



**Climate Action &
Adaptation Plan**

**City of Glendale
Climate Change
Vulnerability Assessment**

SEPTEMBER 2023

rincon

Prepared by
Rincon Consultants, Inc.

Table of Contents

- Executive Summary..... 1
 - Report Organization..... 3
 - Social Vulnerability Assessment..... 3
 - Physical Vulnerability Assessment 4
 - Summary Findings for High and Very High Scores 2
 - Cascading Impacts Assessment..... 2
 - Key Findings 3
- 1 Introduction 4
 - 1.1 Purpose..... 4
 - 1.2 Glendale Snapshot..... 4
 - 1.3 Glossary 6
 - 1.4 Community Engagement..... 7
 - 1.5 Vulnerability Assessment Methodology 9
- 2 Climate Hazards 16
 - 2.1 Climate Indicators..... 17
 - 2.2 Climate Hazards..... 17
- 3 Social Vulnerability Assessment..... 25
 - 3.1 What is Social Vulnerability 25
 - 3.2 Social Vulnerability Index Score 25
 - 3.3 Social Vulnerability Overview..... 31
 - 3.4 Social Vulnerability by Climate Hazard..... 39
- 4 Physical Vulnerability Assessment 67
 - 4.1 What is Physical Vulnerability 67
 - 4.2 Physical Assets at Risk 67
 - 4.3 Physical Vulnerability by Climate Hazard 68
- 5 Cascading Impacts Assessment..... 87
 - 5.1 What are Cascading Impacts 87

- 5.2 System Interdependencies 87
- 6 Conclusion 92
 - 6.1 Problem Statements..... 92
 - 6.2 Vulnerability Analysis 95
- 7 References..... 97

Tables

- Table 1 Social Vulnerability Scores (see Chapter 3 for detailed assessment) 0
- Table 2 Physical Vulnerability Scores (see Chapter 4 for detailed assessment) 1
- Table 3 Impact and Adaptive Capacity Scoring Rubric..... 15
- Table 4 Vulnerability Score Matrix..... 15
- Table 5 Vulnerable Populations in Glendale 27
- Table 6 High Vulnerability Scores..... 96

Figures

- Figure 1 Glendale Climate Change Impacts..... 2
- Figure 2 Climate Change Mitigation and Adaptation 5
- Figure 3 California Adaptation Planning Guide Phases 10
- Figure 4 Vulnerability Assessment Flow Diagram, Phase 2 of the California Adaptation Planning Guide 11
- Figure 5 Social Vulnerability in Glendale 30
- Figure 6 Glendale High Social Vulnerability Areas and Home Owners’ Loan Corporation (HOLC) Neighborhood Redlining Grade 36
- Figure 7 Glendale High Social Vulnerability Areas and Municipality Tree Equity Score 38

Figure 8 Glendale High Social Vulnerability Areas and Wildfire
Hazard Severity Zones.....53

Figure 9 Glendale High Social Vulnerability and Landslide
Susceptibility57

Figure 10 Wildfire Hazard Severity Zones in Glendale 76

Figure 11 Historical Wildfire Events in Glendale 77

Figure 12 Landslide Susceptibility in Glendale80

Appendices

Appendix A - Sustainability Working Group Meeting #1 Feedback

Appendix B - Interested Parties Focus Group Meetings #1 and #2
Feedback

Executive Summary

The City of Glendale's Climate Change Vulnerability Assessment evaluates how climate change may impact community members and physical assets including natural and recreational resources, buildings and facilities, and infrastructure and critical services in Glendale. This report will inform the development of resilience strategies, measures, and actions for the Climate Action and Adaptation Plan (CAAP).

Climate change is a global phenomenon that can impact public health, natural resources, infrastructure, emergency response, and other aspects of society at the local scale as the averages and extremes of climate conditions change. In Glendale, temperature and precipitation are expected to change in the following ways:

- **Increasing temperatures.** Average maximum temperatures in Glendale are expected to increase between 4.2° Fahrenheit (F) and 5.2°F by 2050 and between 5.4°F and 8.6°F by 2100.
- **Increasing intensity of precipitation events and longer dry periods.** It is projected that more precipitation will occur during extreme storm events and dry periods will be longer and more frequent.

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

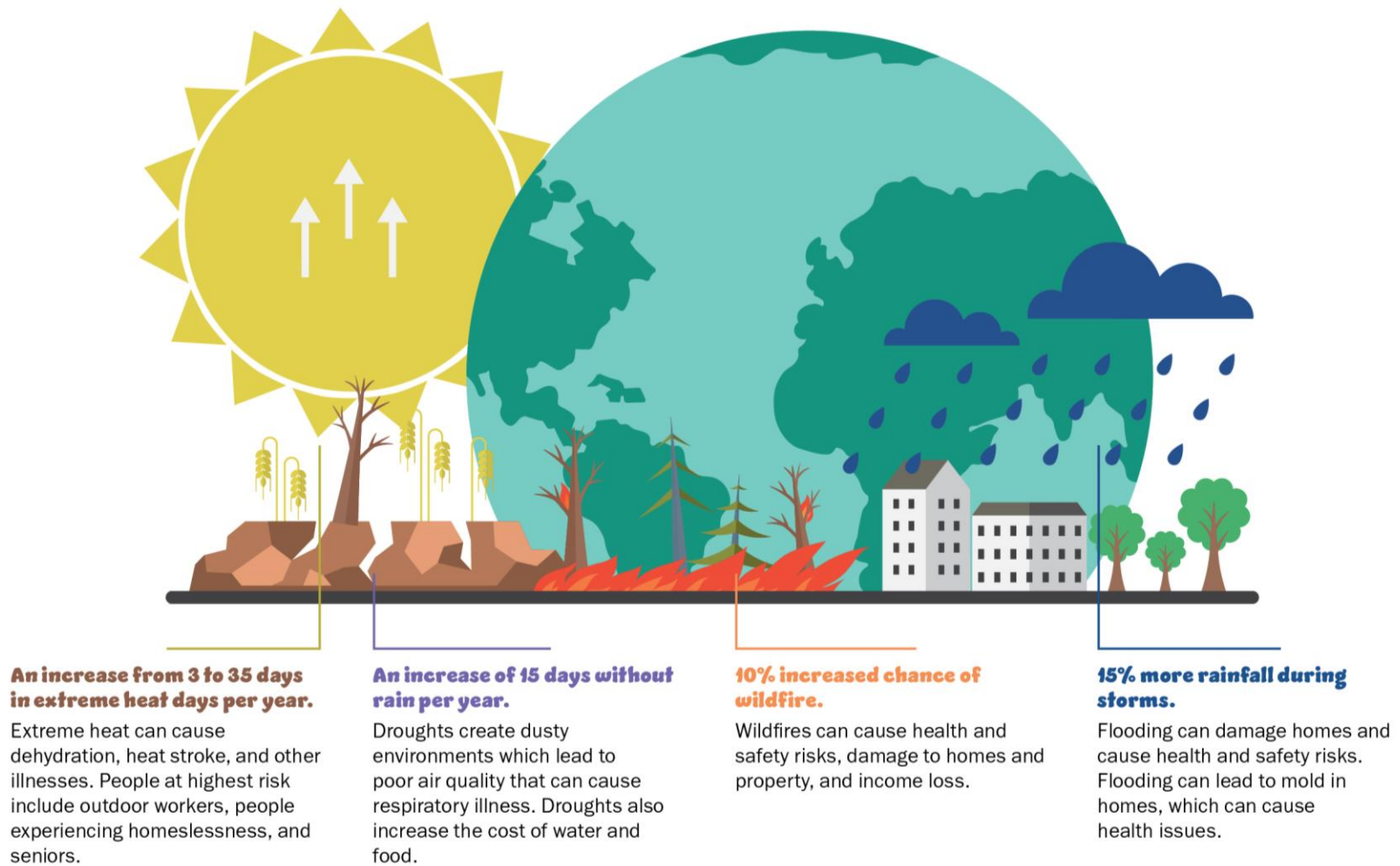
- **Extreme Heat and Warm Nights.** Glendale is projected to experience an increase in the annual number of extreme heat days in the coming decades. In Glendale, an extreme heat day occurs when the maximum temperature is above 97.6°F. The annual number of extreme heat days is projected to increase by

as many as 32 days and the annual number of warm nights is projected to increase by as many as 69 nights by 2100.

- **Drought.** The City is expected to experience increases in the length of dry spells.
- **Wildfire.** The annual wildfire probability in Glendale is anticipated to increase from 20 percent to 30 percent by 2100.
- **Landslides.** The risk of landslides is projected to increase as precipitation variability increases and wildfires increase in frequency, size, and severity.
- **Stormwater Flooding and Extreme Precipitation.** Climate change will cause changes in precipitation patterns, overwhelming Glendale's stormwater infrastructure, leading to localized flooding in highly paved areas throughout Glendale.
- **Poor Air Quality.** Air quality within the Los Angeles region is projected to worsen because of an increase in regional wildfires and average maximum temperature. Longer periods of drought will also contribute to worsening air quality.

See Figure 1 for a summary of climate impacts in Glendale.

Figure 1 Glendale Climate Change Impacts



Report Organization

The report is comprised of the following sections:

1. **Chapter 1 Introduction** provides the purpose of the report, a snapshot of the City of Glendale, and a glossary of key terms. It also describes the community input gathered, methodology, and key data sources used to prepare the Climate Change Vulnerability Assessment.
2. **Chapter 2 Exposure to Climate Hazards** illustrates the City's exposure to climate hazards.
3. **Chapter 3 Social Vulnerability Assessment** characterizes the vulnerability of populations in Glendale. Vulnerability is the degree to which a population may be affected by changing climate conditions. This section identifies the populations and locations that are highly vulnerable to climate change. This section also describes potential impacts of climate hazards on populations, policies, and programs that help communities cope with climate hazard events. Lastly, this section provides a vulnerability score that ranks the effect of climate change on population groups on a scale of 1 to 5, with 5 reflecting the highest vulnerability.
4. **Chapter 4 Physical Vulnerability Assessment** describes the susceptibility and limitations of physical assets and infrastructure to climate change. The physical assets included in this assessment include natural and recreational resources, building and facilities, and infrastructure and critical services. Similar to Chapter 3, this chapter describes policies and programs that help to protect physical assets and infrastructure from the adverse effects of climate change. A vulnerability score is also provided for each asset group.

5. **Chapter 5 Cascading Impacts** analyzes the interconnections between Glendale's critical systems including energy, water, transportation, and communication systems, and the implications of system failures associated with climate change.
6. **Chapter 6 Conclusion** presents the key findings of this report.

Social Vulnerability Assessment

While all populations in Glendale will be affected by climate hazards, some individuals are more vulnerable due to physiological conditions and inequitable systems and structures and, therefore, will be disproportionately impacted. The social vulnerability assessment in Chapter 3 consists of an analysis of 27 population characteristics that correspond to the most climate-vulnerable community members. These 27 population characteristics were grouped into four categories as follows:

1. Individuals with High Outdoor Exposure
2. Under-resourced Individuals
3. Individuals Facing Societal Barriers
4. Individuals with Chronic Health Conditions or Health Related Sensitivities

Grouping the populations into these four categories allows the City to understand the systems and structures that are in place that contribute to increased vulnerability to climate change hazards. Each of these population groups were assessed by climate hazards to produce hazard-specific social vulnerability scores summarized in Table 1.

The geographic location and proportion of vulnerable populations in Glendale who may be more impacted by climate hazards was also evaluated and mapped. The areas of Glendale with the greatest

concentration of vulnerable populations are in south and southwest of the City. Census tracts that are above the 60th percentile are considered to be a high social vulnerability area. Additional areas with high social vulnerability were also identified based on input from community-based organizations. These included areas near major roads and highways, schools, the Scholl Canyon Landfill, and the Grayson Power Plant.

Physical Vulnerability Assessment

The physical assets included in this assessment include natural and recreational resources, building and facilities, and infrastructure and critical services. The physical vulnerability assessment evaluates the direct impact that climate hazards could have on these assets. Hazard-specific vulnerability scores for each asset can be found in Table 2.

Table 1 Social Vulnerability Scores (see Chapter 3 for detailed assessment)

Population Group	Impact Score	Adaptive Capacity Score	Vulnerability Score
Extreme Heat			
Individuals with High Outdoor Exposure	High	Low	5-High
Under-resourced Individuals	High	Low	5-High
Individuals Facing Societal Barriers	High	Low	5-High
Individuals with Chronic Health Conditions or Health Related Sensitivities	High	Low	5-High
Drought			
Individuals with High Outdoor Exposure	Low	Medium	2-Low
Under-resourced Individuals	Medium	Medium	3-Medium
Individuals Facing Societal Barriers	Low	Medium	2-Low
Individuals with Chronic Health Conditions or Health Related Sensitivities	Low	Medium	2-Low
Wildfire			
Individuals with High Outdoor Exposure	High	Medium	4-High
Under-resourced Individuals	High	Medium	4-High
Individuals Facing Societal Barriers	High	Medium	4-High
Individuals with Chronic Health Conditions or Health Related Sensitivities	High	Medium	4-High
Landslides			
Individuals with High Outdoor Exposure	Medium	Medium	3-Medium
Under-resourced Individuals	Low	Medium	2-Low
Individuals Facing Societal Barriers	Low	Medium	2-Low
Individuals with Chronic Health Conditions or Health Related Sensitivities	Medium	Low	4-High
Stormwater Flooding and Extreme Precipitation			
Individuals with High Outdoor Exposure	Low	Medium	2-Low
Under-resourced Individuals	High	Medium	2-Low
Individuals Facing Societal Barriers	Low	Medium	2-Low
Individuals with Chronic Health Conditions or Health Related Sensitivities	Medium	Low	4-High
Poor Air Quality			
Individuals with High Outdoor Exposure	High	Low	5-High
Under-resourced Individuals	High	Low	5-High
Individuals Facing Societal Barriers	High	Low	5-High
Individuals with Chronic Health Conditions or Health Related Sensitivities	High	Low	5-High

Table 2 Physical Vulnerability Scores (see Chapter 4 for detailed assessment)

Population Group	Impact Score	Adaptive Capacity Score	Vulnerability Score
Extreme Heat			
Natural and Recreational Resources	High	Medium	4-High
Buildings and Facilities	N/A	N/A	N/A
Infrastructure and Critical Services	High	Medium	4-High
Drought			
Natural and Recreational Resources	High	Low	5-High
Buildings and Facilities	Low	Low	3-Medium
Infrastructure and Critical Services	High	Medium	4-High
Wildfire			
Natural and Recreational Resources	High	Low	5-High
Buildings and Facilities	High	Medium	4-High
Infrastructure and Critical Services	High	Medium	4-High
Landslides			
Natural and Recreational Resources	Medium	Medium	3-Medium
Buildings and Facilities	Medium	Medium	3-Medium
Infrastructure and Critical Services	Medium	Medium	3-Medium
Stormwater Flooding and Extreme Precipitation			
Natural and Recreational Resources	Medium	Medium	3-Medium
Buildings and Facilities	Medium	Medium	3-Medium
Infrastructure and Critical Services	Medium	Medium	3-Medium
Poor Air Quality			
Natural and Recreational Resources	High	Medium	4-High
Buildings and Facilities	Low	Low	3-Medium
Infrastructure and Critical Services	Medium	Medium	3-Medium

Summary Findings for High and Very High Scores

Based on the assessment, all four vulnerable population groups are expected to experience significant impacts from climate change. Key climate change social vulnerabilities for identified vulnerable populations include extreme heat and poor air quality. Impacts will range from increased rates of heat illness, income and property loss, and exacerbated underlying health conditions resulting in higher rates of mortality. Although the City has some programs in place, including hosting four cooling centers and adopted policies to increase access to community parks in underserved areas, there are many more steps that will be necessary to address the underlying inequitable causes of social vulnerabilities. Additional contributing factors include the lack of tree canopy in areas of high social vulnerability, and historical discriminatory practices, such as redlining.

Physical vulnerabilities include the risk of wildfire and post-wildfire landslides on *Infrastructure and Critical Facilities* assets. *Natural and Recreational Resources* in Glendale are vulnerable to extreme heat, wildfire, drought, and poor air quality.

There are three Glendale Water & Power (GWP) overhead transmission lines and multiple water pump stations, as well as schools, fire stations, and police stations that are located within Very High Fire Hazard Severity Zones. Post-wildfire debris and associated landslides further enhance the vulnerability of these critical facilities. Glendale Water & Power has a Wildfire Mitigation Plan which outlines procedures for vegetation management, wildfire power safety shutoffs, and other activities to reduce infrastructure vulnerabilities. However, more could be done to

increase the City's energy resilience, and protect existing facilities like schools, fire and police stations, and water pump stations.

Natural and Recreational Resources are vulnerable to multiple climate hazards. Extreme heat, wildfire, drought, and poor air quality can cause increased rates of habitat and vegetation mortality, habitat migration, and reduced environmental co-benefits for the urban tree canopy and ecosystem stability. Although the Greener Glendale Plan aims to increase the urban tree canopy, there are additional opportunities to increase the resilience of Glendale's Natural and Recreational Resources.

Cascading Impacts Assessment

The cascading impacts analyzed in Glendale include energy, water, transportation, and communication systems.

Energy System cascading risks include power disruptions in Glendale caused by wildfires, deliberate power shutoffs for public safety, or extreme heat overloading the grid. Power disruption has extensive cascading impacts. Impacts include but are not limited to loss of power in homes, which prevent community members from running their air conditioning or gas or electric heaters, and gas and electric kitchen appliances. For those who rely on in-home medical devices, power disruption could directly impact health and safety. If the power outages occur during bad air quality days from regional wildfire smoke, people with underlying health conditions could experience worsening health conditions. Traffic signals, cell-towers without back-up power, and critical facilities that lack backup power would cease to function. Losing many of these energy dependent amenities during events like heatwaves and wildfires can create increased risks to public health, including heat related illness, food access constraints, evacuation challenges, overloaded emergency services, and increased climate hazard exposure.

Water System cascading impacts include reduced supply for community consumption potentially increasing water rates and associated public health concerns for under-resourced Individuals who may not have the ability to pay the increased rates. Water shortages can also impact power generation with availability of water for generator cooling. Inadequate water supply can impact wildfire mitigation without enough fire flow to fight active fires and/or prevent anticipated fires. Inadequate water can impact the City's tree canopy which is critical for addressing the urban heat island effect and stormwater capture.

Transportation System cascading risks mainly concern mobility isolation of the community, ability for emergency services to respond to climate hazards, and constrained evacuation routes. Transportation impacts can occur from a wide range of causes including direct physical damages on the transportation system associated with climate hazards within City limits or external impacts afflicting regional transportation networks and services, as well as power outages creating traffic signal failures.

Communication System cascading risks primarily result from downed communications creating evacuation and medical complications, community isolation, and heightened risk for community members who are unable to receive hazard information.

Areas across Glendale in hazard zones are more prone to experiencing communication service disruptions and therefore, may experience increased cascading impacts from loss of communication infrastructure.

Key Findings

The Climate Change Vulnerability Assessment identifies key vulnerabilities associated with the following systems:

- Social and Governance Systems
- Urban Ecosystem
- Mobility, Land Use, and Emergency Systems
- Building Systems

Individuals with high outdoor exposure, under-resourced individuals, individuals facing societal barriers, individuals with chronic health conditions or health related sensitivities, natural and recreational resources, buildings and facilities, infrastructure and critical services are the most susceptible to climate change hazards in Glendale. Although the City has some policies and programs in place to prepare for climate related hazards, gaps remain as summarized in the Climate Change Vulnerability Assessment. This assessment will serve as the foundation for establishing adaptation policies and programs in the Glendale CAAP.

1 Introduction

1.1 Purpose

This report evaluates how climate change may impact vulnerable community members; natural and recreational resources; buildings and facilities; and services; and infrastructure in Glendale. The guiding methodology used in this assessment is based on the California Adaptation Planning Guide, which is discussed in the *Vulnerability Assessment Methodology* section.

Understanding the City’s vulnerabilities to climate change provides a foundation for developing climate adaptation measures and actions for the City’s Climate Action and Adaptation Plan (CAAP). The CAAP will also include measures and actions that will help to reduce greenhouse gas (GHG) emissions. The difference between climate mitigation and adaptation measures and actions are illustrated in Figure 2.

1.2 Glendale Snapshot

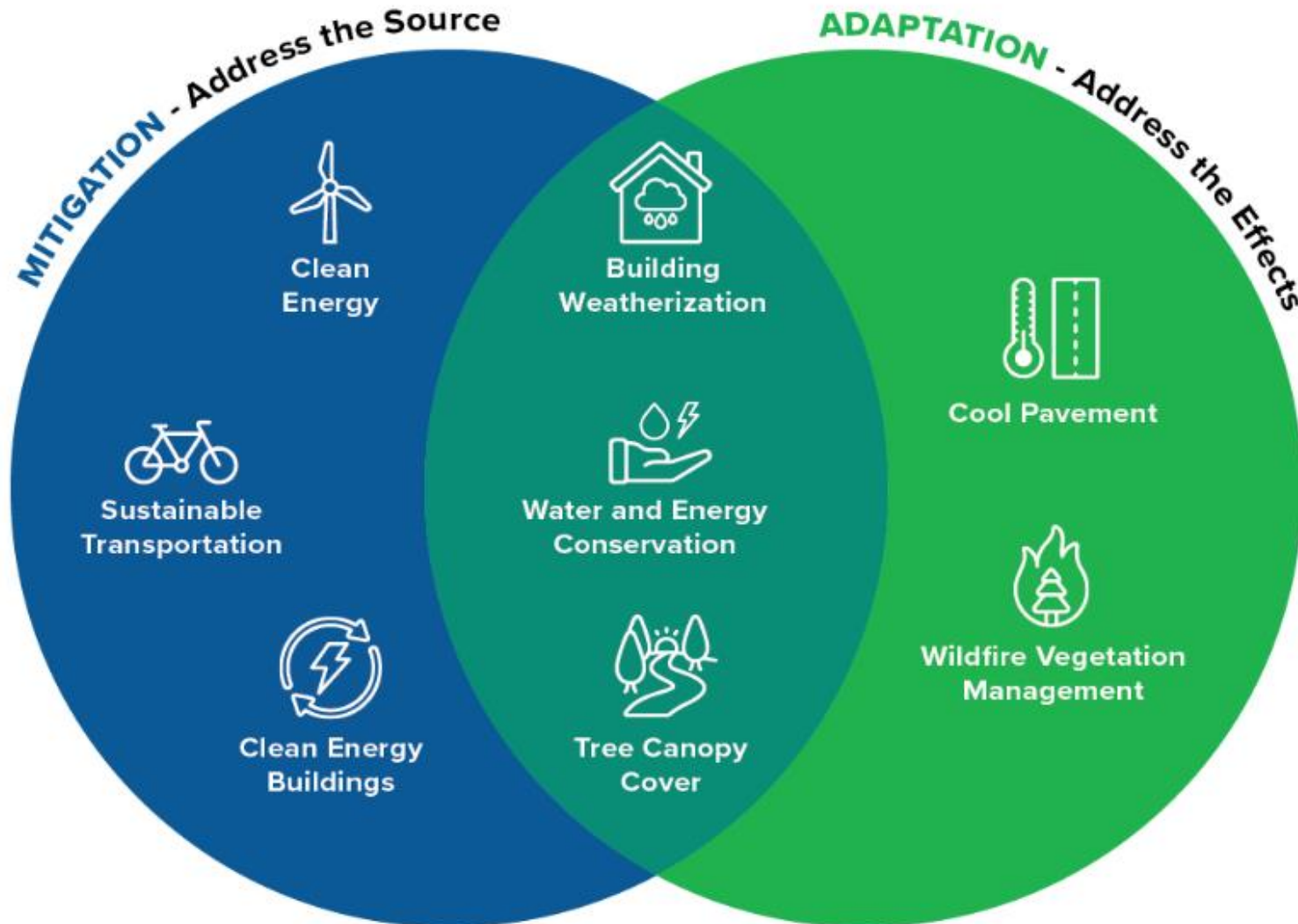
The City of Glendale was incorporated in 1906 and spans approximately 30.6 square miles with a current population of approximately 196,543 people (US Census 2020). Glendale is the fourth largest city in Los Angeles County and is located approximately 10 miles north of downtown Los Angeles. Glendale borders the City of Los Angeles to the north and south, unincorporated Los Angeles to the northeast, cities of La Cañada Flintridge and Pasadena to the east, and the City of Burbank to the west. California State Route 134 (SR 134) and Interstate 210 (I-210) are major freeways that run west to south through the City, and I-5

and SR 2 run north to south through the City. The City is also served by Amtrak and Metrolink which provide commuter rail services and are accessible at the Glendale Transportation Center which is located in south Glendale. The City of Glendale also offers transportation services to meet a variety of needs and demographics, including the Beeline Bus and Dial-A-Ride. Bus service throughout Glendale is provided by Los Angeles County Metropolitan Transportation Authority and Greyhound.

The City is home to the Verdugo Mountains Open Space Preserve, which holds more than 2,300 mature coast live oaks, sycamores, big leaf maples, bay laurels, and other native trees. The area is designated by Los Angeles County as a Significant Ecological Area (MRCA 2023). The City contains 47 parks and facilities including two regional parks (more than 30 acres in size), two community parks, 17 neighborhood parks, 13 mini-parks, and 13 special use facilities with recreational resources that are designated for specific groups (City of Glendale N.d.a).

Existing critical facilities are necessary for a community’s response to and recovery from emergencies. Critical facilities must continue to operate during and following a disaster to reduce the severity of impacts on the community and accelerate recovery. Example critical facilities in Glendale include police and fire stations, power lines, and public libraries.

Figure 2 Climate Change Mitigation and Adaptation



1.3 Glossary

Several words and phrases are used throughout this assessment to illustrate climate vulnerabilities within Glendale.

- **Adaptation.** The process of adjustment to actual or expected climate and its effects, either to minimize harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate (IPCC 2012).
- **Adaptive Capacity.** The City of Glendale’s ability to cope with and adjust to the impacts of climate change (Cal OES 2020).
- **Asset.** Refers to a resource, structure, facility, or service that is relied on by a community.
- **Cascading Impact.** Climate hazard caused impacts that compromise infrastructure or disrupt critical services (e.g., power supply or water conveyance) broadening the scope of impact past a singular subject to reliant subsystems and populations (Collins et al. 2019).
- **Climate Driver.** An increase in the proportion of greenhouse gases in the atmosphere is the primary human-caused source of change to the earth’s climate (USGCRP 2017).
- **Climate Hazard.** A dangerous or potentially dangerous condition created by the effects of the local climate (Cal OES 2020). Climate hazards of concern for Glendale are extreme heat and warm nights, drought, stormwater flooding, wildfire, landslides, and poor air quality.
- **Climate Indicator.** A measure of a particular aspect of the Earth’s climate that can be tracked over time to show trends and changes. Climate indicators relevant to the City of Glendale and discussed in this report are temperature and precipitation.
- **Compounding Risk.** When two or more extreme events or average events occur simultaneously and increase the scope of impact or severity of the event; an additional risk brought about by increased frequency of events from climate change (Seneviratne et al. 2012).
- **Impact.** Effects on natural and human systems including effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate hazards and the vulnerabilities of the system or asset effected (IPCC 2012).
- **Mitigation.** An act or sustained actions to reduce, eliminate, or avoid negative impacts or effects (Cal OES 2020).
- **Resilience.** The capacity of an entity (an individual a community, an organization, or a natural system) to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience (Cal OES 2020)
- **Sensitivities.** The degree to which a species, natural system, community, asset, or other associated system would be affected by changing climate conditions (Cal OES 2020).
- **Vulnerable Populations.** Certain populations experience increased exposure, risk, or vulnerability to climate change impacts and often have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts (Cal OES 2020). Assessing and mitigating impacts to these populations is prioritized given the increased risks and sensitivities.
- **Vulnerability.** The propensity or predisposition to be adversely affected (IPCC 2012).

1.4 Community Engagement

Incorporating input from the community, experts in the field, and interested parties into the development of this Climate Change Vulnerability Assessment provides critical context for how recent climate-driven events in Glendale have impacted critical infrastructure, services, and community members. It also serves to identify existing government-run programs within the City and remaining gaps that can be filled through strategies included in the CAAP.

The Sustainability Working Group meeting with Glendale City staff elicited information on historical climate change impacts, existing and planned efforts to manage climate change impacts now and in the future, and gaps in City programs and services. The Sustainability Working Group identified projects, programs, and policies the City should put into place to increase community resilience.

In addition, the City held two focus group meetings. These meetings were attended by community-based organizations in Glendale and elicited information on vulnerable populations, climate change impacts, and existing community resources that protect the community from climate change hazards.

Information shared by interested parties will further inform climate adaptation policies and programs in the City's CAAP and will continue to provide ongoing guidance on strategies that address key community needs.

Sustainability Working Group Meeting

The City of Glendale assembled a Working Group to help shape the Glendale CAAP. The Sustainability Working Group is made up of representative from the following City departments and divisions:

- City of Glendale Water & Power Department
- City of Glendale Public Works Department
- City of Glendale Integrated Waste Management Division
- City of Glendale Fire Department
- City of Glendale Police Department
- City of Glendale Community Development Department
- Community Services and Parks Department
- City of Glendale Sustainability Office
- City of Glendale Library, Arts and Culture Department
- City of Glendale Economic Development Division

The City hosted its first Sustainability Working Group meeting on May 17, 2023, to gather information on historical impacts and existing and planned programs in the City that increase community resilience. Attendees provided input on the types of impacts that facilities, operations, staff, and the community have experienced from past floods, extreme heat events, landslides, and wildfires. The Sustainability Working Group also provided feedback on primary barriers and constraints preventing adequate preparation or response to climate hazards, steps to overcome these barriers, and types of projects, programs, or plans that are needed to better adapt to climate change. This assessment includes key findings from the Sustainability Working Group meeting, which are included in the *Social Vulnerability by Climate Hazard* section. The Mural Board activity used to gather feedback at the Sustainability Working Group is included as Appendix A.

Interested Parties Focus Group Meetings

To date, the City of Glendale has hosted four focus group meetings for the CAAP which occurred in June and July 2023 with the following community based:

- Adams Hill Neighborhood Association
- Arco
- Armik Avedisian Real Estate Services
- AT&T
- BLK dream Camp Co
- CDBG Commission
- City of Glendale
- Climate Reality Project – Los Angeles Chapter
- Community Foundation of the Verdugos
- Cuningham
- Department of Justice
- Dignity Health – Glendale Memorial Hospital
- Gharibian Real Estate & Finance
- Glendale Community College
- Glendale Environmental Coalition
- Glendale Healthier Community Coalition
- Glendale Kiwanis
- Glendale Parks & Open Space Foundation
- Glendale Students for Sustainability
- Glendale Teachers Association
- Glendale Unified School District
- Glendale Water & Power
- Jackson Vintage Properties
- Keller Williams Commercial Glendale
- Los Angeles Regional Collaborative for Climate Action and Sustainability
- MedProse Consulting
- Montrose Verdugo City Chamber of Commerce
- NAMI Glendale
- Sierra Club Verdugo Hills Group
- Silversher Productions
- Student from Crescenta Valley high School
- Sunroom Desk
- Sustainability Commission, City of Glendale
- Surfrider Foundation South Bay Chapter
- UCLA Students
- USC Verdugo Hills Hospital
- Whiting Woods Property Owners Inc.
- WRP Group
- YWCA Glendale and Pasadena

Each interested party brings unique expertise about Glendale and climate-related solutions to the project. Incorporating this knowledge is critical in understanding the scale of impacts, vulnerabilities, and existing adaptive capacity of the community in the City.

The City provided the focus groups attendees with an overview of potentially vulnerable groups in Glendale. Attendees provided input on additional potentially vulnerable groups in the City, their primary climate hazards of concern, experiences during recent climate hazard events in Glendale, barriers faced when preparing for and/or responding to climate hazards, and plans, programs, and resources

that the community-based organizations currently provide that increase community adaptive capacity. The additional vulnerable groups identified through the focus group meetings are included in this assessment primarily in *Social Vulnerability Assessment*. The Mural Board activities used to gather feedback at the Focus Group meetings is included as Appendix B.

Community Workshop

The City hosted 4 virtual and 8 in-person community workshops in October and November 2023 to share results of this CCVA, present high-level strategies to increase community resilience to climate change, develop actions to achieve strategies with the community, and answer questions related to the CAAP.

Community Engagement as part of Climate Action and Adaptation Plan

As part of the CAAP, the City has a robust community engagement plan. The City is hosting a project website, attending community events, sending out e-blasts, sending out surveys, hosting community workshops, and attending existing meetings held by business associations and community-based organizations to gather feedback on and help guide the direction of the CAAP.

1.5 Vulnerability Assessment Methodology

California Adaptation Planning Guide Phases

The Glendale Climate Change Vulnerability Assessment follows the vulnerability assessment process recommended by the California Governor’s Office of Emergency Services (Cal OES), as documented in the 2020 California Adaptation Planning Guide (Cal APG). The adaptation planning process outlined by the Cal APG consists of four phases, illustrated in Figure 3.

1. Phase 1 consists of scoping a project to define, explore, and initiate the planning process, which the City completed as part of the CAAP initiation.
2. Phase 2 consists of the vulnerability assessment process which encompasses this report and is outlined in more detail in Figure 4.
3. Phase 3 consists of developing adaptation strategies which will be completed as part of the CAAP in which the summarized vulnerabilities of the City are prepared as prioritized adaptation strategies.
4. Phase 4 consists of the implementation, monitoring, evaluation, and adjustment of the adaptation strategies.

This report is also consistent with Government Code § 65302, as amended by Senate Bill (SB) 379, which requires cities and counties across California to prepare a Climate Change Vulnerability Assessment to inform updates to the Safety Element of the General Plan.

Figure 3 California Adaptation Planning Guide Phases

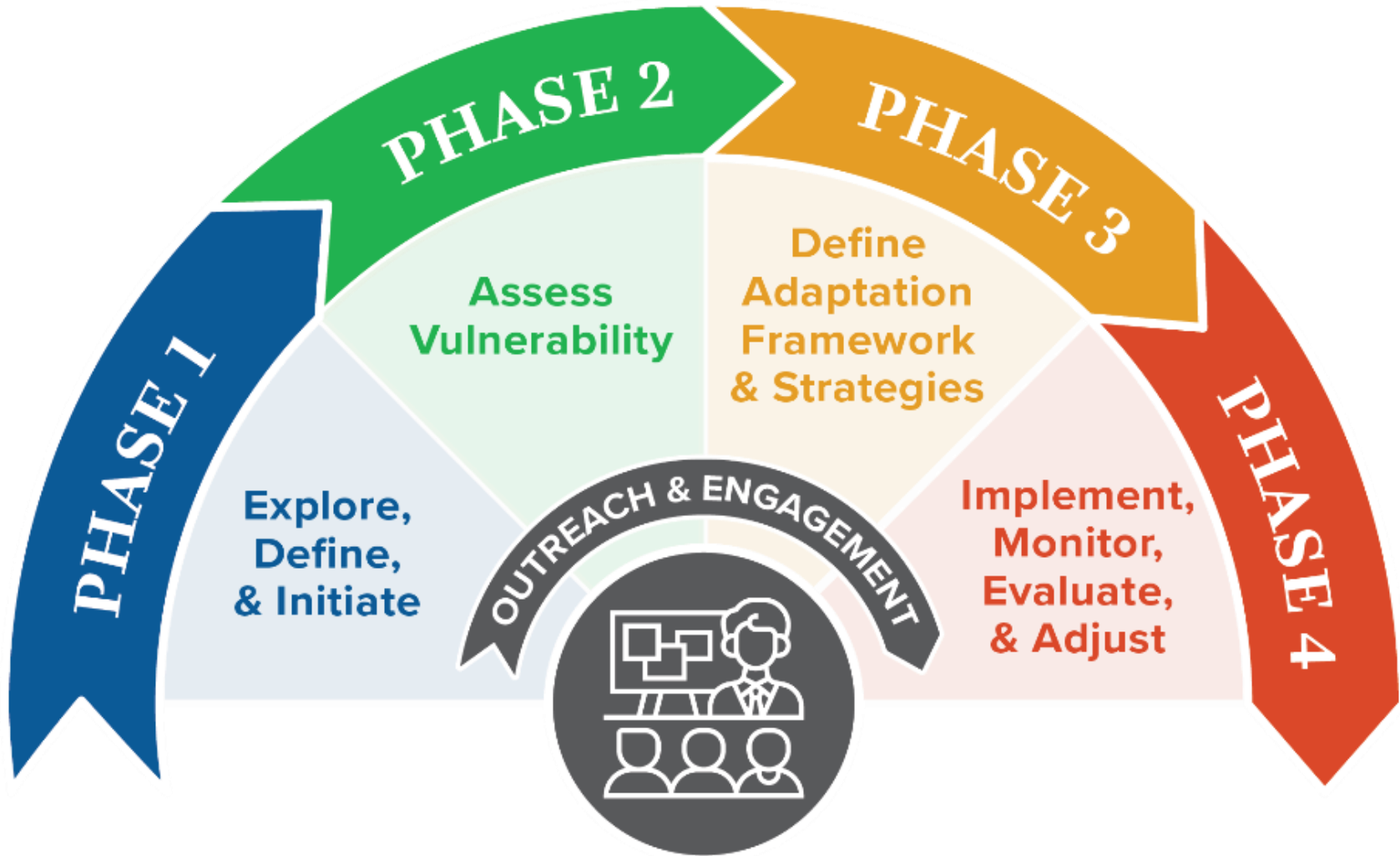
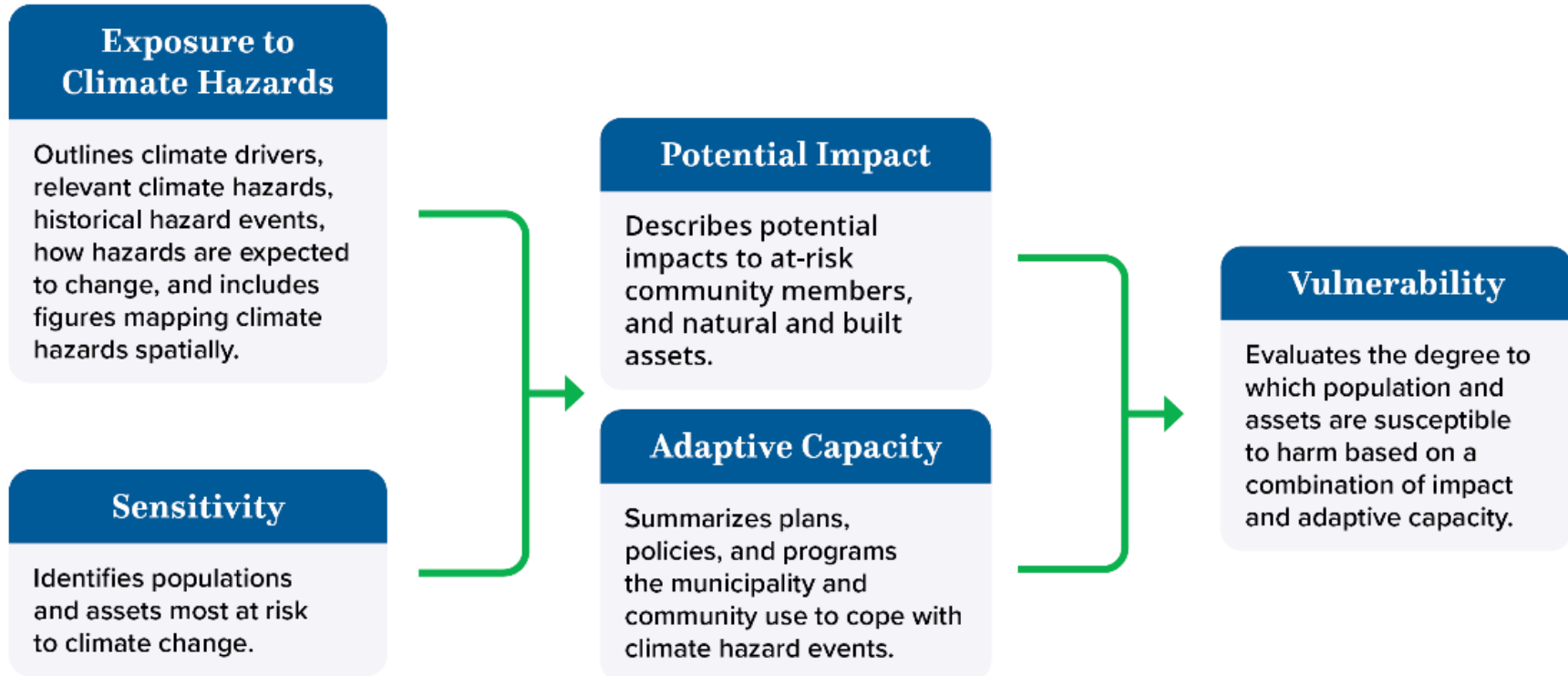


Figure 4 Vulnerability Assessment Flow Diagram, Phase 2 of the California Adaptation Planning Guide



Key Data Sources

The following data sources and tools, many of which are recommended within the Cal APG and Southern California Adaptation Planning Guide (SoCal APG), were used in preparation of this report.

- **Cal-Adapt** is an online tool that presents historic and modeled projections based on 10 different global climate models. The tool was developed and is maintained by the University of California, Berkeley with oversight from the California Energy Commission (CEC). This tool is used to present projection data related to minimum and maximum temperature, precipitation, extreme heat, warm nights, drought, and wildfire. This tool uses data from California's Fourth Climate Change Assessment and is expected to be updated soon with data from the Fifth Climate Assessment as it becomes available.
- **California's Fourth Climate Change Assessment** was developed by the CEC and other State of California coordinating agencies to present up-to-date climate science, projections, and potential impacts associated with climate change. The CEC and coordinating agencies developed nine reports to provide regional-scale climate information to support local planning and action. The Los Angeles Region Summary Report (2018) presents an overview of climate science, regional projections, specific strategies to adapt to climate impacts, and key research gaps needed to spur additional progress on safeguarding the Los Angeles Region from climate change. The Los Angeles Region Summary Report was used to understand regional changes that may affect Glendale both directly and indirectly.
- **California Heat Assessment Tool (CHAT)** is an online mapping tool funded by the California Natural Resources Agency as part of California's Fourth State Climate Change Assessment to help

state and local public health officials understand how heat vulnerability will change with increasing temperatures due to climate change. CHAT uses historical and projected daily maximum and minimum temperature, humidity, and emergency room visit data along with population and environmental characteristics to assign census tracts with heat vulnerability scores and to project the frequency and length of Heat Health Events over the course of the century for two climate scenarios (RCP 8.5 and RCP 4.5). A Heat Health Event (HHE) is any heat event that generates public health impacts, regardless of the absolute temperature.

- **Tree Equity Score** is a mapping tool created by the non-profit organization, American Forests, using tree canopy data from Earth Define. Trees provide numerous environmental and health benefits, including improved air quality, shade, and ambient cooling. Trees are often distributed unequally throughout the neighborhoods in cities. Tree Equity Score is intended to help identify census tracts that could benefit from additional tree planting the most and to estimate the benefits of tree planting to make the case for allocating the resources needed to do so. Tree Equity Scores are based on how much tree canopy and surface temperature align with income, employment, race, age, and health factors. Scores are meant to indicate whether there are enough trees in specific neighborhoods or municipalities for everyone to experience the health, economic, and climate benefits that trees provide.
- **Los Angeles County Climate Change Vulnerability Assessment** is a comprehensive assessment of the social and physical vulnerabilities facing Los Angeles County as a result of climate change. The assessment defines high climate vulnerability as a combination of increased exposure to climate hazards; high susceptibility to negative impacts of exposure; and low adaptive capacity, or ability to manage and recover from exposure. The

assessment includes a Climate Hazard Assessment (CHA) which evaluates potential changes in the frequency and severity of specific climate hazards (extreme heat, wildfire, extreme precipitation and inland flooding, coastal flooding, and drought) resulting from climate change in the coming decades. It also includes a Social Vulnerability Assessment (SVA) which looks at the level of risk across communities and populations and identifies groups and places that are highly vulnerable to climate hazards. The third major section is the Physical Vulnerability Assessment (PVA) which examines how physical infrastructure and facilities across the County face risk of damage from climate hazards and outlines how damage to highly vulnerable facilities could affect people and society. Finally, the Cascading Impacts Assessment explains how infrastructural systems rely on one another and how harm to one type of infrastructure can affect other facilities, related services, and the people who rely on those services.

- **City of Glendale Local Hazard Mitigation Plan** contains a series of proposed action items that when implemented can help reduce the risk from hazards through education and outreach programs, the development of partnerships, and the implementation of preventative activities (e.g., land use programs) that restrict and control development in areas subject to damage from natural hazards. The Plan includes wildfire, flood, and landslide mitigation action items. As of August 2023, the City is in the process of updating the 2019 Plan.
- **U.S. Census, 2021 American Community Survey (ACS)** presents demographic data by census tract and was used in the social vulnerability analysis. U.S. Census data was used to identify the percentage of the Glendale population that corresponds to each vulnerable group.

- **The Center for Disease Control’s (CDC) PLACES Health Data (updated 2023)** presents health demographic data by census tract. CDC PLACES Health Data was used to identify the Glendale population health statistics that correspond with the Social Vulnerability Index and vulnerable populations. This data is based on the 2010 census boundaries.
- **U.S. Department of Energy Low-Income Energy Affordability Data (LEAD)** presents population data on low- and moderate-income households that carry a disproportionate energy burden, as included in the Social Vulnerability Index.

Data Limitations

The limitations of this report and analysis stem from gaps in data availability and completeness of data methods. Census data can miss portions of the population (e.g., individuals experiencing homelessness, undocumented individuals) and general demographic information may not fully identify the full extent of populations at increased risk from climate change impacts. For example, Middle Eastern and Armenian individuals who have traditionally been classified as “white” in census designations face systemic disadvantages from potentially missing funding and resource opportunities that other minority groups may receive (Census Bureau 2022; Warren 2022). Extrapolating air quality hazard exposure data in the context of climate change is difficult because it is at a regional scale and regional GHG impacts have not traditionally been measured or monitored in the same way that local air quality has been. Therefore, the estimates of exposure to these hazards are likely to be underestimated.

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

average water equivalent of mountain snowpack at a given time of year. The averages discussed often downplay the extremes by which daily weather events occur and when presented as an average, only show moderate changes within the climate. What is often lost in averages is that the frequency of extremes, like atmospheric rivers, may increase while low-moderate intensity weather events decrease through the end of the century. In instances of modeled precipitation projections, it maintains an average similar to historic levels which does not account for anticipated fluctuations in extremes (CEC 2023).

Social Vulnerability Methodology

The presence and overall distribution of vulnerable populations in the City of Glendale were identified based on the U.S. Census and American Community Survey data, CDC’s PLACES Health data, and U.S. Department of Energy LEAD Tool. The data used for the social vulnerability analysis were supplemented using information received through the focus group meetings. See *Interested Parties Focus Group Meetings* section of this report for a summary of these meetings. This report follows the Southern California Association of Governments (SCAG) SoCal APG and Los Angeles County Climate Vulnerability Assessment methodologies for identifying, grouping, and analyzing vulnerable populations.

The SoCal APG identifies the following populations as generally experiencing higher risk for climate impacts in a given community:

- Low income
- Experiencing homelessness
- Incarcerated
- Single female heads of households
- Undocumented immigrants
- Non-English speakers

- Unemployed or underemployed
- Seniors and young children
- Military veterans
- Non-white communities
- Renters
- Students
- Visitors and seasonal residents
- Tribal and indigenous communities
- Individuals with impaired health/disabilities
- Isolated individuals (e.g., no car or transit access)
- Individuals with educational attainment less than 4 years of college
- Outdoor workers

Vulnerable populations were identified in Glendale through several state recommended data sources. For groups analyzed using U.S. Census data, the report identified populations in Glendale present at higher rates than the statewide average. Glendale’s vulnerable populations are described in the *Social Vulnerability Assessment* section later in this report.

Vulnerability Scoring Methodology

Vulnerability scoring is a valuable step in the climate vulnerability assessment process because it identifies which assets and populations face the greatest threat from climate hazards. This can aid in the prioritization of adaptation actions. The vulnerability score is a combination of the impact and adaptive capacity scores. The impact and adaptive capacity scores are developed using a qualitative methodology outlined in the Cal APG, as seen in Table 3. Impact and adaptive capacity scores are assigned for each climate hazard for all assets and vulnerable populations. The vulnerability score is prepared by combining the two scores as demonstrated in Table 4. The range of potential impacts spans 1 through 5 with 4-5 representing the highest levels of potential impact.

Table 3 Impact and Adaptive Capacity Scoring Rubric

Score	Impact	Adaptive Capacity
Low	Impact is unlikely based on projected exposure; would result in minor consequences to public health, safety, and/or other metrics of concern.	The population or asset lacks capacity to manage changes; major changes would be required.
Medium	Impact is somewhat likely based on projected exposure; would result in some consequences to public health, safety, and/or other metrics of concern.	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; 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: Cal OES 2020

Table 4 Vulnerability Score Matrix

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

Source: Cal OES 2020

2 Climate Hazards

Climate change is a global phenomenon that can impact local health, natural resources, infrastructure, emergency response, and many other aspects of society. The primary driver of climate change is increased GHGs in the atmosphere due to human activity. Future projections of climate and climate hazards are dependent on both location and the trajectory of global GHG emissions over time. The Cal-Adapt tool provides climate data from global scale models that have been localized (downscaled) to 3.7 mile by 3.7-mile grids (CEC 2023). The data in Cal-Adapt is combined with information from the California Fourth Climate Change Assessment to model future changes in specific types of hazards within this assessment. Climate change projections use different Representative Concentration Pathways (RCP), which describe potential trajectories of global GHG emissions (CEC 2023). Projections in this assessment are based on RCP 8.5, a high emissions scenario in which global GHG emissions continue to rise through the end of the 21st century. The selection of RCP 8.5 for assessing vulnerability is recommended by the Governor’s Office of Planning and Research in the Cal APG (Cal OES 2020).

Additionally, projections are forecasted to mid-century (2035-2064) and end-century (2070-2099) as 30-year averages to be compared to a modeled historical baseline (1961-1990) (CEC 2023).

This section presents information on temperature and precipitation, which are considered climate indicators. Following this section are a series of graphics that display information on projected changes to climate hazards due to changes in climate indicators. These hazards include extreme heat and warm nights, drought, wildfire, landslides,

stormwater flooding and extreme precipitation, and poor air quality.

Causes of Climate Change

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

2.1 Climate Indicators

The climate indicators relevant to Glendale are temperature and precipitation. The following section summarizes projected changes to these climate indicators.

Temperature

Currently, Glendale has an average maximum temperature of 74.9°F and an average minimum temperature of 51.2°F. Average maximum temperatures are expected to increase in Glendale by approximately 5.2°F (RCP 8.5) by the mid-century and 8.6°F (RCP 8.5) by end-century. Average minimum temperature is expected to increase in the City by approximately 4.8°F (RCP 8.5) by mid-century and 8.3°F (RCP 8.5) by end-century (CEC 2023). Temperature increases affect various climate related hazards including extreme heat and warm nights, drought, wildfire, and poor air quality, further described in the illustrative graphics below.

Precipitation

Climate projections show that there will be more frequent and longer dry periods punctuated by increased precipitation intensity of the largest storms or wet periods (Hall et al. 2018). Projections for Glendale predict that annual precipitation totals will remain relatively stable, decreasing slightly by approximately 0.3 inches by end-century (RCP 8.5). However, as already observed in recent years, precipitation changes are largely observed as more extreme variability with intense wet years followed by extreme drought (CEC 2023). Climate change is projected to increase the intensity of extreme precipitation events in the Los Angeles region (Hall et al. 2018). By the end of the century, some locations in the Los Angeles region are expected to experience up to 30 percent more precipitation on the wettest day of the year and the intensity and

frequency of atmospheric reiver events are also projected to occur (RCP 8.5) (Hall et al. 2018). Although changes in average precipitation are small, both wet and dry periods are expected to be more extreme, which can increase the risk of related climate hazards such as stormwater flowing and landslides (Hall et al. 2018). In Glendale, precipitation changes are expected to affect drought, stormwater flooding, wildfire, and air quality.

2.2 Climate Hazards

This section outlines projected changes for the following climate hazards:



Extreme Heat



Warm Nights and Heat Health Events



Drought



Wildfire



Landslides



Stormwater Flooding and Extreme Precipitation Events



Poor Air Quality

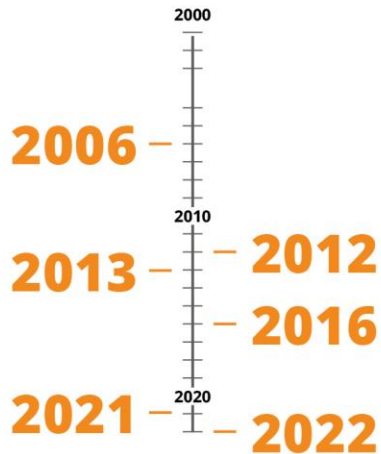


EXTREME HEAT

Past

Extreme heat events across the state have presented historic challenges for all communities, including the City of Glendale, which has experienced six extreme heat events over the past two decades.

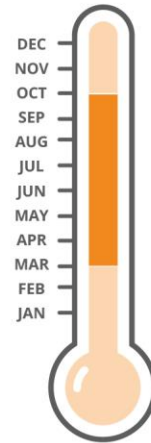
Extreme Heat Events



Present

Extreme heat events are presently defined as days in which the temperature exceeds the 98th percentile (97.6°F). Current extreme heat days occur between the months of March to October, while the 30-year baseline average is 3 days annually.

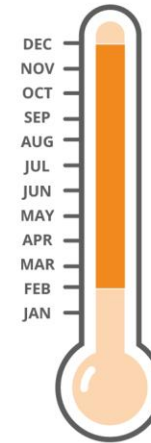
Extreme Heat Months (Baseline Years)



Future

Extreme heat is expected to affect all of Glendale, with greatest impacts to sensitive population groups. Days over 97.6°F are projected to increase by 32 days by the end of the century and occur during a wider range of months from February to December.

Extreme Heat Months (Mid & End-century Years)



Projected Annual Average of Extreme Heat Days



Impacts on the Built and Natural Environment



Cracked Pavement



Grid Overload



Water Scarcity



Wildlife and Vegetative Stress



Strained Emergency Services

Impacts on Vulnerable Populations



Dehydration



Heat Stroke



Health-related Mortality



Mental and Behavioral Health



Heart Disease



Respiratory Illness



Income Loss



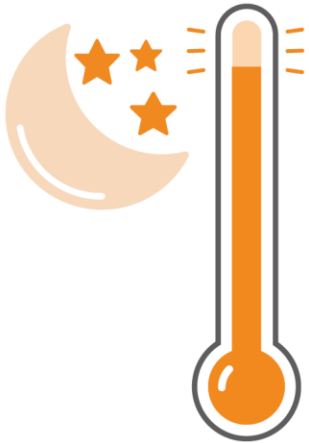
Increase in vector-borne disease



WARM NIGHTS AND HEAT HEALTH EVENTS

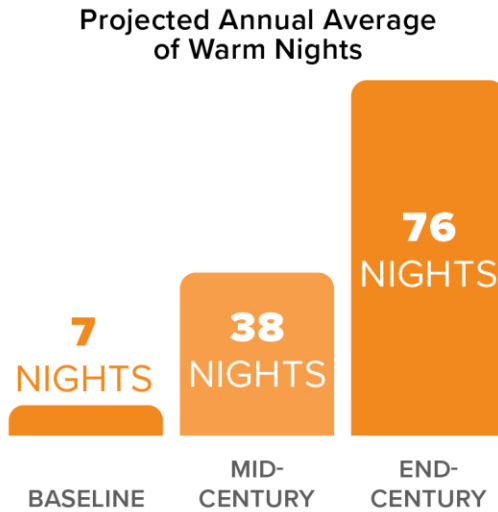
Past

Warm nights are defined as nights when the daily minimum temperature is above a threshold temperature of 97.6°F. Between 1961 and 1990, Glendale experienced an average of 7 warm nights per year.



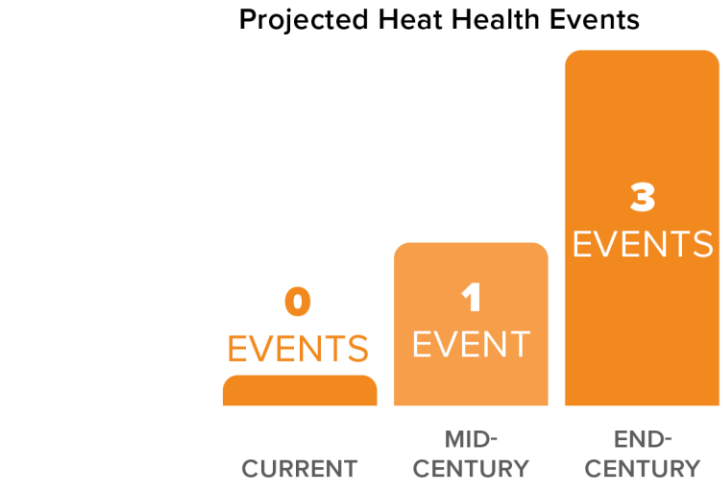
Future - Warm Nights

Warm nights are expected to increase by 69 nights by the end of the century.



Future - Heat Health Events

Heat waves that have public health impacts, referred to as heat health events, are expected to increase from 0.13 events per year to 3 events per year by the end of the century. These projections are tailored to estimate the number of heat events with public health impacts to populations with higher heat-sensitivity than the general population, including those with asthma, seniors, and children.



Impacts on the Built and Natural Environment



Cracked Pavement



Grid Overload



Water Scarcity



Wildlife and Vegetative Stress



Strained Emergency Services

Impacts on Vulnerable Populations



Dehydration



Heat Stroke



Health-related Mortality



Heart Disease



Respiratory Illness



Mental and Behavioral Health

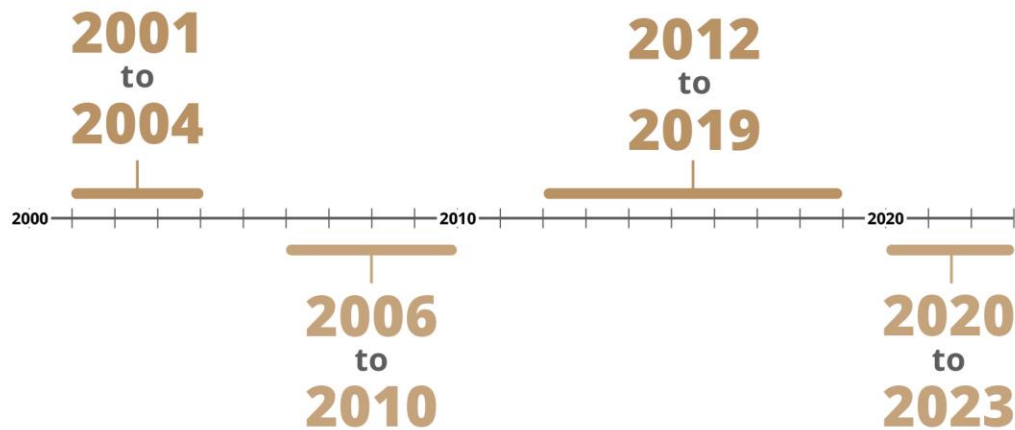


DROUGHT

Past

Over the past two decades, the City of Glendale has experienced more frequent and longer continuous droughts.

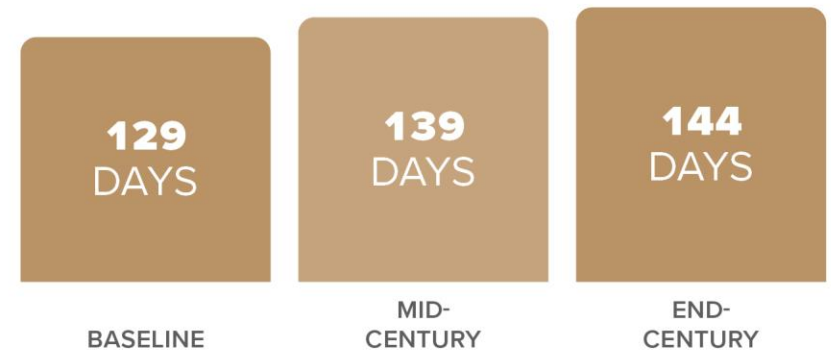
Extreme Drought Events



Present and Future

Glendale is expected to experience increased drought conditions through the end of the century. There is increased likelihood that low precipitation years will coincide with above-average temperature years. The average annual maximum length of dry spell is projected to increase 15 days by the end of the century.

Projected Annual Average Dry Spell Duration



Impacts on the Built and Natural Environment



Vegetative Stress



Water Scarcity



Habitat Loss



Strained Water System

Impacts on Vulnerable Populations



Food security



Air Quality Decline



Mental and Behavioral Health



Respiratory Illness



WILDFIRE

Past

The frequency and intensity of wildfire has historically impacted Glendale and the Region over the past two decades.

Acres Burned by Decade Over the Past 50 Years

Decade	City limits Acres Burned	Total Acres Burned
1970s	1,082	51,778
1980s	896	7,002
1990s	2,642	58,841
2000s	1,629	161,582
2010s	399	7,051

*As of August 2023, there have been no wildfire above 300 acres in the City

Present

Wildfires can be catastrophic, damaging habitat, destroying homes and businesses, disrupting essential services, and damaging critical infrastructure. Two-thirds of the city is highly susceptible to wildfires.

Factors Affecting Wildfires



Weather



Topography



Vegetation & Fuels

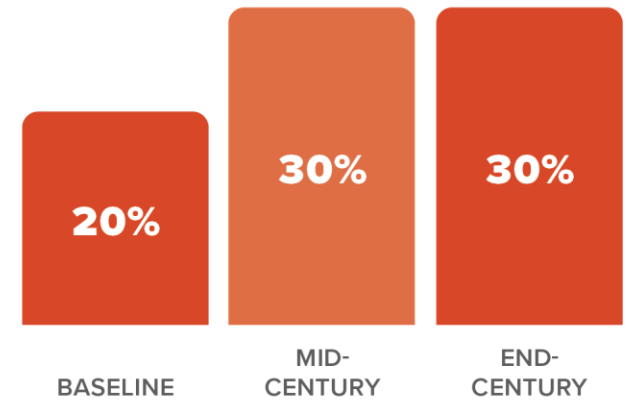


Firefighting Resources

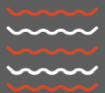
Future

Wildfire risk is projected to increase through the end of the century with more days of extreme wildfire risk and increased wildfire occurrence.

Projected Annual Wildfire Probability



Impacts on the Built and Natural Environment



Worsening Water Quality



Power Delivery Disruption



Structure & Property Damage



Habitat Loss



Strained Emergency Services

Impacts on Vulnerable Populations



Public Health & Safety Risks



Mental & Behavioral Health



Respiratory Illness



Air Quality Decline



Fatal & Nonfatal Injury



Income Loss





LANDSLIDES

Past

Landslide occurrences have historically affected the City of Glendale during extreme precipitation events preceded by intense wildfire.

Major Landslide Occurrences by Year

1962  **2** 

1965 **1** 

1972 **1** 

Present

The highest risk of landslides are in areas with steep geography, as mapped by the California Department of Conservation. Wildfires can trigger heightened short-term landslide or mudflow risk in fire-scarred areas.

Exposed Structures

Area	Most Probable Slope Instabilities
San Gabriel Mountains	Rockfalls, soil slips on steep slopes, soil slumps on the edges of active stream channels, small to large debris flows.
San Rafael Hills <i>(north of Highway 134)</i>	Soil slips and slumps on moderate to steep slopes and in drainage swales, small debris flows, small slides or rockfalls, surficial soil failures on steep man-made slopes.
Verdugo Mountains	Soil slips and slumps on moderate to steep slopes and in drainage swales, small debris flows, small slides or rockfalls, surficial soil failures on steep man-made slopes.

Future

Triggered by extreme precipitation events or wildfires, the susceptibility of the City of Glendale to landslides is projected to increase as precipitation variability increases and wildfires increase in frequency, size, and severity.

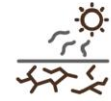
Hazards Affecting Landslides



Wildfire



Flooding



Drought

Impacts on the Built and Natural Environment



Habitat Loss



Erosion



Strained
Emergency
Services



Property
Damage

Vulnerable Populations Impacts



Public Health
& Safety Risks



Fatal & Nonfatal
Injury



Income
Loss



Mental and
Behavioral
Stressors



Water-borne
Disease



STORMWATER FLOODING AND EXTREME PRECIPITATION EVENTS

Past

Historically, major flood events in the City of Glendale are associated with atmospheric rivers. There have been several extreme precipitation events in Glendale with the most severe flood occurring in 1934.

Contributors to Flooding Include:



Local Geology



Built Environment

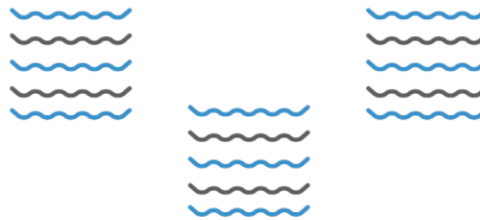


Geography

Present

The City is not within a 100-year or 500-year FEMA floodplain zone. However, flooding can occur as a result of overwhelmed stormwater systems

Glendale Currently Experiences 3 Atmospheric Rivers per Year

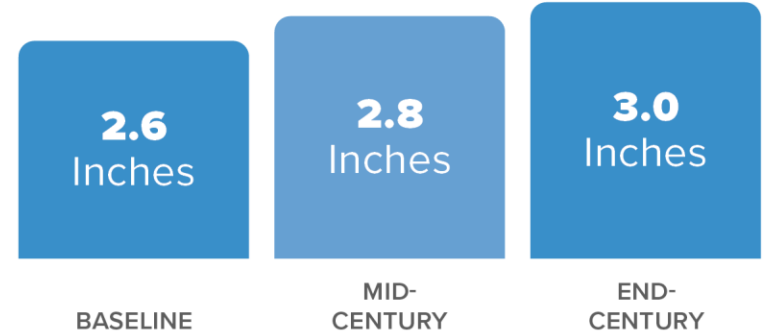


Future

Stormwater systems are designed for a certain rain event based on historical averages. With climate change, the stormwater system could be more frequently overwhelmed when events occur that exceed the storm year design.

The frequency of atmospheric river events may increase in the future with some locations in Glendale experiencing 25-30% increases in the wettest annual day.

Maximum One Day Precipitation



Impacts on the Built and Natural Environment



Strained Emergency Services



Stressed Water Drainages



Property Damage



Habitat Loss

Impacts on Vulnerable Populations



Public Health & Safety Risks



Water-borne Disease



Mental & Behavioral Stressors



Income Loss

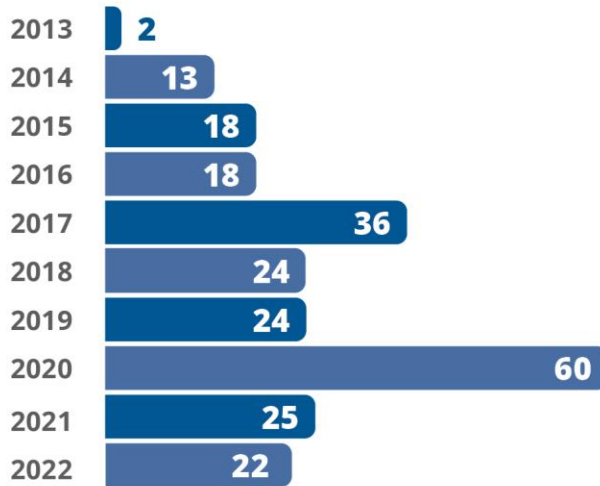


POOR AIR QUALITY

Past

Historic poor air quality events coincide with regional wildfire events, periods of time without wind, extreme heat events, and extended droughts. Data over the last decade indicates an increase in days where ozone levels are above the national standard of 0.070 ppm within the region.

Days Above Standard Ozone Levels



Present

Poor air quality exposure in Glendale is commonly a hazard within the area. Glendale experiences more poor air quality days compared to other areas across the state and even the region. Common types of air quality issues for Glendale include smog and seasonal wildfire smoke.

Types of Air Quality Hazards



Dust



Smog



Fewer Natural Filtrations

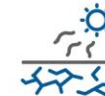


Wildfire Smoke

Future

Climate change may lead to a decline in air quality regionally as well as throughout Glendale. Air quality is expected to worsen in Glendale due to extended droughts, more frequent wildfires, increased ambient temperatures, and sporadic natural filtrations of wind.

Hazards Affecting Air Quality



Drought



Wildfire



Temperature

Impacts on the Built and Natural Environment



Vegetative Stress



Wildlife Stress



Strained Emergency Services

Impacts on Vulnerable Populations



Public Health & Safety Risks



Mental & Behavioral Health



Respiratory Illness

3 Social Vulnerability Assessment

3.1 What is Social Vulnerability

While all populations in a community will be affected by climate hazards, some individuals are more vulnerable due to physiological conditions and inequitable systems and structures and therefore will be disproportionately impacted. For example, seniors (over 65 years old); young children (under 5 years old) and their parents and caregivers; and pregnant women are more at-risk than the general population to heat illness during an extreme heat event. Vulnerable populations experience heightened risk to climate change and have inequitable access to resources to adequately adapt and recover from the associated impacts. Glendale is home to several vulnerable populations (see Table 5 and Figure 5), some of whom have already been disproportionately harmed by climate change.

3.2 Social Vulnerability Index Score

A social vulnerability index was developed to identify the location and areas of highest concentrations of climate-vulnerable population groups in Glendale based on 31 population data indicators (see the highlighted rows in Table 5). Each indicator represents a characteristic that either increases a person's physiological vulnerability to climate hazards or decreases the ability of an individual to prepare for, cope with or recover from climate hazards due to systemic inequities. Selected indicators are consistent with guidance in the Cal APG (Cal OES 2020) and SCAG APG (SCAG 2020). The indicators also reflect input from community-based organizations provided during the City-held Focus Group

Meetings (see *Interested Parties Focus Group Meetings* section above). For more information on why these population characteristics are considered vulnerable to climate change impacts, see the *Social Vulnerability by Climate Hazard* section. Data for these indicators was obtained from the Census Bureau's American Community Survey 2017-2021, CDC's PLACES Health Data, U.S. Department of Energy LEAD Tool, Esri's Crime Index data, and California Immigrant Data Portal.

The 27 population data indicators are organized into four separate groups for the purposes of this assessment. Grouping populations allows the City to understand what systems and structures contribute to increased vulnerability to climate change hazards. Through identification of factors that contribute to population vulnerability, adaptation solutions can be developed that specifically address those contributing factors. Population groupings are as follows:

1. **Individuals with High Outdoor Exposure.**
2. **Under-resourced Individuals.**
3. **Individuals Facing Societal Barriers.**
4. **Individuals with Chronic Health Conditions or Health Related Sensitivities**

The indicators were used to assess the geographic location and proportion of vulnerable populations in Glendale who may be more impacted by climate hazards. Data for these indicators was obtained from the Census Bureau's American Community Survey 2017-2021, CDC's PLACES Health Data, U.S. Department of Energy LEAD Tool, and Esri's Crime Index data. The Social vulnerability analysis was

conducted to identify the concentration of each population group in each census tract in Glendale. Figure 5 displays social vulnerability in Glendale by census tract. Census tracts with high proportions of vulnerable populations, relative to state statistics, have higher percentile rankings on the 0 percent to 100 percent scale. The higher the percentile, the higher the vulnerability to climate change. The areas of Glendale with the greatest concentration of vulnerable populations are in south and southwest Glendale Census tracts that are above the 60th percentile are considered a high social vulnerability area. Notably, the Grayson Power Plant is located in a high social vulnerability area. Figure 5 also displays additional areas with high social vulnerability, beyond what was identified using existing data and state tools, that were identified by representatives from local community-based organizations as part of the City-held Focus Group Meetings (see dotted areas in Figure 5). The additional focus areas were determined using a 1/4-mile buffer around schools (which is where children, a climate-vulnerable population group, spend much of their time), I-5, (SR 134), Brand Boulevard, the Scholl Canyon Landfill and the Grayson Power Plant. In addition, the areas south of SR 134 and west of Brand Boulevard are included as additional vulnerable focus areas, as identified during the Focus Group meetings.

Systemic Inequities

Individuals facing societal barriers include marginalized individuals due to their race, ethnicity, gender, sexual orientation, disability, economic status, or immigration status, all of whom encounter systemic obstacles that can limit their access to opportunities, resources, and fair treatment, are directly impacted by systemic social and economic inequities. These challenges create educational, resource, economic, and health disparities that leave communities extremely vulnerable to climate change impacts (Baird 2008). When looking at the intersectionality and compounding impact of these societal barriers, these communities are more likely to face high outdoor exposure, be systematically under-resourced, be subjected to toxic stress and/or have chronic health conditions, live in high-hazard risk areas and substandard housing, and are less likely to be homeowners (APA 2012). These systemic factors make them disproportionately vulnerable to climate hazards. In the City, many of these individuals face compounding risks associated with linguistic and income barriers. Immigrants and people who are undocumented are often deprived of access to medical services, quality housing, and basic needs, as well as access to social and economic services (Gamble et al. 2016). Additionally, historical mistreatment and underserving by government leads to distrust, which compounds the lack of access to resources even when they do available.

Table 5 Vulnerable Populations in Glendale

Population Type	Population Description	Percentage of Total Population/Household Type
Individuals with High Outdoor Exposure		
Outdoor Workers	Individuals who are employed, 16 and older, and work outdoors	8%
People experiencing houselessness ¹	Individuals who currently lack fixed, regular, and adequate housing	0.1%
Visitors ²	Individuals who are not residents and are visiting the study area for a limited time	Not Available
People who use active transportation*	People who primarily get around by walking, biking, or other active mode of transportation	9%
People who use public transit*	People who primarily get around by buses, trains, subways, and other forms of public transportation	3%
Individuals Facing Societal Barriers		
Black, Indigenous, and People of Color (BIPOC)	Individuals who do not identify as white	23%
Native Americans	Individuals who identify as American Native and Alaskan Native	0.6%
Limited or non-English speakers	Households with individuals who are non or limited English-speaking	11%
Immigrants ³	Individuals residing in the United States with legal documentation	51%
People who are undocumented ⁴	Individuals residing in the United States without legal documentation	6%
Individuals with Chronic Health Conditions or Health Related Sensitivities		
Seniors	Individuals 65 years or older	18%
Young children and their parents/caregivers*	Individuals 5 years and younger	5%
People who are differently abled	Individuals with access and functional needs (physical and mental)	26%
Individuals with asthma*	Individuals diagnosed with asthma	9%
Individuals with cardiovascular disease	Individuals diagnosed with coronary heart disease	6%
People with diabetes*	Individuals diagnosed with diabetes	9%

City of Glendale
Climate Change Vulnerability Assessment

Population Type	Population Description	Percentage of Total Population/Household Type
People with high blood pressure*	Individuals diagnosed with high blood pressure	28%
People with stroke risks*	People with disproportionately high risk for stroke	3%
Military Veterans	Individuals who have served but are not currently serving in the US Armed Forces	2%
Pregnant people*	Individual with a baby or babies developing inside the womb	Not Available
Under-Resourced Individuals		
People experiencing poverty	Household incomes less than 80-% the State median household income	14%
Unemployed	Percentage of population aged 18-64 who are unemployed	7%
Individuals with no health insurance	Individuals aged 18 to 64 years old currently uninsured	7%
Households without a computer	Households without access to a computer	6%
Households without broadband internet	Households without access to broadband internet	26%
Renters	Housing units that are renter occupied	64%
Individuals without vehicle access	Individuals without access to a vehicle	17%
Single female heads of household with kids	Households with kids supported by a single female	14%
Individuals with education attainment less than 4 years of high school	Percentage of people over age 18 without a high school education or higher	10%
People in overcrowded households	Household with more than one person per room	5%
Mobile home households	Housing units that are mobile homes	0.1%
Households experiencing housing burden	Percentage of gross household income spent on housing costs	11%
Students	Individuals 3 years and older enrolled in school	23%
People who live in areas of high violent crime	Percentage of areas that have an above average risk of crime occurring relative to the US average.	63%

Population Type	Population Description	Percentage of Total Population/Household Type
Households using fuels for heating*	Households using solid fuels, kerosene, and gas to heat home	78%
Residents without air conditioning ^{7*}	Households without air conditioning	Not Available
Households experiencing energy burden	Percentage of gross household income spent on energy costs	1%

Highlighted rows indicate population indicators for which census level data for Glendale was available, and therefore were included in the social vulnerability index mapping.

* Populations added based on Focus Group input.

¹ People experiencing houselessness percentage is calculated using data for Glendale from the City’s 2023 Glendale Homeless County (195 sheltered and unsheltered) and the 2020 City of Glendale Population from the Census (196,543). Data for this group was not available at the Census tract level for Glendale and therefore was not included in the Social Vulnerability Index.

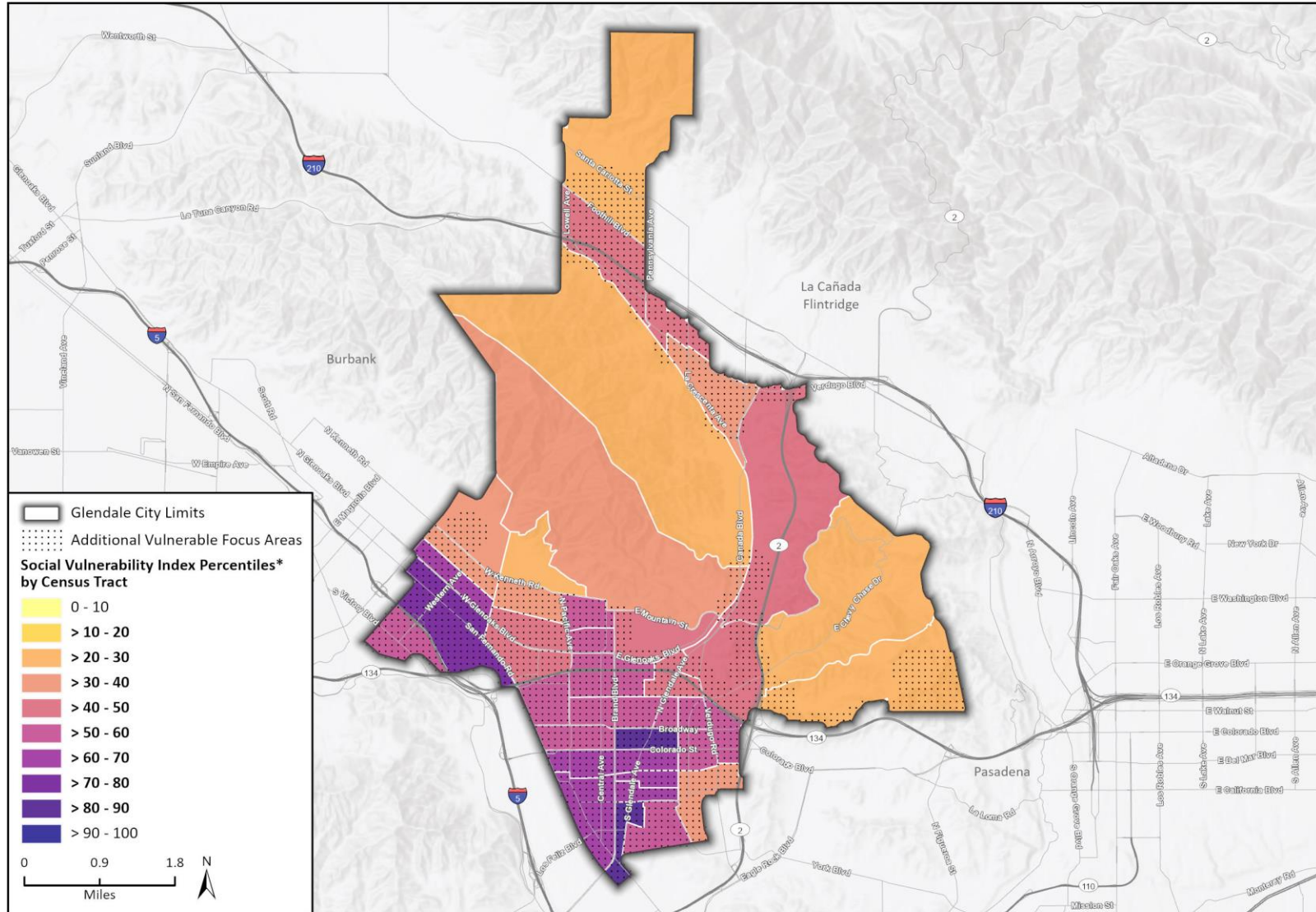
² Data for visitors was not available at the Census tract or City level for Glendale and therefore was not included in the Social Vulnerability Index.

³ Immigrants with legal documentation percentage is calculated using data for Glendale and is sourced from the California Immigrant Data Portal (99,796 immigrants with legal documentation in Glendale in 2019, most recent year available) and the 2020 City of Glendale Population from the Census (196,543). Data for this group was not available at the Census tract level for Glendale and therefore was not included in the Social Vulnerability Index.

⁴ People who are undocumented is calculated using data for Glendale and is sourced from the California Immigrant Data Portal (11,130 undocumented immigrants in Glendale in 2019, most recent year available) and the 2020 City of Glendale Population from the Census (196,543). Data for this group was not available at the Census tract level for Glendale and therefore was not included in the Social Vulnerability Index.

Source: The percentages used in this table were acquired from the U.S. Census, 2021 American Community Survey (ACS), CDC’s PLACES Health Data, Esri’s Crime Index, and U.S. Department of Energy LEAD Tool.

Figure 5 Social Vulnerability in Glendale



Basemap provided by Esri and its licensors © 2023. Additional data provided by Esri Updated Demographics, 2022; U.S. Census Bureau, (ACS 2017-2021), 2020; CDC, 2010; LEAD tool, 2018. Social Vulnerability Analysis calculated by Rincon Consultants, Inc., 2023. * The City of Glendale's Social Vulnerability Index Percentiles range from 20 to 85.

21-11575 Glendale CAAP VA.aprx
 Fig X Social Sensitivity Analysis

3.3 Social Vulnerability Overview

Vulnerability is the propensity or predisposition of a certain asset or population group to be adversely affected by climate change impacts. The following subsection provides an overview of what makes the vulnerable population groups more susceptible to climate change impacts. The *Social Vulnerability by Climate Hazard* Section provides:

- An overview of the impacts of climate hazards
- Potential impacts of climate hazards to each of the four population groups
- City-led and community adaptive capacity
- Vulnerability score which is a combined score of the potential impact and adaptive capacity for each of the four population groups by climate hazard

Information for impacts on populations and adaptive capacity was pulled from government sources and peer reviewed articles and supplemented using information provided by City staff during the Sustainability Working Group meeting and community-based organizations during Focus Group meetings (for more information on these meetings, refer to the *Sustainability Working Group Meeting and Interested Parties Focus Group Meetings* section of the report). Adaptive capacity is the ability to adjust to the consequences of climate change. Types of adaptive capacity include adjustments in behavior, resources, and technologies. There are other forms of adaptive capacity that are led by institutions (e.g., schools, religious institutions), community-based organizations, non-profits, special districts, and other nongovernmental entities. The two types of adaptive capacity that are discussed in this report:

1. **City-led adaptive capacity** indicates the ways in which the City currently manages the negative impacts of climate change through City and utility-led plans and programs.
2. **Community-scale adaptive capacity** The ability of a community to deal with climate-related challenges, like extreme weather, can be improved by features in both the man-made and natural surroundings, as explained in the Los Angeles County Climate Vulnerability Assessment.

Both City-led and community-scale adaptive capacity are assessed for each population group by climate hazard.

An impact score and an adaptive capacity score are identified for each vulnerable population group by climate hazard, along with an overall vulnerability score consistent with the scoring methodology provided in the *Vulnerability Scoring Methodology* Section. Vulnerability scoring helps the City understand which climate effects pose the greatest threats and should be prioritized in adaptation planning and policy.

The results of the analysis will inform the development and prioritization of adaptation policies and programs to increase community resilience as part of the City of Glendale CAAP and Safety Element Update.

Indicators that Drive Community Vulnerability

Below is an overview of the vulnerability indicators for each population group that drive community vulnerability to climate change. This assessment acknowledges how the intersectionality of systems compound individuals' vulnerability across multiple factors at once; however, for the purpose of this assessment, analysis was conducted based on the vulnerability that increases an individual's risk to the greatest degree.

Individuals with High Outdoor Exposure

Outdoor workers, people experiencing houselessness, visitors, and people who use active transportation and public transit face high outdoor exposure, which increases vulnerability to potential climate hazards. Approximately 8 percent of the population in Glendale are outdoor workers and face high risk of climate hazards.

Glendale has an estimated 195 people experiencing houselessness in 2023 (City of Glendale 2023). There is a significant concentration of people experiencing houselessness that are unsheltered in the Downtown Area, particularly in Central Park (City of Glendale 2023). Central Park offers access to vital resources for the unsheltered population, including the Central Library and the Adult Recreation Center (City of Glendale 2023). People experiencing houselessness often suffer from high rates of respiratory conditions, mental illness, and other chronic health conditions and therefore are more vulnerable to climate hazards (CDPH 2020).

Glendale offers hiking trails, a diversity of restaurants, and icon sites such as the Alex Theatre, to visitors. Visitors are at risk because they may not receive warning during emergency events and are more likely to be unsure of how or where to receive help, or how to evacuate. Visitor deterrence, which could occur during and following climate hazards, would have impacts on the local economy (Gamble et al. 2016).

In Glendale, 17 percent of households do not have access to a vehicle (U.S. Census ACS 2021). People without access to a vehicle use active transportation, such as walking and biking, and public transit to get around. People who rely on active transportation or public transit have higher outdoor exposure, such as extreme heat, air pollution, or heavy rainfall, than those who use personal vehicles and are therefore at greater risk to climate hazards. This high risk is compounded by the fact that communities of color are more likely

to have limited or no access to a car, increasing their likelihood of being impacted during heat and other climate hazards (CDPH 2020). People who rely on active transportation or public transit may experience barriers in accessing cooling centers, evacuating in a timely fashion, and have a greater likelihood of encountering interruption in transportation services which could lead to direct income losses from the inability to access their workplace during climate events.

Under-resourced Individuals

Under-resourced individuals have inequitable access to resources with which to prepare for, cope with, and recover from climate change impacts, due to economic disparities, social inequities, geographical location, lack of education, policy gaps, historical factors, and limited social networks, which further exacerbates vulnerability to climate impacts. Individuals who are unemployed or people experiencing poverty often face financial barriers when preparing for and recovering from climate change hazards. Individuals in these groups often live in homes that are less protected against climate hazards or are more likely to be renters so are unable to make needed home improvements. People experiencing poverty may not be able to take time off work to address health concerns either caused by or exacerbated by climate hazards, such as heat-related illnesses, respiratory problems from air pollution, or injuries resulting from extreme weather events, leading to further challenges in managing their well-being and financial stability. People experiencing poverty in conjunction with food and housing insecurity are rendered systematically more vulnerable than the general population to many co-morbid health issues. Glendale's current unemployment rate averaged over 5 years is 6.6 percent, higher than the county and state unemployment rates (Glendale Memorial Hospital and Health Center 2022). The current poverty rate for Glendale is 13.9 percent

with an estimated 27,065 citizens of 195,227 living in poverty (Welfare Info). Neighborhoods experiencing more than 25 percent poverty include densely populated communities adjacent to major roadways such as I-5 in the southern and central parts of the city (City of Glendale Income and Poverty). These neighborhoods largely consist of marginalized communities where population density is 5,000 to 30,000 people per square mile (City of Glendale Census 2010).

Single female heads of households, as defined by the U.S. Census as female householders with children under 18-years-old and no spouse/partner present, are often subjected to high levels of work-life conflict and financial hardship, which can make preparing for, coping with, and recovering from climate hazards difficult. They are also more likely to serve as the primary caretaker of children which can make evacuating during a hazard scenario difficult (Flanagan et al. 2011). Additionally, women's wages, on average, are lower than their male counterparts. According to U.S. Census Bureau data, in 2020, women earned 84 percent of what men earned (Pew Research Center 2021). This disparity is even more extreme for Black women who earned on average 64 percent of what white, non-Hispanic men earned in 2020 (Bleiweis et al. 2021). On average, Glendale single female heads of households experience poverty levels of nearly 22 percent across the city's census blocks. In the most densely populated areas of the city, this rate reaches highs of 37.3 percent (Glendale Memorial Hospital and Health Center 2022). As such, they will likely experience increased difficulties preparing for and recovering from climate hazards.

Individuals with educational attainment of less than 4 years of high school usually have lower earning potential and are twice as likely to be unemployed than those with a high school degree (Association of Public and Land-Grant Universities N.d). Individuals with low educational attainment are more likely to work in outdoor

and/or labor-intensive environments thus increasing the impact of climate events (CDPH 2017). In the Glendale area, 16.5 percent of adults, aged 25 and older, lack a high school diploma (Glendale Memorial Hospital and Health Center 2022). Under-resourced individuals are less likely to have access to transportation, healthcare, and other basic needs and often lack the financial resources to evacuate from a climate hazard or find a safe and affordable place in which to evacuate.

Households without a computer or broadband internet access may be less likely to receive emergency alerts or governmental guidance before, during, or after a climate hazard event, making them particularly vulnerable in evacuation scenarios. Individuals without health insurance are more likely to have undiagnosed pre-existing health conditions and inadequate access to preventative care and treatment, which may make them more vulnerable to health impacts from climate hazards (Gamble et al. 2016). According to the Glendale Memorial Hospital and Health Center Community Health Needs Assessment from 2022, Glendale overall has very high health insurance rates at 96.6 percent. However, minority ethnic groups tend to have lower health insurance rates. Glendale BIPOC communities on average have health insurance rates of 86 percent (Glendale Memorial Hospital and Health Center Report 2022).

Individuals who rent housing have limited ability to weatherize their homes for hazard events. Mobile home households also often do not have adequately weatherized homes. For example, renters may not have temperature control in their housing units and generally experience a higher water and energy utilities cost burden than homeowners (Cooley et al. 2012).

Households experiencing housing cost or energy cost burden are less likely to have financial resources to prepare for, respond to, or recover from impacts. Individuals living in overcrowded housing are more likely to face health and safety concerns and face financial

barriers when preparing for and recovering from climate hazards (EPA 2022). In Glendale, 48.7 percent of owner and renter occupied households are cost-burdened, which is higher than both the county and state rates (Glendale Memorial Hospital and Health Center Report 2022). Over half of the Glendale ZIP codes serviced by the Glendale Memorial Hospital and Health Center have cost-burdened population rates of over 50 percent (Glendale Memorial Hospital and Health Center Report 2022). 2022).

Residents who lack air conditioning are at extreme risk of health impacts particularly associated with extreme heat. About 30 percent of households in California. Of those households without air conditioning, a majority are in low-income communities (Chen et al. 2020)

People who live in areas of high violent crime are more likely to live in areas with neighborhood instability and economic disadvantage. Additionally, one study found that 20 percent of most disadvantaged neighborhoods are predicted to absorb over 50 percent of climate change-related increases in violence. This highlights the critical link between environmental stressors, resource scarcity, and social vulnerability, as these areas often struggle with limited access to essential resources, economic opportunities, and social services. This lack of resources can intensify tensions and conflicts when compounded by the additional pressures brought on by climate change impacts, leading to heightened levels of violence in heat-stressed neighborhoods (Plante and Anderson 2017). In Glendale, from 2012 to 2017, there were 2,887 arrests, generating \$1,196,547 in incarceration rates (MDH 2017). Most of the documented crime in Glendale occurs around densely populated, marginalized communities adjacent to I 5 and SR-134 (Neighborhood Scout 2023). Glendale experiences disproportionate rates of arrests by race and these rates are likely

to continue to increase, exacerbated by heat inequity from climate change impacts.

Students may experience educational disruption and setbacks including reduced rate of graduate and college attendance as a result of climate hazards that cause school closures, loss of personal property, and/or psychological distress, particularly students with additional characteristics that increase sensitivity to climate hazards. Additionally, students have limited ability to modify the physical conditions at school that affect climate hazard exposure and risk such as air filtration and air conditioning (GAO 2022).

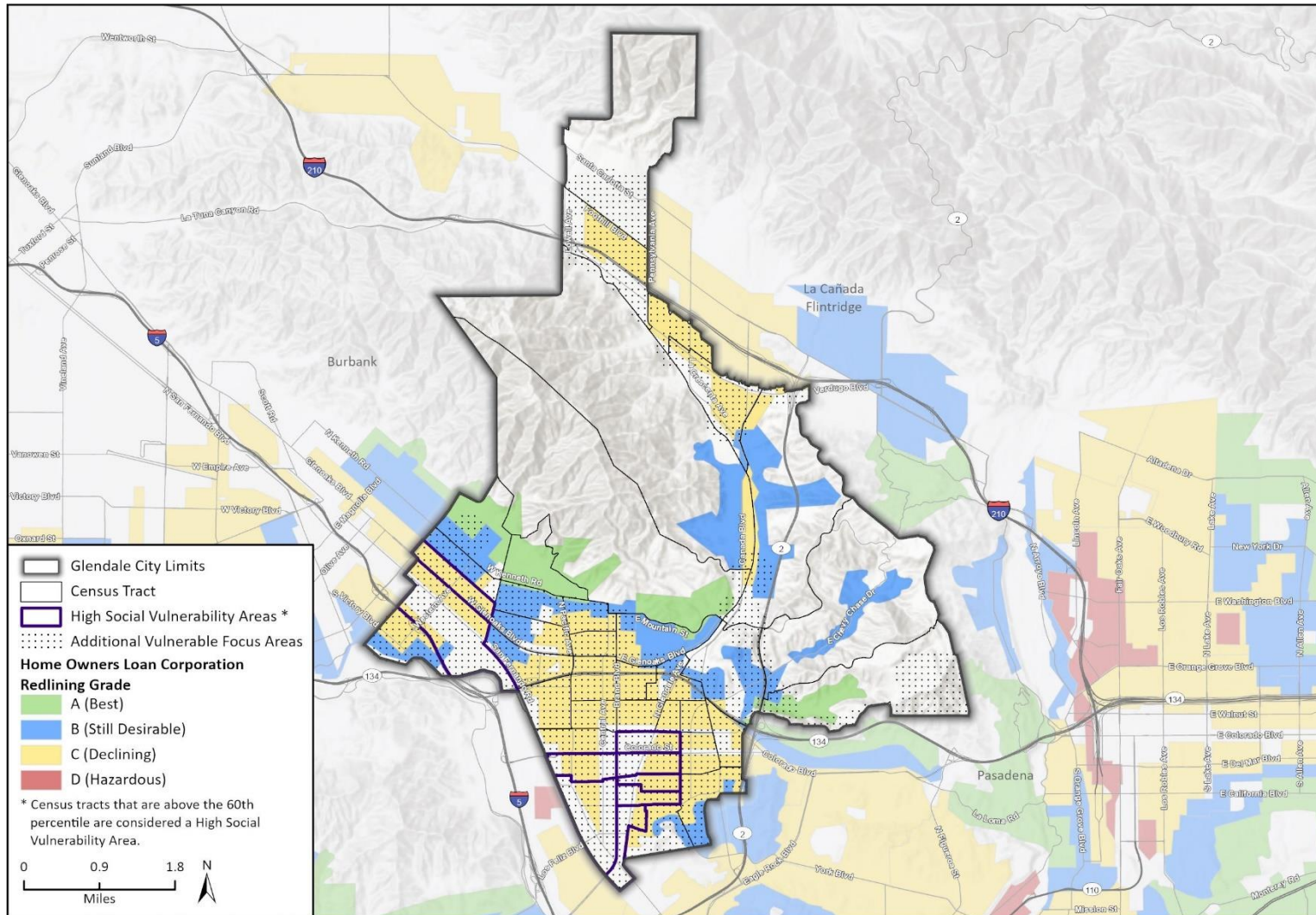
Individuals Facing Societal Barriers

Glendale is located within the ancestral lands of the Tongva people. Because many Native American people experience some degree of the implications of colonial violence, cultural erasure, and social marginalization, they are more likely to be under-resourced and experience poverty (Rogers 2012). Not all City residents who identify as Native American have ties to tribal communities, which affects the ways in which climate hazards impact individuals. In 2020, one in three Native Americans across the United States were living in poverty (Northwestern Institute for Policy Research 2020). Native Americans often experience worse health outcomes and lower life expectancies compared to other populations due to a variety of systemic factors including toxic stress due to regularly experiencing racism and other systemic harms, disproportionate poverty, and discrimination in the delivery or accessibility of health services. Native Americans are also less likely to have health insurance, which may limit their ability to seek medical care for injuries or illnesses caused or exacerbated by climate change impacts (Rogers 2012). Native Americans are more likely to live in high-hazard risk areas and less likely to be homeowners, which

leaves them vulnerable to climate impacts (Gamble et al. 2016). Within the vulnerability analysis, potential impacts to Native American populations are discussed in the context of Black, Indigenous, and People of Color (BIPOC).

Recently, the City of Glendale recognized its past with racial injustices by unanimously passing a resolution apologizing for its history as a “sundown town” (Crouch 2020). A sundown town is the term for predominantly white towns and cities across the nation that attempted to keep their towns minority-free through violence, discriminatory legislation, and harassment. These places were areas in which City officials posted notices that minorities could work and travel in the town, but had to leave by sunset, or “sundown” (Christmas 2021). The history of violence and discriminatory laws against people of color and marginalized communities extends beyond the direct harassment and exclusion of these peoples in Glendale’s history through legislation such as the intentional neighborhood redlining, as described in *Individuals Facing Societal Barriers*. Now, as climate change impacts threaten all of Glendale’s citizens, these communities are feeling the generational effects of racial injustice, stemming from the City’s past as a “sundown town.” These communities predominantly reside in C-graded neighborhoods, as depicted in Figure 6, and face climate vulnerabilities such as increased pavement, lack of trees for adequate cooling (Figure 7), and heat inequity. While Glendale addresses its history as a sundown town, the effects of its past on marginalized communities are being exacerbated by climate change and continue to shape their inequitable climate vulnerabilities.

Figure 6 Glendale High Social Vulnerability Areas and Home Owners' Loan Corporation (HOLC) Neighborhood Redlining Grade



Basemap provided by Esri and its licensors © 2023. Additional data provided by CAL FIRE, 2007 & 2012; City of Glendale, 2023. Additional data provided by Esri Updated Demographics, 2022; U.S. Census Bureau, (ACS 2017-2021), 2020; CDC, 2010; LEAD tool, 2018; HUB Segregation and Integration, AFFH 2.0, 2023. Social Vulnerability Analysis calculated by Rincon Consultants, Inc., 2023. 23-11575 Glendale CAAP VA.aprx Fig X High Social Sensitivity and HOLC Redlining Grade

Tree Equity Score

The number and distribution of trees in cities in the United States, often reflects differences in race and income across city landscapes. While the amount of paved and impermeable surfaces and lack of water features and green spaces can increase the impact of temperature increases from climate change, adding more green spaces and especially trees, can have the opposite effect. Trees provide several critical services to cities and residents including shade, improved air quality, increased rain interception and reduced stormwater runoff, and in great enough numbers, trees can cool ambient temperatures and reduce the impact of climate change and extreme heat on public health.

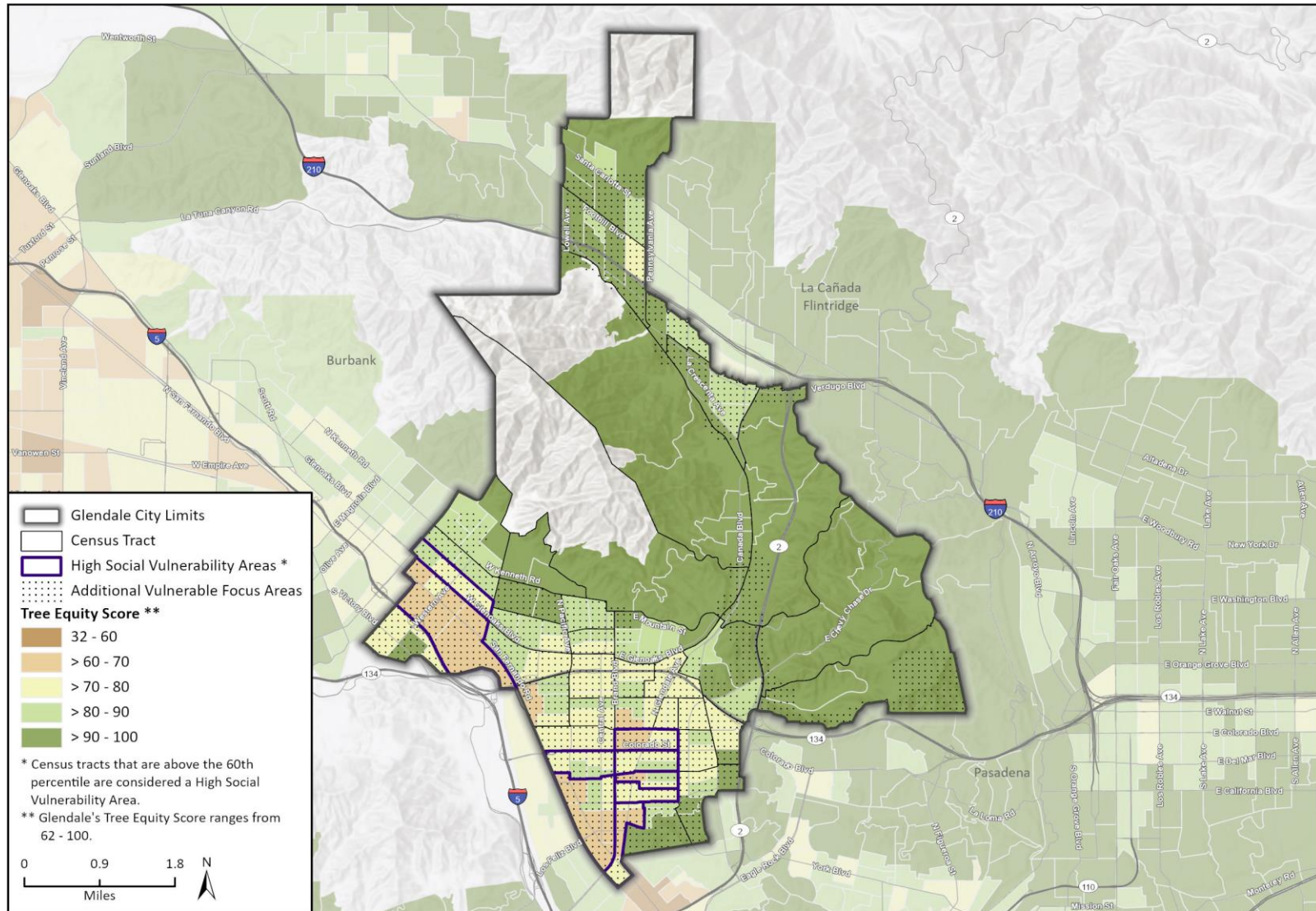
Treeequityscore.org analyzes a range of neighborhood characteristics including the existing tree canopy, population density, income, employment, surface temperature, racial demographics, age distributions, and health metrics to create a single tree equity score between 0 and 100. A score of 100 would indicate that a neighborhood has achieved tree equity.

Of the 137 census block groups included in the Tree Equity Score Municipality Report for Glendale, 11 have a tree equity score below 70.

Comparing the HOLC map in Figure 6 and the Tree Equity Score map in Figure 7 can shed some light on the legacy of redlining and historic disinvestment on current levels of heat risk throughout the City. In line with the research referenced above, the southern and western portions of Glendale that had C (Definitely Declining) graded neighborhoods continue to have fewer trees, and lower tree equity scores relative to the rest of the City. Neighborhoods just north of West Kenneth Road and East Mountain Street and in east

Glendale, north of SR 134 which received an A grade have some of the highest tree equity scores in the City.

Figure 7 Glendale High Social Vulnerability Areas and Municipality Tree Equity Score



Basemap provided by Esri and its licensors © 2023. Additional data provided by CAL FIRE, 2007 & 2012; City of Glendale, 2023. Additional data provided by Esri Updated Demographics, 2022; U.S. Census Bureau, (ACS 2017-2021), 2020; CDC, 2010; LEAD tool, 2018; Tree Equity Score National Explorer, 2023. Social Vulnerability Analysis calculated by Rincon Consultants, Inc., 2023.

Individuals with Chronic Health Conditions or Health Related Sensitivities

Individuals with chronic health conditions or health related sensitivities are socially and physiologically vulnerable to climate change impacts and hazards. Seniors and people who are differently abled may have limited or reduced mobility, mental function, or communication abilities, making it difficult to evacuate during or prepare for a climate hazard event. They may also have medical needs for electricity which may be impacted during a public safety power shutoff or climate hazard event. Individuals in these groups are more likely to have pre-existing medical conditions or chronic illnesses that may exacerbate the risk of illnesses and medical problems from climate hazards. Individuals with asthma, individuals with cardiovascular disease, individuals with diabetes, individuals with high blood pressure, and individuals with stroke risk are more likely to experience health impacts from climate hazards because of pre-existing conditions or diseases. Seniors often face challenges regulating their temperature due to medications or underlying conditions related to age. Young children are socially and physiologically vulnerable to climate hazards. They often have limited understandings of climate hazards and insufficient resources to independently prepare for and safely respond during a climate hazard event. Young children are reliant on their caregivers to ensure their health, safety, and wellbeing. Young children have not fully physiologically developed and are therefore more vulnerable to health effects of climate change impacts. (Kenney et al. 2014). The caregivers of young children are also at risk during some climate hazard events as they may face challenges navigating an evacuation process with young children. Military veterans may have been exposed to a variety of environmental, physical, and chemical stressors during military service which may have caused physiological or psychological health conditions, illnesses, or

different abilities that make them particularly vulnerable to climate hazards (Olenick et al. 2015). Pregnant people and their fetuses are particularly vulnerable to climate hazards as they are susceptible to certain health conditions, including anemia, low birth weight, preterm birth, and miscarriage. Pregnant people are also at increased risk of experiencing post-traumatic stress disorder and depression after a climate hazard event (EPA 2022).

Residents in households using fuels for heating, as opposed to electricity, are more likely to be impacted by indoor combustion pollutants. Combustion pollutants are the gases and particles made by burning any fuel such as natural gas, diesel, and kerosene. Exposure to combustion pollutants may lead to adverse health impacts that can make individuals more at risk of climate hazards. For example, cooking emissions, especially from gas stoves, are associated with increased respiratory disease (CARB 2023).

3.4 Social Vulnerability by Climate Hazard

This section assesses the potential impacts, adaptive capacity, and the resulting social vulnerability, of each population group by climate hazard.



Extreme Heat and Warm Nights

Overview

Extreme heat was a major issue identified during Focus Group Meetings 1 and 2. Specifically, the lack of air conditioning in housing units, limited protection for renters, and the urban heat island effect in areas with high proportions of vulnerable populations were identified as areas of concern. Below is an overview of the urban

heat island effect, historical causes of inequitable heat exposure, tree equity score in Glendale, and compounding risks of housing and heat related illness.

Sustainability Working Group participants also identified extreme heat as a major concern. Participants noted having to close facilities due to broken Heating, Ventilation, and Air Conditioning (HVAC) during extreme heat events, and warnings of rolling blackouts.

URBAN HEAT ISLAND

Urban Heat Island (UHI) refers to developed areas that are hotter than the surrounding landscape primarily due to the use of building materials and surfaces that absorb and re-radiate heat (like roofs and pavements), as well as a lack of vegetation, particularly trees. The UHI effect causes people in cities to have higher heat exposure than residents in less densely developed areas. Within urban landscapes, neighborhoods with more impermeable and dark colored surfaces, and fewer trees, parks, and water features, have greater heat exposure and heat related risk than urban communities with more green space and reflective surfaces. These differences in development patterns typically correspond with income and demographic disparities across the urban environment. Low-income communities and many communities of color across Los Angeles County are the most impacted by the urban heat island effect (LA CDPH 2021). UHI will likely compound the impact and risk of extreme heat days and higher average temperatures resulting from climate change. In some locations, the effect could be twice as strong as the impact of global warming (Huang et al. 2019).

In Glendale, the UHI effect will most likely impact vulnerable communities in densely populated communities without access to green spaces, open areas, or reflective surfaces. According to the Urban Heat Island Interactive Map from the California Environmental Protection Agency (CEPA UHI), the areas of Glendale

which will experience the most intense UHI effect are the southwest neighborhoods along I-5 and the northeast neighborhoods along I-210 (CEPA UHI). These areas have historically been socially vulnerable areas in C-graded neighborhoods (Figure 6) which have experienced racially motivated redlining and currently experience low tree equity scores (Figure 7). The UHI effect is calculated per urban census tract in degree-hours per day, in which the temperature differences every hour per day over 182 warm summer days are summed, then divided by the number of days in the study. In Glendale, the southern socially vulnerable communities have a degree-hour day rating of about 80.53, while the northern socially vulnerable communities have a rating of about 149.75 degree-hour days (CEPA UHI). In A-graded Glendale communities with higher tree equity scores, degree-hour days range from about 74.21 to 99.15 (CEPA UHI). As such, Glendale's most populated urban areas will likely experience the highest UHI effects and heat inequity stemming from historical redlining and lack of access to green open spaces.

HISTORICAL CAUSES OF INEQUITABLE HEAT EXPOSURE

After the Great Depression the U.S. Government undertook numerous projects to stimulate the economy, expand housing stock, and evaluate the riskiness of home mortgages. The Home Owners' Loan Corporation was established in 1933 with the passage of the Home Owners' Loan Act, with the key task of refinancing mortgages and slowing down the rate of foreclosures (FHFA). During the 1930's the HOLC created detailed maps of urban areas across the United States. HOLC maps documented the perceived risk of lending and determined the lending practices of banks and other mortgage lenders administering the federal loans.

These maps graded neighborhoods on a scale from "A" through "D" and the grade correlated with color coding on the maps of green

through red, hence the term “redlining”. A-rated neighborhoods, colored green on the maps, were classified as the most desirable, and least risky for lenders. D-rated neighborhoods, colored red on the maps, were classified as the highest risk neighborhoods, and families in these neighborhoods were typically denied mortgages and their mortgages were often not federally insured if they were granted one (Rothstein 2017). The HOLC neighborhood assessments explicitly used racial makeup of residents as a determinant of neighborhood quality and mortgage risk (Rothstein 2017). Neighborhood descriptions included references to the racial makeup of a neighborhood, in particular the homogeneity, percentage of immigrants and whether they were considered “subversive”, and the number of black, Mexican, and residents of various non-white ethnic groups (Nelson et al., 2023; Rothstein 2017). In the HOLC assessments, racially integrated neighborhoods, and neighborhoods with higher numbers of immigrants and people of color were considered higher risk and perceived as destined to deteriorate in value (Nelson et al., 2023; Rothstein 2017). This led to disinvestment in low-rated areas of cities and a loss of wealth building for generations of American families who were unable to purchase homes (Rothstein 2017). This practice of racial exclusion from homeownership allowed white Americans to accumulate wealth through government backed homeownership while minority communities were excluded and marginalized (Rothstein 2017). Historic disinvestment and constraints on loans to real estate developers tied to racial restrictions resulted in differences in the quality of housing, amount of housing, and the amount of green space and other amenities that were built in different neighborhoods based on the income and racial demographics of potential residents (Nelson et al., 2023; Rothstein 2017).

Many of these development differences still largely persist to this day. Recent research has shown that neighborhoods that HOLC rated as a “D” level of risk are still predominantly low-to-moderate

income and communities of color, while “A” neighborhoods are still predominantly white and above average income. Previously red-lined neighborhoods are also correlated with more impervious paved surfaces, fewer trees and green spaces, and higher average temperatures than the non-redlined, historically white neighborhoods in the same city (Hoffman et al.). Another study assessing 175 of the largest urbanized areas in the United States found that the average person of color lives in a census tract with greater than 2 degrees Celsius higher urban heat island intensity compared to non-Hispanic whites (Hsu et al.). A few degrees of temperature difference, and especially warmer temperatures at night, can translate into an appreciably increased risk of heat stress. This means that communities that faced historical housing discrimination often bear a greater health burden as excessive heat events become more frequent and severe due to climate change. This disparate heat exposure risk is known as heat inequity.

Figure 6 shows the HOLC Neighborhood Redlining Grade for neighborhoods in Glendale. Green colored areas represent neighborhoods that were graded A (Best). Neighborhoods just north of West Kenneth Road and East Mountain Street and in east Glendale, north of SR 134 received an A grade. Several neighborhoods bordering A grade neighborhoods were graded B (Still Desirable) due to deed restrictions that limited development to single family housing and prevented non-white families from purchasing homes. These areas were developed with federal financing and graded favorably on the mortgage risk map as a result of the good quality homes this financing afforded, and the racial segregation achieved through racially restrictive deeds. Neighborhoods graded C (Definitely Declining), yellow areas on the map, are located in north Glendale along I-210, and in south and southwest Glendale. The reasoning provided for C grade neighborhoods was the presence of lower-income and working-class. Residents, powerlines and industrial uses, and mixed quality

of housing. No neighborhoods in Glendale were rated D (Hazardous).

Areas with high social sensitivity in Glendale today fall within neighborhoods rated C (Definitely Declining) by HOLC, as shown in Figure 6.

COMPOUNDING RISKS: HOUSING AND HEAT RELATED ILLNESS

Housing and socio-economic factors can intersect in ways that compound the risks of climate impacts such as extreme heat events. When housing is in short supply and unaffordable this can lead to overcrowding, especially for lower-income communities. Aging, overcrowded, and poorly insulated housing can contribute to risk from heat related illness, which can in turn lead to hospital visits and even increased mortality. If the electricity grid is strained during a heat wave and there are power outages, this can further increase the risk of heat related illnesses if access to adaptations such as air conditioning, fans, and refrigeration are lost.

A study published In 2022 found that housing age, housing crowding ratio, and roof condition were found to be correlated with the risk of heat-related illness indexes and can predict the risk of heat-related emergency department visits and heat-related mortality on a state level. This analysis indicates that housing quality and affordability as characterized by age, crowding, and roof condition can impact heat related illness risk (Hu et al. 2022).

The California 2020 Census Hard-to-Count index rated census tracts in south and southwest Glendale as falling within the highest difficulty level for accurately estimating population numbers. The variables cited for contributing to difficulty in getting accurate counts were renter occupied units, crowded units (in south Glendale), immigrants and limited English-speaking population, multi-unit structures, and households without broadband

subscriptions (CA Census 2020). The large numbers of immigrants, non-English speakers, and crowded housing conditions in south Glendale likely contributed to an undercount of the true population of Glendale.

Housing affordability issues also impact Glendale residents. According to the U.S. Department of Housing and Urban Development (HUD) and the California Department of Housing and Community Development (HCD), housing is considered “affordable” if monthly housing costs are no more than 30 percent of a household’s gross income. In Glendale, 57.8 percent of renter households spend 30 percent or more of their income on housing cost, compared to 55.3 percent regionally. Additionally, 36.1 percent of renter households in Glendale spend 50 percent or more of their income on housing cost, compared to 28.9 percent regionally. These households are considered severely cost burdened (SCAG 2021).

The age of housing stock can indicate housing quality and the likely need for rehabilitation work that can impact public health, including remediation of lead-based paint and maintenance or replacement of major elements such as roofing. 77 percent of the housing stock in Glendale was built prior to 1980, and 20.2 percent of those homes, the largest proportion, were constructed prior to 1939 (SCAG 2021). Typically housing over 30 years of age is likely to need rehabilitation work to major elements of the structure. Given the age of the housing stock in the City, a large majority of Glendale’s housing stock is in substandard condition, with approximately 1,291 units lacking telephone service, 164 units lacking plumbing facilities, and 1,478 units lacking complete kitchen facilities (SCAG 2021). The age, availability, cost burden, and crowding conditions of Glendale housing may contribute to increased risk of heat-related illnesses, especially as climate change contributes to more frequent extreme heat events.

A separate study analyzed exposure and vulnerability to heat by housing type and location using census tract level data combined with housing characteristics, climate projections, and an index of adaptive capacity and vulnerability to heat. The analysis revealed that subsidized housing in California simultaneously has the most sensitive populations and barriers to adaptation while being disproportionately located in the hottest census tracts (C. J. Gabbe et al. 2020). Specifically, while 8 percent of California’s total number of housing units are located in tracts with high heat exposure and high vulnerability populations (high-high tracts), these high-high tracts contain 16 percent of public housing units, 14 percent of Low-Income Housing Tax Credit units, and 10 percent of Section 8 Housing Choice Vouchers (C. J. Gabbe et al. 2020).

These studies show that housing policy should be considered an essential public health and safety mechanism for mitigating climate change-exacerbated health conditions in Glendale. Policies and programs should aim to address heat exposure and adaptation for subsidized housing, highly sensitive populations, and seek to increase housing availability and quality, especially in the hottest parts of the community, in order to help reduce health impacts from extreme heat.

Potential Impacts

This section describes the potential impacts of extreme heat on each vulnerable population group.

INDIVIDUALS WITH HIGH OUTDOOR EXPOSURE

Individuals with high outdoor exposure are at risk of health impacts from extreme heat. Outdoor workers are often subject to strenuous work conditions and are vulnerable during extreme heat events. People experiencing houselessness and displaced individuals are exposed to the health-related impacts associated with extreme heat

because they have limited access to shelter and air conditioning. The primary health impacts to these populations are heat-related illnesses, such as heat stress, heat stroke, and dehydration, which can be life-threatening (CDPH 2020). Visitors are at risk during extreme heat events because they may not be keyed into local heat warning communications and are less likely to know where to seek refuge. People that rely on active transportation or public transit may experience health impacts from extreme heat due to biking and walking in high temperatures and high exposure while waiting for public transit.

UNDER-RESOURCED INDIVIDUALS

Under-resourced individuals may not be able to pay for adequate air conditioning or fans, increasing their exposure to extreme heat. Individuals without vehicles may face challenges traveling to cooling centers or temporary shelters during extreme heat events (Cooley et al. 2012). Residents who lack air conditioning are at risk of health impacts from extreme heat at increased temperatures may make it harder to regulate their body temperatures. Households without a computer or broadband internet may not receive heat advisory warnings or governmental guidance, causing them to experience health impacts from extreme heat exposure (CDPH 2017). Under-resourced individuals are less likely to receive medical care for illnesses triggered or exacerbated by extreme heat, or if treatment is received, they are likely to face a significant medical cost burden and related financial stress. Extreme temperatures may contribute to a rise in high violence crime rates, which increases safety risks to people who live in areas of high violent crimes (Muggah 2021).

INDIVIDUALS FACING SOCIETAL BARRIERS

BIPOC, immigrants, and people who are undocumented are more likely to live in housing with insufficient protection from extreme

heat events and limited or no affordable air conditioning and are less likely to be able to make the home improvements necessary due to financial constraints or because they are renters. Limited or non-English speakers may not be provided heat advisory warnings or governmental guidance in their language, potentially causing them to experience greater exposure to extreme heat (Gamble et al. 2016). The primary health impacts to these populations are heat-related illnesses, such as heat stress, heat stroke, and dehydration, which can be life-threatening (CDPH 2020). Immigrants and people who are undocumented may not have access to medical services to treat heat-related illnesses.

INDIVIDUALS WITH CHRONIC HEALTH CONDITIONS OR HEALTH RELATED SENSITIVITIES

Individuals with chronic health conditions or health related sensitivities are particularly at risk of heat related illnesses during extreme heat events. People who are differently abled, seniors, and children may have difficulty affording or accessing air conditioning or traveling to cooling centers during extreme heat events. Extreme heat events can also trigger power outages which are particularly dangerous for individuals who are electricity-dependent, either for their mobility, communication, or medical devices. Extreme heat conditions can exacerbate asthma, cardiovascular disease, high blood pressure, diabetes, certain different abilities, and other respiratory and cardiovascular conditions, potentially causing heat-related illnesses such as heat stress, heat stroke and dehydration, which can be life threatening (CDPH 2020). Residents in households using fuels for heating may face disproportionate health impacts from extreme heats events as high temperatures may lead to compounding impacts from indoor air pollutants. Young children are still physiologically developing which means that they are less able to regulate their bodies during extreme heat events (Kenney et al. 2014). Young children and seniors are especially at risk of

dehydration as their bodies are not able to regulate as well (Kenney et al. 2014). When exposed to extreme heat, pregnant people and their fetuses are particularly susceptible to heat exhaustion, heat stroke, dehydration, low birth weight, preterm birth, and infant mortality (EPA 2022). Dehydration may exacerbate underlying health conditions and illnesses.

Warm nights affect the body's ability to cool down and recover from heat stress during extreme heat periods exacerbating heat-related health problems including, heat exhaustion, dehydration, and cardiovascular stress, especially for individuals with chronic health conditions and health related sensitivities.

Adaptive Capacity

This section gives an overview of the City-led and community-scale adaptive capacity to extreme heat and warm nights.

CITY-LED ADAPTIVE CAPACITY

Existing efforts that increase the City's resilience to extreme heat include:

- Increasing urban forest, tree canopy coverage, parks, and open space throughout the City are adopted policies and strategies as envisioned in the Greener Glendale Plan and the Glendale Downtown Specific Plan. Policies and strategies seek city-wide or neighborhood-wide improvements, including in vulnerable areas not within 1/3 mile of recreational open space (Greener Glendale Plan – Community 2012) (Glendale Downtown Specific Plan 2019).
- Inventorying backup-generators, medical equipment and supplies, temporary shelters, and other emergency response supplies and equipment are adopted policies and strategies as

envisioned in the Glendale General Plan – Safety Element 2003. (Glendale General Plan— Safety Element 2003).

COMMUNITY-SCALE ADAPTIVE CAPACITY

As described in the Los Angeles County Climate Vulnerability Assessment, the following resources increase the adaptive capacity of vulnerable communities to extreme heat and warm nights in Glendale:

- **Heat refuge:** Cooling centers and other cool indoor public and private locations can provide critical refuge for people to escape extreme heat conditions. The City operates 4 cooling centers placed around the City, with only one of the four located close to areas of high social vulnerability (Glendale News Press 2023).
- **Park access:** Parks and open spaces can provide shade, natural cooling, and mental health benefits to community members seeking refuge from the heat. In their Greener Glendale Plan—Community 2012, Glendale aims to increase parks specifically in areas not currently within 1/3 mile of recreational open space and develop strategies to provide parks or recreational open space in those areas (Greener Glendale Plan – Community Plan 2012). Currently, most Glendale parks and green spaces are not accessible by most vulnerable populations, but Glendale is working to develop strategies to address this imbalance.
- **Tree canopy:** Trees can provide shade, natural cooling, and mitigate the urban heat island effect, providing numerous benefits to residents. According to Glendale’s tree equity report, 19 of 137 block groups have a tree equity score of less than 75. These 19 block groups are located in dense, vulnerable communities adjacent to major roadways like I-5. The lack of tree canopy in these areas will exacerbate the urban heat island effect and increase heat inequity.
- **Thermal building performance:** Older buildings heat up faster during extreme heat events and are less effective at remaining cooler than outdoor temperatures. Improving building insulation and using reflective building materials can increase thermal building performance, increasing community resilience. Thermal building performance in Glendale is likely poor, given that 77 percent of the housing stock in Glendale was built prior to 1980, with 20 percent of those homes, the largest proportion, constructed prior to 1939.
- **Permeable surfaces:** Permeable spaces include green spaces and other cool, ground surfaces that help protect against localized heat gain and reduce the urban heat island effect. Large areas of permeable surfaces are located in areas with the lowest social vulnerability scores, where access to open spaces and cooled surfaces prevent urban heat island effects. In Glendale, these areas have historically been less densely populated areas, typically away from major roadways and in areas with fewer vulnerable populations.

Vulnerability Score – Extreme Heat and Warm Nights

Population Group	Impact Score	Adaptive Capacity Score	Vulnerability Score
Individuals with High Outdoor Exposure	High	Low	5-High
Under-resourced Individuals	High	Low	5-High
Individuals Facing Societal Barriers	High	Low	5-High
Individuals with Chronic Health Conditions or Health Related Sensitivities	High	Low	5-High



Drought

Overview

Prolonged drought conditions can cause long-term public health problems including shortages of drinking water and poor-quality drinking water, impacts on air quality, sanitation and hygiene, and food and nutrition, and more disease, such as West Nile Virus carried by mosquitoes breeding in stagnant water (CDC 2020).

Potential Impacts

This section describes the potential impacts of drought on each sensitive population group.

INDIVIDUALS WITH HIGH OUTDOOR EXPOSURE

Unless there are major water shortages in the City which disrupt drinking water supplies or cooling water features at parks and other public locations, individuals with high outdoor exposure are most likely not at disproportionate risk to drought.

UNDER-RESOURCED INDIVIDUALS

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

INDIVIDUALS FACING SOCIETAL BARRIERS

Unless there are major water shortages in the City, individuals facing societal barriers are most likely not at disproportionate risk to drought.

INDIVIDUALS WITH CHRONIC HEALTH CONDITIONS OR HEALTH RELATED SENSITIVITIES

Unless there are major water shortages in the City, individuals with chronic health conditions or health related sensitivities are most likely not at disproportionate risk to drought.

Adaptive Capacity

This section gives an overview of the City-led and community-scale adaptive capacity to drought.

CITY-LED ADAPTIVE CAPACITY

Existing efforts that increase the City's resilience to drought impacts include:

- Increasing urban forest, tree canopy coverage, parks, and open space throughout the City are adopted policies and strategies as envisioned in the Greener Glendale Plan and the Glendale Downtown Specific Plan. Policies and strategies seek city-wide or neighborhood-wide improvements, including in vulnerable areas not within 1/3 mile of recreational open space (Greener Glendale Plan – Community 2012) (Glendale Downtown Specific Plan 2019).
- Increasing biodiversity of plants and ecosystems are adopted policies and strategies as envisioned in the Greener Glendale Plan (Greener Glendale Plan – Community 2012).
- Glendale Water & Power offers the Utility Users Tax exemption to low-income senior and differently abled customers. Glendale Water & Power also promotes the Low-Income Household Water Assistance Program (LIWAP) which provides funds to assist low-income households with water and wastewater bills (GWP Financial Assistant Programs 2023).

COMMUNITY-SCALE ADAPTIVE CAPACITY

As described in the Los Angeles County Climate Vulnerability Assessment, the following resources increase the adaptive capacity of vulnerable communities to drought.

- **Water conservation practices:** Water conservation practices such as using drought-tolerant vegetation in gardens and open spaces, promoting water reuse for non-potable uses and installing water efficient appliances are important practices for increasing resilience to drought are adopted policies and strategies. Policies and strategies in the Greener Glendale Plan seek city-wide or neighborhood-wide improvements (Greener Glendale Plan – Community 2012).

Vulnerability Score – Drought

Population Group	Impact Score	Adaptive Capacity Score	Vulnerability Score
Individuals with High Outdoor Exposure	Low	Medium	2-Low
Under-resourced Individuals	Medium	Medium	3-Medium
Individuals Facing Societal Barriers	Low	Medium	2-Low
Individuals with Chronic Health Conditions or Health Related Sensitivities	Low	Medium	2-Low



Wildfire

Overview

Wildfires cause direct and indirect impacts to community members. Wildfires that burn within City limits can pose a significant impact to the safety of community members and can burn homes. Indirectly, wildfires both within and outside of City limits can cause power disruption and lead to poor air quality. Focus Group participants identified concerns with wildfires leading to power disruption and affecting air quality through smoke.

Population groups that are located in the additional vulnerable focus areas are at-risk to wildfires, as shown in Figure 8. These include community members within ¼ mile buffer of schools (which is where children, a climate-vulnerable population group, spend much of their time), ¼ mile buffer of I-210 and SR 2, as well as portions of east Glendale.

Potential Impacts

This section describes the potential impacts of wildfire on each vulnerable population group.

INDIVIDUALS WITH HIGH OUTDOOR EXPOSURE

Some outdoor workers, including fire fighters, police officers and other emergency personnel, may be exposed to hazardous work conditions during wildfire events and may become injured from burns and wildfire smoke. Domestic workers that typically service areas under a wildfire evacuation order are impacted by loss of wages, especially where hazard pay is unavailable. In some cases, domestic workers were still required to report to work within emergency evacuation areas, exposing themselves to harm (Climate Resolve 2021). Individuals with high outdoor exposure may face

disproportionate exposure to wildfire smoke which can exacerbate existing respiratory conditions, mental illness, and chronic health conditions. (CDPH 2017). Individuals with high outdoor exposure may be reliant on active and public transportation modes and have a more difficult time evacuating in a timely fashion.

UNDER-RESOURCED INDIVIDUALS

Under-resourced individuals may experience injuries or death from burns and are likely to experience financial burden associated with medical treatment and property loss or damage (CDPH 2017). These individuals may have their belongings and homes damaged by a wildfire. If this occurs, under-resourced individuals are less likely to be covered by insurance and more likely to suffer from the cost burden. Under-resourced individuals are less likely to have adequately hardened and weatherized housing. They are more likely to have limited control over home hardening and improvements that may protect against fire. Subsequently, they may experience economic and health impacts and a greater loss of belongings than affluent homeowners (Gamble et al. 2016).

INDIVIDUALS FACING SOCIETAL BARRIERS

BIPOC, immigrants, and people who are undocumented are generally more likely to live in housing with insufficient protection against wildfire. Individuals facing societal barriers may not have access to language appropriate advisory warnings or government guidance. Individuals in these groups may face systematic and/or cultural barriers to access resources to safely evacuate hazard areas and/or to treat injuries (Gamble et al. 2016) (Mendez et al. 2020). The harm that many community members have experienced when engaging with government systems, including at evacuation centers, may make it harder for them to receive the support and services that they need.

INDIVIDUALS WITH CHRONIC HEALTH CONDITIONS OR HEALTH RELATED SENSITIVITIES

Individuals with chronic health conditions or health related sensitivities may be more susceptible to injuries or death from burns (CDPH 2017). People who are differently abled, young children and their parents/caregivers, military veterans, pregnant people, and seniors may have difficulty evacuating from wildfires, increasing the risk of health impacts from wildfire burns (EPA 2022).

Adaptive Capacity

This section gives an overview of the City-led and community-scale adaptive capacity to wildfire.

CITY-LED ADAPTIVE CAPACITY

Existing efforts that increase the City's resilience to wildfire impacts include:

- Ensuring adequate fire services, such as fire equipment, infrastructure, and response times throughout the City are adopted policies and strategies as envisioned in the General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (General Plan— Safety Element 2003).
- Enforcing fuel management, weed abatement, fire-resistant landscaping, and structure hardening programs and efforts to minimize wildfire risk are adopted policies and strategies as envisioned in the General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (General Plan— Safety Element 2003).
- Designing, constructing, maintaining, and operating Glendale Water & Power electric transmission and distribution system to minimize wildfire risk are adopted policies and strategies as

envisioned in the Glendale Water & Power – Wildfire Mitigation Plan. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale Water & Power— Wildfire Mitigation Plan 2022).

- Coordinating with local and regional jurisdictions and agencies to update and implement disaster preparedness and recovery plans, maintain mutual aid agreements, and carry out evacuation procedures are adopted policies and strategies as envisioned in the Glendale General Plan—Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale General Plan— Safety Element 2003).
- Inventorying backup-generators, medical equipment and supplies, temporary shelters, and other emergency response supplies and equipment are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale General Plan— Safety Element 2003).

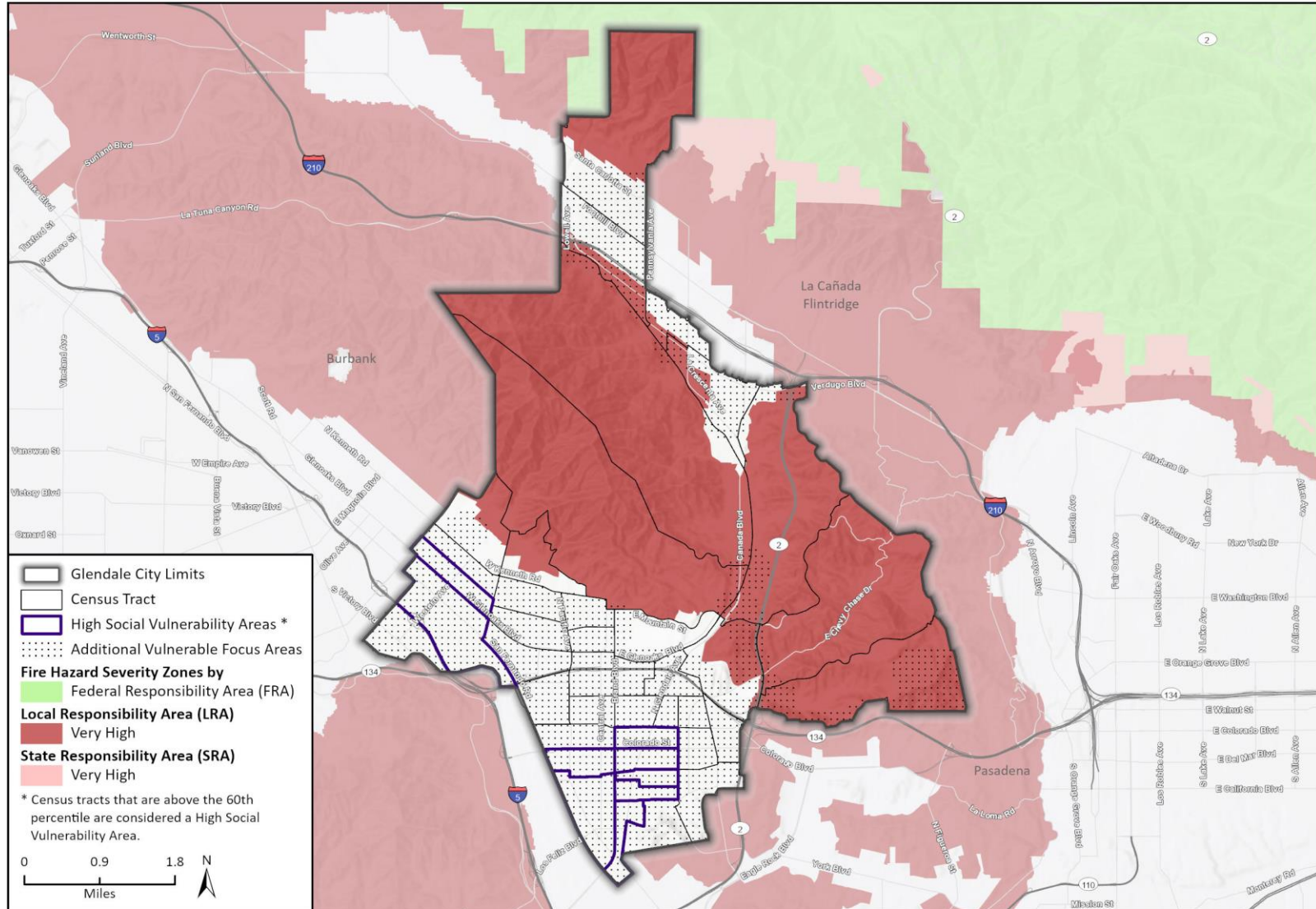
COMMUNITY-SCALE ADAPTIVE CAPACITY

As described in the Los Angeles County Climate Vulnerability Assessment, the following resources increase the adaptive capacity of vulnerable communities to wildfire in Glendale:

- **Fire Safe Structures:** Homes and facilities that are designed and constructed with fire resistant building materials will mitigate potential impacts from fire and smoke.
- **Fire Resistant Landscaping:** Planting fire resistant plants can mitigate the spread of fire in open spaces and surrounding structures. Employing vegetation management techniques (e.g., trimming, pruning, and cleanup) will reduce flammability.

- **Roadway and Access:** Roadway access and street signage ensures adequate ingress/egress for residents and emergency personnel.
- **Fire Service Resources:** Fire equipment, infrastructure, and response times are all critical.

Figure 8 Glendale High Social Vulnerability Areas and Wildfire Hazard Severity Zones



Baseemap provided by Esri and its licensors © 2023. Additional data provided by CAL FIRE, 2007 & 2012; City of Glendale, 2023. Additional data provided by Esri Updated Demographics, 2022; U.S. Census Bureau, (ACS 2017-2021), 2020; CDC, 2010; LEAD tool, 2018. Social Vulnerability Analysis calculated by Rincon Consultants, Inc., 2023. 21-11575 Glendale CAAP VA.aprx Fig X High Social Sensitivity and Wildfire Hazard Severity Zones

Vulnerability Score – Wildfire

Population Group	Impact Score	Adaptive Capacity Score	Vulnerability Score
Individuals with High Outdoor Exposure	Medium	Medium	3-Medium
Under-resourced Individuals	High	Medium	4-High
Individuals Facing Societal Barriers	Medium	Medium	3-Medium
Individuals with Chronic Health Conditions or Health Related Sensitivities	High	Medium	4-High



Landslides

Overview

Population groups that are located in the additional vulnerable focus areas are at-risk to landslides, as shown in Figure 9. These include community members within ¼ mile buffer of schools, ¼ mile buffer of I-210, La Crescenta Avenue, and SR 2, as well as portions of east Glendale.

Potential Impacts

This section describes the potential impacts of landslides on each sensitive population group.

INDIVIDUALS WITH HIGH OUTDOOR EXPOSURE

Individuals with high outdoor exposure (outdoor workers, people experiencing homelessness, visitors, and people who use active transportation and public transit) may not receive timely emergency evacuation information or may have limited access to shelter and transportation to evacuate from hazardous areas (Gamble et al. 2016). Some outdoor workers, including emergency personnel and construction workers, may be exposed to hazardous work conditions during landslide events and may become injured from debris, rocks, or damaged infrastructure or facilities.

UNDER-RESOURCED INDIVIDUALS

Under-resourced individuals may experience injuries or death from landslides and are likely to experience financial burden associated with medical treatment (CDPH 2017). These individuals may have their belongings and homes damaged by a landslide. If this occurs, under-resourced individuals are less likely to be covered by insurance and more likely to suffer from the cost burden. Under-

resourced individuals are less likely to have adequately hardened and weatherized housing. They are more likely to have limited control over home hardening and improvements that may protect against landslides. Subsequently, they may experience economic and health impacts and a greater loss of belongings than homeowners (Gamble et al. 2016).

INDIVIDUALS FACING SOCIETAL BARRIERS

BIPOC, immigrants, and people who are undocumented are generally more likely to live in housing with insufficient protection against landslides. Individuals facing societal barriers may not have access to language appropriate advisory warnings or government guidance. Individuals in these groups may face systematic and/or cultural barriers to access resources to safely evacuate landslide hazard areas and/or to treat injuries (Gamble et al. 2016) (Mendez et al. 2020). The harm that many community members have experienced when engaging with systems, including at evacuation centers, may make it harder for them to receive the support and services that they need.

INDIVIDUALS WITH CHRONIC HEALTH CONDITIONS OR HEALTH RELATED SENSITIVITIES

Individuals with chronic health conditions or health related sensitivities may be more susceptible to injuries or death from a landslide (CDPH 2017). People who are differently abled, young children and their parents/caregivers, pregnant people, and seniors may have difficulty evacuating from landslides, increasing the risk of health impacts and geographical isolation (EPA 2022).

Adaptive Capacity

This section gives an overview of the City-led and community-scale adaptive capacity to landslides.

CITY-LED ADAPTIVE CAPACITY

Existing efforts that increase the City's resilience to landslide impacts include:

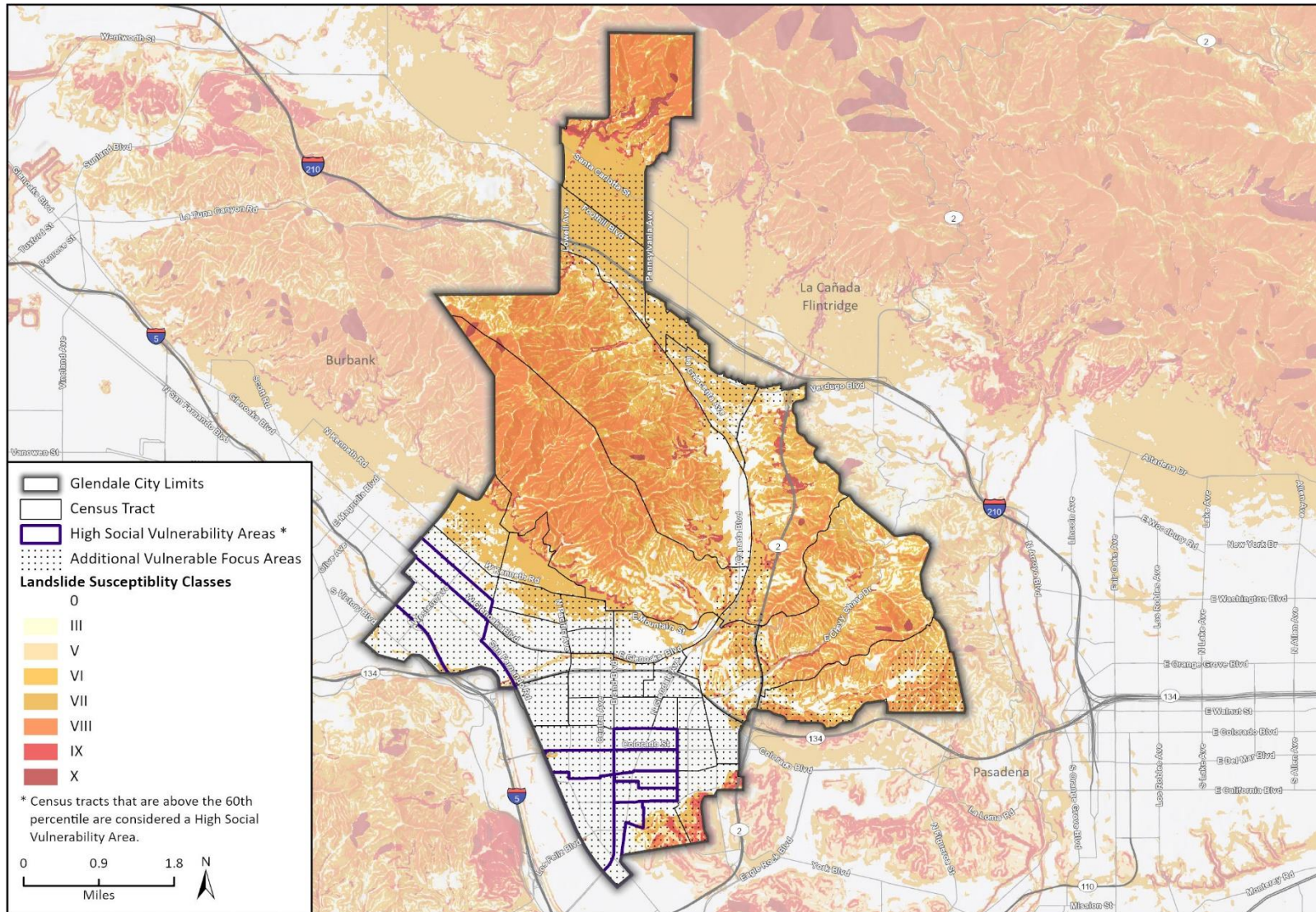
- Mitigating landslide risks and potential damage to structure and infrastructure through requiring geotechnical investigations, regular inspections, and prohibiting reconstruction of structures in areas with failed slopes are adopted policies and strategies as envisioned in the General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (General Plan— Safety Element 2003).

COMMUNITY-SCALE ADAPTIVE CAPACITY

The following resources increase the adaptive capacity of vulnerable communities to landslides in Glendale:

- **Stabilize slopes mechanically or with vegetation:** Vegetation helps stabilize slopes and prevent erosion by strengthening roots in the soil.

Figure 9 Glendale High Social Vulnerability and Landslide Susceptibility



Vulnerability Score –Landslides

Population Group	Impact Score	Adaptive Capacity Score	Vulnerability Score
Individuals with High Outdoor Exposure	Medium	Medium	3-Medium
Under-resourced Individuals	Medium	Medium	3-Medium
Individuals Facing Societal Barriers	Low	Medium	2-Low
Individuals with Chronic Health Conditions or Health Related Sensitivities	Medium	Low	4-High



Stormwater Flooding and Extreme Precipitation

Overview

When an influx of stormwater exceeds a drainage system's capacity to infiltrate water into the soil or to carry it away, localized stormwater flooding can occur. Urban landscapes tend to be built with impermeable surfaces that do not allow much water to infiltrate the ground and this increases the amount of runoff that must be channeled in storm drainage systems and carried elsewhere. Most urban drainage infrastructure was not built to manage stormwater flows from the increased precipitation events that are occurring and will occur more frequently with climate change and can be costly to retrofit. As a result, the costs and impact of urban flooding are expected to increase as precipitation patterns become more extreme due to climate change (NASEM 2019).

Climate change may cause areas throughout Glendale to experience more frequent stormwater flooding. Stormwater systems may be overwhelmed more frequently as more extreme rain events occur, causing localized flooding which could impact properties and leave roads temporarily unusable. Areas with high amounts of impermeable surfaces and those adjacent to drainage systems are prone to stormwater flooding during periods of heavy rainfall.

Flooding impacts directly create physical damage from inundation (Hall et. al 2018). Flooding can also lead to cascading risks due to loss of power, wastewater management issues, pollution carried by stormwater including hazardous materials, and overwhelm storm drainage infrastructure, exacerbating public health concerns.

Potential Impacts

This section describes the potential impacts of stormwater flooding and extreme precipitation on each sensitive population group.

INDIVIDUALS WITH HIGH OUTDOOR EXPOSURE

Individuals with high outdoor exposure (outdoor workers, people experiencing homelessness, visitors, and people who use active transportation and public transit) may not receive timely emergency evacuation information or may have limited access to shelter and transportation to evacuate from hazardous areas (Gamble et. Al 2016). Some outdoor workers, including emergency personnel and police officers, may be exposed to hazardous work conditions during flooding events and therefore are vulnerable to health impacts (CDPH 2020).

UNDER-RESOURCED INDIVIDUALS

Under-resourced individuals may experience injuries or death from high velocity flooding and are less likely to receive medical treatment (CDPH 2017). Individuals in these groups may experience cost burdens if their belongings and homes are damaged from floodwater inundation. Under-resourced individuals are less likely to have adequately hardened and weatherized housing. They are more likely to have limited control over home hardening and improvements that may protect against flooding. Subsequently, they may experience economic and health impacts and a greater loss of belongings than homeowners (Gamble et al. 2016).

INDIVIDUALS FACING SOCIETAL BARRIERS

BIPOC and people who are undocumented are more likely to live in low-lying area that are more susceptible to stormwater flooding. They are also more likely to live in housing with insufficient

protection against stormwater flooding. Individuals facing societal barriers may not have access to language appropriate advisory warnings or governmental guidance. Individuals in these groups may face systemic and/or cultural barriers (including racism and other forms of discrimination) when seeking access to resources needed to safely evacuate hazard areas and/or to treat injuries (Gamble et al. 2016) (Mendez et al. 2020).

INDIVIDUALS WITH CHRONIC HEALTH CONDITIONS OR HEALTH RELATED SENSITIVITIES

Individuals with underlying health conditions may be more at risk of injury/illness due to exposure to mold after flooding events. Molds grow in places with a lot of moisture, particularly areas where there has been flooding and inadequate home hardening to protect from water infiltration. After severe flooding events, damage from flooding may lead to mold infestations, as home interiors are exposed around pipes, windows, and roofs. According to the Center for Disease Control (CDC), exposure to damp and moldy environments may cause health effects ranging from sneezing and mild allergic reactions to fungal infections for more susceptible populations, such as those with chronic respiratory disease. Studies also suggest that early mold exposure in children may lead to the development of asthma and further sensitivity to mold. Young children and their parents/caregivers, seniors, people who are differently abled, pregnant people, and individuals with chronic health conditions or illnesses may not be able to safely evacuate floodwater hazard areas. This could lead to further exposure to mold infestations and increase the likelihood of experiencing serious health-related events for these populations.

Adaptive Capacity

This section gives an overview of the City-led and community-scale adaptive capacity to stormwater flooding and extreme precipitation.

CITY-LED ADAPTIVE CAPACITY

Existing efforts that increase the City’s resilience to stormwater flooding and extreme precipitation impacts include:

- Mitigating flood impacts through discouraging development of critical facilities in flood hazard areas, requiring hydrological studies, and maintaining City-owned storm drain facilities are adopted policies and strategies as envisioned in the General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (General Plan— Safety Element 2003).

COMMUNITY-SCALE ADAPTIVE CAPACITY

As described in the Los Angeles County Climate Vulnerability Assessment, the following resources increase the adaptive capacity of vulnerable communities to stormwater flooding and extreme precipitation in Glendale:

- **Green Infrastructure:** Green infrastructure projects expand permeable areas and reduce flooding potential. According to the City of Glendale Nature Based Development, the City has conducted Indigenous Tree Protection programs and annual street tree planting programs for decades. In 2011, the City completed a re-forestation project within Scholl Canyon and has planted over 5,000 trees in 2020. Additionally, Glendale maintains over 5,000 acres of open space and 286 acres of developed park land, with 47 parks and recreation facilities (City of Glendale Nature Based Development).

Vulnerability Score – Stormwater Flooding and Extreme Precipitation

Population Group	Impact Score	Adaptive Capacity Score	Vulnerability Score
Individuals with High Outdoor Exposure	Medium	Medium	3-Medium
Under-resourced Individuals	High	Medium	4-High
Individuals Facing Societal Barriers	Medium	Medium	3-Medium
Individuals with Chronic Health Conditions or Health Related Sensitivities	Medium	Low	4-High

Poor Air Quality

Overview

Focus Group participants identified concerns with wildfires contributing to poor air quality through smoke.

LOCAL CONDITIONS IMPACTING AIR QUALITY

The City of Glendale is in the South Coast Air Basin (SCAB), which is bounded by the Pacific Ocean to the west and the San Gabriel, San Bernardino, and San Jacinto Mountains to the north and east, and the San Diego County line to the south. The air quality in the SCAB is primarily influenced by a wide range of emissions sources – such as dense population centers, heavy vehicular traffic, industry, and weather (South Coast AQMD N.d.) The general region lies in the semi-permanent high-pressure zone of the eastern Pacific Ocean, resulting in light average wind speeds. The SCAB experiences a persistent temperature inversion (increasing temperature with increasing altitude) because of the Pacific high-pressure zone. This inversion limits the vertical dispersion of air contaminants, holding them relatively near the ground. The combination of stagnant wind conditions and low inversions produces the greatest pollutant concentrations in the SCAB. On days of no inversion or high wind speeds, ambient air pollutant concentrations are lowest. During periods of low inversions and low wind speeds, air pollutants generated in urbanized areas are transported predominantly onshore into Riverside and San Bernardino counties (CARB N.d.)

AMBIENT AIR QUALITY MEASUREMENTS

Air quality monitoring stations throughout the region monitor concentrations of air pollutants and determine whether ambient air quality meets the California and federal standards for various air

pollutants. While air quality has improved in the SCAB over the past several decades, the region has exceeded the federal health 8-hour ozone standard 124 days in 2022, based on preliminary data. Maximum levels are almost twice as high as the federal standard for clean air (South Coast AQMD N.d.)

POOR AIR QUALITY AND CLIMATE CHANGE

Poor air quality is associated with increased health impacts, most frequently from inhalation of pollutants. Examples of inhalable pollutants include particulate matter, carbon monoxide, ozone, nitrogen dioxide, and sulfur dioxide. Of these pollutants, the most common is particulate matter, which refers to inhalable particles that are commonly made up of sulphate, nitrates, ammonia, and other harmful compounds. Higher temperatures are conducive to air pollution formation, and rising temperatures could therefore result in worsened air quality. Worsening air quality due to climate change can create respiratory issues for sensitive populations and impact indoor environments that do not have adequate air filtration systems. There are several types of sources that cause a decline in air quality:

- **Dust.** Increased temperature leads to dry, dusty conditions also associated with drought (Hall et al. 2018). Increases in dust conditions increases exposure to particulate matter, including PM₁₀ (particulates less than 10 microns in diameter). PM₁₀ can cause increased respiratory disease, lung damage, cancer, premature death, and reduced visibility. These adverse health effects have been reported primarily in infants and children, and seniors with preexisting heart or lung diseases (CARB 2022).
- **Smog.** Increases in ambient temperature can lead to higher rates of smog also referred to as ozone. Groups most sensitive to O₃ include children, the elderly, people with respiratory disorders, and people who exercise strenuously outdoors

(USEPA 2021a). Depending on the level of exposure, ozone can cause inflame and damage the airways; make the lungs more susceptible to infection; and aggravate lung diseases such as asthma, emphysema, and chronic bronchitis. Ground-level ozone increases with ambient temperatures and will be experienced at higher rates due to climate change leading to raised cardiovascular and respiratory morbidity and mortality rates (CDPH 2014). Ground-level ozone has also been shown to have particularly disproportionate adverse impacts on populations experiencing homelessness and lower median income (PNAS 2021).

- **Fewer Natural Filtrations.** Precipitation variability and long periods of dry spells lead to less reliable air quality for the entire region. Moisture in the air can filter pollutants and provide for overall improved conditions. Urban vegetation can directly affect air quality. Trees remove gaseous air pollution. Large healthy trees remove more pollution than younger, smaller trees (USDA Forest Service, 2002). Rising temperatures could increase mortality for large healthy trees which would reduce the ability for urban vegetation to reduce air pollutants, therefore increasing pollutant exposure to sensitive populations.
- **Wildfire Smoke.** Temperature, severe wildfire conditions, and the area burned by wildfires have all increased throughout the state and are expected to continue to increase. Higher temperatures accompanied by an increase in the incidence and extent of large wildfires will lead to increased wildfire smoke and associated toxins and air pollution (Hall et al. 2018). Wildfire smoke is comprised of a mixture of gaseous pollutants, hazardous air pollutants, water vapor, and particle pollution (fine airborne particulate matter – PM_{2.5}) with particle pollution being the main component and the principal threat to public health (USEPA 2021b). Smoke from wildfires is known to

contain a large abundance of PM_{2.5} and are estimated to contribute to approximately 18 percent of the total PM_{2.5} atmospheric emissions in the US (Liu 2016). On days where PM_{2.5} exceeds regulatory standards an average of 71.3 percent of the total PM_{2.5} emissions are attributable to wildfires (Liu 2016). Short-term exposures to PM_{2.5} (up to 24-hours duration) has been associated with premature mortality, increased hospital admissions for heart or lung causes, acute and chronic bronchitis, asthma attacks, emergency room visits, respiratory symptoms, and restricted activity days. These adverse health effects have been reported primarily in infants and children, and seniors with preexisting heart or lung diseases (CARB 2022).

COMPOUNDING RISKS: HEAT AND SMOG DURING A RECENT HEAT WAVE

Central and Southern California experienced a heat wave in July 2023 that not only raised the risk of wildfires and heat-related illness, but also resulted in bad air quality. The South Coast AQMD issued an air quality alert for inland areas of the SCAB because of elevated levels of ozone caused by the high temperatures and weak winds that allowed the air to stagnate (LA Times, 2023). As discussed in the *Social Vulnerability by Climate Hazard* section, heat presents a major health risk to community members, especially to those with higher vulnerability to heat. Ozone levels increased alongside temperature throughout the day, peaking around noon and the early afternoon. Since higher temperatures increase ground level ozone, these health risks are compounded during extreme heat events, particularly when local conditions such as low wind speed, prevent the dispersion of pollution.

Potential Impacts

This section describes the potential impacts of extreme heat on each sensitive population group.

INDIVIDUALS WITH HIGH OUTDOOR EXPOSURE

Outdoor workers may become injured from smoke inhalation and poor air quality during heat waves. People experiencing homelessness are particularly at-risk when air quality is poor as they often suffer from respiratory conditions, mental illness, and chronic health conditions that may be exacerbated from poor air quality. People experiencing homelessness have limited access to shelter and often do not have access to transportation to evacuate from smoke engulfed areas (CDPH 2017). Visitors may not have access to emergency public health warnings related to poor air quality. Additionally, poor air quality from smoke or extreme heat may deter visitors, impacting Glendale's economy (Gamble et al. 2016). People who use active transportation and public transit are vulnerable during times of poor air quality because of their higher outdoor exposure.

UNDER-RESOURCED INDIVIDUALS

Under-resourced individuals may experience injuries or death from respiratory issues caused by smoke or poor air quality during heat waves and are likely to experience financial burden associated with medical treatment (CDPH 2017). Renters have limited control over home hardening and improvements, such as filtration, that protect against poor air quality. Individuals living in mobile homes may also face disproportionate risk if their homes do not have adequate filtration.

INDIVIDUALS FACING SOCIETAL BARRIERS

Limited or non-English speakers may not be provided with smoke advisory warnings or governmental guidance in their language, potentially causing them to experience greater exposure to smoke. Individuals in these groups may face systematic and/or cultural barriers to access resources to safely evacuate hazard areas (Gamble et al. 2016). Individuals in these groups may experience injuries or death from smoke inhalation (CDPH 2017). People who are undocumented may not have access to medical services to treat injuries (Mendez et al. 2020). The harm that many community members have experienced when engaging with government systems, including at evacuation centers, may make it harder for them to receive the support and services that they need.

INDIVIDUALS WITH CHRONIC HEALTH CONDITIONS OR HEALTH RELATED SENSITIVITIES

Individuals with chronic health conditions or health related sensitivities may be more susceptible to injuries or death from smoke inhalation (CDPH 2017). These populations are particularly at risk to respiratory health impacts associated with smoke inhalation of wildfire smoke pollutants and pollutant poor air quality during heat waves. Seniors and military veterans are vulnerable to health impacts from wildfire smoke and extreme heat pollutants because they are more likely to have underlying respiratory and/or cardiovascular conditions and illnesses. Young children may experience respiratory health impacts from wildfire smoke and extreme heat pollutants because their respiratory systems are not fully developed and are sensitive to stressors. Individuals with cardiovascular disease, individuals with high blood pressure, and individuals with stroke risk may experience severe cardiovascular health impacts if exposed to wildfire smoke and extreme heat pollutants. Individuals with diabetes face increased risk of all-cause

respiratory and cardiovascular-related physician visits after wildfires and an increased risk of cardiovascular morbidity (Ratter-Rieck et al. 2023). Individuals with asthma may experience severe respiratory health impacts such as difficulty breathing if exposed to wildfire smoke pollutants (EPA 2022). Residents in households using fuels for heating may face disproportionate health impacts from wildfire events and extreme heat as the resulting outdoor air pollutants may lead to compounding impacts from indoor air pollutants. People who are differently abled, young children and their parents/caregivers, pregnant people, and seniors may have difficulty evacuating from wildfires, increasing the risk of health impacts from wildfire smoke inhalation (EPA 2022).

improve air filtration in homes, protecting residents from the impacts of poor air quality.

Adaptive Capacity

This section gives an overview of the City-led and community-scale adaptive capacity to poor air quality.

CITY-LED ADAPTIVE CAPACITY

There are no existing policies or programs led by the City for addressing poor air quality.

COMMUNITY-SCALE ADAPTIVE CAPACITY

The following resources increase the adaptive capacity of vulnerable communities to poor air quality in Glendale:

- **Tree canopy and large open spaces:** Trees and large open spaces can reduce air pollution and provide numerous other benefits to residents, including providing shade, natural cooling, and mitigating the urban heat island effect.
- **Indoor air filtration:** Upgrading central air system filters and using high efficiency portable air cleaners can effectively

Vulnerability Score – Poor Air Quality

Population Group	Impact Score	Adaptive Capacity Score	Vulnerability Score
Individuals with High Outdoor Exposure	High	Low	5-High
Under-resourced Individuals	High	Low	5-High
Individuals Facing Societal Barriers	High	Low	5-High
Individuals with Chronic Health Conditions or Health Related Sensitivities	High	Low	5-High

4 Physical Vulnerability Assessment

4.1 What is Physical Vulnerability

Physical vulnerability is the susceptibility and limitations of physical infrastructure in the context of climate hazards and extreme events. Climate change has the capacity to harm physical infrastructure and disrupt services or restrict accessibility. Given that robust infrastructure is a crucial element in enhancing Glendale’s resilience, this assessment examines the vulnerability of critical infrastructure to understand how climate change will impact them.

4.2 Physical Assets at Risk

Physical Assets Included in the Physical Vulnerability Assessment

The physical assets included in this assessment include natural and recreational resources, building and facilities, and infrastructure and critical services in Glendale.

Natural and recreational resources

Natural and recreational resources within Glendale, as detailed in the General Plan Recreation Element and Open Space and Conservation Plan, include parks, City bikeways, open spaces, waterways, critical habitats, and street trees. The City currently provides 284 acres of total parkland space across 31 parks. Waterways in Glendale include the Los Angeles River and two of its tributaries, Verdugo Wash, and the Burbank Western Channel. Glendale has more than 49,000 City trees. Of those City trees,

43,000 are public rights-of-way along City streets and the remaining 6,000 trees are located in City parks. These resources provide sources of community resilience to the city. These resources are spread throughout the City and face various levels of exposure to climate hazards.

Primary vulnerabilities for parks and natural resources are typically associated with extreme heat and drought related stressors, increasing wildfire frequency and severity, with impacts such as species mortality and loss of habitat.

Buildings and Facilities

Climate change is expected to amplify extreme weather and hazards in Glendale. A jurisdiction’s vulnerability increases when buildings and facilities are not designed, operated, and/or maintained to function effectively under extreme weather conditions. The following buildings and facilities in Glendale are particularly important to assess for climate change impacts because they play a critical role in providing services to the community: City Hall, schools, police stations, libraries, fire stations, hospitals, parks, recycling facilities, water treatment plant, the Grayson Power Plant, potable/recycled water pump stations, and Scholl Canyon Landfill /waste management facilities.

Infrastructure and Critical Services

Within Glendale, there is a variety of infrastructure and critical services that are vulnerable to climate change. Assets within this category include water and wastewater services, storm drainage and flood protection, solid and hazardous waste and recycling, fire

services, emergency services, medical services, energy utilities and major utility corridors, water lines, transmission lines, public transportation, roadways, and active transportation routes. This asset group is sensitive to climate change as the impacts of hazards can affect the ability to provide services and resources; and the infrastructure in place may not be adequately prepared to sustain increasing and compounding hazards.

- Glendale Water & Power provides water and electrical services to City residents and businesses.
- Southern California Gas Company provides natural gas services to the City.
- The Glendale Public Works Maintenance Services maintains the City's sewer system.
- The City's wastewater is processed and reclaimed at the Los Angeles-Glendale Water Reclamation Plant
- Most stormwater drains in Glendale are owned and maintained by the City Public Work Department.
- The Glendale Police Department provides police services to the City.
- The Glendale Fire Department provides fire suppression services in the City.
- Waste and recycling services are provided through the Public Works – Integrated Waste Management Department.
- The Glendale Transportation Division operates the Beeline Bus, Dial-A-Ride and the Glendale Transportation Center.
- The Los Angeles County Metropolitan Transportation Authority operates buses throughout Glendale.
- Amtrak, Los Angeles Department of Transportation Metrolink, and Greyhound serve the Glendale Transportation Center providing rail and bus services.

4.3 Physical Vulnerability by Climate Hazard

Extreme Heat and Warm Nights

Overview

Extreme heat and warm nights impact natural resources, buildings, and infrastructure. As described in the *Climate Hazards* section, extreme heat events are expected to increase in both severity and frequency by mid-century.

Potential Impacts

NATURAL AND RECREATIONAL RESOURCES

Increased temperatures can cause vegetation stress in parks, landscaping, wildlife, and urban forests. Indirect impacts include reduced carbon storage and increased tree and vegetation mortality, as well as increased watering needs and related costs. Wildlife under these conditions face impacts of heat stress and heat related illness as well as disrupted reproductive cycles, and compounding risks associated with early and extended seasonal temperature increases (Backlund 2008). Plants are more likely to experience heat stress and drying, and species' habitat ranges may shift. Some pests can proliferate more easily with warmer temperatures (Hamerlynck 1995), and some plants and animals ill-suited to the new warmer conditions may suffer increased mortality rates (Ackerly et al. 2018). Increased temperatures may also impact outdoor recreation opportunities and residents and visitors would not be as likely to enjoy the mental and physical health benefits associated with outdoor recreation.

BUILDINGS AND FACILITIES

Extreme heat may impact occupants of buildings and facilities that are not adequately weatherized for increased temperatures, however, the buildings and facilities themselves are not at risk to extreme heat or warm nights.

INFRASTRUCTURE AND CRITICAL SERVICES

As temperatures increase, roadways, active transportation routes, and railroads are vulnerable to damages through sustained heat such as buckled railroad ties and cracked surfaces. Additional impacts from extreme heat are associated with increased emergency service calls which could strain medical services. Electrical infrastructure could be overwhelmed by demand and result in blackouts and Glendale Water & Power could conduct power safety shutoffs to avoid impacts to electrical facilities. Power outages have significant impacts on communication networks, water conveyance, and vulnerable populations. See the *Cascading Impacts Assessment* for more information on the cascading impacts of power outages.

Adaptive Capacity

This section gives an overview of the city-led adaptive capacity to extreme heat and warm nights:

- Increasing urban forest, tree canopy coverage, parks, and open space throughout the City are adopted policies and strategies as envisioned in the Greener Glendale Plan and the Glendale Downtown Specific Plan. Policies and strategies seek city-wide or neighborhood-wide improvements, including in vulnerable areas not within 1/3 mile of recreational open space (Greener Glendale Plan – Community 2012) (Glendale Downtown Specific Plan 2019).

- Increasing biodiversity of plants and ecosystems are adopted policies and strategies as envisioned in the Greener Glendale Plan. Policies and strategies seek city-wide or neighborhood-wide improvements. (Greener Glendale Plan – Community 2012).
- Inventorying backup-generators, medical equipment and supplies, temporary shelters, and other emergency response supplies and equipment are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale General Plan-- Safety Element 2003).

Vulnerability Score – Extreme Heat and Warm Nights

Physical Assets	Impact Score	Adaptive Capacity Score	Vulnerability Score
Natural and Recreational Resources	High	Medium	4-High
Buildings and Facilities	N/A	N/A	N/A
Infrastructure and Critical Services	High	Medium	4-High

Drought

Overview

Drought poses a risk to Glendale and the surrounding LA County. The recent 2012– 2016 drought had major impacts on water resources throughout the state, such as permanently reduced groundwater storage capacity because of land sinking caused by excessive extraction of groundwater (Lund et al., 2018). In the future, drought severity, frequency, and length are expected to increase so much so that California may experience long-term droughts at least every decade (Bedsworth et al., 2018). Glendale Water & Power is responsible for maintaining an adequate and reliable water supply. The City purchases between 60 percent and 70 percent of its potable water from the Metropolitan Water district of Southern California. The remaining 30 percent of its water is from local groundwater wells.

Drought can have severe impacts on natural resources, infrastructure, and critical services.

Potential Impacts

NATURAL AND RECREATIONAL RESOURCES

Drought would likely increase irrigation requirements for maintaining landscaping, park facilities, and street trees, while water use restrictions would potentially prevent asset managers from meeting this increased watering demand, resulting in water-stressed vegetation, increased vegetation mortality, and potentially reducing the quality of and benefits provided by recreational resources such as open spaces and parks and the urban forest (Lund et al., 2018; Okin et al., 2018). Drought will disrupt habitats and the

ability for wildlife to survive from dehydration and unreliable food sources.

BUILDINGS AND FACILITIES

Drought can cause increased soil cracking and subsidence in areas with low groundwater tables and high plasticity soils (e.g., clay-heavy soils), causing damage to building foundations and façades (LA County CVA 2021).

INFRASTRUCTURE AND CRITICAL SERVICES

Drought can impact water reliability and water infrastructure. Projected changes in snowpack, temperature, and precipitation rates from climate change across California will result in increased water scarcity through the end of the century (Ackerly et al. 2018). The recent multi-year drought significantly strained the State’s water supply systems, which resulted in water storage levels sinking to historic lows. This led to mandatory water use restriction impacting day to day activities and local economies. Low water supply also led to significant capital investments by water agencies in an effort to increase reliability during extended drought periods, which may lead to future water rate adjustments. Drought can result in an increased dependency on groundwater and lower groundwater levels, causing increased contaminant concentrations in aquifers and permanently impaired aquifers (LA County CVA 2021). Although Glendale has a diverse portfolio of multiple different water sources and providers, the impacts of drought on the water system are regional in scope. Drought can also result in increased maintenance needs, causing cracked pavements compounded with extreme heat (Samuel et al. 2019).

Adaptive Capacity

This section gives an overview of the city-led adaptive capacity to drought:

- Implementing and enforcing water use restrictions for non-essential or wasteful activities by promoting conservation and administering penalties for overuse are adopted policies and strategies as envisioned in the City of Glendale Urban Water Management Plan. Policies and strategies seek city-wide or neighborhood-wide improvements (City of Glendale Urban Water Management Plan 2020).
- Utilizing a phased approach to water use restrictions to account for varying supply (i.e., mandatory water restrictions in times of emergency water shortage) are adopted policies and strategies as envisioned in the City of Glendale Urban Water Management Plan. Policies and strategies seek city-wide or neighborhood-wide improvements (City of Glendale Urban Water Management Plan 2020).
- Maintaining a diversified water portfolio is critical for drought resilience. The City of Glendale purchases between 60 percent and 70 percent of its potable water from the Metropolitan Water District of Southern California and between 30 percent and 40 percent of its water is from local groundwater wells.

Vulnerability Score – Drought

Physical Assets	Impact Score	Adaptive Capacity Score	Vulnerability Score
Natural and Recreational Resources	High	Low	5-High
Buildings and Facilities	Low	Low	3-Medium
Infrastructure and Critical Services	High	Medium	4-High

Wildfire

Overview

Climate change has been linked to increases in wildfire activity and longer wildfire seasons across California (Westerling et al., 2006). Increasing temperatures, earlier snowmelt, megadroughts, and precipitation whiplash events are all contributing factors (Ullrich et al., 2018; Swain et al., 2018). However, wildfire activity and its associated impacts vary depending on factors such as land use, ecology, and topography. Wildfire events typically occur in more rural areas, along the wildland urban interface (WUI), and in wildfire hazard severity zones. Historically wildfires have affected Glendale mainly on a regional level with two wildfires in City limits as show in Figure 11, La Tuna and (2017) and the Mountain Fire (2002). Potable/recycled water pump stations, parks, schools, landfill/waste management stations, police stations, and fire stations are located within the Very High Fire Hazard Severity Zone in northern Glendale, as shown in Figure 10.

Sustainability Working Group participants also identified wildfire impacts to community members due to road closures and smoke. Impacts of wildfire smoke on air quality are described in the *Poor Air Quality* section below. Power disruption is discussed in the *Cascading Impacts Assessment* below.

Wildfire risks are likely to increase in the future. While many critical facilities are located in urbanized areas, where wildfire is less likely to occur, urban assets may be affected by disruptions in the delivery of services (such as electricity) provided by facilities located in the path of wildfire. See *Cascading Impacts Assessment* for more information on these impacts.

Potential Impacts

NATURAL AND RECREATIONAL RESOURCES

Wildfires can cause direct mortality and loss of resources and wildlife as well as indirect mortality due to loss of habitat area and available food sources and seed bank (Backlund 2008). The severity and frequency of wildfires can exacerbate these impacts further through habitat conversions resulting in vegetation communities that no longer support the species using that habitat (Coop et al. 2020). Wildfire impacts on parks can also cause prolonged closure of park facilities, limiting access to important recreational areas and facilities for the public.

BUILDINGS AND FACILITIES

Structures and buildings located within wildfire hazard zones are at risk of direct structural damage from wildfires. There are many critical facilities in Very High Fire Hazard Severity Zones, including potable/recycled water pump stations, parks, schools, landfill/waste management stations, police stations, and fire stations as displayed in Figure 10. These critical facilities could be directly damaged by wildfires. Areas of high exposure include low density residential zoned areas in north Glendale below I-210 and above Markridge Road, between La Canada Boulevard and SR 2, as well as neighborhoods throughout east Glendale as displayed in Figure 10.

INFRASTRUCTURE AND CRITICAL SERVICES

Wildfire hazard zones may expand by the end-of-century which could lead to more critical facilities at risk of structural damage. Additionally, above ground or just below-grade utility lines have the potential to be damaged in wildfire hazard zones, resulting in oil and gas leaks, water loss, and power outages, which can cause fires. Utility lines under certain high wind conditions can also trigger

wildfires through downed power lines (Ackerly et al. 2018). Additionally, public safety power shut offs in response to wildfire risk can affect power service reliability. Three above-ground major transmission lines that GWP maintains are located in Very High Fire Hazard Severity Zones, as shown on Figure 10

Increased frequency of wildfires can place strain on fire and emergency services. Displaced residents can cause service strains and needs for additional community safety services. Increased frequency of wildfires can place strain on fire and emergency services. Evacuation routes could be disrupted during a wildfire event limiting emergency responders’ access and the ability for people to evacuate.

Adaptive Capacity

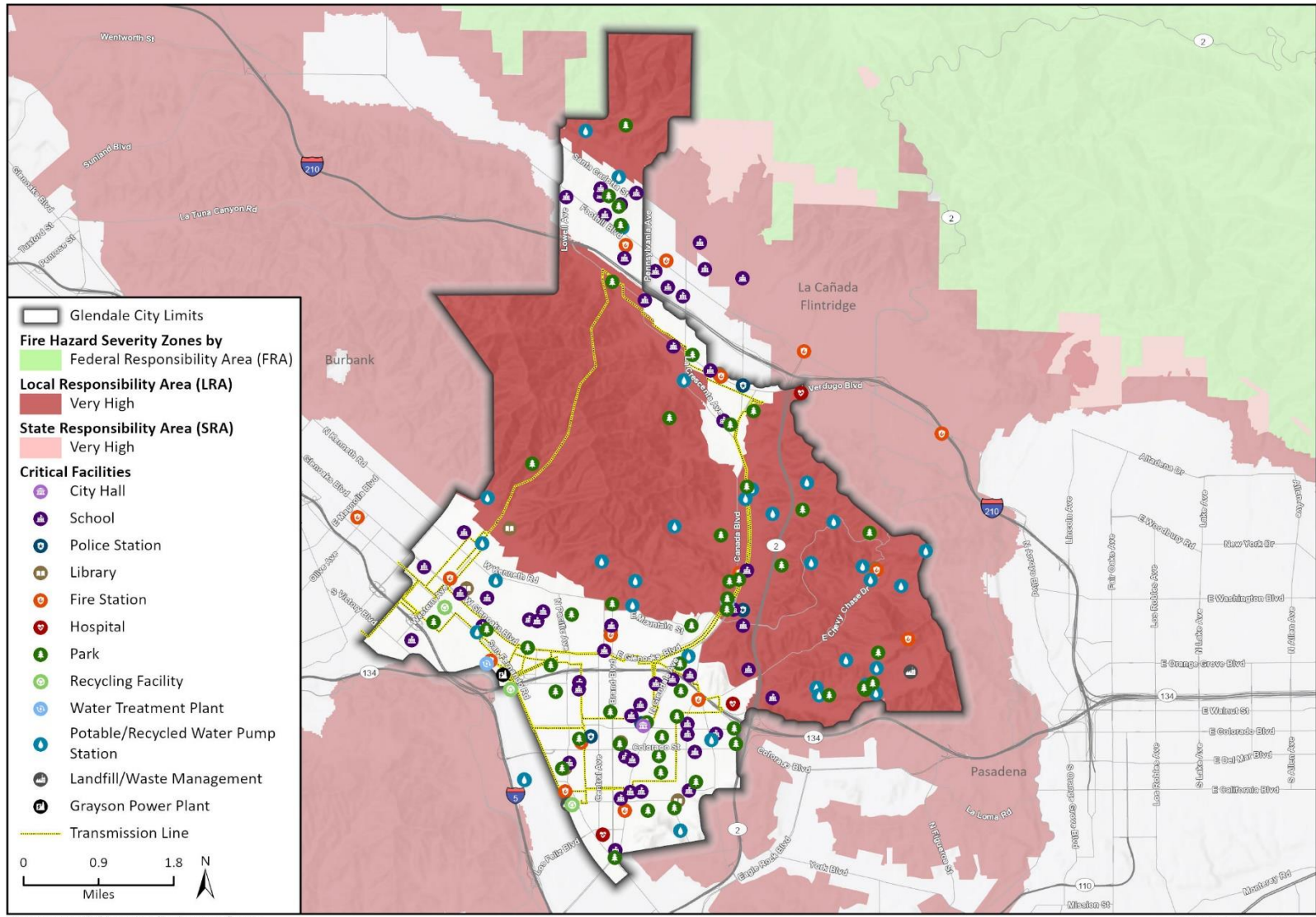
This section gives an overview of the City-led adaptive capacity to wildfire:

- Ensuring adequate fire services, such as fire equipment, infrastructure, and response times throughout the City are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (General Plan— Safety Element 2003).
- Enforcing fuel management, weed abatement, fire-resistant landscaping, and structure hardening programs and efforts to

minimize wildfire risk are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (General Plan— Safety Element 2003).

- Designing, constructing, maintaining, and operating Glendale Water & Power electric transmission and distribution system to minimize wildfire risk are adopted policies and strategies as envisioned in the Glendale Water & Power – Wildfire Mitigation Plan. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale Water & Power— Wildfire Mitigation Plan 2022).
- Coordinating with local and regional jurisdictions and agencies to update and implement disaster preparedness and recovery plans, maintain mutual aid agreements, and carry out evacuation procedures are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale General Plan— Safety Element 2003).
- Inventorying backup-generators, medical equipment and supplies, temporary shelters, and other emergency response supplies and equipment are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale General Plan— Safety Element 2003).

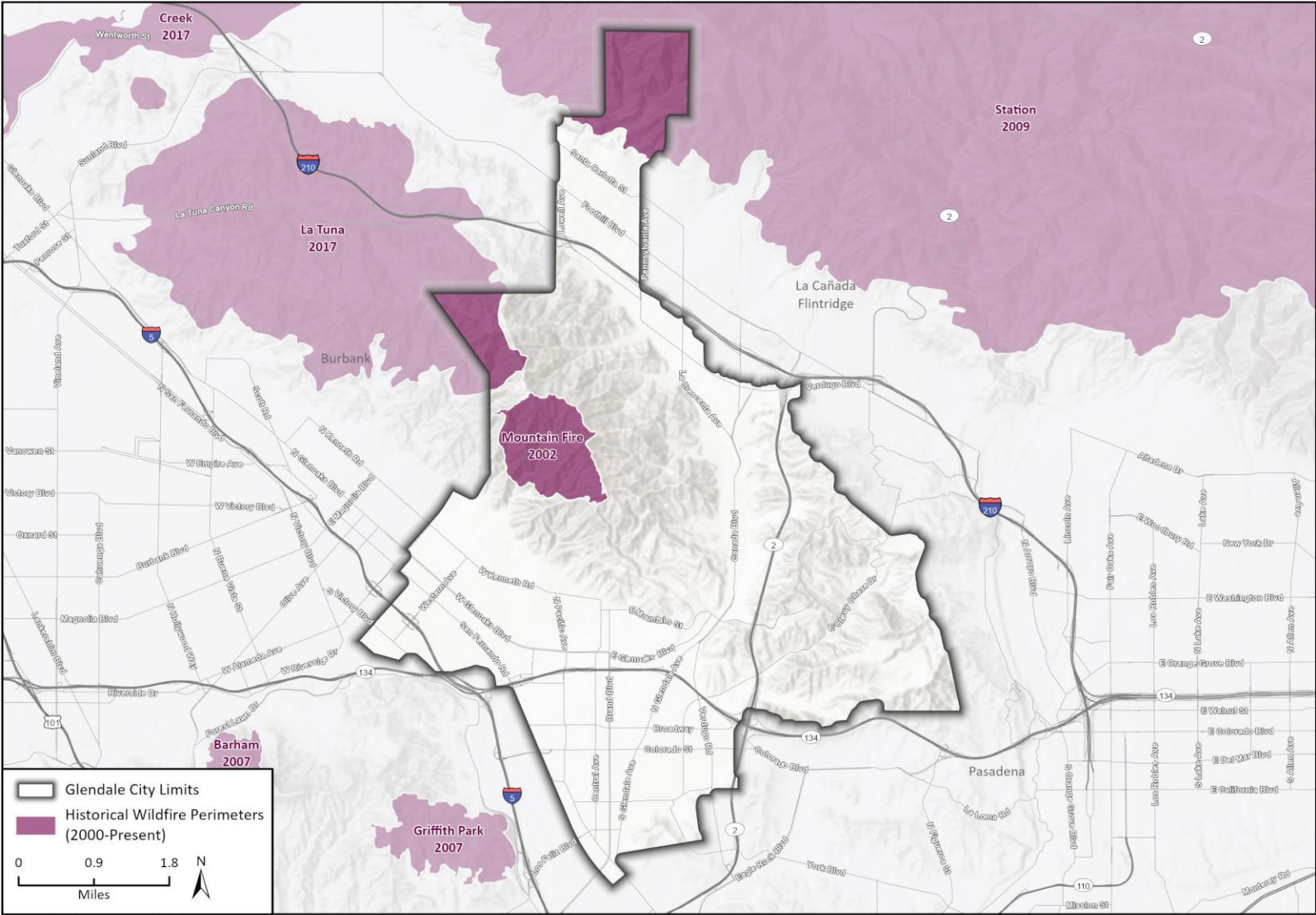
Figure 10 Wildfire Hazard Severity Zones in Glendale



Basemap provided by Esri and its licensors © 2023.
 Additional data provided by CAL FIRE, 2007 & 2012; City of Glendale, 2023.

21-11575 Glendale CAAP VA.aprx
 Fig X Wildfire Hazard Severity Zones and Critical Facilities

Figure 11 Historical Wildfire Events in Glendale



Basemap provided by Esri and its licensors © 2023.
Additional data provided by CAL FIRE, FRAP, 2022.

21-11575 Glendale CAAP VA.aprx
Fig X Historical Wildfire Perimeters

Vulnerability Score – Wildfire

Physical Assets	Impact Score	Adaptive Capacity Score	Vulnerability Score
Natural and Recreational Resources	High	Low	5-High
Buildings and Facilities	High	Medium	4-High
Infrastructure and Critical Services	High	Medium	4-High

Landslides

Overview

Sustainability Working Group participants identified historical issues related to mud and debris flows following the Station Fire and impacts to development and anticipate these impacts to continue due to climate change.

Areas in the north bordering I-210 and La Crescenta Ave, and areas in central Glendale along SR 2 as well as those in east Glendale have high landslide risk, as shown on Figure 7. The San Gabriel Mountains, San Rafael Hills, and Verdugo Mountains are at the greatest risk in the area for having slope instabilities. Historically, landslide occurrences have affected the City of Glendale during extreme precipitation events preceded by intense wildfire. Landslides can cause habitat loss, erosion, property damage, injury, and strained emergency services.

Potential Impacts

NATURAL AND RECREATIONAL RESOURCES

Landslide susceptibility directly overlaps with parks and natural resource areas throughout the City as shown in Figure 12. In the event of a landslide, there is potential for loss of lands, habitat, and disruption of waterbodies in areas of debris flow. There is risk around loss of topsoil and habitat conversions. Wildlife and plants face a compounding risk to landslide events because it creates both habitat displacement and increased mortality risk.

BUILDINGS AND FACILITIES

Buildings and facilities located in the landslide risk zone are susceptible to damage in the event of a landslide event. There are many critical facilities in landslide hazard zones, including potable/recycled water pump stations, parks, schools, landfill/waste

management stations, police stations, and fire stations as displayed in Figure 12. Areas of high exposure include areas in the north Glendale bordering I-210, from Canada Boulevard and SR 2, as well as those in east and southeast Glendale as displayed on, Figure 12.

INFRASTRUCTURE AND CRITICAL SERVICES

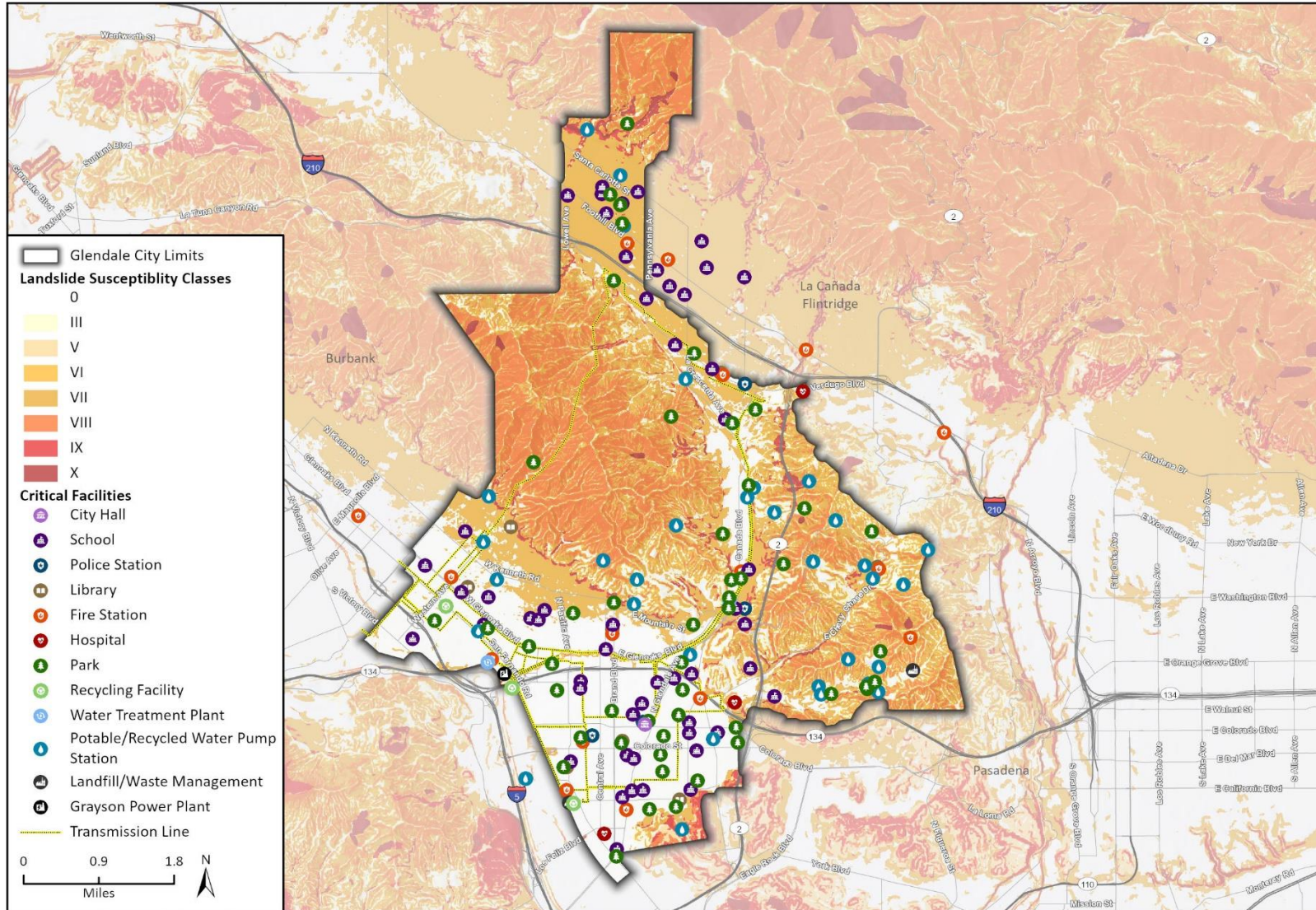
There is high landslide susceptibility along roadways in the northern and east end of the County, shown in Figure 12, and in areas where there are several critical facilities including fire stations, schools, and water pumps, there is a risk of emergency service disruption and impacts to evacuation (CDOC 2021). Pipelines for water, electrical distribution lines, and roadways are vulnerable to landslide impacts which could occur in sloped areas that extend into wildfire zones.

Adaptive Capacity

This section gives an overview of the City-led adaptive capacity to drought:

- Mitigating landslide risks and potential damage to structure and infrastructure through requiring geotechnical investigations, regular inspections, and prohibiting reconstruction of structures in areas with failed slopes are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (General Plan— Safety Element 2003)
- Coordinating with local and regional jurisdictions and agencies to update and implement disaster preparedness and recovery plans, maintain mutual aid agreements, and carry out evacuation procedures are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale General Plan— Safety Element 2003).

Figure 12 Landslide Susceptibility in Glendale



Basemap provided by Esri and its licensors © 2023.
 Additional data provided by CGS, Map Sheet 58, 2018; City of Glendale, 2023.

21-11575 Glendale CAAP VA.aprx
 Fig X Landslide Susceptibility and Critical Facilities

Vulnerability Score – Landslides

Physical Assets	Impact Score	Adaptive Capacity Score	Vulnerability Score
Natural and Recreational Resources	Medium	Medium	3-Medium
Buildings and Facilities	High	Medium	4-High
Infrastructure and Critical Services	High	Medium	4-High

Stormwater Flooding and Extreme Precipitation

Overview

Sustainability Working Group participants identified historical and current flood issues including downed trees, flooded roads and buildings, and downed trees and debris from storms hitting utility lines.

When an influx of stormwater exceeds a drainage system's capacity to infiltrate water into the soil or to carry it away, localized stormwater flooding can occur. Urban landscapes tend to be built with impermeable surfaces that do not allow much water to infiltrate the ground and this increases the amount of runoff that must be channeled in storm drainage systems and carried elsewhere. Most urban drainage infrastructure was not built to manage stormwater flows from the increased precipitation events that are occurring and will occur more frequently with climate change and can be costly to retrofit. As a result, the costs and impact of urban flooding are expected to increase as precipitation patterns become more extreme due to climate change (NASEM 2019).

Climate change may cause areas throughout Glendale to experience more frequent stormwater flooding. Stormwater systems may be overwhelmed more frequently as more extreme rain events occur, causing localized flooding which could impact properties and leave roads temporarily unusable. Areas with high amounts of impermeable surfaces and those adjacent to drainage systems are prone to stormwater flooding during periods of heavy rainfall.

Flooding impacts directly create physical damage from inundation (Hall et. al 2018). Flooding can also lead to cascading risks due to loss of power, wastewater management issues, pollution carried by

stormwater including hazardous materials, and overwhelm storm drainage infrastructure, exacerbating public health concerns. Cascading impacts are discussed in the *Cascading Impacts Assessment* section.

The Verdugo Wash is a 9.4-mile-long tributary of the Los Angeles River in Glendale. It flows southeast along the eastern edge of the Verdugo Mountains and is entirely encased in a concrete flood control channel. The City is working toward a re-envisioned Verdugo Wash that includes a linear park to increase public access and aesthetics in the area. The project will create a 9.4-mile-long linear park and nature trail for walking and cycling with access to business and entertainment venues increase connections between nature, people, places, and culture as it weaves several important City centers, services, and neighborhoods together that make up a large area of Glendale (City of Glendale N.d.b).

The Los Angeles River runs through the City of Glendale from north to south along the eastside of Griffith Park south to Elysian Park. This narrow, seven-mile stretch of the Los Angeles River is known as the Glendale Narrows. It is currently one of the only stretches of the Los Angeles River that does not contain a concrete bottom, and as a result, provides crucial habitat for local vegetation and wildlife. The City is working towards finishing the Glendale Narrows Riverwalk, which will provide approximately one mile of trails for bicyclists and pedestrians. This project will include parks, rest areas, river overlooks, an equestrian facility, public art projects, interpretive signage, and the Garden River Bridge connecting to Griffith Park (City of Glendale Narrows Riverwalk).

The Burbank Western Channel is a 6.3-mile-long tributary of the Los Angeles River in the eastern San Fernando Valley that serves as a flood control channel. Intersecting the Los Angeles River at the start of the Glendale Narrows, the Burbank Western Channel allows for

excess water in the river to flow north into this area and avoid flooding the surrounding north Glendale and south Burbank areas.

Potential Impacts

NATURAL AND RECREATIONAL RESOURCES

California’s Fourth Climate Change Assessment projects more extreme precipitation events will occur throughout the Los Angeles region, which may lead to areas throughout Glendale to experience more frequent flooding. Heavy precipitation can lead to erosion which may impact vegetation and wildlife. Because there is a low risk of flooding in open spaces in Glendale, the impact on natural and recreational resources is deemed to be low.

BUILDINGS AND FACILITIES

Flooding may cause damage to buildings and facilities or render them temporarily unusable should flooding of buildings or facilities occur.

INFRASTRUCTURE AND CRITICAL SERVICES

Impervious surfaces can impede the absorption of water and augment stormwater flooding in areas of Glendale. There is risk of damage from increased extreme precipitation events including localized flooding, erosion, transport of debris, and sediment deposition. Storm drainage and flood protection services for the City may be impacted by these events, and flooded roadways may be temporarily impassable, disrupt or delay provision of emergency services, or increase risk to road users.

Adaptive Capacity

This section gives an overview of the city-led adaptive capacity to drought:

- Increasing urban forest, tree canopy coverage, parks, and open space throughout the City are adopted policies and strategies as envisioned in the Greener Glendale Plan and the Glendale Downtown Specific Plan. Policies and strategies seek city-wide or neighborhood-wide improvements, including in vulnerable areas not within 1/3 mile of recreational open space (Greener Glendale Plan – Community 2012) (Glendale Downtown Specific Plan 2019).
- Mitigating flood impacts through discouraging development of critical facilities in flood hazard areas, requiring hydrological studies, and maintaining City-owned storm drain facilities are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (General Plan— Safety Element 2003).
- Coordinating with local and regional jurisdictions and agencies to update and implement disaster preparedness and recovery plans, maintain mutual aid agreements, and carry out evacuation procedures are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale General Plan— Safety Element 2003).

Vulnerability Score – Stormwater Flooding and Extreme Precipitation

Physical Assets	Impact Score	Adaptive Capacity Score	Vulnerability Score
Natural and Recreational Resources	Medium	Medium	3-Medium
Buildings and Facilities	Medium	Medium	3-Medium
Infrastructure and Critical Services	Medium	Medium	3-Medium

Poor Air Quality

Overview

Poor air quality events often coincide with regional wildfire events, periods of time without wind, extreme heat events, and extended droughts. As climate change is expected to result in an increased severity and frequency of those extreme events, it is likely that poor air quality will worsen in the future and under worse climate scenarios. Poor air quality can harm wildlife and vegetation as well as cause strained emergency services based on the negative health impacts associated with poor air quality.

Potential Impacts

NATURAL AND RECREATIONAL RESOURCES

The direct effects of air quality declines on natural resources and parks relate to plant and wildlife health as increased levels of air pollutants cause stress and mortality. Impacts from poor air quality can further impact natural resources since air quality declines correspond with other hazards, such as extreme heat, compounding risks. The degradation of plant and wildlife health could impact the quality of recreational resources such as open spaces and parks. Impacts from poor air quality can also make outdoor recreational resources dangerous or unhealthy for vulnerable groups identified in the *Social Vulnerability Assessment* section.

BUILDINGS AND FACILITIES

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

INFRASTRUCTURE AND CRITICAL SERVICES

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

Adaptive Capacity

This section gives an overview of the city-led adaptive capacity to drought:

- Inventorying backup-generators, medical equipment and supplies, temporary shelters, and other emergency response supplies and equipment are adopted policies and strategies as envisioned in the Glendale General Plan – Safety Element. Policies and strategies seek city-wide or neighborhood-wide improvements (Glendale General Plan— Safety Element 2003).

Vulnerability Score – Poor Air Quality

Physical Assets	Impact Score	Adaptive Capacity Score	Vulnerability Score
Natural and Recreational Resources	High	Medium	4-High
Buildings and Facilities	Low	Low	3-Medium
Infrastructure and Critical Services	Medium	Medium	3-Medium

5 Cascading Impacts Assessment

5.1 What are Cascading Impacts?

Glendale community members rely on an interdependent network of critical facilities, services, and infrastructure that are vulnerable to climate change. Electrical infrastructure could be overwhelmed by peaks in demand and result in blackouts or public safety power shutoffs instituted by GWP to avoid impacts to electrical facilities. Power outages have significant cascading impacts on communication networks, water conveyance, transportation systems, emergency services, and vulnerable populations. Water systems can fail from lack of power or supply creating city-wide shortages and issues related to power generation cooling or wildfire mitigation. Transportation systems could fail from a variety of direct physical vulnerabilities through climate hazards as well as through power reliant infrastructure which could isolate community members to unsafe conditions. These interconnected, or cascading impacts, could broaden the scope of impact past a single system or neighborhood to reliant subsystems and populations.

The Los Angeles County Climate Change Vulnerability Assessment includes a detailed analysis of the interconnections between various systems to better understand the different paths a climate hazard impact may have (Los Angeles County 2021). A systems map was created that identifies critical nodes (e.g., aqueduct volume, imported water supply) and the potential pathways of cascading impacts from one node to another.

Based on the Los Angeles County Climate Change Vulnerability Assessment systems map, electricity was found to strongly influence every other infrastructure sector and was found to have the most

connections. Highway system reliability and communications were nodes that had the second and third highest number of outgoing connections. Water was also found to be heavily relied upon by other infrastructure nodes. Community function, defined as human health, well-being, and livelihood in the Los Angeles County Climate Change Vulnerability Assessment, was found to be an interconnected node when considering indirect connections. Maintaining community function is the actual purpose of energy, communications, and transportation services, but it is people who keep infrastructure running. Therefore, when climate hazards interfere with workforce availability, there are significant cascading impacts to reliant subsystems.

Unlike most other municipalities, Glendale has direct control over its own water and electricity, through GWP. These two interconnected sectors and associated cascading impacts unique to Glendale are discussed in this chapter, followed by an assessment of cascading impacts associated with transportation and communications.

5.2 System Interdependencies

The following section builds on Glendale's physical and social vulnerabilities through an analysis of the interconnections between Glendale's energy, water, transportation, and communication systems and highlights the more prominent cascading risks across Glendale's systems.

Electricity System

The electricity delivery system, often times referred to as the “grid”, is made up of three primary subsystems; electricity generation, transmission, and distribution. Each of these systems needs to be operational in order for community members to receive the electricity they rely on for lighting, internet, communication, heat, hot water, and more recently, mobility. Each of these systems can be impacted by a physical threat such as wildfire burning facilities or infrastructure, wind or vegetation damage, or extreme heat which can decrease the effectiveness of transmission and distribution lines. Increased heat can also increase electricity demand (for example when extreme heat triggers additional cooling demand) that exceeds the amount electricity is available (generation) or the capacity of the infrastructure to move that electricity (transmission and/or distribution).

Electricity Generation

Glendale Water & Power relies on both locally sourced and external sources of energy to meet its demand. Local sources of energy generation include the Grayson power plant, existing solar and planned battery storage. External sources of energy are obtained via the Pacific DC and Southwest AC interties, which are transmission line interconnection points with an energy grid that spans the Western United States. The Glendale Water & Power Integrated Resource Plan (2019) outlines the makeup of Glendale’s energy portfolio as well as an analysis of load and resource needs based on projected climate changes, state requirements of renewable resources, and changing needs of the community (City of Glendale Water & Power 2019).

GWP produces local sourced energy at the Grayson Power Plant, which is a collection of 9 gas burning engines, that produces 173 MW from units 1-8 and 48 MW from unit 9 during peak load. Units 1-8 were set to expire in 2022. According to the Integrated Resource Plan, alternatives to energy generation within Glendale are limited. It is estimated that GWP would need 12.4 square miles of solar panels to adequately power Glendale, which is equivalent to about 40 percent of Glendale’s land area. Even with GWP investments in locally produced energy sources the City is constrained by land, resource, and infrastructure availability (Ascend 2021).

To address these energy generation constraints, GWP has proposed to replace Grayson Units 1, 2, 3, 4, 5, 8A, and 8BC at the Grayson Power Plant to install reciprocating internal combustion engines which generate electricity using a variety of fuels, but predominately natural gas in the short term. This system change is intended to address existing energy shortfalls within the antiquated system currently in place at the Grayson Power Plant. These engines are intended to operate as backup power generation during peak demand hours (Ascend 2021).

With anticipated upgrades to the Grayson Power Plant, and assuming a certain amount of EV charging¹ and associated charging infrastructure, increased ambient temperatures, and projected energy demands, GWP anticipates meeting demand pending approval of the Grayson Power Plant changes upon construction and implementation of the newer engines. Until changes occur, the energy supply of local sources and external sources will not meet forecasted or current peak demand (Ascend 2021).

¹ Per the IRP GWP anticipates a load increase from 28 GWh in 2019 to 173 GWh in 2030, and 290 GWh in 2038 for Electric Vehicles using the states assumption of 5 million EV's by 2030.

The Grayson Power Plant in southeast Glendale is located in close proximity to a Very High Fire Hazard Severity Zone, which is located just outside City limits (City of Glendale Water & Power 2019).

Electricity Transmission

GWP has access to a limited amount of external transmission through the Pacific DC and Southwest AC interties. The interties provide approximately 212 Megawatts of peak load. Typically, Glendale needs 478 MW of peak load. During high heat days, the actual megawatts obtained through the interties is likely lower, as heat reduces load capacity on transmission lines. The limited access Glendale has to external sources of energy necessitates over half of the peak load energy generation to be produced within City limits (Ascend 2021).

Climate hazards could result in direct and indirect impacts on power delivery to Glendale community members. There are three overhead transmission lines owned and operated by GWP that pass through the Very High Fire Hazard Severity Zones in north Glendale. GWP engages in several programs to reduce the impacts associated with potential power disruption due to wildfire events. According to the GWP Wildfire Prevention Mitigation Plan, GWP has a Public Safety Shutoff Events program that involves providing 24–48-hour advanced notice as well as more immediate shutoff notifications to limit risk of triggering a wildfire and to avoid damaging electrical infrastructure from peak demand periods. Since wildfires are most often triggered by vegetation coming into direct contact with electric utilities, GWP also maintains a Vegetation Management Plan to reduce risks (City of Glendale 2022). In addition, impacts anywhere along those transmission lines outside of Glendale could also cause issues within Glendale if enough capacity is not available locally to meet demand.

Electricity Distribution

The third part of the grid are the smaller distribution lines, transformers, and service lines running directly to each individual building. Distribution systems can be disrupted by similar impacts as transmission lines (wildfire, wind, vegetation, extreme heat), but at a local level. Small areas of wildfire, neighborhood trees, or demand outstripping capacity for a local transformer or distribution line.

Summary

Between higher rates of extreme heat days and increasing wildfire probability due to climate change, the possibility of power disruption is high (City of Glendale 2022).

Power disruptions in Glendale, whether caused by factors like wildfires, deliberate power shutoffs for public safety, or extreme heat, have extensive cascading impacts. Impacts include but are not limited to loss of power in homes, which prevent community members from running their air conditioning or gas or electric heaters, and gas and electric kitchen appliances. For those who rely on in-home medical devices, power disruption could directly impact health and safety. If the power outages occur during bad air quality days from regional wildfire smoke, people with underlying health conditions could experience worsening health conditions. Traffic signals, cell-towers without back-up power, and critical facilities that lack backup power would cease to function. Losing many of these energy dependent amenities during events like heatwaves and wildfires can create increased risks to public health, including heat related illness, food access constraints, evacuation challenges, overloaded emergency services, and increased climate hazard exposure.

Natural Gas System

Southern California Gas Company provides natural gas services to the City through transmission lines and high pressure distribution

lines. Natural gas lines have the potential to be damaged in wildfire hazard zones, resulting in oil and gas leaks and power outages, which can cause fires or explosions. Significant landslides after wildfires or during an extreme rain event may also damage natural gas lines. In addition, natural gas leaks, such as the 2016 leak at the Aliso Canyon natural gas storage facility in Southern California, can lead to temporary closures of natural gas facilities. In the case of Aliso Canyon, the loss of the facility's storage capacity was unable to be offset by short term increase in the volume of gas deliveries through the regional supply network. This event exposed the limitations of the region's natural gas system to effectively respond to the prolonged disruption to a critical component of its energy storage infrastructure (Hall et al. 2018).

Water System

Per the City of Glendale's Urban Water Management Plan (2020), Glendale is anticipated to experience water supply disruption for outdoor water use during drought conditions. GWP acquires water from a variety of sources including water purchased from the Southern California Metropolitan Water District, groundwater from the Verdugo and San Fernando Basins, and recycled water from the Los Angeles-Glendale Water Reclamation Plant (City of Glendale Urban Water Management Plan 2020). These sources enter the City through 11 different conveyance points and are distributed through water distribution lines and pump stations across the entire City. Water pump stations are located in landslide risk areas and Very High Fire Hazard Severity Zones (City of Glendale Urban Water Management Plan 2020).

Many relationships between higher water usage and lower water availability are observed. There are several demonstrated positive feedback loops wherein the City's water systems can be strained due to drought and extreme heat conditions, which in turn lead to

diminished water availability, influenced by both consumer demand and climatological factors. Water usage for regional and city-specific wildfire mitigation aligns with heightened drought conditions and decreased water supplies. These interconnected impacts within the water sector compound, resulting in extreme strains on water supply and introducing additional challenges for Glendale.

During drought conditions, there is an increase in demand for water, however, that is when water supply is constrained. Increased demand for water during drought conditions include water needs for landscaping, and water-cooling features for community members. Drought conditions typically increase the risk of wildfire, further compounding the effects of drought on the community. The cascading impacts of an adversely impacted water system include reduced supply for community consumption potentially increasing water rates and associated public health concerns for under-resourced Individuals who may not have the ability to pay for increased water rates. Water shortages can also impact power generation with availability of water for generator cooling. Inadequate water supply can also impact wildfire mitigation without enough fire flow to fight active fires and/or prevent anticipated fires. Inadequate water can impact the City's tree canopy which is critical for addressing the urban heat island effect and stormwater capture.

Transportation System

Several freeways and major arterial routes run directly through wildfire and landslide hazard zones in Glendale creating broad transportation system and infrastructure vulnerabilities. There are many resulting cascading impacts from transportation sector disruptions which could result in mobility isolation for the community, reduced ability for emergency services to respond, and constrained evacuation routes. Transportation impacts can occur

from a wide range of causes including direct physical damage associated with climate hazards within City limits or external climate impacts afflicting regional transportation networks and services. Power outages could cause traffic signal failures. Transit system failures could place the community in increased danger with inability to evacuate or seek medical attention.

I-210 and I-5 as well as SR 134 and 2 overlap multiple hazard zones and simultaneously serve as major evacuation routes. This type of infrastructure exposure can result in both city-wide and regional cascading impacts limiting evacuation and emergency service accessibility.

Communications System

Like other sectors, the initial vulnerability within Glendale's communication systems and infrastructure relates to physical

exposure to climate hazards. Communication networks consisting of utility, telephone, and broadband infrastructure can experience disruptions and service failures from exposure to extreme heat, wildfires, landslides, and flooding. The viability of a communication network is greatly improved with redundant communication networks, backup power, and alternative forms of communication (e.g., radio) to help minimize the extent of impact to community members. The cascading impacts resulting from downed communications can vary from interrupted evacuation communications to general isolation and heightened risk due to inability to receive hazard information. Areas across Glendale in hazard zones are more prone to experiencing communication service disruptions and, therefore, may experience increased cascading impacts from loss of communication infrastructure.

6 Conclusion

Climate change can have far-reaching consequences on the Glendale community. This report evaluates how climate change may impact community members and physical assets including natural and recreational resources, buildings and facilities, and infrastructure and critical services.

Consistent with Phase 3 of the Cal APG, major problem statements are provided to characterize the overall climate impacts Glendale may experience. These problem statements will be utilized to frame and generate climate adaptation strategies for the Glendale CAAP.

6.1 Problem Statements

The following problem statements are intended to guide the development of adaptation policies and programs for the City's CAAP. Problem statements are organized based on four systems that have the greatest influence on climate resilience, as well as greenhouse gas emissions reduction.

Building Systems

Residential Buildings. Weatherized or fire-hardened residential buildings are critical to increasing community resilience to the effects of extreme heat, wildfires, landslides, stormwater flooding, and poor air quality. A large majority of Glendale's housing stock was built over 50 years ago and needs rehabilitation to address climate stressors. Individuals facing societal barriers are generally more likely to live in housing with insufficient protection against climate hazards. Particularly in south Glendale, overcrowding, poor housing conditions, a large number of immigrants, and non-English

speakers render the households disproportionately vulnerable to climate hazards. Under-resourced individuals are less likely to have adequately hardened and weatherized housing. They are more likely to have limited control over home hardening, improvements, and air conditioning/filtration systems that protect against climate hazards. Residential buildings are located in Very High Hazard Severity Zones in northern and eastern Glendale. Residential buildings are also located in landslide susceptibility zones in areas north bordering I-210 and La Crescenta Ave, and areas in central Glendale along SR 2 as well as east Glendale.

Critical Public Facilities. Critical public facilities are structures and institutions that provide Glendale with resources and services and are essential to the health and welfare of residents. Weatherized and energy resilient critical public facilities are important for a community to be able to better respond to and recover from a climate hazard event. These facilities must continue to operate during and following a climate hazard event to reduce the severity of impacts and accelerate recovery. Critical public facilities located in landslide susceptibility areas and Fire Hazard Severity Zones include schools, police stations, and fire stations.

Resilient Energy System. The reliability of Glendale's energy system is critical to the resilience of the City's services and community members. Glendale's energy system and power infrastructure are highly vulnerable to extreme heat which causes increased energy demand due to cooling needs, wildfire, and landslides. Energy infrastructure and dependent populations experience cascading impacts around power outages from downed utility lines, power safety shutoffs, and grid overload. All forms of power outages can

affect how critical services are able to perform their needed functions during a climate hazard. Three above-ground major transmission lines that Glendale Water & Power maintains are located in Very High Fire Hazard Severity Zones. The Grayson Power Plant, which generates electricity using natural gas, exacerbates the poor air quality conditions in southeast Glendale. This area is designated as a high social vulnerability area in Glendale. Individuals with chronic health conditions or health related sensitives are disproportionately susceptible to health impact associated with air pollutants. The Grayson Power Plant is located in close proximity to a Very High Fire Hazard Severity Zone, which is located just outside City limits.

Mobility, Land Use, and Emergency Systems

Alerts and Evacuation. Emergency communications and timely evacuations are an essential part of emergency operation planning and community safety. Emergency communication and evacuation orders will be key to alert the Glendale community regarding various climate hazards, including wildfires and landslides, extreme heat events, and poor air quality days. Barriers to communication and evacuation can occur from deficiencies in the energy, transportation, and communication systems, as well as inequitable access and distribution of resources. Individuals with chronic health conditions or health related sensitivities may have difficulty evacuating in a timely fashion during a hazardous event which can result in direct impacts to health and safety and exacerbate chronic health problems. Individuals facing societal barriers may not have access to language appropriate advisory warnings or government guidance and may face systematic and/or cultural barriers to access resources to safely evacuate hazard areas and/or to treat injuries. Under-resourced individuals and individuals that rely on public transportation are less likely to have access to transportation for

evacuation purposes and often lack the financial resources to evacuate from a climate hazard or find a safe and affordable place in which to evacuate.

Transportation and Communication Infrastructure for Emergency Evacuation. Major freeways and arterial routes in Glendale are located within landslide and Very High Fire Hazard Severity Zones, including the I-210, I-5, SR 134, SR 2, La Canada Boulevard, N Verdugo Road, and La Crescenta Ave. These routes serve as major evacuation routes, allowing community members to evacuate during emergency orders and allowing emergency personnel to enter emergency evacuation zones. Should these transportation networks be directly impacted by landslides or wildfires, or are impacted by regional threats outside City limits, emergency evacuation could be adversely impacted. Communication infrastructure (such as cell towers) damaged by wildfires or landslides would hinder emergency communications and impact the health and safety of emergency personnel and community members.

Equitable Access to Services. People who rely on active transportation or public transit may experience barriers in accessing cooling centers, parks, and other critical services, and have a greater likelihood of encountering interruption in transportation services which could lead to direct income losses from the inability to access their workplace during climate events. They also have higher outdoor exposure, such as extreme heat, air pollution, or heavy rainfall, than those who use personal vehicles and are therefore at greater risk to climate hazards. This high risk is compounded by the fact that communities of color are more likely to have limited or no access to a car, increasing their likelihood of being impacted during heat and other climate hazards. Under-resourced individuals are less likely to have access to transportation, healthcare, and other basic needs which increases their vulnerability to climate hazards.

Building on systemic inequities, these disproportionate exposures can leave community members isolated and/or without the needed resources during a climate hazard event.

Urban Ecosystems

Water Reliability and Consumption: Water supply infrastructure, such as pipelines and pump stations, can be damaged by climate hazards, impacting water reliability throughout the City which has direct implications on wildfire mitigation, community members, and critical services. Several water pump stations are located in landslide susceptibility areas and Very High Fire Hazard Severity Zones in northern Glendale. Glendale’s water potable supplies, including those from the Southern California Metropolitan Water District and groundwater from the Verdugo and San Fernando Basins, have declined in recent years due to lower-than-average rainfall. Extended drought conditions that impact availability of water supply can increase the cost of water and affect water quality, resulting in disproportionate impacts to vulnerable populations.

Natural and Recreational Resources. Natural and recreational resources in Glendale, including parks, City bikeways, open spaces, waterways, critical habitats and street trees, face exposure to climate hazards. All of these resources provide community benefits either directly or indirectly and face heightened risks of drought, landslides, stormwater flooding, wildfires, extreme heat and poor air quality. Primary vulnerabilities for natural resources are associated with extreme heat and drought related stressors, increasing wildfire frequency and severity, with potential impacts including species mortality and loss of habitat. Climate hazard events may impact outdoor recreation opportunities and residents and visitors may not be as likely to enjoy the mental and physical health benefits associated with outdoor recreation. Parks in

northern and eastern Glendale are located in landslide susceptibility areas and Very High Fire Hazard Severity Zones.

Resilient Landscapes. Significant areas of northern and eastern Glendale are located within Very High Fire Hazard Severity Zones. Glendale is expected to experience increased decadal wildfire probability throughout the entire City by the end of the century. Very High Fire Hazard Severity Zones encompass many natural and recreational resources, entire residential communities, and critical public facilities and utility infrastructure. Wildfires may exacerbate poor air quality and water quality declines, structural damages, service line disruptions and strain, human and wildlife mortality, and habitat loss. This broad level of exposure and projected impacts across all asset groups makes wildfire one of the greatest climate hazard risks for the City. Adapting existing and planned landscapes in residential areas, open spaces, and adjacent to critical public facilities and utility infrastructure is critical to reducing ignitability and wildfire risk. Removing or modifying live and dead vegetation in high-risk areas can reduce the potential spread of wildfire ignitions and increase community safety.

Social and Governance Systems

Equitable Community Safety As climate change impacts occur, virtually all populations in a community will be affected; however, some individuals will be disproportionately impacted by climate hazards due to inequitable systems and structures. The areas of the City with the greatest concentration of vulnerable populations are in south and southwest Glendale. Census tracts that are above the 60th percentile is considered a high social vulnerability area. Additional areas with high social vulnerability include historically redlined areas as well as areas identified based on input from community-based organizations. These included areas near major roads and highways, schools, the Scholl Canyon Landfill and the

Grayson Power Plant. Community members in these areas are also at-risk for disproportionate impacts from climate change. Inequitable access to, and distribution of resources, critical services, and resilient infrastructure systems decreases the ability for sensitive populations to prepare for, cope and recover from climate impacts.

All Hazards Awareness and Capacity Building. The overall exposure of Glendale to climate change hazards creates vulnerabilities throughout the entire community. Virtually all vulnerable populations face barriers in accessing information and/or adaptive resources targeting climate hazard resilience. Glendale community members may possess informal networks creating resilience to climate change which the City can further augment through tools and resourcing of both individuals and community-based organizations.

Recovery and Reconstruction. Adaptation to climate change involves both preparedness and recovery and reconstruction. The way in which a community is resourced after experiencing a climate hazard event can be a source of community resilience or of systemic inequities. Individuals across all vulnerable population groupings face larger barriers to recovering from hazards without adequate accessibility to resources for recovery and reconstruction.

Extreme Heat and Air Quality Protection. All vulnerable communities in Glendale are significantly exposed to poor air and extreme heat. Changes in annual average maximum temperature by the end of the century will increase across the entire region increasing incidences of extreme heat. Impacts from temperature increases and extreme heat events are expected to include heat-related illness, such as heat stress, heat stroke, and dehydration, which can be life threatening.

6.2 Vulnerability Analysis

In addition to problem statements, vulnerability scoring helps the City understand which climate change hazards pose the greatest threat to specific asset groups and would need to be prioritized in adaptation planning and policy development. Vulnerability scores were determined by combining the impact scores with adaptive capacity scores assigned within Chapters 3 and 4. A list of asset categories with high vulnerability scores is provided in Table 6.

Table 6 High Vulnerability Scores

Population Group	Impact Score	Adaptive Capacity Score	Vulnerability Score
Extreme Heat			
Individuals with High Outdoor Exposure	High	Low	5-High
Under-resourced Individuals	High	Low	5-High
Individuals Facing Societal Barriers	High	Low	5-High
Individuals with Chronic Health Conditions or Health Related Sensitivities	High	Low	5-High
Natural and Recreational Resources	High	Medium	4-High
Infrastructure and Critical Services	High	Medium	4-High
Drought			
Natural and Recreational Resources	High	Low	5-High
Infrastructure and Critical Services	High	Medium	4-High
Wildfire			
Under-resourced Individuals	High	Medium	4-High
Individuals with Chronic Health Conditions or Health Related Sensitivities	High	Medium	4-High
Natural and Recreational Resources	High	Low	5-High
Buildings and Facilities	High	Medium	4-High
Infrastructure and Critical Services	High	Medium	4-High
Landslides			
Individuals with Chronic Health Conditions or Health Related Sensitivities	Medium	Low	4-High
Buildings and Facilities	High	Medium	4-High
Infrastructure and Critical Services	High	Medium	4-High
Stormwater Flooding and Extreme Precipitation			
Under-resourced Individuals	High	Medium	5-High
Individuals with Chronic Health Conditions or Health Related Sensitivities	Medium	Low	4-High
Poor Air Quality			
Individuals with High Outdoor Exposure	High	Low	5-High
Under-resourced Individuals	High	Low	5-High
Individuals Facing Societal Barriers	High	Low	5-High
Individuals with Chronic Health Conditions or Health Related Sensitivities	High	Low	5-High
Natural and Recreational Resources	High	Medium	4-High

7 References

- American Psychological Association (APA). (2012). “Fact Sheet: Health Disparities and Stress”
<https://www.apa.org/topics/racism-bias-discrimination/health-disparities-stress?clearcache=true>
- Association of Public & Land-Grant Universities (APLGU). N.d. “How does a college degree improve graduates’ employment and earnings potential?” <https://www.aplu.org/our-work/5-archived-projects/college-costs-tuition-and-financial-aid/publicvalues/publicvalues-resources/q3/employment-and-earnings.pdf>
- Ackerly, David, Andrew Jones, Mark Stacey, Bruce Riordan. (University of California, Berkeley). 2018. San Francisco Bay Area Summary Report. California’s Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005.
- Ascend Analytics (Ascend). 100% Clean Energy by 2030 Feasibility Study. 2021.
<https://www.glendaleca.gov/home/showpublisheddocument/70260/638145623762470000>
- Backlund, Peter, Anthony C. Janetos, and David Steven Schimel. The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States. Vol. 4. US Climate Change Science Program, 2008.
- Bedsworth, Louise, et al. Statewide Summary Report. California’s Fourth Climate Change Assessment, Governor’s Office of Planning and Research, State of California Energy Commission, and California Natural Resources Agency, Aug. 2018, www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUMCCCA4-2018-013_Statewide_Summary_Report_ADA.pdf.
- Bleiweis, Robin, Frye, Jocelyn, and Khattar, Rose. 2021. Women of Color and the Wage Gap.
<https://www.americanprogress.org/article/women-of-color-and-the-wage-gap/>
- C. J. Gabbe & Gregory Pierce (2020): Extreme Heat Vulnerability of Subsidized Housing Residents in California, Housing Policy Debate, DOI: 10.1080/10511482.2020.1768574
- California Air Resources Board (CARB). 2022. Overview Diesel Exhaust & Health.
<https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health>
- California Air Resources Board (CARB). 2023. Combustion Pollutants & Indoor Air Quality.
<https://ww2.arb.ca.gov/resources/documents/combustion-pollutants-indoor-air-quality>
- California Air Resources Board (CARB). N.d. South Coast Air Basin Ozone Weight of Evidence Analysis.
https://ww2.arb.ca.gov/sites/default/files/2022-12/Jan_2023_SC_CV_70ppb_Staff_Report_App_B.pdf
- California Census 2020. California Department of Finance Demographic Research Unit. “California Hard-to-Count Interactive Map”..
<https://cacensus.maps.arcgis.com/apps/webappviewer/index.html?id=48be59de0ba94a3dacff1c9116df8b37>

- California Department of Conservation (CDOC). 2021. CGS Map Sheet 58: Deep-Seated Landslide Susceptibility. <https://www.arcgis.com/home/item.html?id=3cdc744bec6b45c28206e472e8ad0f89#>
- California Department of Public Health (CDPH). 2014. "Average Daily Maximum Ozone Concentration." https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/BRACE_Ozone_801_Narrative.pdf
- California Department of Public Health (CDPH). 2020. "Climate Change and Health Vulnerability Indicators for California." <https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx>
- California Energy Commission (CEC). 2023. Cal-Adapt Local Climate Change Snapshot for Glendale. 2022. <https://cal-adapt.org/tools/local-climate-change-snapshot/>. Accessed April 2023.
- California Environmental Protection Agency Urban Heat Island Interactive Maps. 2023. <https://calepa.ca.gov/urban-heat-island-interactive-maps/>
- California Governor's Office of Emergency Services (Cal OES). 2020. *California Adaptation Planning Guide*. <https://www.caloes.ca.gov/HazardMitigationSite/Documents/CA-Adaptation-Planning-Guide-FINAL-June-2020-Accessible.pdf>.
- California Heat Assessment Tool. <https://cal-heat.org/>
- Census Bureau. (2022). Census Bureau Releases Estimates of Undercount and Overcount in the 2020 Census. <https://www.census.gov/newsroom/press-releases/2022/2020-census-estimates-of-undercount-and-overcount.html>
- Centers for Disease Control and Prevention (CDC). (2020). *Health Implications of Drought*. <https://www.cdc.gov/nceh/drought/implications.htm#:~:text=Drought%20can%20also%20cause%20long,hygiene%2C%20and%20food%20and%20nutrition>
- Centers for Disease Control and Prevention (CDC). (2021). PLACES: Local Data for Better Health - Place Data. Accessed August 2023. <https://data.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-Place-Data-202/epbn-9bv3>
- Centers for Disease Control and Prevention (CDC). (2022). *Extreme Heat and Pregnant Women*. https://www.cdc.gov/disasters/extremeheat/heat_and_pregnant_women.html
- Centers for Disease Control and Prevention (CDC). (2022). *Basic Facts about Mold and Dampness*. <https://www.cdc.gov/mold/faqs.htm#:~:text=Mold%20will%20grow%20in%20places,carpet%2C%20fabric%2C%20and%20upholstery>
- Christmas, Michael. (2021). Humboldt Geographic: Humboldt State University. "California's Former Sundown Town Faces Up to Racist Legacies". <https://digitalcommons.humboldt.edu/cgi/viewcontent.cgi?article=1043&context=humboldtgeographic>
- City of Glendale. 2018. Local Hazard Mitigation Plan. <https://www.glendaleca.gov/Home/ShowDocument?id=48980>.
- City of Glendale. 2010. Census Information. <https://www.glendaleca.gov/our-city/demographics/census-information>
- City of Glendale. 2023. Income and Poverty. <https://www.glendaleca.gov/government/departments/co>

- community-development/planning/services/census-information-income-and-poverty
- City of Glendale. 2023. Nature Based Development. <https://www.glendaleca.gov/government/departments/management-services/office-of-sustainability/programs-and-services#Nature%20Based%20Development>
- City of Glendale. N.d.(a) Parks, Facilities, & Historic Sites. <https://www.glendaleca.gov/government/departments/community-services-parks/parks-facilities-historic-sites/list-of-parks-facilities-historic-sites>.
- City of Glendale. N.d.(b) Verdugo Wash. <https://www.glendaleca.gov/government/departments/community-development/planning/plans-for-mobility/verdugo-wash>.
- City of Glendale. 2023. Glendale Homeless Count. <https://www.glendaleca.gov/home/showpublisheddocument/71115/638205459970370000>
- City of Glendale. 2022. Glendale Water & Power - Wildfire Mitigation Plan. <https://www.glendaleca.gov/home/showpublisheddocument/68582/638016006890530000>
- City of Glendale. 2020. Urban Water Management Plan. <https://www.glendaleca.gov/home/showpublisheddocument/62412>
- City of Glendale. 2019. Glendale Downtown Specific Plan. <https://www.glendaleca.gov/home/showpublisheddocument/50230/636904148989570000>
- City of Glendale. 2023. Glendale Narrows Riverwalk, Phase II. <https://www.glendaleca.gov/government/departments/public-works/projects/glendale-narrows-riverwalk-phase-ii>
- City of Glendale. 2012. Greener Glendale Plan. <https://www.glendaleca.gov/government/departments/management-services/office-of-sustainability/greener-glendale>
- City of Glendale. 2003. Glendale General Plan - Safety Element. <https://www.glendaleca.gov/home/showpublisheddocument/4551/635242148319870000>
- City of Glendale Water & Power. 2019. Integrated Resource Plan. <https://www.glendaleca.gov/home/showpublisheddocument/51814/638258694171330000>
- City of Glendale Projects. 2023. Glendale Water & Power's Investments in Infrastructure. Accessed September 2023. <https://www.glendaleca.gov/government/departments/glendale-water-and-power/projects>
- Climate Resolve. 2021. Lessons from the Woolsey Fire Report – Lesson 8. <https://www.climateresolve.org/lessons-from-the-woolsey-fire-report/>
- Collins M., M. Sutherland, L. Bouwer, S.-M. Cheong, T. Frölicher, H. Jacot Des Combes, M. Koll Roxy, I. Losada, K. McInnes, B. Ratter, E. Rivera-Arriaga, R.D. Susanto, D. Swingedouw, and L. Tibig. 2019. "Extremes, Abrupt Changes and Managing Risk." In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. https://www.ipcc.ch/site/assets/uploads/sites/3/2022/03/08_SROCC_Ch06_FINAL.pdf
- Cooley Heather, Eli Moore, Matthew Heberger, and Lucy Allen. 2012. "Social Vulnerability to Climate Change in California."

<https://pacinst.org/wp-content/uploads/2012/07/social-vulnerability-climate-change-ca.pdf>

- Coop, et al. 2020. Wildfire-Driven Forest Conversion in Western North American Landscapes *BioScience* 70: 659–673. Published by Oxford University Press on behalf of the American Institute of Biological Sciences. doi:10.1093/biosci/biaa061
- Crouch, Angie. 2020. “City of Glendale Apologizes for Its History as a ‘Sundown Town’”. NBC Los Angeles. Accessed September 2023. <https://www.nbclosangeles.com/news/local/city-of-glendale-apologizes-for-its-history-as-a-sundown-town/2443011/>
- Environmental Protection Agency. 2022. “Climate Change and the Health of Socially Vulnerable People.” Accessed September 2023. <https://www.epa.gov/climateimpacts/climate-change-and-health-socially-vulnerable-people>
- Feinstein Laura, Phurisamban Rapichan, Ford Amanda, Christine Tyler, and Crawford Ayana. 2017. “Drought and Equity in California.” https://pacinst.org/wp-content/uploads/2017/01/PI_DroughtAndEquityInCA_Jan_2017_Executive_Summary.pdf
- FHFA (Federal Housing Finance Agency). A Brief History of the Housing Government-Sponsored Enterprises. N.D. <https://www.fhfa.gov/Content/Files/History%20of%20the%20Government%20Sponsored%20Enterprises.pdf>
- Flanagan Barry, Gregory Edward, Heitgerd Janet, Lewis Brian. 2011. “A Social Vulnerability Index for Disaster Management.” <https://svi.cdc.gov/A%20Social%20Vulnerability%20Index%20for%20Disaster%20Management.pdf>

- Gamble & Balbuls. 2016. “The Impacts of Climate Change on Human Health in the United States.” https://health2016.globalchange.gov/low/ClimateHealth2016_09_Populations_small.pdf
- GAO (United States Government Accountability Office). Disaster Recovery: School Districts in Socially Vulnerable Communities Faced Heightened Challenges After Recent Natural Disasters. January 2022. <<https://www.gao.gov/assets/gao-22-104606.pdf>>
- Glendale News Press. 2023. “Glendale Activates City Cooling Centers to Beat the Heat”. <https://glendalenewspress.outlooknewspapers.com/2023/07/17/glendale-activates-city-cooling-centers-to-beat-the-heat/>
- Glendale Memorial Hospital and Health Center. 2022. Community Health Needs Assessment 2022. <https://www.dignityhealth.org/content/dam/dignity-health/pdfs/chna/2022-chna/gmhhc-chna-22.pdf>
- Hall Alex, Neil Berg, and Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report California’s Fourth Climate Change Assessment. https://www.energy.ca.gov/sites/default/files/2019-11/Reg%20Report-%20SUM-CCCA4-2018-007%20LosAngeles_ADA.pdf
- Hamerlynck, Erik & Knapp, Alan. (1995). High temperature and light responses of two oaks at the western limit of their distribution.
- Hand S. Michael, Smith W. Jordan, Peterson L. David, Brunswick A. Nancy, and Brown P. Carol. 2018. “Chapter 10: Effects of Climate Change on Outdoor Recreation.”

- https://www.fs.usda.gov/rm/pubs_series/rmrs/gtr/rmrs_gtr375/rmrs_gtr375_316_338.pdf
- Herbert, Natalie, et al. 2023. "Improving adaptation to wildfire smoke and extreme heat in frontline communities: Evidence from a community-engaged pilot study in the San Francisco Bay Area." *Environmental Research Letters*.
- Hispanic Access Foundation. Climate Change: Heat & Drought. <https://www.hispanicaccess.org/climate-change-heat-drought>
- Hoffman, Jeremy S., Vivek Shandas, and Nicholas Pendleton. "The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas." *Climate* 8, no. 1. January 2020. <https://www.mdpi.com/2225-1154/8/1/12/htm>
- Hsu, Angel, Glen Sheriff, Tirthankar Chakraborty, and Diego Manya. "Disproportionate Exposure to Urban Heat Island Intensity Across Major US Cities". *Nature Communications* 12, no. 1. 2721.
- Hu, Ming, Kai Zhang, Quynh Camthi Nguyen, Tolga Tasdizen, and Krupali Uplekar Krusche. 2022. "A Multistate Study on Housing Factors Influential to Heat-Related Illness in the United States" *International Journal of Environmental Research and Public Health* 19, no. 23: 15762. <https://doi.org/10.3390/ijerph192315762>
- Huang Kangning, Xia Li, Xiaoping Liu, and Karen C Seto. 2019. "Projecting global urban land expansion and heat island intensification through 2050." *Environmental Research Letters*. Lett. 14 114037.
- Intergovernmental Panel on Climate Change (IPCC). 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, a special report of Working Groups I and II of the IPCC, ed. C. B. <https://www.ipcc.ch/site/assets/uploads/2018/03/SREX_FD_SPM_final-2.pdf>.
- IPCC. *The Intergovernmental Panel on Climate Change Sixth Assessment Report*. 2021. <https://www.ipcc.ch/report/ar6/wg1/#FullReport>.
- Kenney WL, Craighead DH, Alexander LM. 2014. "Heat waves, aging, and human cardiovascular health." *Med Sci Sports Exerc*. doi: 10.1249/MSS.0000000000000325
- LA County Department of Public Health (LA CDPH). N.d. "Extreme heat: What DPH is Doing." <http://publichealth.lacounty.gov/eh/climatechange/ExtremeHeatDPH.htm#:~:text=The%20urban%20heat%20island%20effect,the%20urban%20heat%20island%20effect>.
- Liu JC, Mickley LJ, Sulprizio MP, Dominici F, Yue X, Ebisu K, Anderson GB, Khan RFA, Bravo MA, Bell ML. 2016. "Particulate Air Pollution from Wildfires in the Western US under Climate Change." *National Library of Medicine*. doi: 10.1007/s10584-016-1762-6.
- Los Angeles County. 2021. *LA County Climate Vulnerability Assessment*. <https://ceo.lacounty.gov/wp-content/uploads/2021/10/LA-County-Climata-Vulnerability-Assessment-1.pdf>
- Los Angeles Times (LA Times). 2023. *Worse air quality in L.A. expected during heat wave. Why do high temperatures cause more smog?* <https://www.latimes.com/california/story/2023-07-18/l-a-region-expected-to-see-worse-air-quality-during-heat-wave-why-do-high-temperatures-lead-to-pollution>

- Lund, Jay, et al. 2018. "Lessons from California's 2012–2016 Drought." *Journal of Water Resources Planning and Management*, vol. 144, no. 10, [ascelibrary.org/doi/10.1061/%28ASCE%29WR.1943-5452.0000984](https://doi.org/10.1061/%28ASCE%29WR.1943-5452.0000984).
- Méndez M, Flores-Haro G, Zucker L. The (in)visible victims of disaster: Understanding the vulnerability of undocumented Latino/a and indigenous immigrants. *Geoforum*. 2020 Nov;116:50-62. doi: 10.1016/j.geoforum.2020.07.007. Epub 2020 Aug 7. PMID: 32834081; PMCID: PMC7413658.
- Million Dollar Hood. (2023). LAPD 2012-2017 by Neighborhoods. Map Room. Accessed September 2023. <https://milliondollarhoods.pre.ss.ucla.edu/test-iframe-2/>
- Mountains Recreation & Conservation Authority (MRCA). 2023. Verdugo Mountains Open Space Preserve. <https://mrca.ca.gov/parks/park-listing/verdugo-mountains-open-space-preserve/>.
- Muggah, R. (2021). Climate Change and Crime in Cities. Igarapé Institute. <https://igarape.org.br/wp-content/uploads/2021/07/Climate-change-and-crime-in-cities.pdf>
- National Academies of Sciences, Engineering, and Medicine (NASEM). 2019. *Framing the Challenge of Urban Flooding in the United States*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25381>.
- Neighborhood Scout. (2023). Safest Glendale Neighborhoods. <https://www.neighborhoodscout.com/ca/glendale/crime>
- Nelson, Robert K, LaDale Winling, Richard Marciano, Nathan Connolly, et al., "Mapping Inequality," American Panorama, ed. Robert K. Nelson and Edward L. Ayers, <https://dsl.richmond.edu/panorama/redlining/#loc=14/33.973/-118.216&city=los-angeles-ca>
- Northwestern Institute for Policy Research. 2020. What Drives Native American Poverty? Beth Redbird. <https://www.ipr.northwestern.edu/news/2020/redbird-what-drives-native-american-poverty.html>
- Office of the State Fire Marshall (OSFM). Fire Hazard Severity Zones (FHSZ). <https://osfm.fire.ca.gov/divisions/community-wildfire-preparedness-and-mitigation/wildfire-preparedness/fire-hazard-severity-zones/>
- Okin, G. S., Dong, C., Willis, K. S., Gillespie, T. W., & MacDonald, G. M. (2018). The impact of drought on native southern California vegetation: Remote sensing analysis using MODIS-derived time series. *Journal of Geophysical Research: Biogeosciences*, 123(6), 1927-1939.
- Olenick, Maria et al. 2015. "US veterans and their unique issues: enhancing health care professional awareness." *Advanced Medical Education Practice*. 2015. Accessed September 2023. <https://pubmed.ncbi.nlm.nih.gov/26664252/>
- Pew Research Center. 2021. "Gender pay gap in U.S. held steady in 2020." <https://www.pewresearch.org/fact-tank/2021/05/25/gender-pay-gap-facts/>
- Plante, C., Anderson C.A. (2017). "Global Warming and Violent Behavior". *Association for Psychological Science*. Accessed <https://www.psychologicalscience.org/observer/global-warming-and-violent-behavior#:~:text=Numerous%20cross-sectional%20and%20time-series%20studies%20using%20real-world%20heat,as%20age%2C%20race%2C%20poverty%2C%20and%20culture%20of%20honor.>

- Proceedings of the National Academy of Sciences of the United States of America (PNAS). 2021. "Spatial variation in the joint effect of extreme heat events and ozone on respiratory hospitalizations in California." <https://doi.org/10.1073/pnas.2023078118>
- Ratter-Rieck, J. M., Roden, M., & Herder, C. (2023). Diabetes and climate change: current evidence and implications for people with diabetes, clinicians and policy stakeholders. *Diabetologia*, 66(6), 1003-1015.
- Rogers, Tom. Native American Poverty. Opportunity Nation: The Forum for Youth Investment. 2012. Accessed September 2023. <https://opportunitynation.org/latest-news/blog/native-american-poverty/>
- Rothstein, Richard. *The Color of Law: A Forgotten History of How Our Government Segregated America*. First Edition. New York. Liveright Publishing Corporation. 2017.
- Samuel A. Markolf, Christopher Hoehne, Andrew Fraser, Mikhail V. Chester, B. Shane Underwood, Transportation resilience to climate change and extreme weather events – Beyond risk and robustness, *Transport Policy*, Volume 74, 2019, Pages 174-186, ISSN 0967-070X, <https://doi.org/10.1016/j.tranpol.2018.11.003>.
- Seneviratne, S.I., Et.al. 2012. "Changes in climate extremes and their impacts on the natural physical environment," In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 109-230. https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap3_FINAL-1.pdf
- Simes, Jack, et al. Summary Report: Los Angeles Basin Study. U.S. Department of the Interior and County of Los Angeles Department of Public Works, Nov. 2016, www.usbr.gov/watersmart/bsp/docs/fy2017/LABasinStudySummaryReport.pdf
- South Coast Air Quality Management District (South Coast AQMD). N.d. About Us. <http://www.aqmd.gov/nav/about>.
- Southern California Association of Governments (SCAG). 2020. *Southern California Adaptation Planning Guide (APG)*. https://scag.ca.gov/sites/main/files/file-attachments/socaladaptationplanningguide_oct2020_0.pdf
- Southern California Association of Governments (SCAG). 2021. *Local Housing Data for the City of Glendale*. <https://scag.ca.gov/sites/main/files/file-attachments/glendale-he-0421.pdf?1620797773>.
- Swain, Daniel L., et al. 2018. "Increasing Precipitation Volatility in Twenty-First-Century California." *Nature Climate Change*, vol. 8, pp. 427–33, www.nature.com/articles/s41558-018-0140-y.
- The National Aeronautics and Space Administration (NASA). 2022. "The Effects of Climate Change." <https://climate.nasa.gov/effects/>
- Tree Equity Score. *Tree Equity Score Municipality Report for Glendale, CA*. <https://www.treeequityscore.org/reports/place/glendale-ca>
- Ullrich, P. A., et al. 2018. "California's Drought of the Future: A Midcentury Recreation of the Exceptional Conditions of 2012–2017." *Earth's Future*, vol. 6, no. 11, pp. 1568–87, agupubs.onlinelibrary.wiley.com/doi/10.1029/2018EF001007

- United States Census Bureau. 2020. Decennial Census P1 | Race.
<https://data.census.gov/table?g=160XX00US0630000&tid=DECENNIALPL2020.P1>
- United States Department of Agriculture (USDA) Forest Service. 2020. "Preparing Wildlife for Climate Change: How Far Have We Come?"
https://www.fs.usda.gov/nrs/pubs/jrnl/2021/nrs_2021_led_ee_001.pdf
- United States Department of Agriculture (USDA) Forest Service. 2002. "The Effects of Urban Trees on Air Quality."
https://www.nrs.fs.fed.us/units/urban/local-resources/downloads/Tree_Air_Qual.pdf.
- United States Department of Energy. Low-Income Energy Affordability Data (LEAD) Tool.
<https://www.energy.gov/scep/slsc/low-income-energy-affordability-data-lead-tool>
- United States Environmental Protection Agency (USEPA). 2021a. "Criteria Air Pollutants." <https://www.epa.gov/criteria-air-pollutants> (accessed February 2021).
- United States Environmental Protection Agency (USEPA). 2021b. "Why Wildfire Smoke is a Health Concern."
<https://www.epa.gov/wildfire-smoke-course/why-wildfire-smoke-health-concern>
- United States Global Change Research Program (USGCRP). 2017. *Climate Science Special Report: Fourth National Climate Assessment, Volume*. U.S. Global Change Research Program, Washington, DC, USA, 470 pp, doi: 10.7930/J0J964J6.
- Warren, R. (2022). 2020 American Community Survey: Use with Caution, An Analysis of the Undercount in the 2020 ACS Data Used to Derive Estimates of the Undocumented Population. *Journal on Migration and Human Security*, 10(2), 134–145.
<https://doi.org/10.1177/23315024221102327>
- WelfareInfo.2023. Poverty Rate in Glendale, California.
<https://www.welfareinfo.org/poverty-rate/california/glendale/>
- Westerling, A. L., et al. 2006. "Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity." *Science*, vol. 313, no. 5789, pp. 940–43, www.science.org/doi/full/10.1126/science.1128834