | $113,203,067 |
| Schools | - | - | Irvine Unified School District and Tustin Unified School District Facilities | N/A |
| **Total** | **55** | **3** | | **$130,593,212** |

* Based on the City of Irvine insured replacement values

** Includes three bridges that may be affected by Sea Level Rise ($40,571,700)

*** Replacement Values unavailable

Table 3-11: Critical Facilities and Facilities of Concern (500-Year Flood)

| Category | Number of Facilities | | Examples | Potential Loss* |
|---|---|---|---|---|
| | Critical | Concern | | |
| City Vital Operations | - | - | City Hall, Police Station, Operations Support | $0 |
| City Community Centers | 1 | - | Community Centers | $462,067 |
| City Resident Services | 1 | - | Senior Centers, Animal Shelter, Daycare, Other Community Facilities | $2,148,923 |
| City Recreation Support | - | 2 | Parks, Recreation Amenities, Sports Complexes, and support facilities | $1,499,624 |
| Bridges | 4 | - | Overpasses and underpasses within the City | $8,450,960 |
| Schools** | - | - | Irvine Unified School District and Tustin Unified School District Facilities | N/A |
| **Total** | **6** | **2** | **-** | **$12,561,574** |

* Based on the City of Irvine insured replacement values

**Replacement Values unavailable

Table 3-12: Flooding - Vulnerable Populations shows the proportions of Irvine's vulnerable populations who are likely to face a greater threat from a flood event in the City. Median household income in the 100-year flood zone is significantly higher than the citywide average. In addition, households with one member aged 65 years and older is significantly lower (4.8 percent) than the citywide average (19.5 percent). The demographics for the 500-year flood zone are like the 100-year flood zone statistics, with exception to a lower median household income and a higher percentage of households with one member aged 65 years and older.

### Table 3-12: Flooding - Vulnerable Populations

| | 100-Year Flood | 500-Year Flood | City of Irvine |
|---|---|---|---|
| Total Population[1] | 370 | 7,635 | 262,665 |
| Percent of residents that are children (less than 10 years)[2] | 19.1% | 10.3% | 10.4% |
| Percent of households that have people 65+ years[1] | 16.5% | 12.6% | 20.6% |
| Percentage of households with at least one person living with a disability[1] | 12.1% | 7.9% | 12.3% |
| Median age[2] | 36.4 | 35.5 | 34.0 |
| Total households[1] | 141 | 2,685 | 94,490 |
| Median household income[2] | $156,785 | $98,260 | $113,097 |
| Percent of rental households[2] | 33.3% | -[3] | 48.7% |
| Percent of household income below poverty level[1] | 12.1% | 12.0% | 13.1% |

Source: US Census Bureau, American Community Survey (ACS) 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2], Data discrepancy – no value provided for rental occupied housing units.

As shown in Table 3-13: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 100-Year Flood and Table 3-14: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 500-Year Flood, the majority of the estimated the residents in the 100-year or 500-year flood zones aged 5 years and older are fluent in English. 7.7 percent of residents in the 100-year flood zone and 6 percent of residents in the 500-year flood zone are not fluent in English.

### Table 3-13: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 100-Year Flood

| | Number of Speakers | Percent Not Fluent in English |
|---|---|---|
| English Only | 138 | - |
| Spanish | 2 | 0% |
| Indo-European Languages | 32 | 6.3% |
| Asian and Pacific Island Languages | 177 | 15.3% |
| Other Languages | 2 | 0% |

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

Table 3-14: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 500-Year Flood

| | Number of Speakers | Percent Not Fluent in English |
|---|---|---|
| English Only | 3,145 | - |
| Spanish | 282 | 4.6% |
| Indo-European Languages | 999 | 2.4% |
| Asian and Pacific Island Languages | 2,427 | 14.5% |
| Other Languages | 255 | 13.3% |

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

## COASTAL FLOODING AND INUNDATION

### Coastal Flooding

While Irvine is not considered a coastal community, their drainage infrastructure connects to the ocean and may be tidally influenced. In the event future sea level rise affects drainage infrastructure, it could impact future flooding within the City. As an inland community that has coastally influenced drainage infrastructure another concern that should be addressed is the potential influence of sea level rise on flood control infrastructure. In the case of Irvine, a small portion of the flood control infrastructure in the northwestern corner of the City may be influenced by sea level rise in the future.

According to OPC's *State of California Sea-Level Rise Guidance: 2018 Update*, based on projected sea-level rise for Los Angeles, there is a 0.5 percent probability that Irvine could experience between 0.7 feet of sea level rise by 2030, 1.8 feet by 2050, 6.7 feet by 2100 under the high emissions, RCP 8.5 scenario.[134]

These projections were used to select corresponding localized sea level rise modeling thresholds produced by the United States Geological Service (USGS) through their Coastal Storm Modeling System version 3.0 (CoSMoS). CoSMoS produces projections of coastal flooding and inundation that could result from sea level rise and storms while factoring in changes in beaches and the retreat of cliffs and bluffs along the California coast.[135]

The OPC projections were translated to the closest data available from CoSMoS. Based on this data selection process, the following sea level rise projections were used to estimate the exposure from daily average flooding and storm surge (100-year) flooding: 0.25 meters of sea level rise (2030 timeframe), 0.5 meters (2050 timeframe), and 2.0 meters of sea level rise (2100 timeframe).[136]



[134] Ocean Protection Council. 2018. State of California Sea-Level Rise Guidance: 2018 Update.

[135] USGS. (n.d.). Coastal Storm Modeling System (CoSMoS). https://www.usgs.gov/centers/pcmsc/science/coastal-storm-modeling-system-cosmos?qtscience_center_objects=0#qt-science_center_objects. Accessed April 6, 2022.

[136] Sea level rise (SLR) projections from the Ocean Protection Council (OPC) were provided in feet. The United States Geological Survey's CoSMoS 3.0 model used to map the extent of flooding operates using the metric system. The OPC SLR projections (with associated timeframes) were matched to the closest value in CoSMoS for use in the analyses. As a result, the scenario elevations from CoSMoS may differ from the OPC projections.

Storm surge (100-year storm) flooding was used to estimate exposure to more severe but periodic flooding and represents the extent of flooding that would occur during a 100-year (one percent annual chance) storm assuming each sea level rise scenario. The storm surge flooding scenario is not additive to the daily flooding scenario.

## Exposure

Table 3-15: Critical Facilities and Facilities of Concern (0.25-meter, 1 meter, and 2-meter SLR, both with and without 100-Year Storm Event) illustrates only the extent of flooding that would occur during a 100-year (one percent annual chance) storm at 2 meters because it represents the most severe case for the City and yet still had no impact on Critical Facilities, Facilities of Concern, or hazardous materials sites, or homes. Three bridges would be affected by projected sea level rise, but as they are concrete or pre-stressed concrete intended for water use, the effect of increased water levels should be minimal.

Table 3-15: Critical Facilities and Facilities of Concern (0.25-meter, 1 meter, and 2-meter SLR, both with and without 100-Year Storm Event)

| Category | Number of Facilities | | Examples | Potential Loss* |
|---|---|---|---|---|
| | Critical | Concern | | |
| City Vital Operations | - | - | City Hall, Police Station, Operations Support | $0 |
| City Community Centers | - | - | Community Centers | $0 |
| City Resident Services | - | - | Senior Centers, Animal Shelter, Daycare, Other Community Facilities | $0 |
| City Recreation Support | - | - | Parks, Recreation Amenities, Sports Complexes, and support facilities | $0 |
| Bridges | 3 | - | Overpasses and underpasses within the City | $ 40,571,700 |
| Schools | - | - | Irvine Unified School District and Tustin Unified School District Facilities | N/A |
| **Total** | **3** | **-** | | $ 40,571,700 |

* Based on the City of Irvine insured replacement values



## Sensitivity: Major Community Elements

### Transportation Systems

Flooding may temporarily stop any type of transportation in the City. Debris carried by floodwaters can block roadways, hinder access for vehicles, and potentially affect emergency response services. Rushing water only one foot deep is enough to carry small vehicles. The city has key underpasses beneath major freeways and rail lines, that if flooded could impact circulation throughout the city.[137]

[137] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

### Lifeline Utility Systems

Water pipes, wastewater pipes, and wastewater pump stations show low to medium vulnerability to coastal flooding and high vulnerability to coastal erosion. Flooding would not have a severe impact on underground pipes or pump stations, but erosion could compromise the functionality of the system.

In addition, flooding in watersheds could impact water quality by bringing more nutrients and total dissolved solids into the water supply.

Electronic or mechanical equipment on the ground could become waterlogged and nonfunctional.

### Hazardous Materials

Flood water may have high levels of raw sewage or other hazardous substances. During a flood, underground storage tank (UST) systems may become displaced or damaged and release their contents into the environment, causing soil, surface water, and groundwater contamination. Flooding events can generate tons of debris, including building rubble, soil and sediments, green waste (e.g.., trees and shrubs), personal property, ash, and charred wood.[138]

### Economic Elements

A severe flood situation where the maximum anticipated flood depth of one foot is realized, may prevent people who own smaller vehicles from driving to work, leading to reduced economic activity. Severe flooding that causes serious damage to homes and businesses may also result in reduced economic activity until repair work is completed.

### Natural Resources Areas

Storm events could cause erosion on trails. Periodic flooding may temporarily limit access to parks, but once flood waters recede the park should be usable again with limited clean up.

Precipitation-driven flooding has the potential to impact habitats. Increased precipitation patterns could encourage the growth of invasive species.

## Sensitivity: Vulnerable Populations

The threat of a flood will primarily affect those residents living within the 100-year and 500-year flood zones. Many of these zones are located along drainages within the City. Floodwaters in these areas are anticipated to rise to more than a maximum of one foot. Flooding of this type would likely inundate curb cuts as well as sidewalks to some extent. Any people in Irvine who walk or bike as their main form of transportation may encounter greater difficulties with their mobility if they do not have access to an alternative means of transportation. Seniors, persons with disabilities, and low-income persons are those most likely to be threatened.

In a flood event, any people in Irvine who walk or bike as their main form of transportation may encounter greater difficulties with their mobility if they do not have access to an alternative means of transportation. Seniors, persons with disabilities, and low-income persons are those most likely to be threatened.



[138] United States Environmental Protection Agency. 2022. https://www.epa.gov/natural-disasters/flooding. Accessed May 6, 2022.

Flooding is the second most deadly weather-related hazard in the United States, which can be attributed mostly to drowning. Other effects can include building damage, mold, and respiratory damage.[139]

Additionally, persons who are experiencing homelessness may be caught outside during flood conditions without any shelter. Though floodwaters in Irvine are not expected to exceed a depth of one foot, even a floodwater depth of six inches may render any makeshift structures uninhabitable during the flood event. Possessions such as sleeping bags or electronic devices may be damaged or swept away by the floodwaters. Factors that make people sensitive to flooding are related to their ability to evacuate or escape the flood.[140]

As shown in **Table 3-13: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 100-Year Flood** and **Table 3-14: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 500-Year Flood**, the majority of the estimated the residents in the 100-year or 500-year flood zones aged 5 years and older are fluent in English. While 27 of the 351 residents in the 100-year flood zone and 423 of the 7,108 residents in the 500-year flood zone are not fluent in English, the City implements programs intended to communicate information to the diverse community of residents and workers with different backgrounds including the City of Irvine's website offers translation for 81 languages[141] and the Irvine Police Department is prepared to communicate with individuals with limited English proficiency[142]

## Adaptive Capacity

The City has addressed flooding in planning documents such as their Local Hazard Mitigation Plan, Emergency Management Plan, and Evacuation Plan (Annex XIII). The City also has regulations and programs in place that are beneficial during flooding by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

### City of Irvine Local Hazard Mitigation Plan (2020)

The 2020 LHMP included mitigation actions to decrease the risks associated with flooding, including:

- Investigate permeable paving and use landscaped swales for new and replacement of City-owned hardscaped areas.
- Encourage the use of porous surfaces on new and significantly retrofitted residential and commercial developments to reduce runoff.
- Conduct frequent cleanings of storm drain intakes, especially before and during the rainy season.
- Update the City's Master Plan of Drainage on a regular basis to incorporate new data and/or address emerging issues.
- Analyze if new critical facilities can be built a minimum of 1 foot higher than the anticipated 500-year flood elevation height, to determine where it is feasible.
- Retrofit roadway medians to capture storm water during rain events.
- Prioritize retrofit improvements along major arterials/ roadways throughout the City.

[139] Hall, A., N. Berg, and K. Reich. 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. University of California, Los Angeles. Publication number: SUM-CCCA4-2018-007.
[140] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[141] City of Irvine. 2022. https://www.cityofirvine.org/. Accessed May 3, 2022.
[142] City of Irvine. n.d. Policy 345. Limited English Proficiency Services.

- Evaluate City assets and resources to ensure effective response (accepting evacuees) during a tsunami evacuation incident.

### Floodplain Districts

While there is limited physical or social vulnerability to onshore precipitation-driven flooding, the City is well prepared to adapt to future effects of climate change related to flooding. The City recognizes that the flood hazard areas of the City of Irvine are subject to periodic inundation which results in loss of life and property, health and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures for flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety, and general welfare. In addition, these flood losses are caused by uses that are inadequately elevated, floodproofed, or protected from flood damage. The cumulative effect of obstructions in areas of special flood hazards which increase flood heights and velocities also contributes to the flood loss.

In response, the City of Irvine has adopted floodplain management regulations with the purpose of "promot[ing] the public health, safety, and general welfare, and to minimize public and private losses due to flood conditions in specific areas." The City applies a Floodplain District designation to all areas identified as flood channels and floodplains on maps published by the Federal Emergency Management Agency, Federal Insurance Administration, and flood insurance rate maps designating the floodway/ floodplain areas. Any development within this zone is required to incorporate a series of improvements or modifications to ensure the ability of structures to withstand periodic flooding.[143]

### Municipal Code

The City of Irvine's construction codes are based upon the California Code of Regulations, Title 24 that includes the California Administrative Code, Building Code, Residential Code, Electrical Code, Mechanical Code, Plumbing Code, Energy Code, Historical Building Code, Fire Code, Existing Building Code, Green Building Standards Code, and California Referenced Standards Code. They are the minimum necessary to protect the public health, safety, and welfare of the City's residents.

## 3.3.2.5 GEOLOGIC AND SEISMIC HAZARDS

In the context of climate change vulnerability, increased liquefaction and heightened possibility of landslide events are a concern. Both hazards an indirect effect of increased precipitation and flooding because soils must be saturated with water for liquefaction or landslides to occur.

- Liquefaction occurs when seismic energy shakes an area with low-density, fine grain soil, like sand or silt, which is also saturated with water. When the shaking motion reaches these areas, it can cause these loosely packed soils to suddenly compact, making the waterlogged sediment behave more like a liquid than solid ground.
- Landslides occur when earth on slopes become destabilized, typically after heavy rains, when the precipitation saturates the soil and makes it less stable, or when significant erosion from rainfall destabilizes the ground. Slopes that have recently burned face a greater risk from rain-induced landslides, as the fires burn the trees, brush, and other vegetation that help stabilize the earth.

[143] City of Irvine. 1995. Municipal Code, Division 5- Overlay Districts, Chapter 5-2- Floodplain District. https://library.municode.com/ca/irvine/codes/zoning?nodeId=ZOOR_DIV5OVDI_CH5-2FLDI_S5-2-1STAU. Accessed May 3, 2022.

Earthquakes may also be a source of liquefaction and landslides as the shaking can destabilize already loosened soils. Southern California is considered as one of the most seismically active regions in the United States because the faulting is dominated by the compression regime associated with the "big bend" of the San Andreas Fault Zone.

While no active faults (Alquist-Priolo Special Study Zones) are located within Irvine, there are several regional faults within Alquist-Priolo Special Study Zones near the City that could result in seismic hazards should an earthquake occur along one of them. While earthquake faults have been located in the City, they are not considered active (shown movement at the surface in the past 13,000 years) and therefore do not require delineation within a special study zone.[144]

### Historical Earthquake Events

- The largest recent fault rupture near Irvine was the 1994 Northridge earthquake, a 6.7 Mw event approximately 56 miles from Irvine, and the most destructive earthquake in the United States in nearly 100 years. This event killed sixty people, injured more than 7,000, left 20,000 people homeless and damaged more than 40,000 buildings in Los Angeles, Ventura, Orange, and San Bernardino Counties. Damage to Angel Stadium occurred as a result of this event.[145]
- More recently and closer to the City, a 5.1 Mw earthquake occurred in La Habra in 2014. This event caused fault rupturing adjacent to but not directly on the Puente Hills and Whittier faults (Graves n.d.).
- Most recently a significant swarm of earthquakes in the Ridgecrest area occurred on July 4th and 5th 2019. Three tremors ranging from 5.4 to 7.1 Mw occurred within the Eastern California shear zone, a region of distributed faulting associated with motion across the Pacific-North America plate boundary, and an area of high seismic hazard.[146]

## VULNERABILITY

### Exposure

Liquefaction potential is predominantly located within the northern portion of the City, as well as along stream courses in the Santa Ana foothills and San Joaquin Hills. **Table 3-16: Critical Facilities and Facilities of Concern (Liquefaction)** identifies the areas susceptible to liquefaction and location of CFs and FOC. Give the extent of the liquefaction zone and density of City facilities, this hazard poses the greatest potential loss. Over $233 million in City assets composed of 78 CFs and 30 FOC are located within these areas. Potential losses include 70 bridges and 20 schools in the City of Irvine.



[144] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[145] 2022. M 6.7 - 1km NNW of Reseda, CA (Northridge Earthquake) Overview. Accessed May 6, 2022. https://earthquake.usgs.gov/earthquakes/eventpage/ci3144585/executive
[146] 2022. M 7.1 - 2019 Ridgecrest Earthquake Sequence Overview https://earthquake.usgs.gov/earthquakes/eventpage/ci3144585/executive. Accessed May 6, 2022.

Table 3-16: Critical Facilities and Facilities of Concern (Liquefaction)

| Category | Number of Facilities | | Examples | Potential Loss* |
|---|---|---|---|---|
| | Critical | Concern | | |
| City Vital Operations | 2 | - | City Hall, Police Station, Operations Support | $56,786,352 |
| City Community Centers | 4 | - | Community Centers | $3,331,110 |
| City Resident Services | 2 | 3 | Senior Centers, Animal Shelter, Daycare, Other Community Facilities | $9,029,015 |
| City Recreation Support | - | 7 | Parks, Recreation Amenities, Sports Complexes, and support facilities | $31,486,344 |
| Bridges | 70 | - | Overpasses and underpasses within the City | $132,520,697 |
| Schools** | - | 20 | Irvine Unified School District and Tustin Unified School District Facilities | N/A |
| **Total** | **78** | **30** | | **$233,153,518** |

* Based on the City of Irvine insured replacement values



A large proportion of the City's population (over 37 percent) face the threat of impact due to liquefaction. Thankfully, much of the construction that has occurred over the years throughout the City has taken liquefaction into consideration. Newer buildings constructed in these areas are anticipated to contain moderate- and high-income tenants that would have greater amounts of disposable income to use during recovery after an incident. However, lower income residents and residents located in areas of older construction may be impacted greater due to the lack of financial resources need to make repairs and/or the cost associated with retrofitting older buildings.

Figure 3-7: Liquefaction Zones highlights areas with potential for liquefaction, specifically along the City boundary and in the northern center of the City, primarily in low-lying zones.[147] In Irvine, there may be a potential for liquefaction in areas with loose sandy soils combined with a shallow groundwater table, which typically are in alluvial river valleys/basins and floodplains. The underlying dataset combine existing liquefaction areas from local maps, National Earthquake Hazards Reduction Program which rates soils from hard to soft and known hydric soils from the United States Department of Agriculture Soil Survey to identify the potential areas where liquefaction may occur.[148]

[147] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.
[148] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

Figure 3-7: Liquefaction Zones

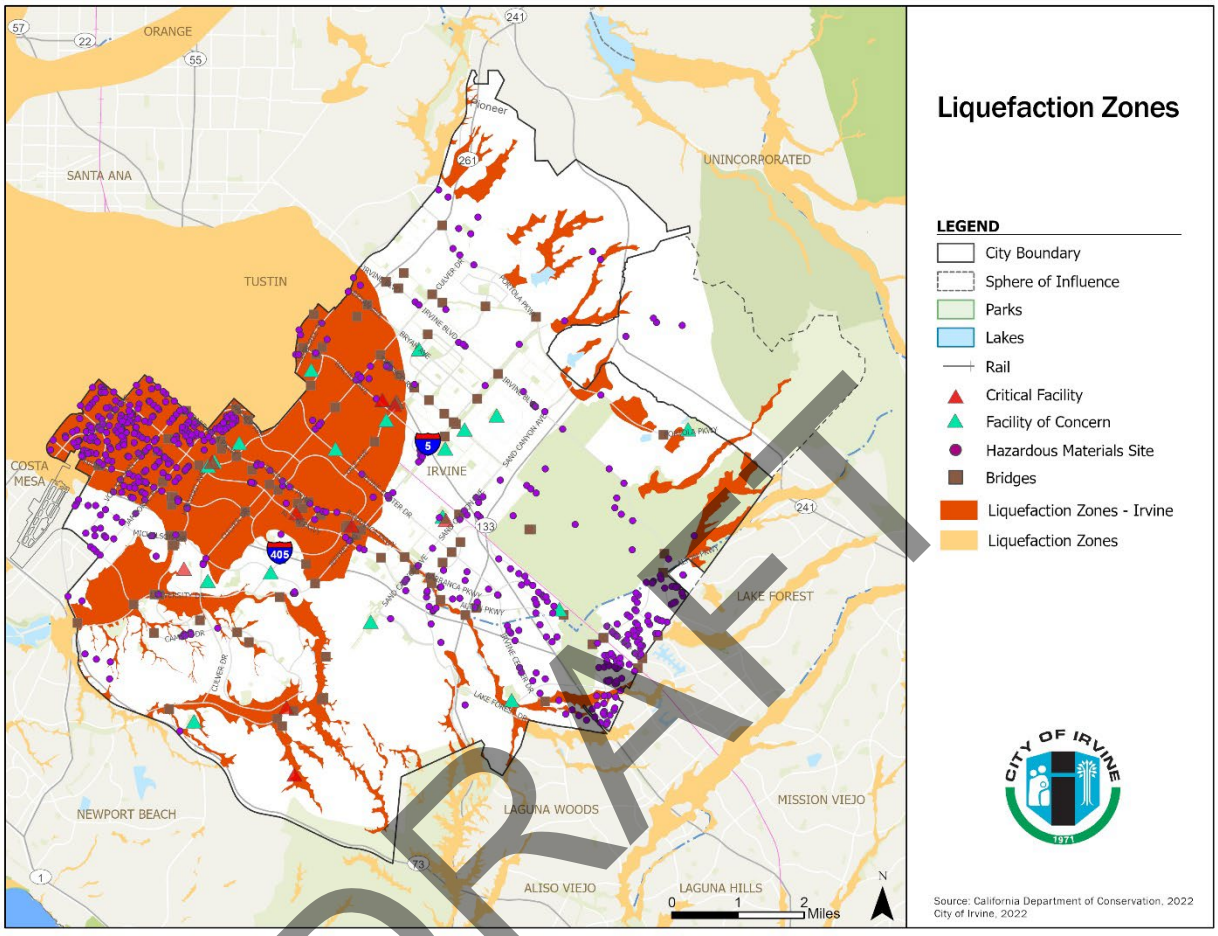





Table 3-17: Liquefaction Zones – Vulnerable Populations compares the populations within the liquefaction hazard zones with city wide populations. This hazard zone covers the largest population and number of households by far, which have a median household income that is approximately $3,000 higher than the Citywide figure. Persons living with a disability is approximately 25 percent higher than the City average, while households with a member aged 65 years and older is approximately 20 percent higher than the City average.

### Table 3-17: Liquefaction Zones – Vulnerable Populations

| | Liquefaction | Irvine |
|---|---|---|
| Total Population[1] | 96,491 | 262,665 |
| Percent of residents that are children (less than 10 years)[2] | 9.9% | 10.4% |
| Percent of households that have people 65+ years[1] | 24.0% | 20.6% |
| Percentage of households with at least one person living with a disability[1] | 15.0% | 12.3% |
| Median age[2] | 36.0 | 34.0 |
| Total households[1] | 34,164 | 94,490 |
| Median household income[2] | $108,995 | $113,097 |
| Percent of rental households[2] | 53.2% | 48.7% |
| Percent of household income below poverty level[1] | 11.4% | 13.1% |

Source: US Census Bureau, ACS 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2]

As shown in **Table 3-18: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Liquefaction Zones**, the majority of the estimated the residents in the liquefaction zone aged 5 years and older are fluent in English. 6.6 percent of residents in the liquefaction zone are not fluent in English.

### Table 3-18: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Liquefaction Zones

| | Number of Speakers | Percent Not Fluent in English |
|---|---|---|
| English Only | 46,225 | - |
| Spanish | 5,294 | 5.8% |
| Indo-European Languages | 10,497 | 10.9% |
| Asian and Pacific Island Languages | 25,627 | 15.5% |
| Other Languages | 536 | 17.2% |

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

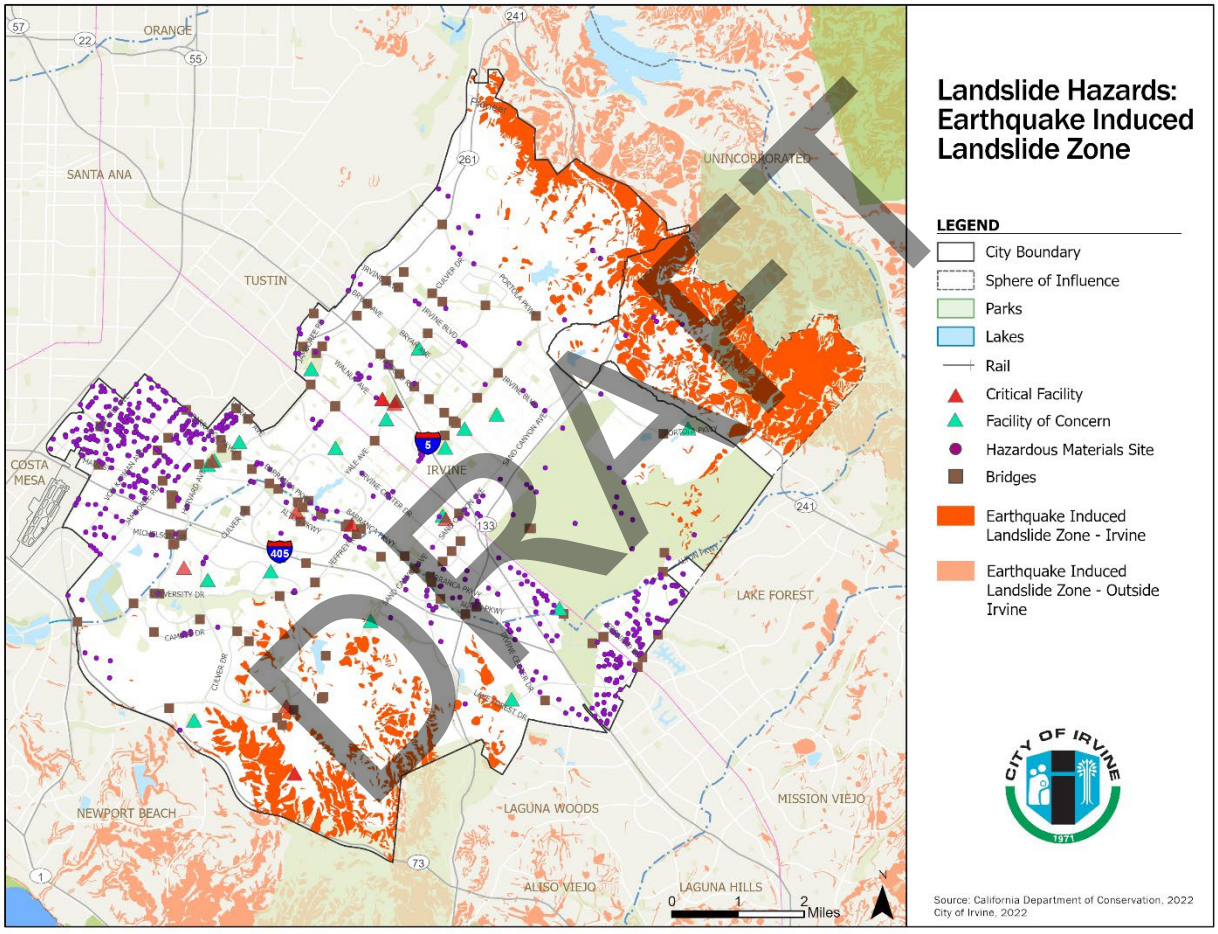


## Landslides

Landslides occur when earth on slopes become destabilized, typically after heavy rains, when the precipitation saturates the soil and makes it less stable, or when significant erosion from rainfall destabilizes the ground. Slopes that have recently burned face a greater risk from rain-induced landslides as the fires burn up many of the trees, brush, and other vegetation that help stabilize the earth. Earthquakes may also be a source of landslides as the shaking can destabilize already loosened soils. There is the potential for landslides in the steeper portions of the foothills of the Santa Ana Mountains to the northeast of the City and the San Joaquin Hills to the southwest of the City. These areas are characterized with steep topography and geologic units that can become unstable. Figure 3-8: Earthquake Induced Landslide Zone identifies the areas of the City that are considered vulnerable to seismic induced landslides. Even these areas, however, are designated as having a moderately low risk of landslides due to seismic conditions, and a low likelihood of a landslide under other conditions (Dept. of Conservation 1976). While no definitive scale for measuring landslides exists, landslide events are usually measured using the amount of material that is displaced (i.e., the cubic feet of earth that moved).

Given the topography and geologic units within the foothills of the Santa Ana Mountains and San Joaquin Hills, it is anticipated that landslide risk will remain high in those areas. However, the City requires mitigation of these types of conditions, which reduces landslide potential in the developed areas of the City. Regarding seismic activity, as **Figure 3-8: Earthquake Induced Landslide Zone** illustrates areas of the foothills of the Santa Ana Mountains and San Joaquin Hills that have the potential to fail during an earthquake. Destabilization of slopes and hills due to intense rainstorms also has the potential to cause future landslides. These can be further exacerbated after a wildfire, where vegetation becomes loosened and therefore more susceptible to becoming part of a future landslide. Overall, the probability of future occurrence within Irvine is considered occasional.[149]

**Figure 3-8: Earthquake Induced Landslide Zone**




As shown in **Table 3-19: Earthquake-Induced Landslide Zone - Vulnerable Populations** less than one percent of the city' households are potentially exposed to this landslide hazards. The demographics of vulnerable populations differ from those of the entire city, with a 40 percent increase in people aged 65 years and older, consistent with a higher median age.

[149] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

However, with only one-third of the number of total City households living below the poverty level, a greater percentage of homeowners, and an equivalent household income, the vulnerable populations may better resources to adequately adapt to a hazardous situation or reside in a structure with adequate safety measures in place.

Table 3-19: Earthquake-Induced Landslide Zone - Vulnerable Populations

| | Landslide | Irvine |
|---|---|---|
| Total Population[1] | 1,999 | 262,665 |
| Percent of residents that are children (less than 10 years)[2] | 12.7% | 10.4% |
| Percent of households that have people 65+ years[1] | 28.3% | 20.6% |
| Percentage of households with at least one person living with a disability[1] | 12.6% | 12.3% |
| Median age[2] | 38.8 | 34 |
| Total households[1] | 612 | 94,490 |
| Median household income[2] | $116,840 | $113,097 |
| Percent of rental households[2] | 31.1% | 48.7% |
| Percent of household income below poverty level[1] | 4.2% | 13.1% |

Source: US Census Bureau, American Community Survey (ACS) 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2]

As shown in **Table 3-20: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Landslide Zone**, the majority of the estimated the residents in the earthquake induced landslide zone aged 5 years and older are fluent in English. 10.2 percent of residents in the earthquake induced landslide zone are not fluent in English.

Table 3-20: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Landslide Zone

| | Number of Speakers | Percent Not Fluent in English |
|---|---|---|
| English Only | 1,065 | - |
| Spanish | 84 | 3.6% |
| Indo-European Languages | 104 | 2.9% |
| Asian and Pacific Island Languages | 553 | 32.4% |
| Other Languages | 5 | 0% |

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

## Sensitivity: Major Community Elements

### Liquefaction and Landslides

As climate change is anticipated to change the usual precipitation patterns in Southern California, including Irvine, periods of both rain and drought are anticipated to become more intense and frequent. Therefore, climate change could, depending on the circumstances, increase the future risk of liquefaction in Irvine.

### Essential Facilities

During liquefaction events, the liquified soil can lose its stability which can cause damage to buildings and infrastructure built upon it. In severe cases, buildings may completely collapse. (See Figure 3-7: Liquefaction Zones and Figure 3-8: Earthquake Induced Landslide Zone).

### Transportation Systems

Services and mobility may be disrupted during and following a liquefaction event. Sidewalks, roadways, and pipelines may become fractured and disjointed as a result of the liquefying soils. Roads and sidewalks may be usable in some form, but a severe liquefaction event may render them impassible until they are repaired. Landslides may block roadways causing long-term disruptions to the roadway network, infrastructure systems and city capabilities.

### Lifeline Utility Systems

Broken gas and water pipelines would result in utilities outages in Irvine homes and businesses. Since these are underground, the duration of the outage could likely be extended until the pipelines are excavated and replaced by utility operators. Damage to power lines is unlikely since the power lines themselves are not rigid structures and can move if any of the transmission towers experience slight leaning.[150]

Underground utility lines in slide-prone areas or above-ground lines built on or above them, can be damaged in a landslide, causing service outages.

### Hazardous Materials

Pipelines or other utility lines running through a liquefaction zone can be breached during an event, potentially leading to flooding or release of hazardous materials. The shaking of the ground can also damage or destroy underground utilities or pipelines, potentially leading to releases of hazardous materials as well as flooding if water lines are breached. Sinking of the ground could also reduce the distance to the groundwater table, which could raise the risk of contamination from hazardous materials.[151]

### Economic Elements

Homes may be damaged and mid-rise office buildings in the Centerpointe Complex would likely be rendered unsafe for occupancy if they experience any leaning or structural damage resulting from the liquefaction. Homes and businesses are typically damaged or destroyed by landslides. In addition to potentially causing significant injuries or fatalities, this can cause economic harm and create a need for long-term emergency sheltering and temporary housing until these buildings can be reconstructed.

In consideration of future degradation of structures, the City will want to monitor the quality of older housing stock to ensure it is still safe in a liquefaction event. The U. S. Department of Housing and Urban Development may consider units substandard if they were built before 1940. Fortunately for the City, less than one percent of housing units were built before 1940.[152]

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[150] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[151] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[152] US Census. 2020 ACS 5-Year Estimates Data Profiles/Housing Characteristics. https://data.census.gov/cedsci/table?tid=ACSDP5Y2020.DP04&g=0400000US06_1600000US0636770&hidePreview=true. Accessed May 3, 2022.

Irvine is a relatively new master-planned community with multiple homeowners' associations that monitor the external physical and property conditions of housing units throughout the City. The median year structures were built was 1998.[153]

### Natural Resource Areas

Landslides could affect sensitive ecological areas around the community, causing localized harm to the region's ecosystem, although widespread disruptions are unlikely.[154]

## Sensitivity: Vulnerable Populations

As shown in Table 3-18: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Liquefaction and Table 3-20: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Landslide, the majority of the estimated the residents in the liquefaction or earthquake induced landslide zones aged 5 years and older are fluent in English. While 5,815 of the 88,179 residents in the liquefaction zone and 185 of the 1,811 residents in the earthquake induced landslide zone are not fluent in English, the City implements programs intended to communicate information to the diverse community of residents and workers with different backgrounds including the City of Irvine's website offers translation for 81 languages[155] and the Irvine Police Department is prepared to communicate with individuals with limited English proficiency[156]

## Adaptive Capacity

The City has addressed geologic and seismic events in planning documents such as their Local Hazard Mitigation Plan, Emergency Management Plan, and Evacuation Plan (Annex XIII). The City also has regulations and programs in place that are beneficial during geologic and seismic events by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

### City of Irvine Local Hazard Mitigation Plan (2020)

The 2020 LHMP included mitigation actions to decrease the risks associated with liquefaction and landslides, including:

- Coordinate with Irvine Ranch Water District and the Navy on subsidence monitoring in areas of active groundwater extraction and work with water utilities to develop strategies based on the amount and severity of subsidence occurring.
- Consider reducing land use densities in areas of significant landslide threat and identify strategies for existing development downstream of these hazard areas.
- Encourage the installation of resilient (seismically appropriate) piping for new or replacement pipelines, in close coordination with local water, natural gas, and other providers.
- Assess soft story conditions for apartment buildings constructed prior to 1980.
- Conduct an educational campaign and incentives to encourage the use of reinforced chimneys, anchored rooftop-mounted equipment, window film, and other preventative measures to reduce damage at private buildings.

[153] Irvine Ranch Water District. 2021. 2020 Water Shortage Contingency Plan. June 28.
[154] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[155] City of Irvine. 2022. https://www.cityofirvine.org/. Accessed May 3, 2022.
[156] City of Irvine. n.d. Policy 345. Limited English Proficiency Services.

- Educate community groups and industry representatives assist in outreach to residents and businesses to obtain earthquake insurance through the California Earthquake Authority.
- To the extent feasible, construct all new and significantly retrofitted City-owned facilities to remain operational in the event of a major earthquake.
- Improve local understanding of the threat of a major earthquake by conducting a city-wide scenario modeling potential loss of life and injuries, destroyed and damaged structures, and interruptions to key services.
- Retrofit key critical City facilities with seismically rated window film treatments that ensure glass windows do not shatter during a strong seismic event. Promote retrofit of key community facilities not owned by the City.
- In coordination with Caltrans, update facilities condition assessments for bridges along evacuation routes to identify bridges that need seismic retrofitting. Consider pursuing highest standard improvement options (e.g., replacement instead of retrofitting) for bridges with seismic deficiencies.
- Pursue ground improvement projects, such as constructing a high strength capping layer, soil mixing, stone columns, soil wicks, chemical and pressure grouting, and other soil improvement techniques that reduce liquefaction susceptibility for key critical facilities in the event of an earthquake.
- Incentivize utilities to install flexible jointing and pipelines across fault segments located within the City. Ensure these pipelines have the necessary countermeasures to ensure breakage of lines is kept to a minimum and adequate shut off mechanisms to reduce exposure of pipeline contents to residents and businesses.

## Hillside Overlay District

The purpose of the Hillside Overlay District is to provide regulations for the development of those areas in the City of Irvine and the sphere of influence which, due to their topography, require special consideration to assure that they are developed in a way that will substantially maintain their natural character and environmental and aesthetic values.[157]

### Irvine Ranch Water District: Water Shortage Contingency Plan (2021)

IRWD's Water Shortage Contingency Plan provides a series of response actions that IRWD may implement in the event of a water shortage due to drought or emergency. It assumes that under a climate change scenario, that the anticipated Water Bank Usage would be 7,300 to 11,500 acre feet per year.[158] (See Drought: Adaptive Capacity



[157] City of Irvine. 1994. Municipal Code, Division 5- Overlay Districts, Chapter 5-2- Floodplain District. https://library.municode.com/ca/irvine/codes/zoning?nodeId=ZOOR_DIV5OVDI_CH5-4HIOVDI. Accessed May 3, 2022.
[158] Irvine Ranch Water District. 2021. 2020 Water Shortage Contingency Plan. June 28.

# 3.3 VULNERABILITY SCORING

The goal of this step is to identify priority climate vulnerabilities based on systematic scoring. Vulnerability scores are based on the combination of potential impact and adaptive capacity and help identify the major climate vulnerabilities. The scoring process utilizes numerical values, yet is primarily qualitative in nature.

Potential impacts are ranked through a method known as "vulnerability scoring," which is the recommended method identified in the 2020 update of the California Adaptation Planning Guide (APG 2.0). Major community elements and vulnerable populations at risk for each climate change–related effects were previously discussed per hazard according to exposure, sensitivity, and adaptive capacity. These scores are then used to determine an overall vulnerability score.

## Methodology

This analysis uses the 2020 Irvine LHMP Hazard Scoring FEMA-based methodology as a baseline to score exposure and sensitivity. For the LHMP, each hazard is assigned a score of 1 to 4. The four criteria are:

- Probability: The likelihood that the hazard will occur in Irvine in the future.
- Location: The size of the area that the hazard would affect.
- Maximum probable extent: The severity of the direct damage of the hazard to Irvine.
- Secondary impacts: The severity of indirect damage of the hazard to Irvine.

The 2020 LHMP Committee assigned a weighting value to each criterion, giving a higher weight to the criteria deemed more important, and multiplied the score for each criterion by the weighing factor to determine the overall score for each criterion. The weighting values were recommended by FEMA:

- Probability: 2.0
- Location: 0.8
- Maximum probable extent: 0.7
- Secondary impacts: 0.5

After calculating the total impact score for each hazard (sum of the location, maximum probable extent, and the secondary impact). FEMA guidance recommends multiplying the total impact score by the overall probability to determine the final score for each hazard. A final score between 0 and 12 is considered a low-threat hazard, 12.1 to 42 is a medium-threat hazard, and a score above 42 is considered a high-threat hazard as illustrated in Table 3-21: Criterion Scoring (LHMP).

Table 3-21: Criterion Scoring (LHMP)

| **Probability** | | **Maximum Probable Extent** | |
|---|---|---|---|
| **The estimated likelihood of occurrence based on historical data.** | | **The anticipated damage to a typical structure in the community. (Primary Impact)** | |
| **Probability** | **Score** | **Impact** | **Score** |
| Unlikely—less than a 1 percent chance each year. | 1 | Weak—little to no damage | 1 |
| Occasional—a 1 to 10 percent chance each year. | 2 | Moderate—some damage, loss of service for days | 2 |
| Likely—a 10 to 90 percent chance each year. | 3 | Severe—devastating damage, loss of service for months | 3 |
| Highly likely—more than a 90 percent chance each year. | 4 | Extreme—catastrophic damage, uninhabitable conditions | 4 |
| **Location** | | **Secondary Impact** | |
| **The projected area of the community affected by the hazard.** | | **The estimated secondary impacts to the community at large.** | |
| **Affected Area** | **Score** | **Impact** | **Score** |
| Negligible—affects less than 10 percent of the planning area. | 1 | Negligible—no loss of function, downtime, and/or evacuations | 1 |
| Limited—affects 10 to 25 percent of the planning area. | 2 | Limited—minimal loss of functions, downtime, and/or evacuations | 2 |
| Significant—affects 25 to 75 percent of the planning area. | 3 | Moderate—some loss of functions, downtime, and/or evacuations | 3 |
| Extensive—affects more than 75 percent of the planning area. | 4 | High—major loss of functions, downtime, and/or evacuations | 4 |

Source. City of Irvine. 2020. Local Hazard Mitigation Plan. October.

To perform the climate vulnerability ranking, the APG scoring rubric (See Table 3-22: Potential Impact and Adaptive Capacity Scoring Rubric) was applied to the LHMP final Hazard Scores (See Table 3-23: Hazard Scores) so the potential impact and adaptive capacity of each Major Community Element could be compared. Scores of 0 – 20 were considered Limited Impact, scores of over 20 to 40 were considered Moderate Impact, and scores above 40 were considered High Impact.

Table 3-22: Potential Impact And Adaptive Capacity Scoring Rubric (APG)

| Score* | Potential Impact | Adaptive Capacity |
|---|---|---|
| **Limited** | Impact is unlikely based on projected exposure; would result in minor consequences to public health, safety, and/or other metrics of concern. | The population or asset lacks capacity to manage climate impact; major changes would be required. |
| **Moderate** | Impact is somewhat likely based on projected exposure; would result in some consequences to public health, safety, and/or other metrics of concern. | The population or asset has some capacity to manage climate impact; some changes would be required. |
| **High** | Impact is highly likely based on projected exposure; would result in substantial consequences to public health, safety, and/or other metrics of concern. | The population or asset has high capacity to manage climate impact; minimal to no changes are required. |

Source: CalOES APG 2.0, Modified.

Table 3-23: Hazard Scores (LHMP)

| Hazard Type* | Probability | Impact | | | Total Score | Potential Impact Score |
|---|---|---|---|---|---|---|
| | | Location | Primary Impact | Secondary Impacts | | |
| Seismic Hazards[1] | 4 | 4 | 4 | 4 | 64.0 | High |
| Wildfire | 4 | 3 | 3 | 3 | 48.0 | High |
| Drought | 3 | 4 | 4 | 4 | 48.0 | High |
| Extreme Heat[2] | 3 | 4 | 2 | 2 | 33.6 | Moderate |
| Geologic Hazards[3] | 2 | 2 | 3 | 3 | 20.8 | Moderate |
| Flooding[4] | 2 | 3 | 2 | 2 | 19.2 | Limited |

*Climate Change considerations discussed as appropriate within this hazard.

[1] Seismic Hazards includes: Fault Rupture, Seismic Shaking, Liquefaction

[2] The original category was Severe Weather includes: Extreme Heat, Severe Wind, Rain

[3] Geologic Hazards includes: Expansive Soils, Landslides, Methane Containing Soils, and Subsidence

[4] Flooding includes a discussion regarding sea level rise

Source: Irvine LHMP 2020, modified.

Applying these generalized "Potential Impact Scores" from Table 3-23: Hazard Scores (LHMP) to the APG Vulnerability Score matrix (See Table 3-24: Vulnerability Score Matrix) produces an Irvine-focused vulnerability score for each Major Community Element and Vulnerable Population in Irvine by climate hazard (See Table 3-25: Climate Hazard Vulnerability Scores).

Note: The LHMP generalized the hazard impacts to the full community and this assessment considers subcomponents (i.e., Major Community Elements). Therefore, the "Potential Impact Scores" from the Table 3-23: Hazard Scores (LHMP) were considered only as a baseline. Additional information from this report's evaluation of Major Community Elements and Vulnerable Populations exposure and sensitivity to climate hazards may have altered the final climate vulnerability scores as shown in Table 3-25: Irvine Climate Hazard Vulnerability Scores.

Table 3-24: Vulnerability Score Matrix

| Potential Impacts | High | Moderate | Limited |
|---|---|---|---|
| **High** | 3 | 4 | 5 |
| Moderate | 2 | 3 | 4 |
| Limited | 1 | 2 | 3 |

**Adaptive Capacity**

Source: CalOES APG 2.0

Table 3-25: Irvine Climate Hazard Vulnerability Scores

| **Liquefaction** | **Impact** | **Adaptive Capacity** | **Score** |
|---|---|---|---|
| Essential Facilities | High | Moderate | 4 |
| Transportation Systems | High | Limited | 5 |
| Lifeline Utility Systems | High | Moderate | 4 |
| Hazardous Materials | High | Moderate | 4 |
| Economy | Moderate | High | 2 |
| Natural Resource Areas | Limited | High | 3 |
| Vulnerable Populations | Moderate | Moderate | 3 |

| **Wildfire + Smoke** | **Impact** | **Adaptive Capacity** | **Score** |
|---|---|---|---|
| Essential Facilities | High | Moderate | 4 |
| Transportation Systems | Moderate | High | 2 |
| Lifeline Utility Systems | High | Moderate | 4 |
| Hazardous Materials | High | Moderate | 4 |
| Economy | Moderate | Moderate | 3 |
| Natural Resource Areas | High | Limited | 5 |
| Vulnerable Populations | High | Moderate | 4 |

| **Drought** | **Impact** | **Adaptive Capacity** | **Score** |
|---|---|---|---|
| Essential Facilities | Limited | High | 4 |
| Transportation Systems | Limited | High | 1 |
| Lifeline Utility Systems | High | Moderate | 4 |
| Hazardous Materials | Limited | High | 4 |
| Economy | Moderate | Moderate | 3 |
| Natural Resource Areas | High | Limited | 5 |
| Vulnerable Populations | Limited | Moderate | 2 |

Table 3-25: Irvine Climate Hazard Vulnerability Scores (continued)

| Extreme Heat | Impact | Adaptive Capacity | Score |
|---|---|---|---|
| Essential Facilities | Moderate | High | 2 |
| Transportation Systems | Moderate | Moderate | 3 |
| Lifeline Utility Systems | High | Moderate | 4 |
| Hazardous Materials | Moderate | Moderate | 3 |
| Economy | Moderate | Moderate | 3 |
| Natural Resource Areas | High | Limited | 5 |
| Vulnerable Populations | High | Limited | 5 |

| Landslide | Impact | Adaptive Capacity | Score |
|---|---|---|---|
| Essential Facilities | Limited | High | 1 |
| Transportation Systems | Moderate | High | 2 |
| Lifeline Utility Systems | Moderate | Moderate | 3 |
| Hazardous Materials | Limited | Moderate | 2 |
| Economy | Limited | High | 1 |
| Natural Resource Areas | Limited | High | 1 |
| Vulnerable Populations | Limited | High | 1 |

| Flooding | Impact | Adaptive Capacity | Score |
|---|---|---|---|
| Essential Facilities | Limited | High | 1 |
| Transportation Systems | Moderate | Moderate | 3 |
| Lifeline Utility Systems | Moderate | Moderate | 3 |
| Hazardous Materials | Limited | High | 1 |
| Economy | Limited | High | 1 |
| Natural Resource Areas | Limited | High | 1 |
| Vulnerable Populations | Limited | High | 1 |

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