City of Sacramento Climate Action and Adaptation Plan

Appendix G - Climate Change Vulnerability Assessment

PRELIMINARY PUBLIC REVIEW DRAFT

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Table of Contents

Executive Summary **1**
1 Introduction **4**
1.1 What is Climate Vulnerability? 5
2 Climate Change Effects **7**
2.1 Broad Changes in the Climate System 7
2.2 Primary and Secondary Impacts 10
3 Vulnerability **66**
3.1 Vulnerable Populations 66
3.2 Critical Facilities 91
4 Adaptive Capacity **104**
4.1 Climate Change Readiness Landscape 104
4.2 Existing Adaptive Capacity 114
5 Conclusions **126**
5.1 Risk Assessment Summary 126
6 Appendix: Understanding Cal-Adapt and Key Scenario Assumptions . **128**

List of Figures

Figure 2-1: Average Annual Temperatures 14
Figure 2-2: Annual Number of Extreme Heat Days 15
Figure 2-3: Average Number of Extreme Heat Days per Year 16
Figure 2-4: Average Number of Extreme Heat Events per Month 16
Figure 2-5: Average Maximum Temperature from Extreme Heat Events 17
Figure 2-6a: Number of Heat Waves Per Year 18
Figure 2-6b: Number of Heat Waves Per Year 18
Figure 2-7: Maximum Heat Wave Duration 19
Figure 2-8: Maximum Heat Wave Duration 19
Figure 2-9: Annual Number of Warm Nights 26
Figure 2-10: Annual Number of Warm Nights 26
Figure 2-11: Average Number of Warm Nights Per Month 27
Figure 2-12: Average Nighttime Temperature 27
Figure 2-13: Longest Stretch of Consecutive Warm Nights 28
Figure 2-14: Longest Stretch of Consecutive Warm Nights 28
Figure 2-15: Total Annual Precipitation 33
Figure 2-16: Average Annual Precipitation 33
Figure 2-17: Number of Extreme Precipitation Events Per Year 34
Figure 2-18: Annual Inches of Rainfall from Extreme Precipitation Events 34
Figure 2-19: Average Number of Extreme Precipitation Events Per Month 35
Figure 2-20: Average Total Rainfall Due to Extreme Precipitation Events Per Month 35
Figure 2-21: Average Statewide April Snow Water Equivalence (Inches) 45

List of Tables

Table 2-1: Primary and Secondary Climate Change Impacts in Sacramento 11
Table 2-2: Temperature Increase 13
Table 2-3: Changes in Precipitation Patterns 31
Table 2-4: Major Flood Events in the Sacramento Region, 1986 - 2017 37
Table 2-5: Wildfire 51
Table 2-6: Sea Level Rise 61
Table 5-1: Risk Assessment Matrix 127

List of Maps

Map 1: Urban Heat Island 22
Map 2: Tree Canopy 24
Map 3: Sacramento-San Joaquin Delta Levees Anatomy 40
Map 4: Repetitive Loss Areas and FEMA Flood Zones 41
Map 5: Historical Snowpack (1961 – 1990) 46
Map 6: Snowpack Mid-Century (2040 – 2049) 47
Map 7: Snowpack End-of-Century (2090 – 2099) 48
Map 8: Historical Annual Average of Area Burned by Wildfires (1961 - 1990) 54
Map 9: Annual Average of Area Burned by Wildfires Mid Century (2040 – 2099) 55
Map 10: Annual Average of Area Burned by Wildfires End-of-Century (2090 - 2099) 56
Map 11: Composite Air Quality by Census Tract 59
Map 12: Extreme Sea Level Rise Average Model 2040 to 2060 and FEMA Flood Zone 64
Map 13: Extreme Sea Level Rise Average Model 2060 to 2080 and FEMA Flood Zone 65
Map 14: Children Under 6 68
Map 15: Percentage of Adults Over 65 70
Map 16: Disability 72
Map 17: Communities of Color 74
Map 18: Racial Distribution 75
Map 19: Concentration of Poverty 78
Map 20: Housing Cost Burdened Households 80
Map 21: Renter-Occupied Housing Units 82
Map 22: Rate of Linguistic Isolation 85
Map 23: Urban Heat Island and DACs 87
Map 24: DACs in Repetitive Loss Areas and FEMA Flood Zones 88
Map 25: Emergency Evacuation Shelters and FEMA Flood Zones 97
Map 26: Industrial Facilities and FEMA Flood Zones 98
Map 27: Public Safety Facilities and FEMA Flood Zones 99
Map 28: Transportation Facilities and FEMA Flood Zones 100
Map 29: Disadvantaged Communities, Opportunity and Promise Zones 102

Executive Summary

Extreme heat, flooding, wildfires, and other climate-change-related hazards pose significant risks to the City of Sacramento. In order to begin preparing for these risks, the City must first understand how climate change could affect people, buildings, infrastructure, and the economy as well as impact assets and services owned or managed by the City. This Vulnerability Assessment details current City actions that are being taken to address climate change, key climate change impacts that affect Sacramento, key features that may put residents at risk to climate change, and the City's ability to build adaptive capacity to respond to climate change. This report details those findings, which are summarized below.

CLIMATE CHANGE EFFECTS

The primary climate change impacts that are expected to be experienced in Sacramento include increases in average temperature, the number of extreme heat days, wildfire frequency and intensity, shifts in the water cycle, and sea level rise and flooding.

- **Temperature.** Temperatures are projected to increase by four to five degrees Fahrenheit (°F) throughout Sacramento by mid-century (2050). Under these conditions, Sacramento could experience hotter and significantly drier conditions. The effects of temperature increase are likely to be felt throughout Sacramento, especially in more densely developed areas with less green space. Overall temperature increase can also lead to an increase in the number of extreme heat days and heatwaves, the intensification of the urban heat island effect, heat-related illnesses such as heart stroke and exhaustion, reduced air quality, and stress to infrastructure.
- **Wildfire.** Wildfire risk and intensity will continue to increase as further development occurs along urban-wildland interface accompanied by shifts in forest management, invasive species such as bark beetles. Climate change brings increasing temperatures, reducing snowpack, and altering precipitation patterns. While wildfire is unlikely within City limits, Sacramento will be impacted by wildfires occurring throughout the region via impacts on air, water, and soil quality; damage to energy infrastructure and roads; and strain on local firefighting resources as the fire department is called to respond to fires across the region and state. Most wildfires are human-caused and there is a notable increase in arson cases over the past several years.

- **Storms and Droughts.** Annual precipitation is expected to increase in the Sacramento region. Sacramento has historically experienced about 19.8 inches of precipitation per year, which could increase to about 23.5 inches per year at the end of the century. This increase, however, will not occur at a uniform rate throughout the year. Rainfall will become more concentrated in the winter months and occur in fewer, higher-intensity events. These storms may produce higher volumes of runoff, contribute to increased flood risk, damage infrastructure, increase burden on the City's internal drainage system, and threaten the stability of levees. In addition, warmer temperatures will cause precipitation to fall primarily as rain rather than snow, leading to less winter snowpack. This is especially true for the Northern Sierras, which are a primary water source for the Sacramento Valley region and are expected to have almost no annual snowpack by the end of the century.[1] Meanwhile, the spring and summer months are expected to see reductions in rainfall, and lesser volumes of snowpack will melt earlier in the year – which could lead to flooding, increased challenges in operating water storage facilities, drought, increased wildfire risk, changes in streamflow, vulnerability to local habitats, and strain to health, energy, and infrastructure systems.
- **Sea Level Rise.** While Sacramento is not a coastal city, the Sacramento and American Rivers drain into the Sacramento-San Joaquin Delta, which in turn drains into the San Francisco Bay and the Pacific Ocean. As such, sea level rise would exacerbate flood risk in Sacramento and can affect the health of aquatic ecosystems and threaten the structural integrity of the levee system that protects the city. Sea level rise would increase saltwater intrusion in the Sacramento-San Joaquin Delta, impacting freshwater quality, agricultural production, the wellbeing of aquatic species, and the City's ability to satisfy regulatory requirements for providing drinking water.

VULNERABILITY

Climate change impacts will affect key community features and services provided by the City of Sacramento. These key features include critical infrastructure and facilities, the damage or disruption of which may interfere with the operation of key transportation, power, communication, health, and safety systems, or expose residents to significant health and safety risks. Many critical facilities, infrastructure, and services are at risk of flooding hazards, including industrial facilities, public safety facilities, and transportation facilities shown in Maps 25, 26, 27, and 28. While areas with a higher probability of annual flooding may be unsuitable locations for existing critical facilities and may require relocations in the future, facilities in areas with lower probabilities of annual flooding may be good candidates for green infrastructure interventions to mitigate the extent and duration of flood impacts.

In addition, the health and economic impacts of climate change are not experienced equally, or in the same way, by all members of the population. Climate change effects manifest on top of a dynamic and complex socio-cultural landscape in which various groups already experience

[1] Benjamin Houlton and Jay Lund, California's Fourth Climate Change Assessment - Sacramento Summary Report (University of California, Davis: 2018), Publication number: SUM-CCCA4-2018-002, https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-002_SacramentoValley_ADA.pdf.

different levels of access to economic, health, and political resources. Historically, many of these resources have been out of reach to the socially marginalized. Thus, the inequitable impacts of climate change produce unique individual and community levels of exposure, degrees of sensitivity, and adaptive capacities to climate change hazards. One important element of understanding and addressing climate change vulnerability is understanding how and why this vulnerability is disproportionally distributed among different subsets of the population.

It is important to understand where vulnerable populations are prevalent in Sacramento in order to provide targeted services and infrastructure that improves responses to climate-related hazards and thus increases climate resilience and equity within the city. Populations that are particularly vulnerable to climate change include children, older adults, individuals with disabilities, low-income individuals and households, outdoor and seasonal workers, households in substandard housing, cost-burdened households, renters, homeless individuals, linguistically isolated individuals, and communities of color. Identifying where concentrations of such populations overlap with areas of high risk can help prioritize future public investments that bolster the City's adaptive capacity.

ADAPTIVE CAPACITY

Climate change adaptation is the process of adjusting to current or anticipated effects of climate change, in order to reduce harm and improve livability. Adaptive capacity can be improved in a variety of ways, including emergency response and hazard response services, the collection and distribution of climate-relevant information, and strategic infrastructure investments and maintenance. Prioritizing adaptation actions is a multi-step process that involves identifying which climate impacts are most likely to impact Sacramento, when these impacts will be felt, how severe these impacts will be, and which City services and communities are most likely to be affected. Ideally, the most pressing climate change impacts should be given priority when considering adaptation, with special consideration given to areas with the most vulnerable populations.

In addition to the existing climate change readiness landscape in California and the Sacramento region, the City of Sacramento has already taken preliminary steps to establish adaptive capacity in response to the climate risks that affect the city. This includes plans, programs, and services that are continually updated and maintained to respond to environmental and community changes, as well as ongoing projects to mitigate known hazards. The synergies between these efforts such as Local Hazard Mitigation Plans and the General Plan Safety Element help bolster the City's adaptive capacity. This Vulnerability Assessment builds on those plans and identifies additional actions that can be taken to more specifically address the climate change vulnerabilities identified in this document as well as leverage other opportunities to efficiently and effectively build resilience in Sacramento's communities.

1 Introduction

From flooding to drought, extreme heat, and wildfires, the Sacramento region has a long history of confronting natural hazards. Understanding how climate change might exacerbate the region's risks and vulnerabilities to extreme weather is fundamental to formulate strategic priorities to enhance public health, resilience, and sustainability. The purpose of this Climate Change Vulnerability Assessment is to assist the City and its residents in planning for the future by identifying the climatic changes that are likely to influence life and wellbeing in Sacramento over the next several decades, especially for the populations and community services that these changes are most likely to affect. This document was prepared in parallel with the City's 2040 General Plan Update to comply with California Senate Bill 379 (Stats. 2015, codified at Government Code section 65302(g)), which requires all cities and counties in California to address climate adaptation and resiliency in their General Plans, and is part of the City's Climate Action and Adaptation Plan (CAAP).

A climate change vulnerability assessment is a document that identifies and summarizes the risks that climate change poses to a local area, highlighting specific locations and communities that are most likely to be severely impacted by climate change. This Vulnerability Assessment synthesizes climate change projections created by Cal-Adapt (a statewide climate change assessment tool, further discussed in Section 2.1: Broad Changes in the Climate System), historical data pertaining to natural events and hazards, and sociodemographic information collected by the United States Census Bureau to determine which climate impacts are most likely to affect the City of Sacramento, where these impacts may manifest, who will be affected, and how severely. The assessment considers existing and planned development in identified at-risk areas, including structures, roads, utilities, and essential public facilities. The assessment identifies the federal, state, regional, and local agencies with responsibility for the provision of public health, safety, transportation, and environmental services, including special districts and local offices of emergency services.

- **Chapter 1** of this document provides context for this document and introduces the concept of climate vulnerability.
- **Chapter 2** outlines key climate change impacts that are likely to affect the Sacramento region such as temperature increase, changes in precipitation patterns, wildfire, and sea level rise. This chapter discusses the origin of these impacts, their projected severity, permanence, and rate of increase, as well as key secondary disruptions to the climate, weather, the environment, infrastructure, and health and safety that may result.
- **Chapter 3** identifies vulnerable areas and populations at risk to climate change hazard events. Critical facilities and infrastructures potentially at risk to climate hazards are also identified.
- **Chapter 4** describes actions currently being taken within the state and Sacramento region to address climate change and identifies existing federal, state, regional, and local agencies implementing adaptation and mitigation strategies. This includes an assessment of the capacity of public agencies and the community to adapt and respond to climate hazards.
- **Chapter 5** provides a risk assessment matrix and identifies potential gaps in existing adaptation strategies and recommendations for future improvements.

1.1 What is Climate Vulnerability?

Climate change vulnerability refers to the extent to which individuals, communities, or infrastructure are exposed to, susceptible to, and/or unable to cope with or adapt to the effects of climate change, including climate variability and extremes.[2] Climate change vulnerability emerges across time and space from the interaction of several related components of both the climate system and surrounding social, physical, and political environment. These components include exposure, sensitivity, and adaptive capacity.[3]

Exposure describes whether and to what degree a community or individual will experience a stress or hazard due to climate change.[4] A low-lying coastal community, for example, has a higher degree of exposure to sea level rise than a community that is located in the mountains far above sea level. If sea level rise does occur in a community, the community may be more or less affected depending on such factors as the location of housing developments and roads. A community that locates major housing developments or critical healthcare or utility services within a coastal, low-lying area will be more severely affected by sea level rise than a community that preserves or restores wetlands in this location instead. This degree to which a community, system, or individual is affected by a climate change impact is referred to as its **sensitivity**.

Adaptive capacity refers to the ability to respond to climate change impacts. If a community has the ability to construct levees, flood walls or natural landscaping buffers, flood-proof homes, and educate residents and home developers about the potential risk associated with living and building in an area likely to be exposed to sea level rise, then these resources are referred to as the adaptive capacity of the community to address sea level rise. Factors influencing adaptive capacity include levels of economic resources, technological capacity, education and awareness, and equity in access and distribution of resources. All else being equal, those individuals, communities, and cities with a greater degree of adaptive capacity will suffer less harm from exposure to climate impacts and will recover more quickly from the impact.[5]

The concept of **resilience** is closely related to that of adaptive capacity. Resilience has been described as the ability of a system, community, structure, or individual to withstand and recover from distress or perturbation while maintaining its core functions or meeting the core needs of community members. Resilience involves the ability to be responsive to change while simultaneously preserving core structure and function.[6] Citywide resilience-building features can take many forms, including strong and supportive social ties within a community, redundancies in key infrastructural systems that prevent service interruptions, and responsive governance. Climate resilience is a specific subtype of resilience that deals with the ability to anticipate, prepare for, and

[2] Cal-Adapt, "Frequently Asked Questions," 2018. Accessed October 29, 2019: https://cal-adapt.org/help/faq/.

[3] Thomas, K., Hardy RD., Lazrus H., Mendez M., Orlove B., Rivera-Collazo, I., Roberts JT., Rockman M., Warner BP., Winthrop R., Explaining differential vulnerability to climate change: A social science review (December 2018). Oct 29 2019: https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.565.

[4] Nutters, H., Addressing Social Vulnerability and Equity in Climate Change Adaptation Planning, June 2012, Oct 29 2019: http://www.adaptingtorisingtides.org/wp-content/uploads/2015/04/ART_Equity_WhitePaper.pdf.

[5] Nutters, H., 2012.

[6] Nutters, H., 2012.

respond to hazardous events, trends, or disturbances related to climate change. This assessment is designed to improve the City's understanding of climate-related risks as a first step to enhancing Sacramento's climate resilience.

Exposure is often an inherent feature of the climate system—the underlying probability that a given climate change impact will occur in a particular location. Knowing a community's changing exposure level is a critical piece of understanding vulnerability and thus of making well-informed growth and development decisions that minimize long-term risk. Exposure, however, is not something that a community will likely be able to significantly change on its own. In contrast, making well-informed development and investment decisions can help a community improve its sensitivity and adaptive capacity.

Measures of a community's sensitivity and adaptive capacity can also be highly subjective. Different members of the community will see different community features as being worthy of protection, will be affected by climate change impacts in different ways or to different degrees, and will see relatively more or fewer benefits from a given adaptive capacity-building strategy. For that reason, it is important to take stock of a variety of voices and experiences throughout the vulnerability assessment process, highlighting Sacramento's rich diversity both in terms of how different groups of people may experience climate change differently and in terms of the wide range of response and resilience strategies that different communities are able to employ.

Likewise, it is important to remember that vulnerability is not an inherent and unchallengeable characteristic of an individual, community, or city. Vulnerability emerges from a dynamic and interacting web of physical, environmental, and social factors such as environmental exposure, infrastructural integrity, and historical and present-day decisions regarding development patterns, allocation of key resources, and distribution of political power.[7] It is the cumulative unequal distribution of exposure, sensitivity, and adaptive capacity that creates an unequal distribution of climate change vulnerability, and this distribution often reflects patterns of structural inequality present in society. Climate change is likely to amplify pre-existing disparities in health and wealth on the global, regional, and municipal scales. This makes the work of analyzing and responding to vulnerability all the more urgent. If created early and leveraged often, information about the distribution of climate change vulnerability within a community can be used to promote more equitable social and health outcomes.

[7] Thomas, K., et. al, 2018.

2 Climate Change Effects

This chapter provides an overview of how climate change impacts are likely to manifest in the City of Sacramento. It begins with a brief discussion of the nature of climate modeling, then discusses the nature of the effects that temperature increase, change in precipitation, wildfire, and sea level rise are predicted to have on the city.

2.1 Broad Changes in the Climate System

Climate change represents more than a mere short-term extreme weather event, but rather a long-term, large-scale shift in the entire climate system. Everything in the climate system is connected. This means that climate change manifests not only in discrete, observable weather events, but a host of other climatic and geophysical states and processes such as air quality, erosion rates, water quality, soil composition, and growing seasons. Each of these secondary climate change impacts manifest at different rates, in different ways, and may have more severe impacts on some community members than others.

The primary climate change impacts that are expected to be experienced in California include:

- Increased wildfire frequency and intensity
- Shifts in the water cycle
- Increases in average temperature and number of extreme heat days
- Sea level rise and flooding

Between 2000 and 2020, the average maximum temperature in Sacramento was about 75.2°F, with maximum temperatures during summer months (May to September) averaging a maximum of about 89.0°F.[8] Average temperatures from baseline levels (1961-1990) are expected to increase by between 5.5 and 10.9°F by the end of this century, while the average annual number of extreme heat days (when the maximum temperature is above 103.9°F[9]) is projected to increase by between 18 and 58 days per year.[10] These temperature increases will be accompanied by intense heat waves, a reduction in the number of cool nights, and lower air quality. These changes pose a health risk—especially for those unable to seek shelter from heat and those whose physiology makes it difficult to regulate body temperature. Changes in temperature regimes will also impact regional snowmelt and wildfire patterns and increase warm season electrical load.

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[8] National Centers for Environmental Information, Climate Data Online - Global Historical Climatology Network daily [obtained for Sacramento, CA US (CITY:US060027) for 1/1/2000 to 1/1/2020], National Oceanic and Atmospheric Administration, accessed October 3, 2022: https://www.ncei.noaa.gov/cdo-web/search?datasetid=NORMAL_DLY.

[9] This threshold is determined as the 98th percentile maximum daily temperature over a historical baseline period of April to October from 1961 to 1990. This value is used to better account for the local ecosystem.

[10] Geospatial Innovation Facility - University of California, Berkeley, Cal-Adapt (version 2.0), November 2019: https://cal-adapt.org/.

Annual frequency and intensity of wildfires are expected to increase, often exacerbated by hotter temperatures. Statewide, total annual hectares burned by wildfire is projected to almost double by the end of the century. Changes in wildfire regimes can give rise to a host of secondary social and environmental consequences, including changes in forest composition, impacts to transmission lines, safety threats to those living in high-exposure areas, and reductions in air quality due to the presence of smoke. Health problems related to wildfire smoke exposure can be as mild as eye and respiratory tract irritation and as serious as worsening of heart and lung disease, including asthma, and even premature death.

As global temperatures rise, precipitation patterns in California are expected to change. Less precipitation will fall as snow, and instead, more will fall as rain. In fact, the Northern Sierras, which are a primary water source for the Sacramento Valley, are expected to have virtually no annual snowpack by the end of the century.[11] Unless mitigated, reduced winter snowpack will negatively impact local water availability, particularly during drought periods, because less snow means less water is temporarily stored in the form of snow and metered into water reservoirs as snow melts. Additionally, smaller bodies of snowpack will have less resistances to changes in temperature, leading to greater and more concentrated volumes of surface runoff. Water storage capacities will need to account for this pattern of runoff by releasing reservoirs for flood control, potentially leaving less water supply in the summer. Further, intermittent, intense episodes of rain may become the norm, which will strain local stormwater management systems, increase flood risk, and exacerbate erosion. Warmer water also negatively affects water treatment and the ecosystem. Temperature management in the Lower American River often drives operational decisions in storage reservoirs to protect aquatic species.

Sea level rise can expose coastal areas to inundation and flooding, impact water quality, and increase rates of coastal erosion. Since Sacramento is not a coastal community, it is not as vulnerable to the direct impacts of sea level rise as some other California cities. However, Sacramento will still feel impacts from sea level rise in the form of rising water levels within the Sacramento-San Joaquin Delta. For instance, higher sea level will push saltwater from the ocean into the fresher waters of the Sacramento-San Joaquin Delta, which could result in saltwater intrusion into areas from which water is pumped for agricultural and municipal uses.[12] Sea level rise may also exacerbate flood risk in Sacramento and can affect the health of aquatic ecosystems and threaten the structural integrity of the levee system that protects the city.

INTERPRETING CLIMATE CHANGE PREDICTIONS

The summaries of the extent, severity, rate of onset, and duration of the climate change impacts discussed in this document draw from climate change projections provided by Cal-Adapt. Cal-Adapt is the result of a partnership between the California Energy Commission, California Natural Resources Agency, and the Public Interest Energy Research Program, which provides an online climate data visualization tool that allows users to explore a wealth of climate data pertaining to climate change impacts in California. Cal-Adapt data contributors include the Pacific Institute,

[11] Houlton and Lund, 2018.
[12] Houlton and Lund, 2018.

Santa Clara University, Scripps Institution of Oceanography, UC Berkeley, UC Merced, and the U.S. Geological Survey.

In order to understand the descriptions and visualizations of projected climate change impacts that appear in this document, it is important to understand the types of data provided through Cal-Adapt, its strengths, and limitations.

Cal-Adapt provides projections of different future climate scenarios. Climate projections are not definitive statements about what types of weather patterns or climate impacts are guaranteed to occur in a particular year but provide general guidance on how climatic conditions might be expected to change over time. Climate projections are the output of global climate models—sophisticated computer modeling tools that simulate how the global climate system works. Scientists can input certain assumptions about how this global climate system works, as well as different predicted patterns of greenhouse gas emissions, to obtain a prediction for climatic conditions.

Despite the sophistication of these computer programs, the complexity of the global climate system and the significant uncertainty regarding long-term greenhouse gas emissions means that the results of different climate projections can look quite different. Cal-Adapt helps demonstrate this variability in modeling results by allowing users to work with different emissions scenarios and different climate models. Each tool in Cal-Adapt shows possible outcomes for two different greenhouse gas emission scenarios: a high-emissions scenario, in which greenhouse gas emissions continue to rise over the 21st century (RCP 8.5), and a low-emissions scenario, in which greenhouse gas emissions level off around the middle of the 21st century and are lower than 1990 levels by the end of the century (RCP 4.5).[13] This assessment uses the high-emissions scenario as the basis for Map 6: Snowpack Mid-Century, Map 7: Snowpack End-of-Century, Map 9: Annual Average of Area Burned by Wildfires Mid-Century, Map 10: Annual Average of Area Burned by Wildfires End-of-Century, Map 13: Extreme Sea Level Rise Average Model 2040 to 2060 and FEMA Flood Zone, and Map 14: Extreme Sea Level Rise Average Model 2060 to 2080 and FEMA Flood Zone. However, results from both high and low emissions scenarios are discussed in the text. This was done in order to help decision-makers prepare for worst case climate scenarios, while also providing an indication of the scale of future climate variability. However, it is important to keep in mind that both the low and high emissions scenarios are based on assumptions of likely—not guaranteed— future emissions patterns; future greenhouse gas emissions may not adhere to either of these scenarios.

As a default, Cal-Adapt allows users to compare the results produced by four different climate models: CanESM2 (Average), HadGEM2-ES (Warm/Drier), CNRM-CM5 (Cooler/Wetter), and MIROC5 (Complement). These results each represent the average values from a variety of models. This document uses the CanESM2 model because it represents an average primary climate model. For additional details regarding the emissions scenarios and climate models, see the Appendix at the end of this document.

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[13] Cal-Adapt, "How to Use Cal-Adapt," 2018. Accessed October 29, 2019: http://v1.cal-adapt.org/resources/using-caladapt/.

For the sake of this document, there are two time periods of interest: Midcentury, extending from 2040 to 2049, and End of Century, occurring from 2090 to 2099. The midcentury period was defined to coincide with the projected build-out date of the City of Sacramento's General Plan Update. When speaking of projections of climate conditions, Midcentury and End of Century conditions are averages of the projected conditions occurring in these windows unless otherwise noted. These future scenarios are compared against a historical baseline period, which also is a 30-year average, from 1961 to 1990. Rather than reflecting current (e.g., 2022) conditions, which would reflect a point-in-time snapshot, the best practice in climate science analyzes long-term trends. Cal-Adapt uses 1961 to 1990 as the historical baseline to represent the time period when the majority of California's critical infrastructure was developed and when anthropogenic climate change signals were beginning to be felt. Use of the terms "historical" or "historically" in this document refers to this historical baseline period defined by Cal-Adapt unless otherwise stated.

2.2 Primary and Secondary Impacts

This work begins with an assessment of the primary and secondary climate change impacts most likely to affect the City of Sacramento. Primary and secondary impacts are identified in accordance with the California Adaptation Planning Guide: Planning for Adaptive Communities and via consultation with City of Sacramento staff, where a primary impact can be understood as a major disruption to the weather or environment that results from climate change, and a secondary impact is a shift in the weather or environment that occurs as a result of the primary impact. Primary and secondary climate impacts are organized as outlined in the Table 2-1.

Potential effects on human health and critical infrastructures are discussed under secondary impacts where appropriate. Each primary impact contains an assessment of that impact's temporal and spatial scale, as well as its level of uncertainty and estimated level of disruption to community function.

Table 2-1: Primary and Secondary Climate Change Impacts in Sacramento

Impacts[1]	*Temporal Extent*	*Spatial Extent*	*Permanence*	*Level of Disruption*	*Level of Uncertainty*
Temperature Increase • Heat waves • Urban heat islands • Warm nights	**Moderate.** Effects will be most extreme in July and August, but may be felt anytime between May and October	**High.** Effects will be felt throughout the City, but will be most extreme in and around urban heat islands	**High.** The most extreme effects will be seasonal, but average ambient temperatures will increase steadily over the century	**High.** Increased strain and potential physical damage to energy, utility, and transportation infrastructure from extreme heat; risk of blackouts; and heat-related illness/death. Higher source water temperature create need for additional water treatment technologies.	**Low.**
Precipitation Changes • Flooding • Snowpack reduction • Drought • Groundwater reduction • Increased water temperature	**High.** Increased likelihood of riverine flooding in winter/early spring. Reduced surface water supply in summer due to reductions in winter snowpack	**High.** Nearly all of the city is low-lying and dependent on levee protection, but areas already susceptible to localized, riverine, and flash flooding and/or have limited stormwater infrastructure will be most affected by increased winter rain and flows. Drought will affect most areas and increase demand for groundwater use.	**High.** The most extreme effects will be seasonal, with continued changes expected over the century	**High.** A large storm could cause significant health and infrastructure impacts over potentially large portions of the City. Increased water temperature is harmful to water treatment, reservoir and hydroelectric operation, and ecological health.	**Moderate.** While impacts vary year to year, climate change is increasing the likelihood of a storm event capable of significant flooding; drought frequency is projected to increase in California.
Wildfire • Declines in air quality	**Moderate.** Projected wildfire extent/severity is highly variable, but will generally increase over the	**High.** A wildfire is unlikely to break out within City limits, but wildfire smoke will affect the entire city	**Moderate.** Wildfire intensity is expected to gradually increase, with significant	**Moderate.** The wildfire impact most likely to have a significant impact on the city is air pollution from wildfire smoke	**Moderate.**

Impacts[1]	*Temporal Extent*	*Spatial Extent*	*Permanence*	*Level of Disruption*	*Level of Uncertainty*
• Soil and water quality impacts	century. Future fire seasons may become longer		year-to-year variability.		
Sea Level Rise • Flooding • Saltwater Intrusion • Ecosystem impacts	**Low.** Sea level rise is projected to occur gradually over the course of the century	**Low.** Research is being conducted to determine if and how much sea level rise will impact Sacramento**.**	**High.** Flooding may impact low lying areas of the City. Saltwater intrusion may affect ability to treat and receive drinking water.	**Low.** Effects may be more severe when coinciding with riverine or flash flooding. Increasing salinity of water may increase burden on upper watershed resources.	**Low.**

1. Primary impacts are shown in **bold** and secondary impacts are listed by bullets (•) in the first column.

TEMPERATURE INCREASE

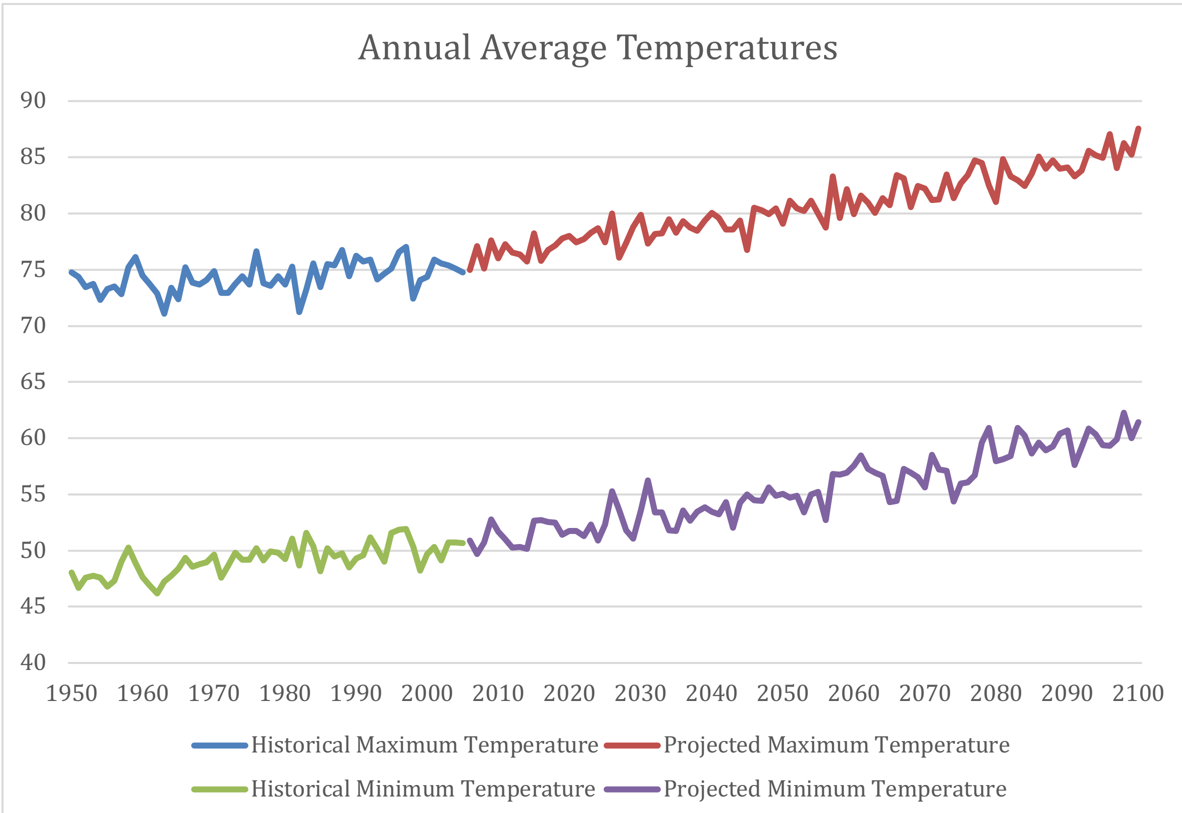
Climate models consistently report rising average temperatures across California.[14] Historically, the average annual maximum temperature in the City of Sacramento has been 74.1°F. This value is projected to increase to between 78.3°F and 79.4°F by midcentury, and to between 79.6°F and 85°F by the end of the century (Figure 2-1). Increasing average daytime temperatures are expected to be accompanied by higher nighttime temperatures. Historically, the average annual minimum temperature has been 49.1°F. This number is projected to increase to between 53°F and 54.2°F by midcentury and to between 53.7°F and 60°F by the end of the century (Figure 2-1). Overall temperature increase is associated with several secondary impacts, including increased incidence of extreme heat days, warm nights, and heatwaves, urban heat islands, heat-related health impacts, and heat-related damage to infrastructure (Table 2-2), as discussed below.

Table 2-2: Temperature Increase

Temporal Extent	• Effects will be felt most acutely in July and August, but excessive heat may occur May through October
Spatial Extent	• The entire City of Sacramento is likely to be affected • Effects will be felt most acutely in highly built-up areas, where the urban heat island effect is most likely to occur
Permanence	• Annual average temperatures are projected to continue to increase through the end of the century, though the projected rate of increase is higher under a high emissions scenario
Level of Disruption	High
Nature of Disruption	• Increased heat strains the electrical service sector by reducing the efficiency of electrical transmission and increasing demand for air conditioning • Greater incidence of heat-related illnesses and deaths may increase hospital visits and demand for medical services • High temperatures can physically damage utility and transportation infrastructure, disrupting services and increasing discomfort associated with active and public transportation • Increased water temperature affects drinking water treatment and quality, can lead to algal blooms, and is harmful to spawning anadromous fish and reservoir operations
Level of Uncertainty	• Low

[14] Sacramento Municipal Utility District, Climate Readiness Assessment and Action Plan (2016). Oct 28 2019: https://www.smud.org/-/media/Documents/Corporate/Environmental-Leadership/2016-Climate-Readiness-Action-Plan.ashx.

Figure 2-1: Average Annual Temperatures



Created using historical and projected annual temperature data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. Both the average maximum and minimum temperatures are projected to increase over the course of the century.

Secondary Impacts

Extreme Heat Days

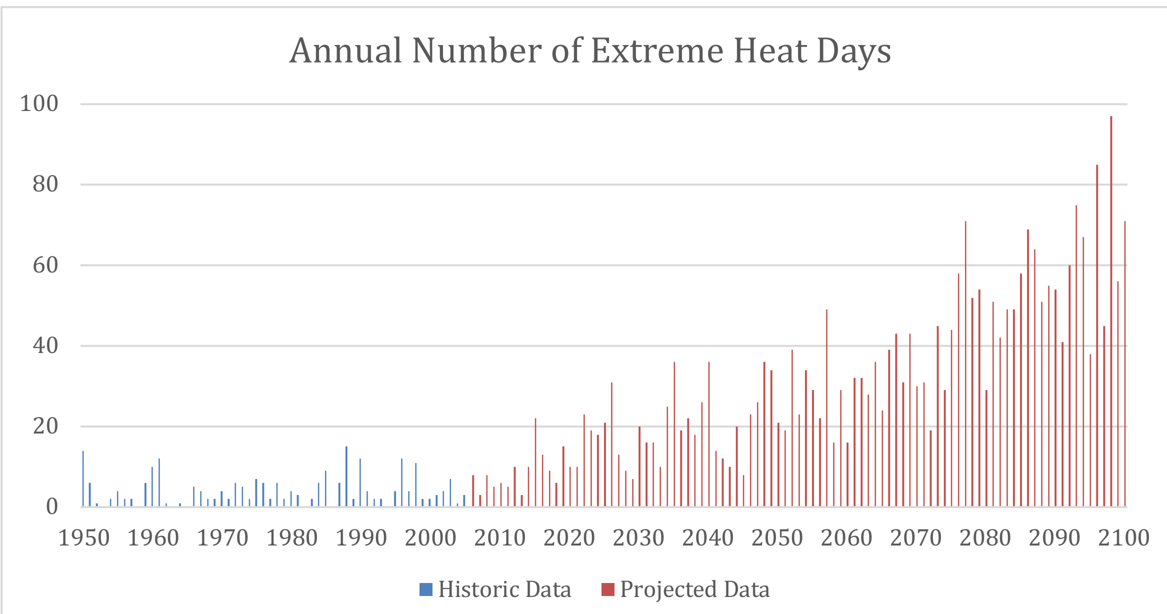
Cal-Adapt defines an extreme heat day as a day falling between April and October where the maximum daily temperature exceeds the 98th percentile of daily maximum temperature, based on historical data from between 1961 and 1990[15] (for the City of Sacramento, 103.8°F). Historically, the City of Sacramento has experienced about four extreme heat days per year. By midcentury, the city is projected to experience between 19 and 22 extreme days per year. At the end of the century, this number is anticipated to be between 22 and 62 extreme heat days per year (Figure 2-2 through 2-3). July and August are likely to be the most critical months for increased temperature effects. Historically, these months have experienced the highest temperatures; they are also projected to

[15] Cal-Adapt, "Extreme Heat Days & Warm Nights," generated for Sacramento city, California [Place (Incorporated and Census Designated, 2015)], 2018. Accessed October 28, 2019: https://cal-adapt.org/tools/extreme-heat/.

experience the highest temperature increases during the 21st century.[16] By the end of the century, about three of every four days in the month of July may be an extreme heat day (Figure 2-4). However, the effects of high heat days will likely be felt throughout spring and summer. Historically, high heat days in May, September, and October have been rare (on average, one or fewer high heat days every two years). By the end of the century, each of these months is projected to experience an average of at least one high heat day per year (Figure 2-4). Dynamic weather patterns over the past two years have brought late summer heatwaves to the region, with record-setting temperatures reached in 2022. Most concerningly, the late season heatwave in 2022 did not appear on long-range forecasts until a week prior, adding to the uncertainty of what future dynamic extreme heat events may bring.

The average temperature of extreme heat days is projected to gradually increase over the course of the century. Historically, the average temperature of a high heat day has been about 106.1°F. By the end of this century, this value may increase to 108.4°F (Figure 2-5).

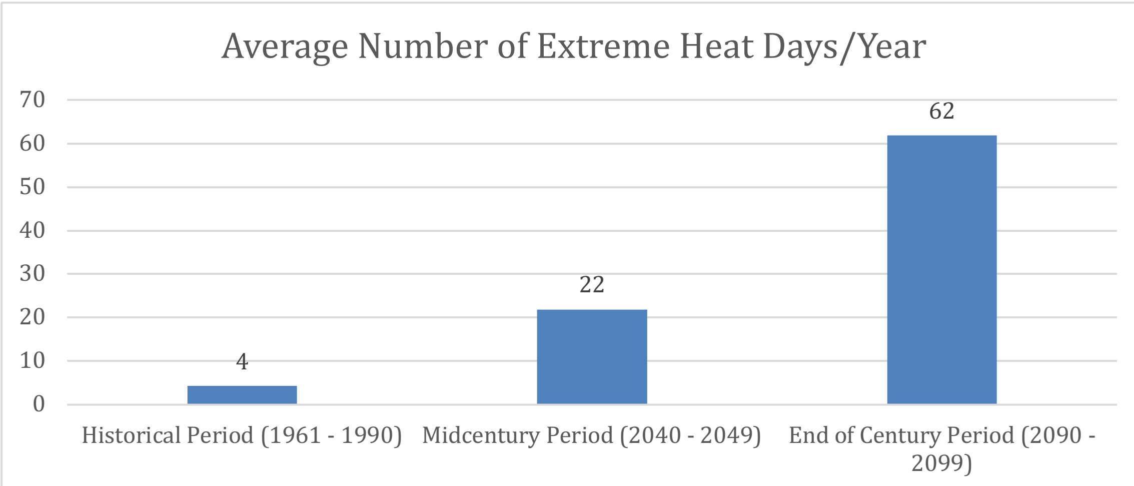
Figure 2-2: Annual Number of Extreme Heat Days



Created using historical and projected annual temperature data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. Historical data (modeled and observed) is capped at 2005. While some variability in the annual number of extreme heat days is projected to occur in the future, there is a clear upwards trend in the number of extreme days that occur per year. By the end of the century, the annual number of extreme heat days is projected to be significantly higher than anything that has been observed historically.

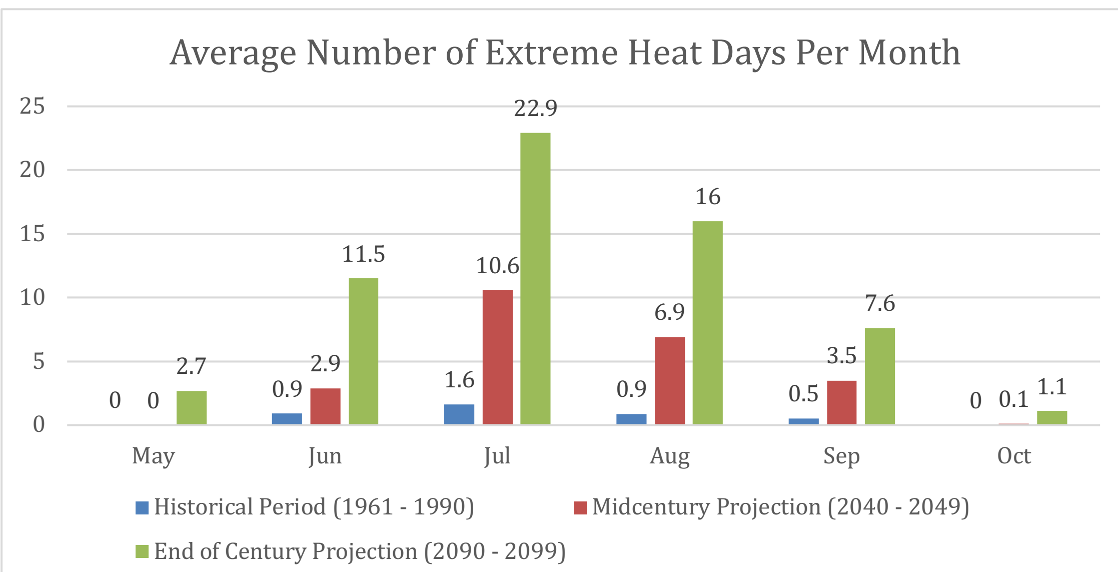
[16] Sacramento Area Council of Governments, Sacramento Region Transportation Climate Adaptation Plan, 2015. Accessed August 25, 2022: https://www.sacog.org/sites/main/files/file-attachments/fullplanwithappendices.pdf.

Figure 2-3: Average Number of Extreme Heat Days per Year



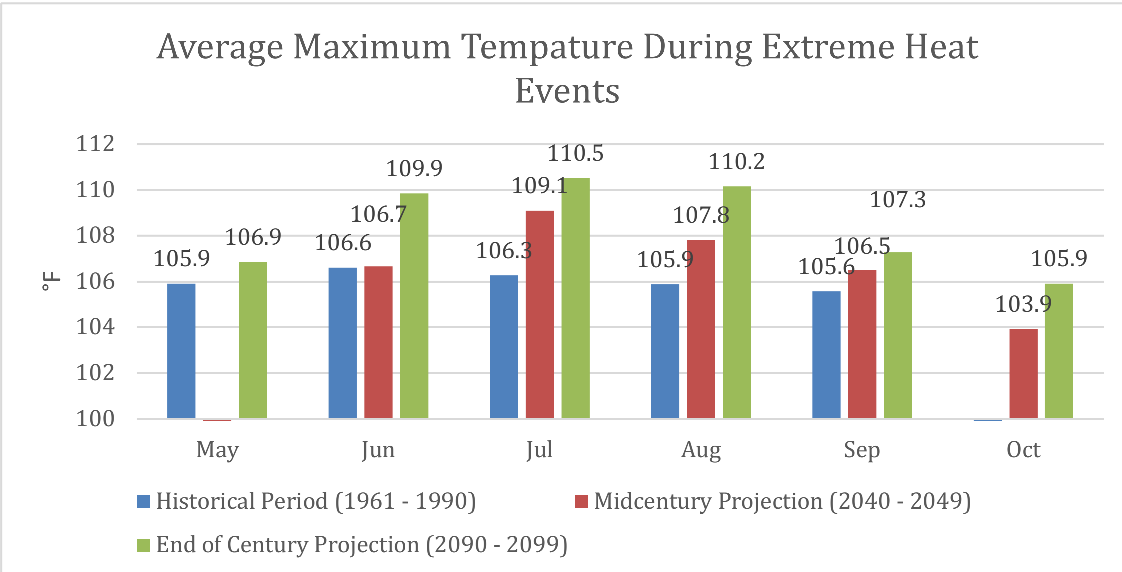
Created using historical and projected annual temperature data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. This chart shows the number of extreme heat events either observed or projected to occur, averaged over the time period indicated.

Figure 2-4: Average Number of Extreme Heat Events per Month



Created using historical and projected annual temperature data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. The number of extreme heat events occurring per month are projected to increase dramatically by the end of the century, particularly in the months of June, July, and August.

Figure 2-5: Average Maximum Temperature from Extreme Heat Events



Created using historical and projected annual temperature data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. Dramatic increases in the average daily high of extreme heat days are projected to occur, particularly in July in August and, by the end of the century, June. Mid- and end-of-century projections indicate that extreme heat days will begin to occur in October at least by 2040, a phenomenon that was not observed during the historical period.

Heat Waves

While there is no universal definition of a heat wave, heat waves are characterized as periods of sustained, extreme heat. Cal-Adapt defines a heatwave as a period of four consecutive extreme heat days or warm nights[17]. Between 1961 and 1990, the Sacramento region experienced about one to two heatwaves per decade.[18] Heatwaves are projected to increase in intensity and duration.[19] By midcentury, the City of Sacramento may experience between 2.7 and 2.8 four-day heat waves per year. At the end of the century, this range is predicted to rise to between 3.2 and 10.9 four-day heat waves per year (Figure 2-6). The typical heat wave duration is predicted to grow to between 7.6 and 9.1 days by midcentury and up to 20.8 days by the end of the century (Figure 2-7 through 2-8).

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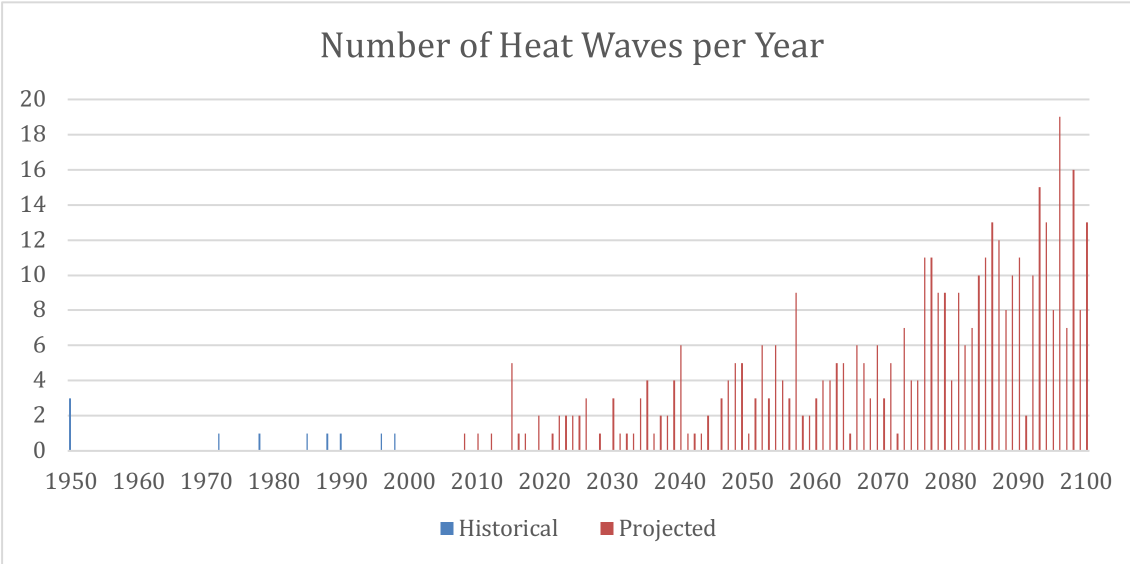
[17] Cal-Adapt, "Extreme Heat Days & Warm Nights," 2018.

[18] Ascent Environmental, Climate Change Vulnerability Assessment for the Sacramento County Climate Action Plan: Communitywide Greenhouse Gas Reduction and Climate Change Adaptation (2017).

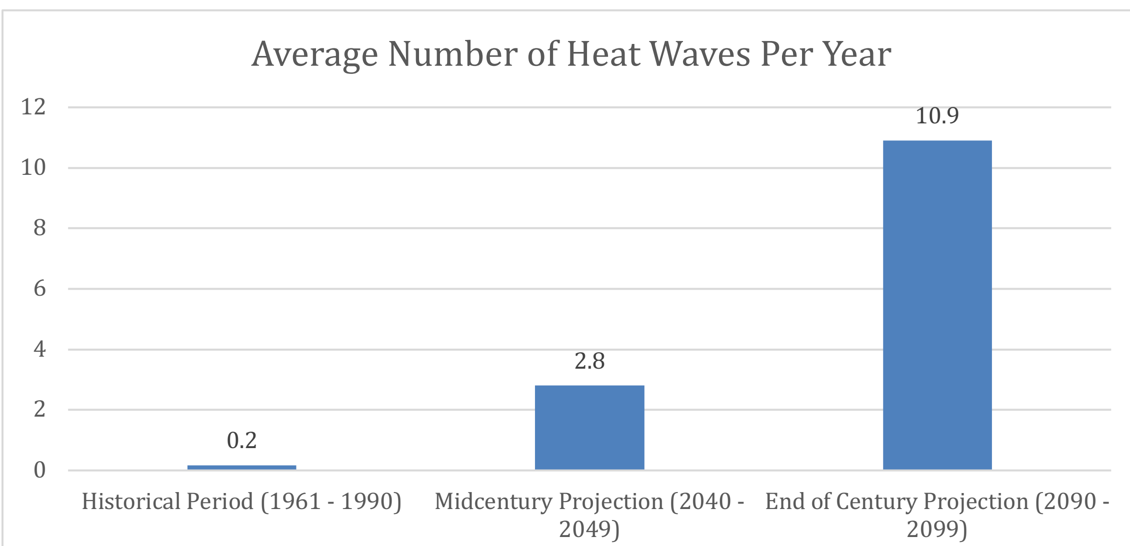
[19] Sacramento Municipal Utility District, SMUD 2018 Local Hazard Mitigation Plan (2018). Oct 28 2019: https://www.smud.org/-/media/Documents/Corporate/About-Us/Reports-and-Documents/2018/Local-Hazard-Mitigation-Plan-public-comment-draft.ashx.

Figure 2-6a: Number of Heat Waves Per Year



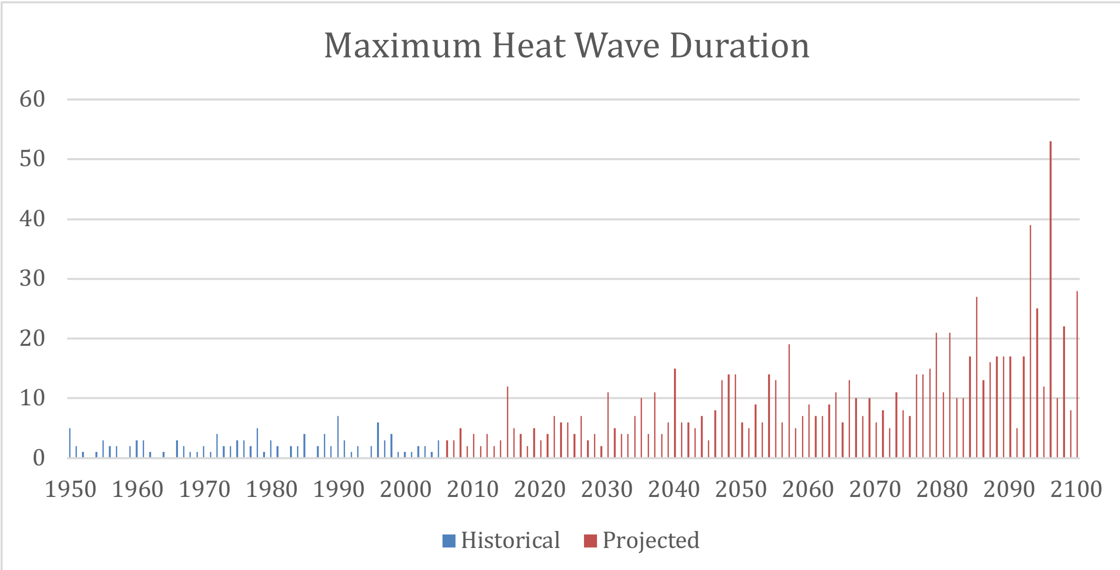
Created using historical and projected heat wave data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. Historical data (modeled and observed) is capped at 2005. While considerable variability in the annual number of heat waves is projected to continue, the number of heat waves projected to occur per year does increase dramatically by the end of the century.

Figure 2-6b: Number of Heat Waves Per Year



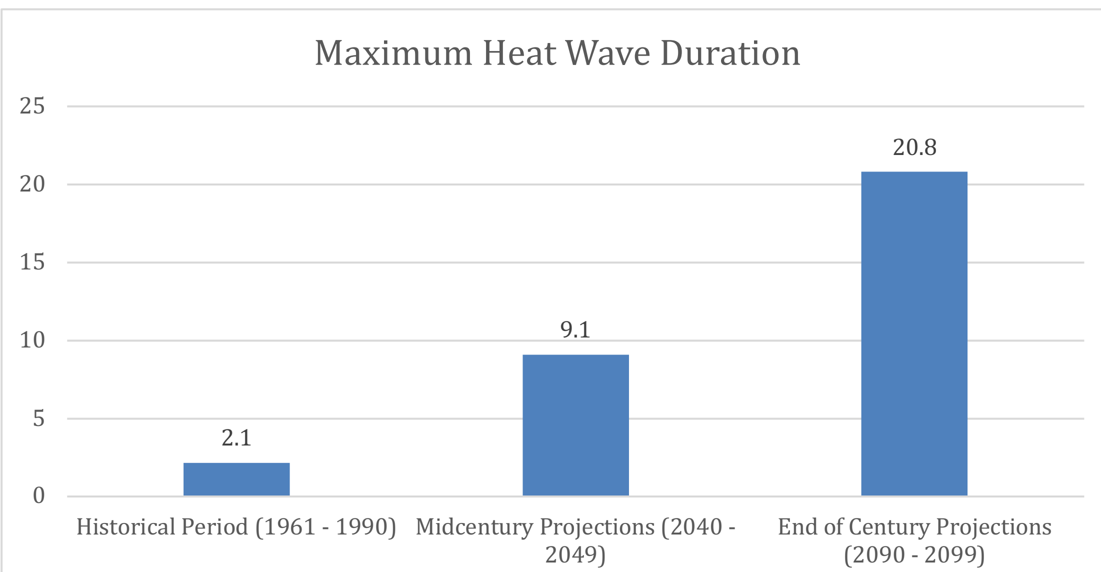
Created using historical and projected heat wave data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. While considerable variability in the annual number of heat waves is projected to continue, the number of heat waves projected to occur per year does increase dramatically by the end of the century.

Figure 2-7: Maximum Heat Wave Duration



Created using historical and projected heat wave data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. Historical data (modeled and observed) is capped at 2005. The length of the longest heat wave is projected to gradually increase over the course of the century.

Figure 2-8: Maximum Heat Wave Duration



Created using historical and projected heat wave data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento.

Urban Heat Islands

Increases in urban temperature may be felt particularly acutely by those living in urban heat islands. Urban heat islands are pockets of the urban environment where temperatures can dramatically exceed those in neighboring non-urban areas. Urban heat islands are associated with a number of negative environmental and health effects, as well as increased demands for energy.

Urban heat islands form where high levels of development intersect with limited landscape vegetation. Natural elements such as trees and green spaces provide cooling via evapotranspiration and shade.[20] In contrast, the materials that constitute the built environment, such as asphalt and concrete, absorb heat. These materials re-radiate absorbed heat and can raise nearby temperatures by several degrees.[21] [22] Other anthropogenic activities such as running air conditioners and operating internal combustion engines can also raise urban temperatures.[23] [24] The location of urban heat islands can also shift with changes in atmospheric conditions such as prevailing wind patterns.[25]

The pockets of high temperature created by urban heat islands facilitate the formation of ozone and smog.[26] Additionally, high pavement and rooftop surface temperatures can heat stormwater runoff. This heated runoff can enter local rivers and lakes, where it may upset the metabolism and reproduction of aquatic species.[27]

Increased daytime temperatures, reduced nighttime cooling, and higher air pollution levels associated with urban heat islands can exacerbate the health effects associated with excessive heat, warm nights, and air pollution. Potential health complaints include general discomfort, dehydration, respiratory difficulties, heat cramps and exhaustion, heat stroke, and heat-related

[20] Golden JS, "The Built Environment Induced Urban Heat Island Effect in Rapidly Urbanizing Arid Regions – A Sustainable Urban Engineering Complexity," *Environmental Sciences*, 2004. May 1, 2020: https://www.tandfonline.com/doi/abs/10.1080/15693430412331291698.

[21] Golden JS, 2004.

[22] United States Environmental Protection Agency, "Learn About Heat Islands," last updated September 2, 2022. Accessed October 27, 2022: https://www.epa.gov/heatislands/learn-about-heat-islands.

[23] Memon RA, Leung DY, Chunho L, "A review on the generation, determination and mitigation of urban heat island," *Journal of Environmental Sciences*, 2008. May 1, 2020: https://www.ncbi.nlm.nih.gov/pubmed/18572534.

[24] Salamanca F. Georgescu M, Mahalov A, Moustaoui M, Wang M. "Anthropogenic heating of the urban environment due to air conditioning." *Advancing Earth and Space Science*, May 9, 2014. May 1, 2020: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2013JD021225.

[25] Wilby, RL. "A Review of Climate Change Impacts on the Built Environment." *Built Environment*, Mar 13 2007. May 4 2020: https://www.ingentaconnect.com/content/alex/benv/2007/00000033/00000001/art00003

[26] Akbari, H. "Energy Saving Potentials and Air Quality Benefits of Urban Heat Island Mitigation." (2001). May 1, 2020: https://www.osti.gov/servlets/purl/860475.

[27] United States Environmental Protection Agency, "Heat Island Impacts," last updated September 2, 2022. Accessed October 27, 2022: https://www.epa.gov/heatislands/heat-island-impacts

mortality.[28] [29] [30] Seeking relief from excess heat, many urban residents may turn to air conditioning. While air conditioning can alleviate some of the most immediate health impacts of urban heat islands, air conditioning use also increases energy use[31], straining the electrical grid and potentially releasing both greenhouse gases and excess heat into the environment.

California's energy mix is transitioning from dispatchable thermal generation to variable and intermittent renewable resources, which impacts reliability and availability during peak demand. Peak demand has shifted from mid-day to late afternoon-evening when solar production drops off, and during high-heat events energy use is at its greatest due to widespread air conditioning use. Updates to continuity plans should have response protocols for heat waves, to include warnings on charging electric vehicles from early afternoon into the evening and plans to keep non-critical infrastructure buildings at certain temperatures, notably during flex alerts and heat events that last several days.

The impact of urban heat islands is particularly pronounced during the summer months and heat waves[32], when maximum temperatures reach their peaks, but hotter temperatures can also extend into early morning and night.[33] [34] This is significant because these cooler periods typically provide relief, especially for people who reside in or around urban heat islands and cannot afford or lack access to air conditioning, but latent heat accumulated throughout the day can severely dampen this effect and lead to prolonged heat exposure and health effects. Similarly, warmer nights will also increase energy costs and demand for air conditioning.

Map 1: Urban Heat Island, illustrates the incidence of urban heat islands in the City of Sacramento. Darker red and orange colors indicate locations where the average urban temperature exceeds that of associated rural areas. Urban heat island effects are most prevalent in the northeast quadrant of the city, including neighborhoods such as Northpointe, Glenwood Meadows, Raley Industrial Park, and Del Paso Heights, as well as the Central City.

This heat island map, created using urban heat island index (UHII) data produced by the Sacramento Metropolitan Air Quality Management District's Capital Region Urban Heat Island Mitigation Project, calculated UHIIs using air temperatures at human height levels, as opposed to the surface temperatures of roads or buildings. This focus on air-temperature data provides a more accurate reflection of temperatures as experienced by Sacramento residents. UHII expresses the cumulative temperature difference between an urban location and a non-urban reference point summed over a certain time interval. The units of UHII are degree-hours or degree-days and

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[28] United States Environmental Protection Agency, "Heat Island Impacts," 2022.

[29] Laaidi K, Zeghnoun A, Dousset B, Bretin P, Vandentorren S, Giraudet E, Beaudeau P. "The Impact of Heat Islands on Mortality in Paris during the August 2003 Heat Wave." *Environmental Health Perspectives*, Feb 1, 2012. May 1, 2020: https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.1103532

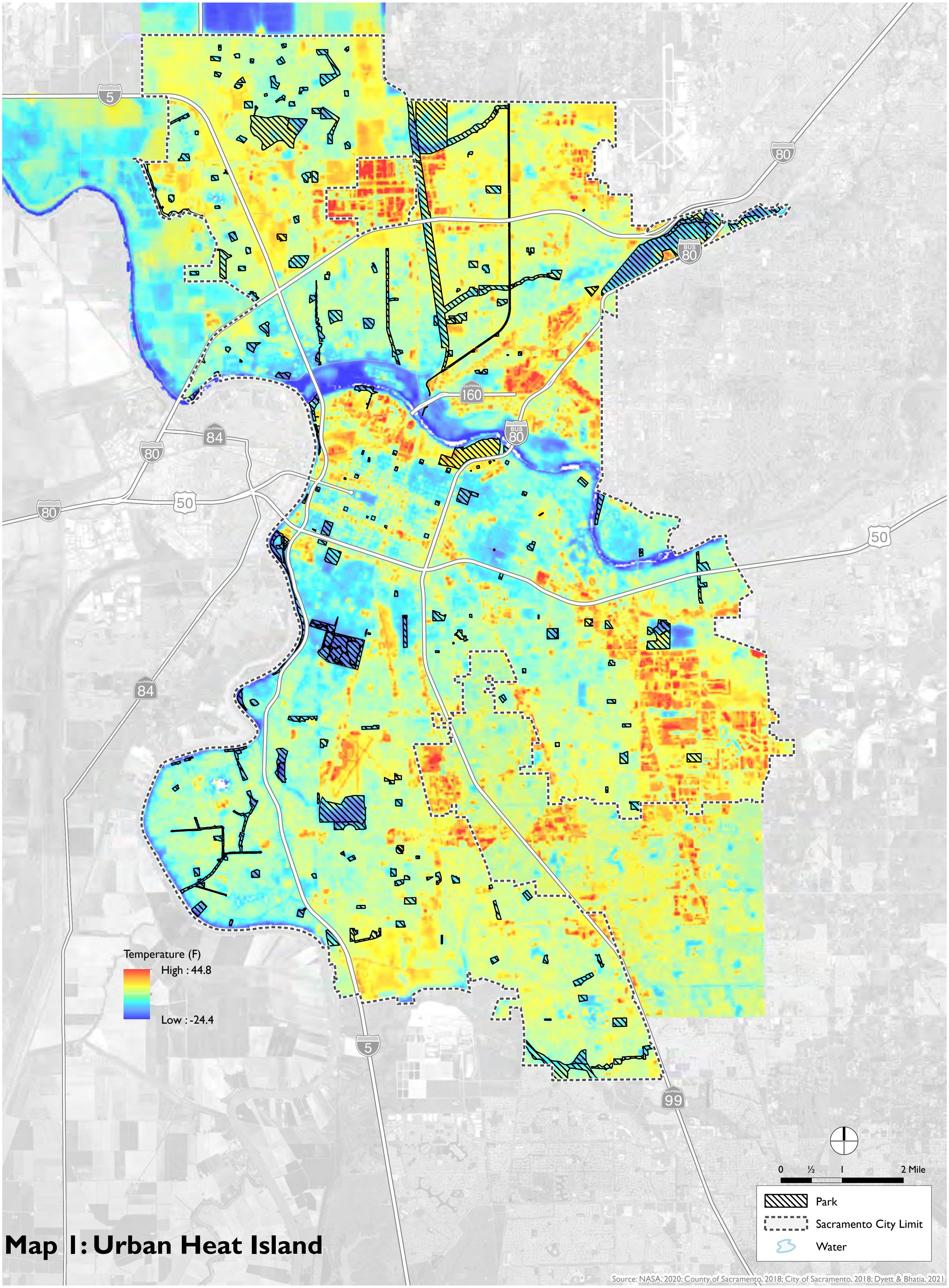
[30] Memon RA, Leung DY, Chunho L, 2008.

[31] United States Environmental Protection Agency, "Heat Island Impacts," 2022.

[32] Sacramento Municipal Utility District, 2016.

[33] Memon RA, Leung DY, Chunho L, 2008.

[34] Golden JS, 2004.



Map 1: Urban Heat Island

represent the total urban heat island effect added up over a period of time. The UHII illustrated in Map 1 was computed for the May to September period for years 2013 through 2016 and was calculated for all hours (24-hour day), specific hours (6am, 1pm, and 3pm), and for ranges of hours representing peak periods for the electricity system.[35]

The urban heat island effect is currently prevalent throughout Sacramento, particularly in areas adjacent to major roadways and in the northeast quadrant of the city. Over the course of the next several decades, UHII is expected to increase. In areas that are already urbanized, local climate change will be the primary contributor to future changes in UHII. In areas that will be urbanizing between now and 2050, the impacts on air temperature will result from both changes in land use type and changes in climate.

One feature of the natural and built environment that can both reduce intensity of the urban heat island effect and improve air quality is the presence of trees and other forms of vegetation. As seen in Map 2: Tree Canopy, Sacramento's tree canopy is typically the densest in areas neighboring—but not immediately within—downtown. Tree cover is highest in wealthy historic neighborhoods and tends to decrease in areas that lie along the borders of the city. In addition, trees will be more vulnerable to patterns of increased heat, drought, and storms, causing them to be more vulnerable to stress and disease. Hardier species will need to be incorporated into the tree population,

It is important to note that there may be tradeoffs in adaptation strategies. For instance, water conservation and drought resilience efforts could have a negative impact on urban heat islands due to removal of vegetation and use of heat-absorbent materials such as rock or artificial turf. These unintended consequences will need to be weighed alongside potential co-benefits when prioritizing adaptation measures.

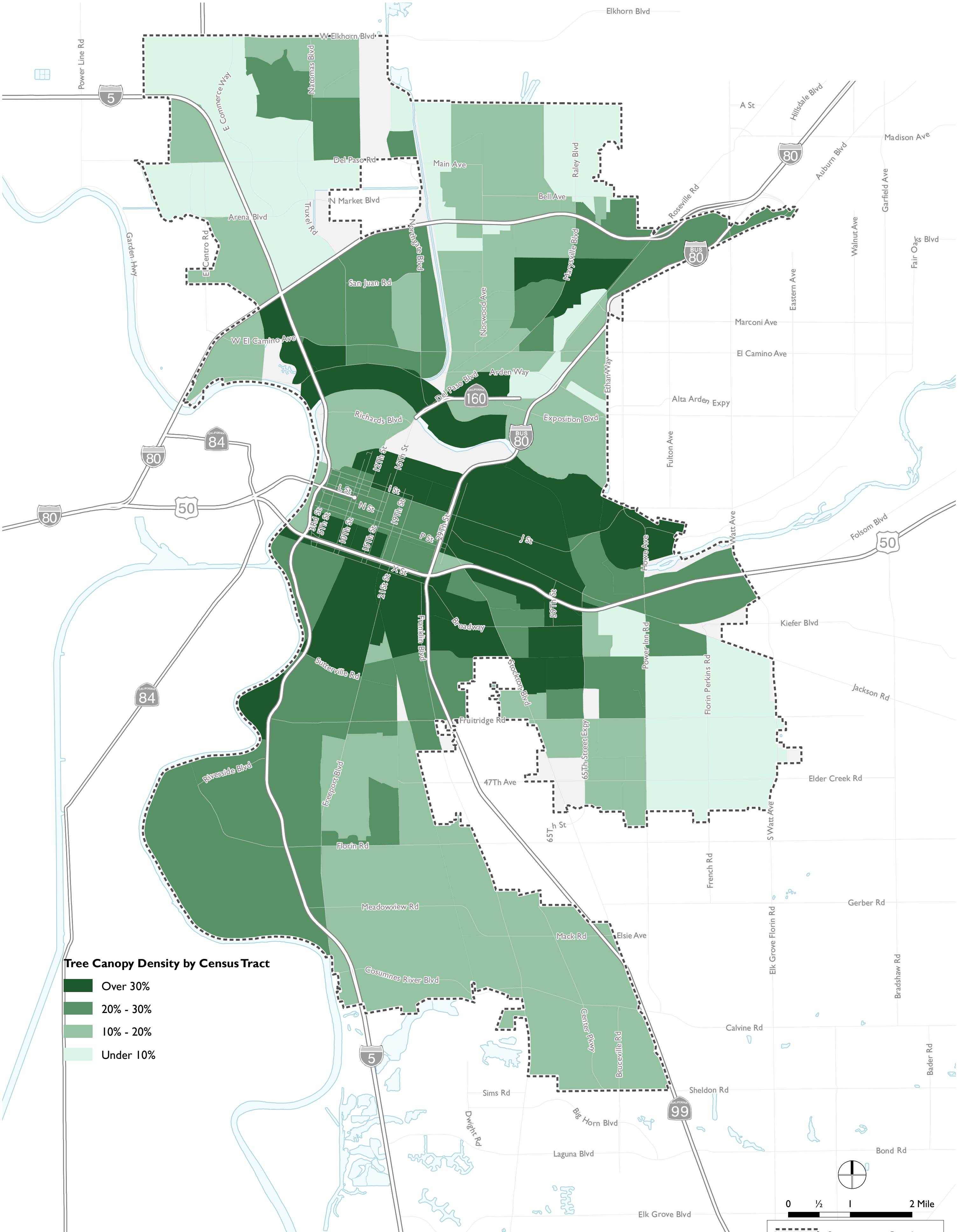
Warm Nights

Cal-Adapt defines a warm night as a night falling between April and October when the daily minimum temperature exceeds the 98th historical percentile of daily minimum temperatures observed from 1961 to 1990[36] (for the City of Sacramento, 66.6°F). Both the frequency and intensity of warm nights are projected to increase in the future. Historically, the City of Sacramento experienced an average of four warm nights per year. By midcentury, the city is predicted to experience approximately 32 to 44 warm nights per year. By the end of the century, this figure could climb as high as 114 warm nights per year (Figure 2-9 and 2-10). The majority of these warm nights are projected to occur between June and September. By the end of the century, almost every night in July and August may be a warm night. Warm nights may also become a larger concern in May and October, months in which warm nights have historically been rare (Figure 2-11).

[35] Sacramento Metropolitan Air Quality Management District, Summary Report: Capital Region Urban Heat Island Mitigation Project (2020).

[36] Cal-Adapt, "Extreme Heat Days & Warm Nights," 2018.

Map 2: Tree Canopy



Source: Urban Forestry/Department of Public Works, 2018; City of Sacramento, 2019; Dyett and Bhatia, 2019

Historically, the average warm night temperature has been about 68.8°F. By midcentury, average warm night temperature is projected to increase to 70.1°F. By the end of the century, average warm night temperature is projected to further increase to 71.4°F. The most dramatic increases in nighttime temperature are projected to occur in July and August (Figure 2-12).

Stretches of consecutive warm nights are also expected to increase in length. Historically, it has been unusual to see significantly more than two warm nights in a row. By midcentury, consecutive stretches of warm nights may be between 9 and 13 nights long. At the end of the century, the length of the average stretch of consecutive warm nights may climb up to 71 nights in a row (Figure 2-13, 2-14).

Elevated nighttime temperatures limit the body's opportunity to offload excess heat acquired during the day, increase mortality risk[37] [38], and can disrupt sleep.[39] Within the city, the effects of warm nights may be felt most acutely in heavily built-up areas with limited vegetation. These areas can become very warm during the day and continue to radiate heat

at night.[40] Nighttime air conditioner use, while providing relief to residents, may actually exacerbate these effects by releasing waste heat into the environment.[41] Additionally, should air conditioner systems fail, those who had come to rely on them may have few other options for relieving heat.[42]

Just as cool nights help the body recover from high daytime temperatures, firefighters have traditionally relied on cooler evening and nighttime temperatures to slow wildfire growth. Higher nighttime temperatures enable wildfires to blaze through the night.[43] [44]

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[37] Laaidi K, et.al, 2012.

[38] Murage P, Hajat S, Kovats S. "Effect of night-time temperatures on cause and age-specific mortality in London." Environmental Epidemiology, Dec 13, 2017. May 1, 2020: https://journals.lww.com/environepidem/FullText/2017/12000/Effect_of_night_time_temperatures_on_cause_and.1.aspx.

[39] Obradovich N, Migliorini R, Mednick SC, Fowler JH. "Nighttime temperature and human sleep loss in a changing climate." *Science Advances*, May 26, 2017. May 1, 2020: https://advances.sciencemag.org/content/3/5/e1601555.

[40] Lenart M, Guido Z. "Rising temperatures bump up risk of wildfires." *Southwest Climate Outlook*, March 2011. May 1, 2020: https://climas.arizona.edu/sites/default/files/pdf2011marrisingtempsfirerisk.pdf.

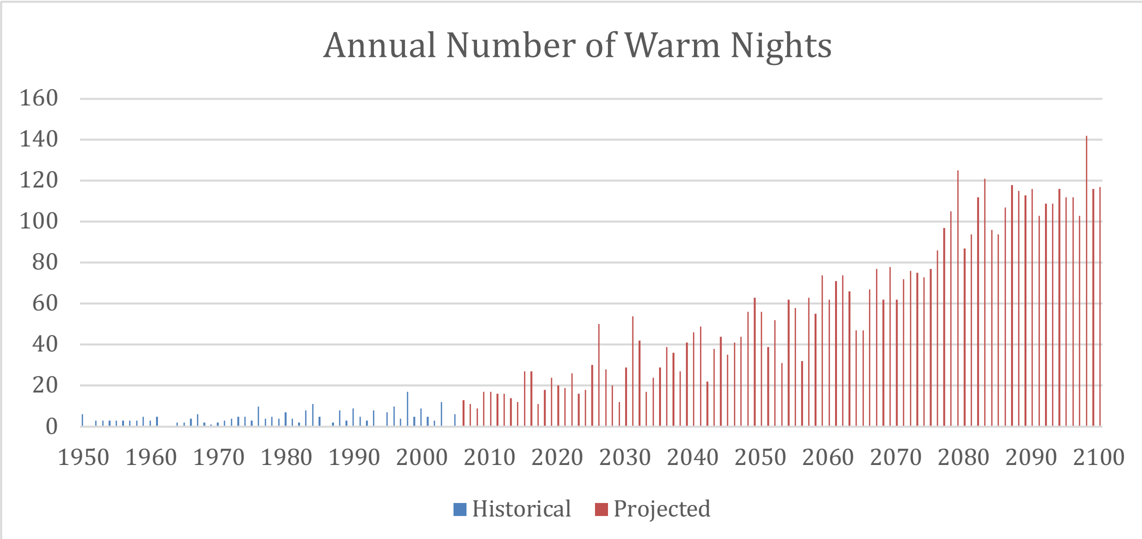
[41] Salamanca F., et.al., 2014..

[42] Gronlund CJ. "Racial and Socioeconomic Disparities in Heat-Related Health Effects and Their Mechanisms: s Review." *Current Epidemiology Reports*, 2014. May 3 2020: https://link.springer.com/article/10.1007/s40471-014-0014-4.

[43] McCann H, Mount J. "Managing Wildfires Requires New Strategies." *Public Policy Institute of California*, Sep 23, 2015. May 1, 2020: https://www.ppic.org/blog/managing-wildfires-requires-new-strategies/.

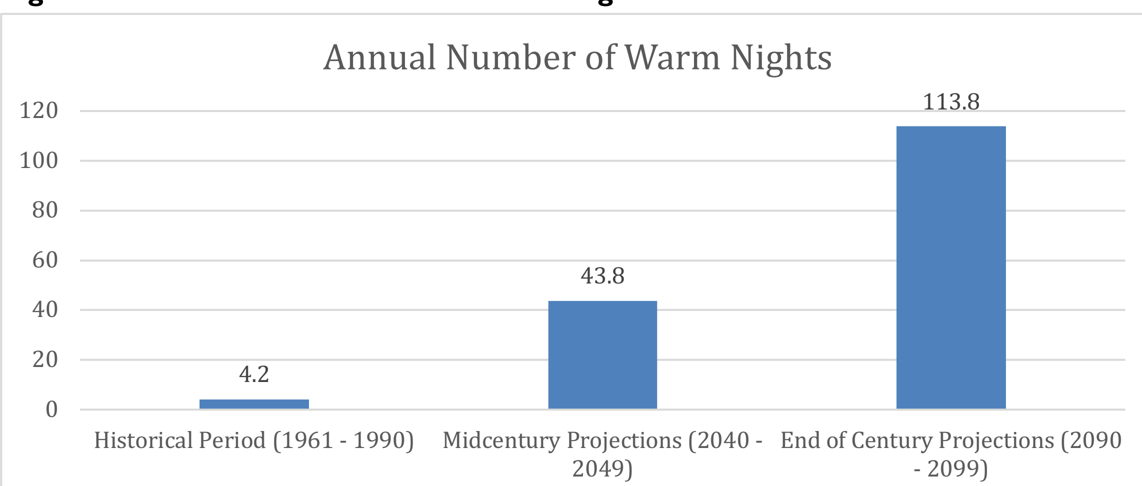
[44] Lenart M, Guido Z. "Rising temperatures bump up risk of wildfires." *Southwest Climate Outlook*, March 2011. May 1, 2020: https://climas.arizona.edu/sites/default/files/pdf2011marrisingtempsfirerisk.pdf.

Figure 2-9: Annual Number of Warm Nights



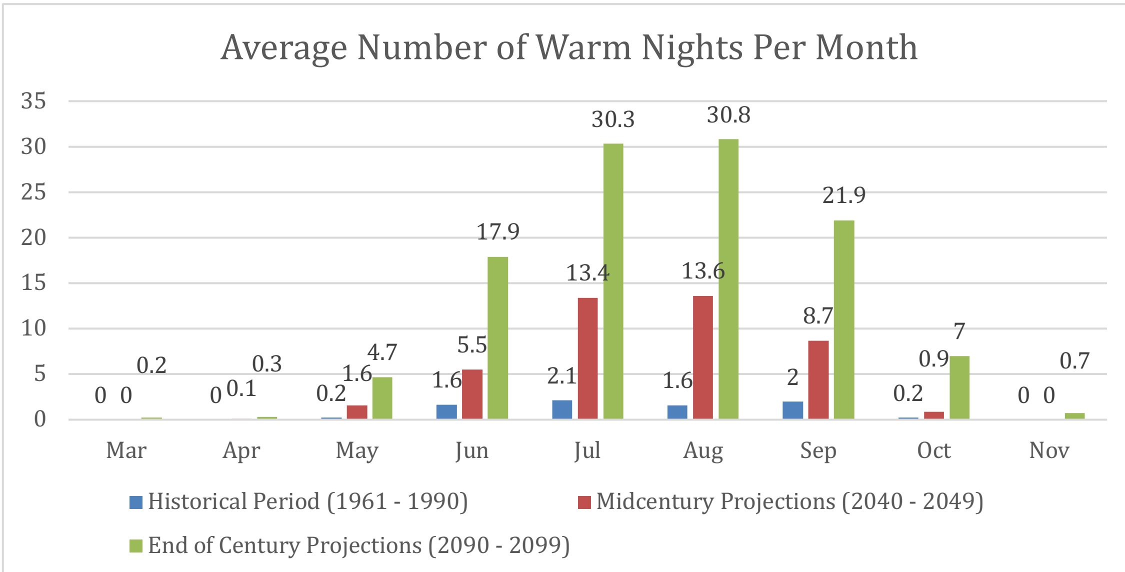
Warm nights refer to nights between April and October when the daily minimum temperature exceeds the 98th historical percentile of daily minimum temperatures observed from 1961 to 1990 (for the City of Sacramento, 66.6°F). Created using historical and projected warm night data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. Historical data (modeled and observed) is capped at 2005. While some degree of variability in the annual number of warm nights that occur per year is projected to continue into the future, projections demonstrate a steadily increasing trend through the end of the century. By the end of the century, the annual number of warm nights is projected to far exceed anything that has been observed between 1950 and 2005.

Figure 2-10: Annual Number of Warm Nights



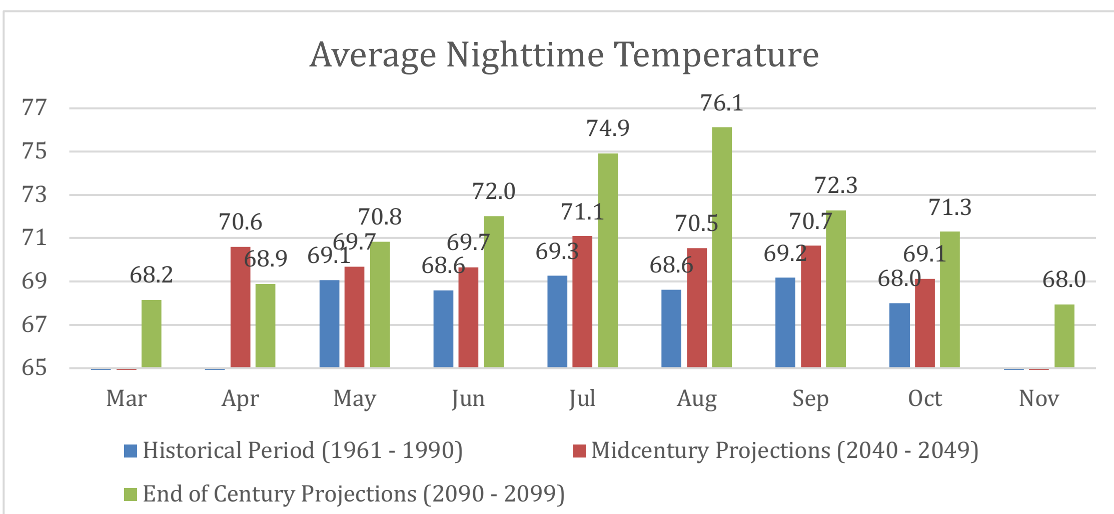
Warm nights refer to nights between April and October when the daily minimum temperature exceeds the 98th historical percentile of daily minimum temperatures observed from 1961 to 1990 (for the City of Sacramento, 66.6°F). Created using historical and projected warm night data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento.

Figure 2-11: Average Number of Warm Nights Per Month



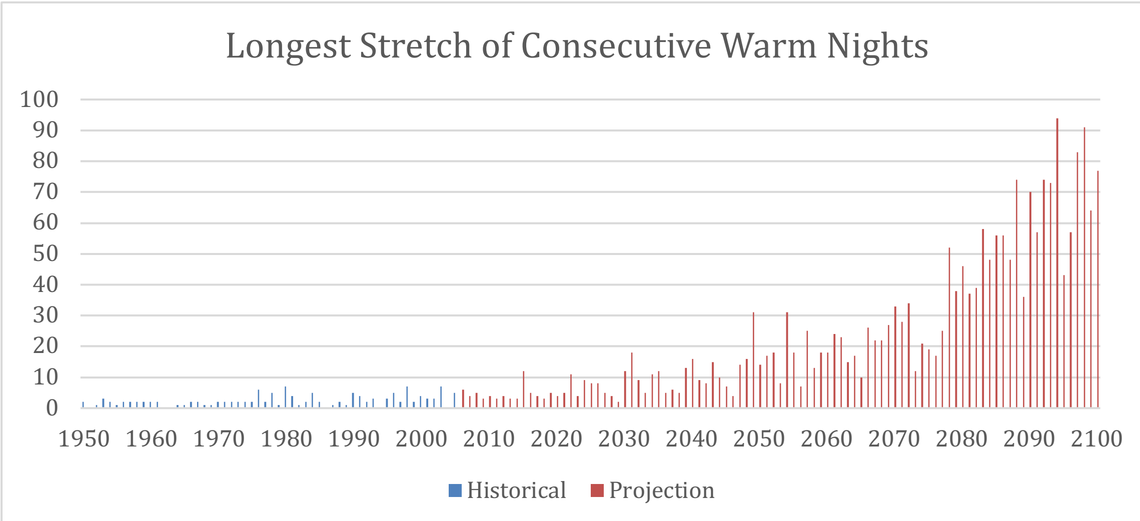
Warm nights refer to nights between April and October when the daily minimum temperature exceeds the 98th historical percentile of daily minimum temperatures observed from 1961 to 1990 (for the City of Sacramento, 66.6°F). Created using historical and projected warm night data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. The average number of warm nights is projected to increase most dramatically in the summer months. However, temperature projections also illustrate increase in the number of warm nights that occur in the Spring and Fall.

Figure 2-12: Average Nighttime Temperature



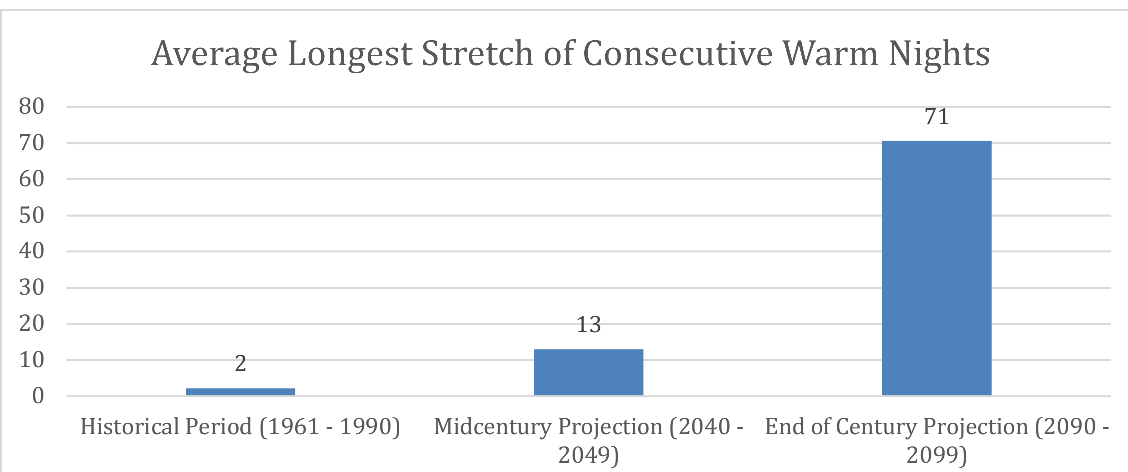
Created using historical and projected warm night data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. Average minimum temperature is projected to increase most dramatically in July and August. However, warm nights are also to projected to occur in March, April, and November by the end of the century, a phenomenon that has not been observed historically.

Figure 2-13: Longest Stretch of Consecutive Warm Nights



Warm nights refer to nights between April and October when the daily minimum temperature exceeds the 98th historical percentile of daily minimum temperatures observed from 1961 to 1990 (for the City of Sacramento, 66.6°F). Created using historical and projected warm night data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. Historical data (modeled and observed) is capped at 2005. While considerable variability is projected to remain in the typical length of a nighttime heat wave up through the end of the century, nighttime temperature projections do demonstrate a clear upward trend in nighttime heatwave length. This increase may occur somewhat gradually up through the middle of the century but then begin to increase rapidly thereafter.

Figure 2-14: Longest Stretch of Consecutive Warm Nights



Warm nights refer to nights between April and October when the daily minimum temperature exceeds the 98th historical percentile of daily minimum temperatures observed from 1961 to 1990 (for the City of Sacramento, 66.6°F). Created using historical and projected warm night data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. The chart above displays the historical and projected longest stretch of consecutive warm nights, averaged over the years indicated.

Sensitivity

Heat-Related Illness

Heat waves and sustained high heat days directly harm human health through heat-related illness such as heat cramps, heat exhaustion, and heat stroke.[45] Heat intensifies the photochemical reactions that produce smog, ground level ozone, and fine particulates, which exacerbate respiratory diseases in children, the elderly, and people with pre-existing cardiovascular, respiratory, and cerebrovascular disease and diabetes-related conditions.[46] [47] Prolonged exposure to high temperatures is associated with increased hospital admissions for cardiovascular, kidney, and respiratory disorders.[48] [49] Increased heat can also promote the growth of pollen-producing plants, which are associated with allergies.[50] On especially hot days, cooler nights have typically provided a period of respite. Increases in nighttime temperature prevent people from being able to adequately cool down at night, further increasing their risk of suffering heat-related illness.[51] [52]

Most people find it relatively easy to take measures, such as locating to a cooler environment, that reduce their exposure to excessive heat. However, opportunities to reduce heat exposure are not evenly distributed throughout the population. Segments of the population who face especially high levels of heat exposure include those experiencing homelessness, outdoor workers, individuals that depend on medical equipment, individuals with impaired mobility,[53] and those without access to adequate home insulation, air conditioning, or ventilation.[54] [55]

Survey data collected from residents of the greater Sacramento region revealed that the character of heat-related discomfort differs with socioeconomic status. A third of respondents with household incomes under $40,000 reported feeling the most heat-related discomfort at home, compared to 12 percent of those with household incomes over $100,000. Thirty-seven percent of those who reported that their greatest source of heat-related discomfort came from outdoor activity

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[45] Sari Kovats R, Hajat S. "Heat Stress and Public Health: A Critical Review." *Annual Review of Public Health*, Nov 21 2007. May 3 2020: https://www.annualreviews.org/doi/full/10.1146/annurev.publhealth.29.020907.090843.

[46] Maizlish N, English D, Chan J, Devin K, English P, Climate Change and Health Profile Report: Sacramento County (Sacramento, CA, 2017). Oct 28 2019: https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHPRs/CHPR067Sacramento_County2-23-17.pdf.

[47] U.S. Climate Resilience Toolkit, Extreme Heat—NIHHIS. Oct 28 2019: https://toolkit.climate.gov/topics/human-health/extreme-heat.

[48] U.S. Global Change Research Program, Climate and Health Assessment (Washington D.C., 2016). Oct 28 2019: https://health2016.globalchange.gov/temperature-related-death-and-illness.

[49] Gronlund CJ, 2014..

[50] Maizlish N, et.al, 2017.

[51] U.S. Climate Resilience Toolkit, Extreme Heat—NIHHIS.

[52] U.S. Global Change Research Program, 2016.

[53] Sacramento Municipal Utility District, 2018.

[54] Maxwell, K., Julius S., Grambsch A., Kosmal A., Larson L., Sonti, N., Built Environment, Urban Systems, and Cities. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* (Washington D.C., 2018). Oct 28 2019: https://nca2018.globalchange.gov/chapter/11/.

[55] Gronlund CJ, 2014.

had household incomes of over $100,000, compared to 14 percent of from households earning $40,000 or less. Of those who reporting feeling no discomfort due to heat at all, about 60 percent were respondents earning $60,000 or more. Only 6 percent of those earning $40,000 or less said they felt no heat impacts, compared to 14 percent of those earning over $100,000. Survey results also show race contributing to experiences of heat. Higher percentages of American and Alaskan Native (36 percent), Latinx (26 percent), Asian (27 percent), and Middle Eastern or North African (44 percent) respondents reporting feeling their highest heat stress at home, as opposed to 19 percent of white respondents. Black respondents were more likely to report feeling heat-related discomfort during their commute (15 percent) and at work (19 percent) compared to white respondents (6 percent and 12 percent, respectively).[56]

Personal perceptions regarding heat risk and safety can also influence responses to heat. Those who fear exposure to crime may hesitate to open windows or travel to cooler locations, while some may not be aware of the dangers posed by high heat or may not think of themselves as susceptible.[57]

Studies have shown that cooling of the body is achieved through increased blood flow to the skin and sweating, cooling mechanisms that rely heavily on the cardiovascular system, as well as the endocrine, urinary, and integumentary processes.[58] Certain segments of the population whose natural cooling systems are inhibited are thus more sensitive to the health effects of heat. These groups include the elderly, those taking certain types of medication (anticholinergic, antihypertensive, and antipsychotic drugs), and children.[59] [60] [61] [62] Conditions such as dementia and Parkinson's have also been found to be important risk factors for heat mortality. Additionally, social, cultural, and linguistic isolation have also been shown to contribute to heat's adverse health effects.[63] Sometimes limited transportation options for the elderly can also make it more difficult to relocate to cooler locations when local temperatures become extreme.

Just as cool nights help the body recover from high daytime temperatures, firefighters have traditionally relied on cooler evening and nighttime temperatures to slow wildfire growth. Higher nighttime temperatures enable wildfires to blaze through the night.[64] [65]

Heat-Related Infrastructure Impacts

High temperatures can have detrimental impacts on key infrastructures including energy generation and distribution and transportation. High temperatures decrease the efficiency of power

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[56] Sacramento Metropolitan Air Quality Management District, 2020.

[57] Gronlund CJ, 2014.

[58] Gronlund CJ, 2014.

[59] Sari Kovats R and Hajat S, 2007..

[60] U.S. Global Change Research Program, 2016.

[61] Gronlund CJ, 2014.

[62] U.S. Global Change Research Program, 2016.

[63] Gronlund CJ, 2014.

[64] McCann H, Mount J. "Managing Wildfires Requires New Strategies." *Public Policy Institute of California*, Sep 23, 2015. May 1, 2020: https://www.ppic.org/blog/managing-wildfires-requires-new-strategies/.

[65] Lenart M, Guido Z. "Rising temperatures bump up risk of wildfires." *Southwest Climate Outlook*, March 2011. May 1, 2020: https://climas.arizona.edu/sites/default/files/pdf2011marrisingtempsfirerisk.pdf.

lines while increasing the demand for energy-intensive uses such as air conditioning and cooling equipment [66]. This results in a higher risk of energy blackouts[67 68] and increases energy bills.[69] These impacts can strain household budgets, increase exposure to heat, and negatively impact the provision of medical and social services.[70]

Extremely high temperatures can damage roadways, railways, and bridges, as well as reduce the comfort and feasibility of walking, biking, and taking public transit.[71] Roads and sidewalks absorb and radiate heat, subjecting those nearby, including walkers and transit riders, to increased heat burdens.[72] The Sacramento Regional Transit (SacRT) powers their light rail system with overhead catenary systems lines, which can stretch with heat and may lead to severing of the connection with the rail car.[73]

Increased temperatures can also have cascading effects through the environment as they increase the risk of wildfire and influence local precipitation patterns, as discussed later in this report.

CHANGES IN PRECIPITATION PATTERNS

Climate change models predict changes in the seasonal distribution of precipitation, with rainfall becoming more concentrated in the winter months and falling in fewer, higher-intensity events. Meanwhile, increasing average temperatures will cause more precipitation to fall in the form of rain, as opposed to snow. These changes may result in a number of secondary impacts, such as flooding, reduction in winter snowpack, drought, increased wildfire risk, changes in streamflow, and strain to health, energy, and infrastructure systems, as described below and in Table 2-3.

Table 2-3: Changes in Precipitation Patterns

Temporal Extent	• Increases in annual rainfall projected to continue through the end of the century • Most dramatic increases in extreme rainfall events projected to occur in the winter months • April snowpack level projected to continue to decline through the end of the century
Spatial Extent	• Flooding effects will be felt most strongly in low-lying areas, areas dependent on levee protection, and areas with inadequate stormwater infrastructure
Permanence	• Effects may be felt most acutely in winter months, with drought periods also becoming more likely

66 Sacramento Municipal Utility District, 2016..
67 Sacramento Area Council of Governments, 2015.
68 U.S. Climate Resilience Toolkit, Extreme Heat—NIHHIS.
69 Maxwell, K., et. al., 2018.
70 Maxwell, K., et. al., 2018.
71 Sacramento Area Council of Governments, 2015.
72 Sacramento Metropolitan Air Quality Management District, 2020.
73 Sacramento Metropolitan Air Quality Management District, 2020.

Level of Disruption	• High
Nature of Disruption	• A large storm could cause significant health and infrastructure impacts over potentially large portions of the City. • Increased water temperature is harmful to water treatment, reservoir and hydroelectric operation, and ecological health.
Level of Uncertainty	• Low

Overall, annual precipitation is expected to increase in the Sacramento region. Between the years of 1961 and 1990, the City of Sacramento received about 18.9 inches of rain per year. By midcentury, this number is projected to increase to between 20.3 and 22.8 inches per year. Annual precipitation may reach 24 inches per year by the end of the century (Figure 2-15 through 2-16). However, this increase will not occur at a uniform rate throughout the year. Cal-Adapt predicts that the Sacramento region will experience a slight increase in fall and winter precipitation—which will fall more as rain and less as snow—while spring and summer months are generally expected to see less rainfall compared to historical patterns. Much of this increase in rainfall projected during winter months may be attributable to high-intensity or extreme storms. Cal-Adapt defines an extreme rain event for the City of Sacramento as an event where the two-day rainfall total exceeds 1.19 inches. Historically, the City of Sacramento has experienced about 12 extreme rain events per year. This number could increase to about 14 extreme rain events by the end of the century.

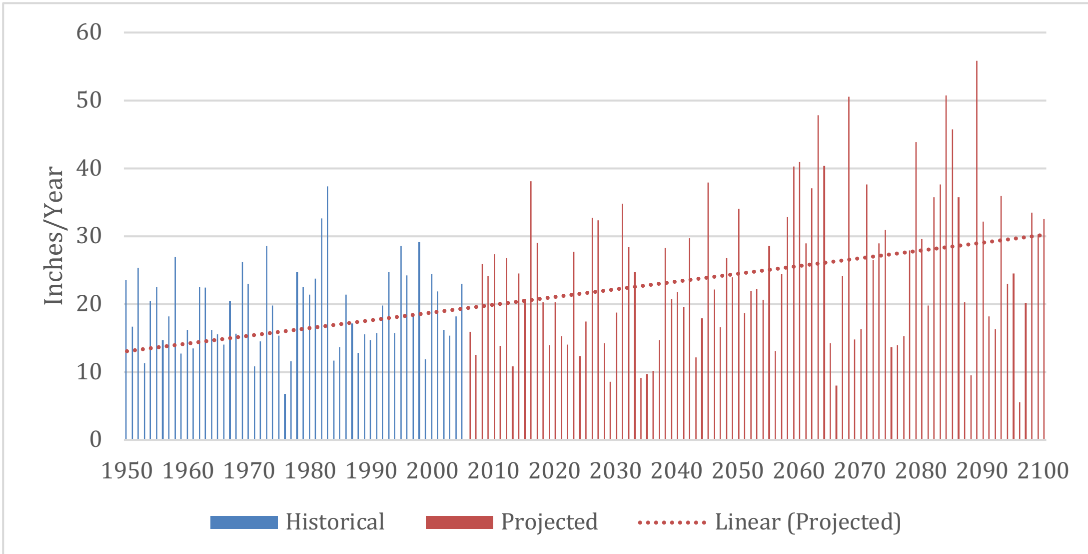
The most significant increases in extreme rainfall frequency are projected to occur in January and February, which are projected to experience 10 or more extreme rain events per year by the end of the century. By mid-century, extreme rain events may also be common in November and December, though the frequency of these events may taper off towards the end of the century (Figure 2-19).

These high-intensity storms may produce higher volumes of runoff, contribute to increased flood risk[74], intensify weatherization of transportation infrastructure such as roads and bridges, contribute to levee failure[75], lead to overtopping of the rivers and creeks, and increase the burden on the City's internal drainage system. Shifts in winter precipitation will also cause a significant conflict between flood control and water supply, discussed further below.

[74] Ascent Environmental, 2017.

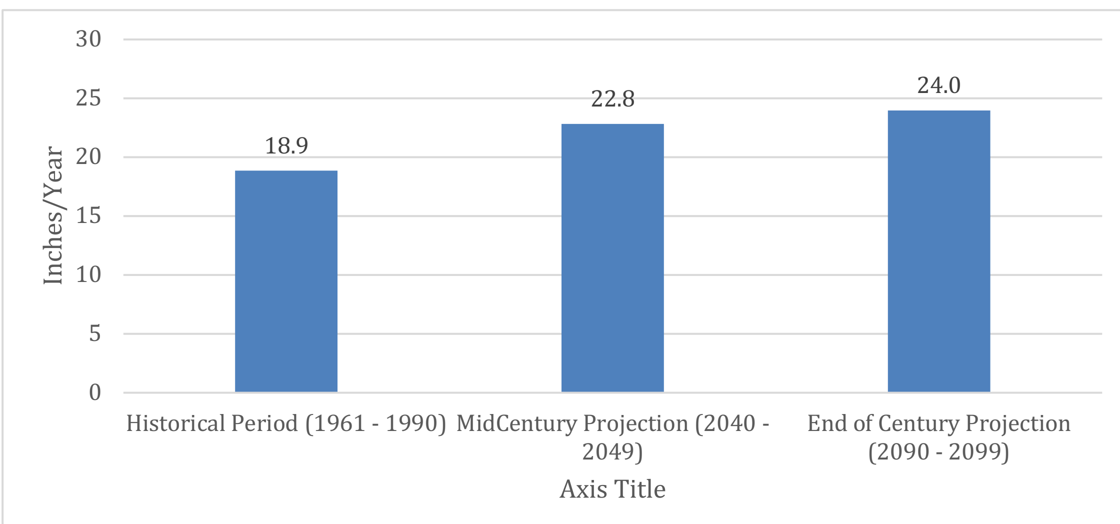
[75] Sacramento Area Council of Governments, 2015.

Figure 2-15: Total Annual Precipitation



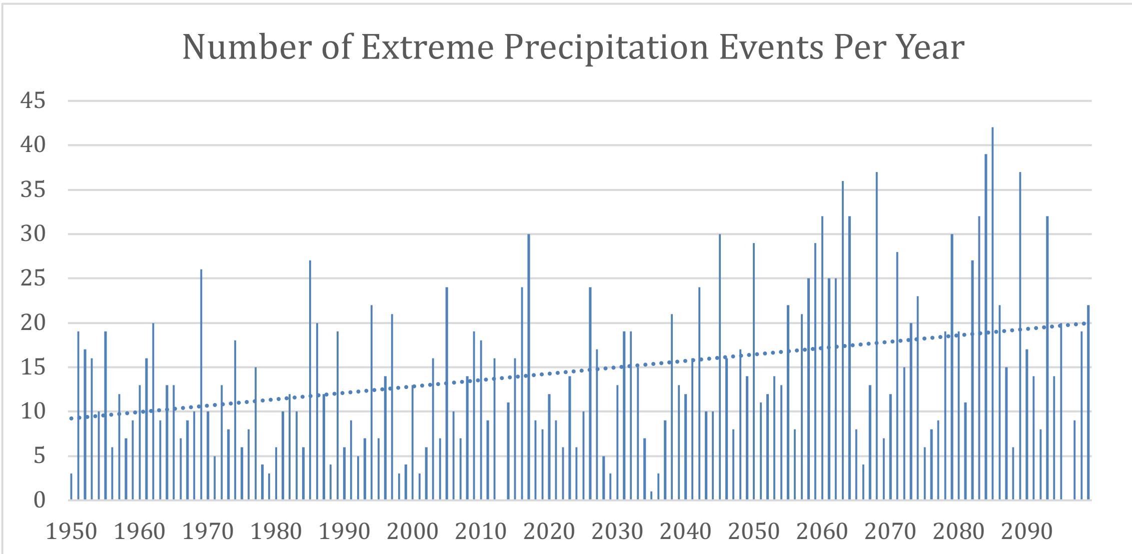
Created using historical and projected precipitation data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. Historical data (modeled and observed) is capped at 2005. While significant variability in annual rainfall is projected to continue into the future, the dotted linear trendline illustrates a gradual increase in annual rainfall over time.

Figure 2-16: Average Annual Precipitation



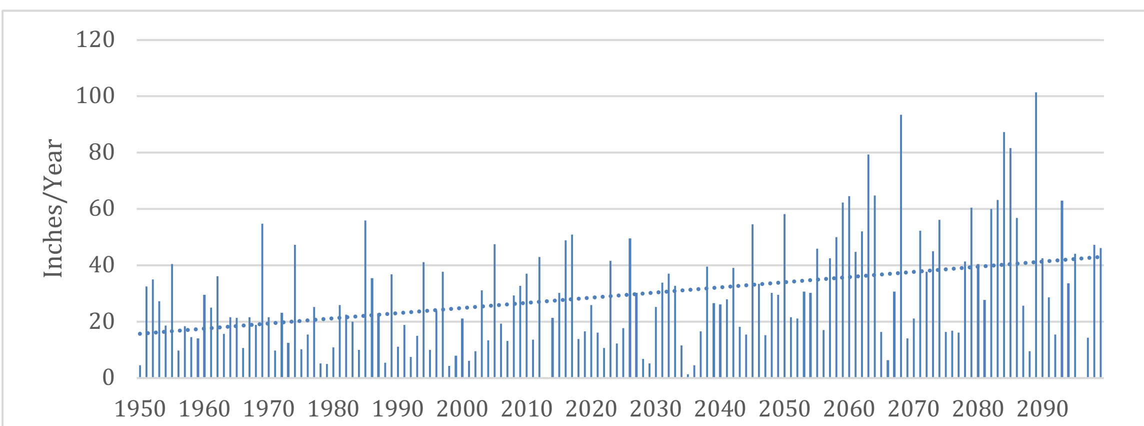
Created using historical and projected precipitation data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. There is a projected to be a larger jump in annual precipitation between the historical trends and midcentury than between mid- and end-of-century.

Figure 2-17: Number of Extreme Precipitation Events Per Year



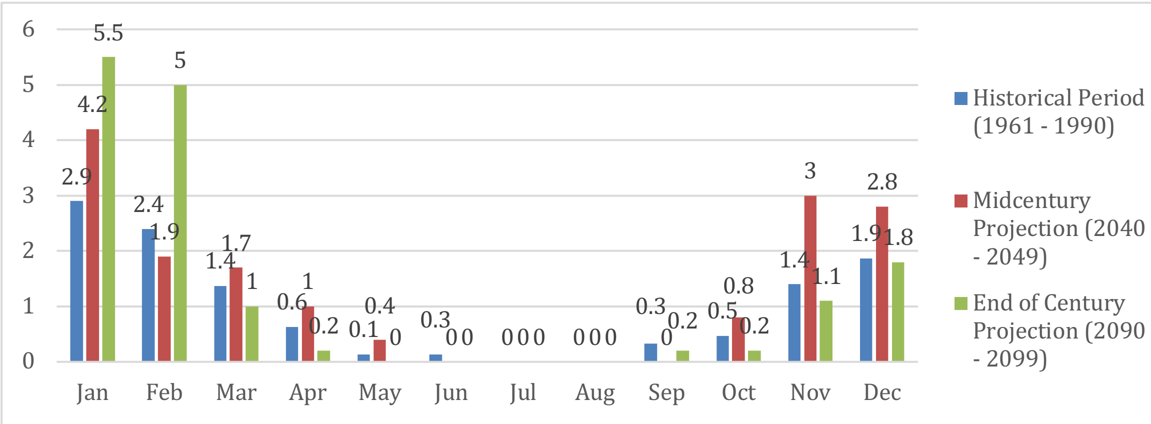
Created using historical and projected precipitation data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. A high degree of variability in the number of extreme rainfall events is projected to continue into the future. However, the dotted linear trendline illustrates, the amount of precipitation that falls during extreme events each year is projected to gradually increase.

Figure 2-18: Annual Inches of Rainfall from Extreme Precipitation Events



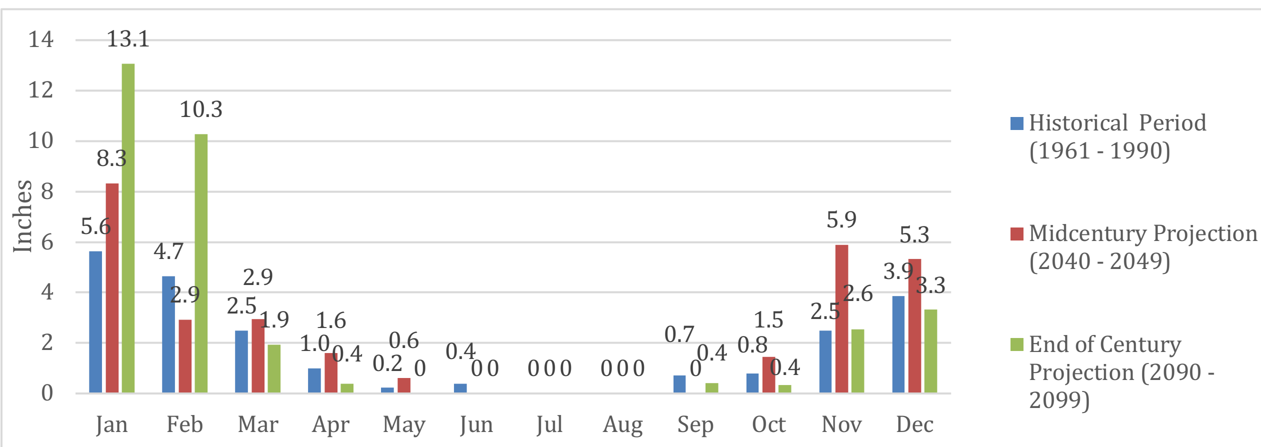
Created using historical and projected precipitation data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. A high degree of variability in the amount of rainfall from extreme rainfall events is projected to continue into the future. However, the dotted linear trendline illustrates, the amount of precipitation that falls during extreme events each year is projected to gradually increase.

Figure 2-19: Average Number of Extreme Precipitation Events Per Month



Created using historical and projected precipitation data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. The number of extreme precipitation events occurring in January and February is projected to increase dramatically by the end of the century; the number of extreme rain events occurring in October through December may rise at midcentury but taper off by the century's end.

Figure 2-20: Average Total Rainfall Due to Extreme Precipitation Events Per Month



Created using historical and projected precipitation data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the City of Sacramento. The amount of precipitation that falls during extreme events in January and February is projected to increase significantly by the end of the century. In November and December, the amount of precipitation falling during extreme events is projected to rise around midcentury but may level off by the end of the century.

Secondary Impacts

Flooding

Sacramento sits at the confluence of the Sacramento and American Rivers, which collectively drain water from a watershed the size of West Virginia.[76] Prior to the development of levees and other flood management infrastructure, Sacramento was vulnerable to significant flood events. Historically, the future site of Sacramento could be transformed into a vast inland sea during particularly wet years. The region's extensive network of levees, dams, and weirs therefore face a very challenging task that will become increasingly challenging as infrastructure ages and climate change induces larger storms and promotes sea level rise.

Historically, flooding has been the most frequent natural hazard occurring in the Sacramento region. The Sacramento area has experienced major recent floods in 1986, 1995, 1997, 2006, and 2017.[77] [78] Between 1996 and 2015, the National Climatic Data Center (NCDC) reported 32 flood events within Sacramento County, amounting to a total of $13,326,000 in lost property damages. These floods have damaged bridges and levees and resulted in significant numbers of people injured, killed, or forced to evacuate (Table 2-4). Large floods can result in multiple severe and widespread impacts including damage to electric and transportation infrastructure, destruction of homes and businesses, increased rates of flood-borne disease, and loss of life.

Severe flooding is often the result of a combination of topographic features, severe weather or excessive rainfall, and infrastructure characteristics such as inadequate stormwater drainage, high levels of impervious surface, and dam or levee failure.

The Sacramento area is vulnerable to riverine flooding, flash flooding, as well as flooding associated with localized stormwater overflow and levee failure. Riverine flooding (also referred to as overtopping), or flooding that occurs when streams or rivers exceed their water-carrying capacity, generally occurs as a result of prolonged rainfall or from the combined effects of rainfall and snowmelt in the Sierras.[79] Within Sacramento County, riverine flooding can occur anytime from November through April.[80] Flooding is more severe when preceded by rainfall that saturates nearby ground surface.

The Sacramento and American Rivers are susceptible to flooding. High water levels in these rivers are common in the winter and early spring months due to high flows from storm runoff and snowmelt. The Sacramento River is also affected by ocean tides that periodically raise and lower the water level.[81]

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[76] Sommer, L. "California Cities Will Flood, So Why Aren't We Ready?" *KQED* Sep 25 2017. May 8 2020: https://www.kqed.org/science/1915937/california-cities-will-flood-so-why-arent-we-ready

[77] Sacramento County, "Storm Ready: Region's Flooding History." Nov 8 2019: https://waterresources.saccounty.net/stormready/Pages/Region's-Flooding-History.aspx.

[78] Esri, "Sacramento at Risk: Understanding Floods in California." Nov 8 2019: https://www.arcgis.com/apps/MapJournal/index.html?appid=8e7c54b2d9cf4c3cb8de0a093d5509e3.

[79] Sacramento Municipal Utility District, 2018.

[80] Sacramento County, 2016.

[81] Sacramento County, 2016.

An extensive system of dams, levees, and other infrastructure have been established to protect surrounding areas from flooding. However, flooding remains a major concern for the City. Flooding north of the American River is most likely to affect the Campus Commons, Cal Expo, Arden, and Natomas areas. Flooding occurring south of the American River is most likely to affect downtown Sacramento.[82] Flash floods are short, intense floods that occur within relatively confined areas. Flash floods usually result from heavy rainfall and are most likely to occur in winter and spring. The amount of water flowing through the levee system can be controlled by Folsom Dam on the American River and the reserve overflow area of the Yolo Bypass on the Sacramento River. The dam is owned and operated by the U.S. Bureau of Reclamation. Folsom Lake and its afterbay, Lake Natoma, release water to the lower American River and to the Folsom South Canal. The operation of Folsom Dam directly affects most of the water utilities on the American River system. Water flows into the Yolo Bypass via the Fremont Weir northwest of the city and the Sacramento Weir west of the city. The Sacramento River bypass system was federally authorized in 1917 and includes a system of flood relief structures and weirs that release Sacramento River flows into the bypass system west of the Policy Area when flows exceed downstream channel capacity. Downstream of the American River confluence, the Sacramento River has a design capacity of 110,000 cubic feet per second (cfs).

Table 2-4: Major Flood Events in the Sacramento Region, 1986 - 2017[83] [84] [85]

`Year	Summary of Flood Impacts
1986	February rains across northern California resulted in 10 inches of rainfall in Sacramento over an 11-day period. Floodwaters resulted in significant damages to home foundations and levees.
1995	Heavy rains caused widespread localized flooding, particularly in the Arcade, Morrison, Florin, Union and Dry Creek areas.
1997	Early January storms caused riverine flooding and damage to levees along the Cosumnes River. Floodwaters inundated 33,000 acres of cropland and 84 homes, resulting in $2,400,000 of property damage. This flood was responsible for one death. Heavy rains in late January were responsible for flooding 1,500 homes around Arden-Arcade and Chicken Ranch Slough.
2006	A series of winter storms resulted in heavy rain, mudslides, flooding, and high winds across northern California. Levee overtopping, breaching, and river flooding occurred along the Feather and Sacramento Rivers, as well as along smaller rivers, creeks, and streams. Transportation infrastructure was impacted by road closures due to severe flooding and mudslides along Interstate 80 and US Highway 50. This series of floods resulted in $4,500,000 of property damage within Sacramento County.

[82] Sacramento Municipal Utility District, Climate Readiness Assessment and Action Plan (2016). Oct 28 2019: https://www.smud.org/-/media/Documents/Corporate/Environmental-Leadership/2016-Climate-Readiness-Action-Plan.ashx.

[83] Sacramento County, "Storm Ready: Region's Flooding History." Nov 8 2019: https://waterresources.saccounty.net/stormready/Pages/Region's-Flooding-History.aspx.

[84] Sacramento County, "2016 Sacramento Countywide Local Hazard Mitigation Plan Update." 2016.

[85] Kasler D, Reese P, Sabalow R. "After years of drought, Sacramento confronts an old foe: Flood Risk." *Sacramento Bee* Jan 24 2017. May 8 2020: https://www.climatesignals.org/headlines/after-years-drought-sacramento-confronts-old-foe-flood-risk.

Table 2-4: Major Flood Events in the Sacramento Region, 1986 - 2017[83] [84] [85]

`Year	Summary of Flood Impacts
2017	January storms impacted several parts of Sacramento County. Several levees were breached along the Cosumnes River. The Sacramento Weir, a flood-release valve used to flush excess water from the Sacramento River, was open for the first time in a decade.
2021	In October 2021, a record-breaking 500-year storm event with more than five inches of rain per day resulted in localized flooding. However, the Department of Utilities and Citywide response and management fared exceptionally well.

The American River, however, enters the Sacramento River with a design capacity of 180,000 cubic feet per second (cfs). During periods of high flow, the 2-mile portion of the Sacramento River between the Sacramento Bypass and the American River confluence can support reverse river flow so that a portion of the American River input flows upstream and through the Sacramento Weir. The Sacramento Weir diverts floodwaters west down the mile-long Sacramento Bypass into the Yolo Bypass. The Sacramento Weir was most recently opened in 1998, 2005, and 2017. It is a key structure protecting the City of Sacramento during high flows on the Sacramento River, diverting flows through the Sacramento Bypass into the Yolo Bypass for safe passage to the Delta.

The City has approximately 65,183 improved parcels, $27.2 billion of structure and contents value, and 161,675 residents within areas that are protected by levees, meaning that the threat of flooding via levee failure poses a great risk to life and welfare within the City. The majority of Sacramento's urban center, as well as vital public utilities, are dependent on levee protection.[86] [87] The majority of these levees are Delta levees, which are not built to the same strict engineering standard applied to levees under the Federal Flood Control Project. Many of these Delta levees are susceptible to subsidence, making the levee system less stable over time.[88] [89] [90] In the event of a significant levee failure, repair and dewatering could take over a year and costs could run as high as $480,000,000.[91] [92] However, there are measures within the city to help relieve pressure from the rivers as water gets high. For example, the Yolo Bypass is a restored wetland that protects Sacramento and neighboring communities from flooding. During wet seasons, the bypass carries Sacramento River water overflow

[86] Sacramento Municipal Utility District, 2018.

[87] Water Education Foundation, "Sacramento-San Joaquin Delta Levees." Nov 9 2019: https://www.watereducation.org/aquapedia/sacramento-san-joaquin-delta-levees.

[88] Water Education Foundation, "Sacramento-San Joaquin Delta Levees.".

[89] United States Geological Survey, "Subsidence in the Sacramento-San Joaquin Delta." Nov 8 2019: https://www.usgs.gov/centers/ca-water-ls/science/subsidence-sacramento-san-joaquin-delta?qt-science_center_objects=0#qt-science_center_objects.

[90] Ingebritsen SE, Ikehara ME. "Sacramento-San Joaquin Delta: The sinking heart of the state." *United States Geological Survey*. May 8 2020: https://pubs.usgs.gov/circ/circ1182/pdf/11Delta.pdf.

[91] Porter K., et al., "Overview of the ARkStorm Scenario." United States Geological Survey (2010). July 1 2020: https://pubs.usgs.gov/of/2010/1312/.

[92] Cost estimates are based on modeling by USGS under the ARkStorm Scenario (footnoted above). Property damage methodology is based on FEMA's HAZUS-MH, census data, and other information developed for the ARkStorm Scenario. For more information see: https://pubs.usgs.gov/of/2010/1312/of2010-1312_text.pdf

to the delta, preventing flooding within the city. Map 3: Sacramento-San Joaquin Delta Levees Anatomy, illustrates the nature of the extensive levee system on which the City of Sacramento depends. On Map 4: Repetitive Loss Areas and FEMA Flood Zones, the 100 Year Flood Zone refers to the area in which, historically, there is a one percent annual chance of experiencing a flood. Similarly, the 500 Year Flood Zone in which there is a 0.2 percent annual chance of experiencing a flood.

Climate and topographic factors that affect flood risk and magnitude include rainfall amount, intensity and duration; soil moisture; type of vegetation; snow depth; and impermeability of surfaces due to land use decisions, development patterns, and building and infrastructure material.[93] Warmer temperatures and reduced winter snowpack will contribute to greater, more concentrated volumes of surface runoff, which will peak in February through March, which is significantly earlier than historical peaks in May. Local flood management, such as of Folsom Reservoir, will correspondingly need to account for water capacity in anticipation of flood events, with consequent reductions in drinking water available in Folsom during summer and fall for drinking water, hydropower, irrigation and recreation. It is noted that federal storage facilities and operation of upstream water storage facilities will also play a pivotal factor in regional flood control management, given that Folsom Reservoir by itself is currently undersized for additional flood control management. Localized flooding associated with smaller creeks in the City are also a factor that may cumulatively pose substantial flood risk.

Although flooding due to levee failure may result in more catastrophic damage, most of the City's flooding damage since 1955 has been due to drainage deficiencies of underground storm drainpipes.[94] Failure of the City's internal drainage system therefore is a considerable risk factor affected by the increase in frequency and severity of storm events. Stormwater flooding is most likely to occur in areas with high levels of impervious surface and in places where stormwater infrastructure is impaired or inadequate.[95]

Several repetitive loss areas are identified within the City of Sacramento's 2017 Comprehensive Flood Management Plan. Repetitive loss areas are areas that have experienced significant flood damage numerous times within the past several decades. Repetitive loss properties are widely distributed throughout the City of Sacramento. The City's analysis indicated that the majority of repetitive loss properties within the city flooded during winter storms occurring in 1995 and 1997 due to undersized drainage conveyance systems, power outages at pump stations, and the properties' relatively low elevation within their respective neighborhoods.[96]

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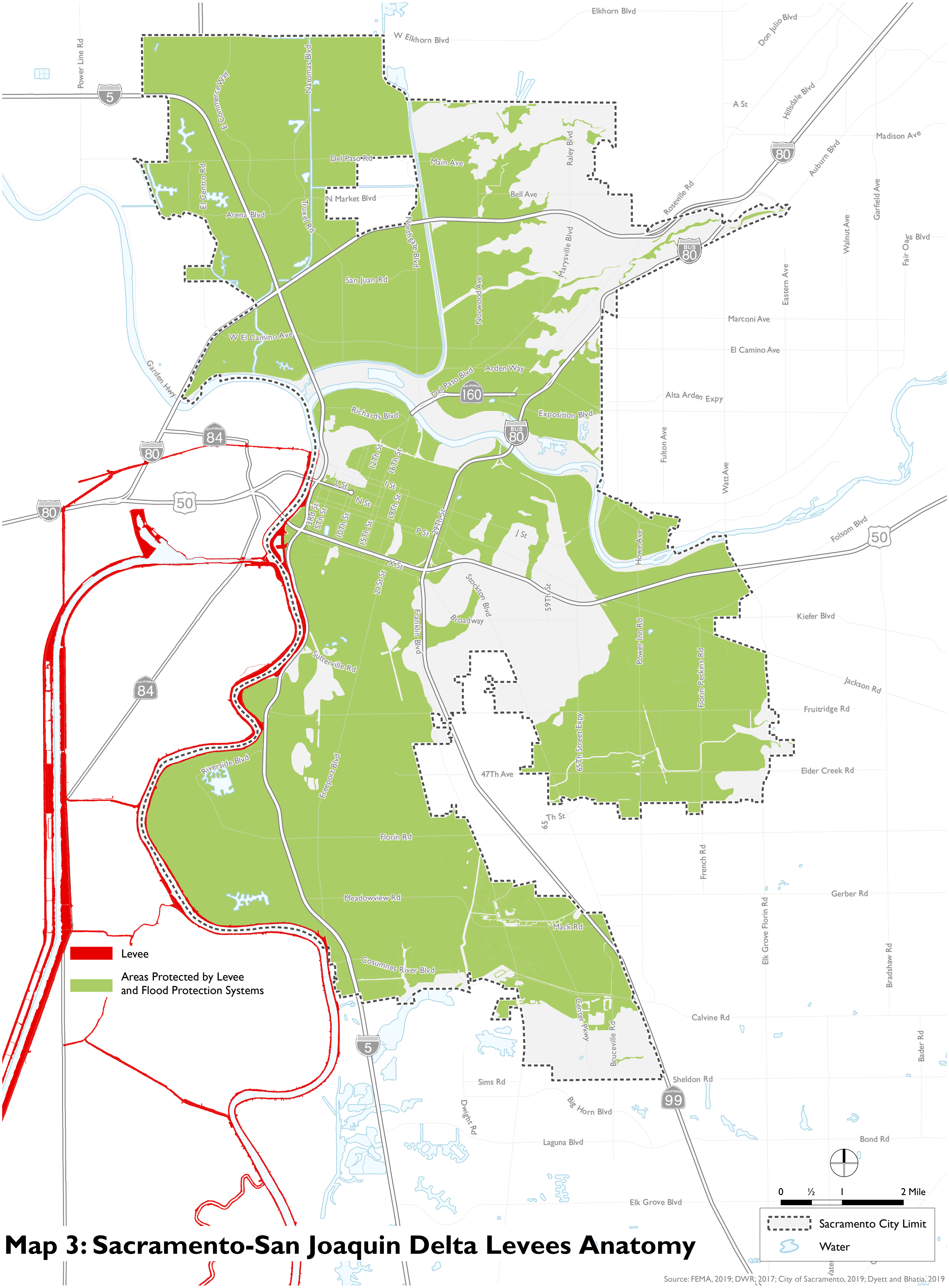
[93] Ascent Environmental, 2017.

[94] City of Sacramento Department of Utilities, Comprehensive Flood Management Plan, February 2016, https://www.cityofsacramento.org/~/media/Corporate/Files/DOU/Flood-Ready/2016%20CFMP.pdf.

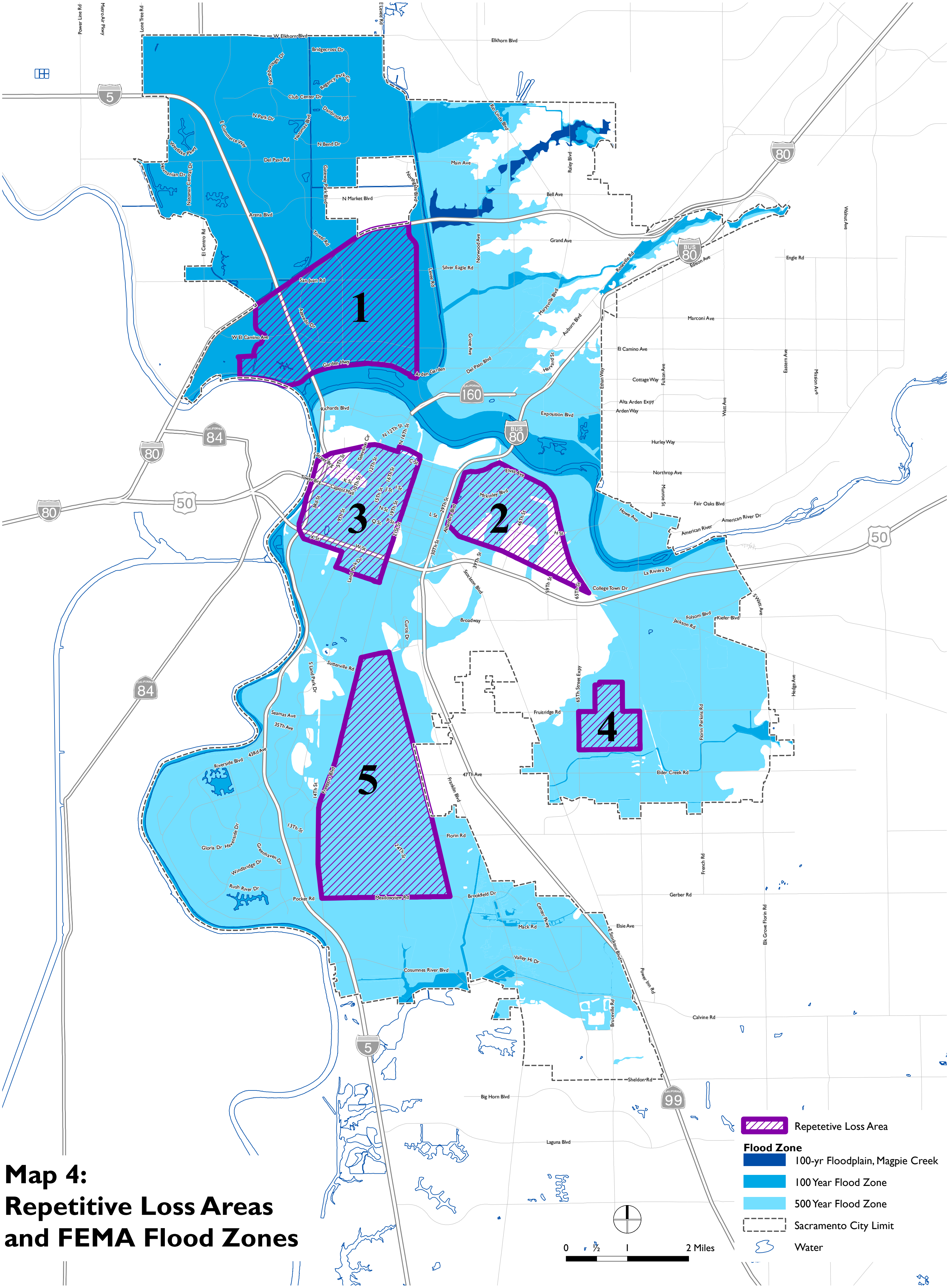
[95] Ascent Environmental, 2017.

[96] City of Sacramento, City of Sacramento Comprehensive Flood Management Plan (2017). Nov 8 2019: https://www.cityofsacramento.org/-/media/Corporate/Files/DOU/Flood-Ready/Chapter-X-Appendix-D-RLAA-UPDATED_Final.pdf?la=en.



Map 3: Sacramento-San Joaquin Delta Levees Anatomy

Source: FEMA, 2019; DWR, 2017; City of Sacramento, 2019; Dyett and Bhatia, 2019



Map 4:
Repetitive Loss Areas and FEMA Flood Zones

Source: CalAdapt/UC Berkeley, 2016; FEMA, 2015; City of Sacramento, 2019; Dyett and Bhatia, 2019

The City of Sacramento's Repetitive Loss Analysis defines five Repetitive Loss Areas (RLA), as indicated in Map 4:

- **RLA 1**, South Natomas, sits within the Natomas Basin. The Natomas Basin is surrounded by levees, and is at risk to riverine flooding, levee breech, and flooding due to internal drainage issues. Within RLA 1, factors found to exacerbate flood risk and damage include high levels of development, presence of landfill with associated uneven land grading, and elevation changes.
- **RLA 2**, Downtown East, corresponds to the neighborhoods of River Park, McKinley Park, and Coloma Terrace. These are older areas of the City that may experience overbanking, erosion, and seepage from the American River levees. Undersized drainage systems were also found to contribute to flood risk in this area.
- **RLA 3**, Downtown West, is located just east of the Sacramento River in Downtown Sacramento. The repetitive loss properties in this RLA are residential, the primary source of flooding is an undersized combined sewer system that is overwhelmed during large storms.
- **RLA 4**, Southeast Sacramento, is a residential area located at the Southeast portion of the city limits. Flooding in this area has occurred when water from higher-elevation adjacent properties has flowed into lower-lying areas, causing some homes to flood.
- **RLA 5**, Sutterville/Meadowview, extends from Sutterville to Meadowview Road. The RLA is surrounded by levees and is primarily residential. Investigations within the RLA revealed that common sources of flooding are undersized drainage systems and low-lying elevation.

Flooding can have negative impacts on infrastructure integrity and human health. Flooding impacts transportation infrastructure, inhibiting the movement of vehicles and increasing accident rates,[97] and can damage electricity and telecommunications infrastructure, leading to service outages.[98] [99] Floodwaters can also inundate important infrastructure such as sewer systems, water treatment facilities, and hazardous materials facilities, leading to contamination.[100] [101] These impacts can take extensive time and resources to address, meaning that a flooded area may continue to experience flooding impacts for many months after the initial flood event. Damage to transportation networks, businesses, and related infrastructure may impede worker's ability to get to work and adversely affect

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[97] Mitsakis E, Stamos I, Diakakis M, Salanova Grau JM. "Impacts of high-intensity storms on urban transportation: applying traffic flow control methodologies for quantifying the effects." *International Journal of Environmental Science and Technology* Apr 10 2014. May 11 2020: https://link.springer.com/article/10.1007/s13762-014-0573-4.

[98] Lane K, Charles-Guzman K, Wheeler K, Abid Z, Graber N, Matte T. "Health Effects of Coastal Storms and Flooding in Urban Areas: A Review and Vulnerability Assessment." *Journal of Environmental and Public Health* May 30 2013. May 11 2020: https://www.hindawi.com/journals/jeph/2013/913064/.

[99] Porter K., et al., 2010.

[100] Rudolph L, Harrison C, Buckley L, North S. "Climate Change, Healthy, and Equity: A Guide for Health Departments." Public Health Institute, American Public Health Association (2018). May 11 2020: https://www.apha.org/-/media/files/pdf/topics/climate/climate_health_equity.ashx?la=en&hash=14D2F64530F1505EAE7AB16A9F9827250EAD6C79.

[101] Porter K., et al., 2010.

local employment opportunities and business revenues. Ability to reach work and other key services may be especially significant for those who rely on public transportation.[102]

Flood waters can contain a myriad of hazardous substances including dirt, oil, animal waste, and industrial chemicals.[103] These waters can overwhelm sanitary sewer lines, causing wastewater to back up into low-lying areas and homes and providing a breeding ground for bacteria such as e. coli.[104] Water intrusion into buildings can result in mold contamination, leading to indoor air quality problems and exacerbation of asthma, allergic reactions, and respiratory infections.[105] [106] Even as floodwaters begin to dissipate, remaining pools of stagnant water can provide breeding grounds for mosquitoes.[107] Exposure to floodwater can thus increase risk of exposure to viral and bacterial contamination.

Flooding can also result in forced evacuation, which may strain local and regional emergency response resources and disrupt family and community stability.[108] Indeed, extreme climate events, including major storms and flooding, have been shown to be associated with mental health consequences, exacerbating pre-existing conditions and increase incidence of stress, post-traumatic stress disorder, anxiety, and depression.[109] By disrupting access to health services, these extreme events can continue to adversely impact health even after the event has passed.[110]

Groups especially vulnerable to the health effects of flooding include the elderly, pregnant women, people with preexisting mental illness, low-income households, people experiencing homelessness, tribal and Indigenous communities, and emergency responders.

Geological Impacts

Stormwater runoff, particularly during high-intensity storms, can lead to erosion and transport and redistribution of soils, sediments, and rock materials. Such activities are expected to result in significant impacts to local species and habitats and pose a risk to human health and structures. Landslides triggered by severe storms have caused hundreds of millions of dollars in damage and numerous casualties across California.[111]

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[102] Constible J, Chang B, Morganelli C, Blandon N. "On the Front Lines: Climate Change Threatens the Health of America's Workers." Natural Resources Defense Council Jun 2020. July 31 2020: https://www.nrdc.org/sites/default/files/front-lines-climate-change-threatens-workers-report.pdf.

[103] Sacramento County, "2016 Sacramento Countywide Local Hazard Mitigation Plan Update," 2016.

[104] Sacramento County, 2016.

[105] CalBRACE, Climate Change and Health Profile Report Sacramento County (2017).

[106] Lane K, et.al., 2013.

[107] Sacramento County, 2016.

[108] Maxwell, K., et.al., 2018.

[109] Lane K, et.al., 2013.

[110] Maxwell, K., et.al., 2018.

[111] Porter K., et al., 2010.

Severe Winds

The strong winds that can occur during heavy storms can damage structures and pose a threat to electricity infrastructure. Wooden crossbars and pole-mount transformers on distribution-voltage utility poles can be damaged by wind speeds as low as 60 miles per hour. Moderate winds can also cause lines to sway, touch, and cause cross-phase shorting.[112] Individuals living in mobile homes are especially vulnerable to the effects of high winds.[113]

Changes in Winter Snowpack

Historically, the Sierra snowpack and its spring and summer snowmelt has been a key part of the water planning process in the Sacramento region and throughout the watersheds of the Sierra Nevada. California's municipalities, industries, and ecosystems rely on the gradual melting of the Sierra snowmelt to provide a reliable supply of summertime freshwater and hydroelectric power.[114] As temperatures increase, more precipitation will fall as rain instead of snow, and snowmelt will occur earlier in the year, leading to more concentrated volumes of surface runoff.[115] [116] Statewide, average April snow water equivalence, or the depth of water that would occur if all the snow were melted, has been 2.2 inches between 1961 and 1990. By the middle of this century, this number could decline to between 1.3 and 0.9 inches. By the end of the century, April snow water equivalence is projected to be between 0.9 and 0.5 inches (Figure 2-21).

The Sierra winter snowpack plays a pivotal role in regulating water availability throughout the State by providing a steady supply of freshwater that can be stored in dams, supplementing the scant summer rainfall, and used to produce electricity. Disruption to the processes that ensure adequate snow supply may therefore have a significant impact on energy generation, water availability, flood risk, and ecosystem health throughout California and the Sacramento region.[117] Higher levels of Sierra rainfall and faster rates of snowmelt produce quantities of water that are anticipated to exceed the State's reservoir capacity and therefore cannot be effectively stored for later consumption or used to generate electricity[118] [119], while increasing risk of flooding. Ecological impacts of decreased flows and increased temperatures in the Lower American River in summer and fall can threaten native Chinook salmon during future fall spawning. Additionally, earlier snowmelt will reduce the

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[112] Porter K., et al., 2010.

[113] The National Severe Storms Laboratory, "Severe Weather 101: Damaging Winds Basics," July 1, 2020: https://www.nssl.noaa.gov/education/svrwx101/wind/.

[114] Meisen P, Phares N. "Impacts of Climate Change on California's Water Supply." Global Energy Network Institute (2011). May 6 2020: https://www.geni.org/globalenergy/research/impact-of-climate-change-on-californias-water-supply/Impacts%20of%20Climate%20Change%20on%20California%92s%20Water%20Supply.pdf

[115] United States Department of the Interior Bureau of Reclamation, Reclamation Managing Water in the West. West-Wide Climate Risk Assessment Sacramento and San Joaquin Basins Climate Impact Assessment (2014). Nov 8 2019: https://www.usbr.gov/watersmart/baseline/docs/ssjbia/ssjbia.pdf.

[116] Reich KD, Berg N, Walton DB, Schwartz M, Sun F, Huang X, Hall A. "Climate Change in the Sierra Nevada: California's Water Future." UCLA Center for Climate Science (2018). May 6 2020: https://www.ioes.ucla.edu/wp-content/uploads/UCLA-CCS-Climate-Change-Sierra-Nevada.pdf

[117] Sacramento Municipal Utility District, 2016.

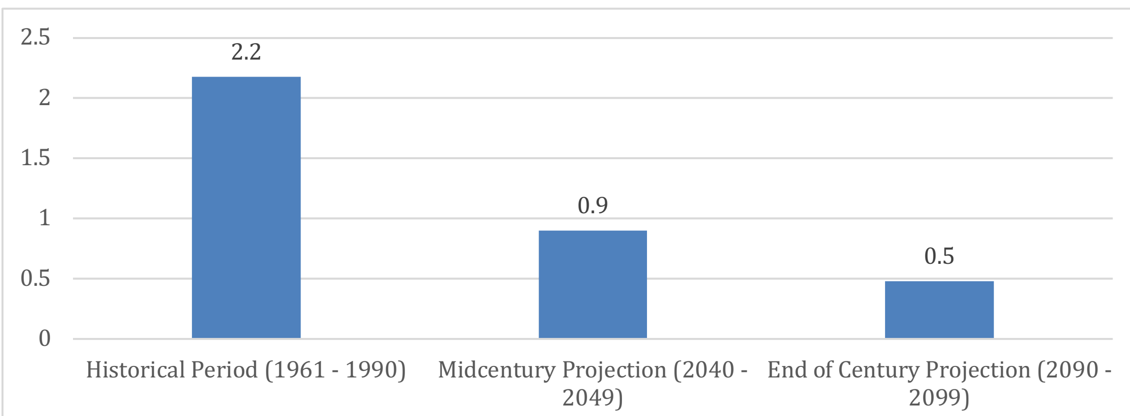
[118] Meisen P and Phares N., 2011.

[119] Reich KD, et.al., 2018.

amount of water available for consumption during the summer, potentially leading to water scarcity. The City of Sacramento has senior water rights to natural flows and stored water that are sufficient to meet the needs of its residents as well as projected growth. As such, Sacramento residents are at less pronounced risk than other water users throughout the State with lower priority access to surface water through the State Water Resources Control Board water rights process.

Reductions in winter snowpack are associated with declines in summer soil moisture content, which increases wildfire risk.[120] Additionally, reduced water flow during summer and fall months may lower water quality via reduced levels of dissolved oxygen, higher detritus and bacterial content, and increased salinity.[121] Maps 5, 6, and 7 illustrate historically observed and projected April snowpack levels at the middle and end of this century. The stark contrast in snowpack volume demonstrated in these figures demonstrates the significant degree to which Sacramento may experience limited access to vital Sierra snowpack water resources as the century unfolds.

Figure 2-21: Average Statewide April Snow Water Equivalence (Inches)



Created using historical and projected precipitation data from Cal-Adapt. Projected data was generated for the high emissions (RCP 8.5) scenario and the averaged (CanEMS2) climate model for the State of California. Snow water equivalence is projected to decline steadily through the end of the century.

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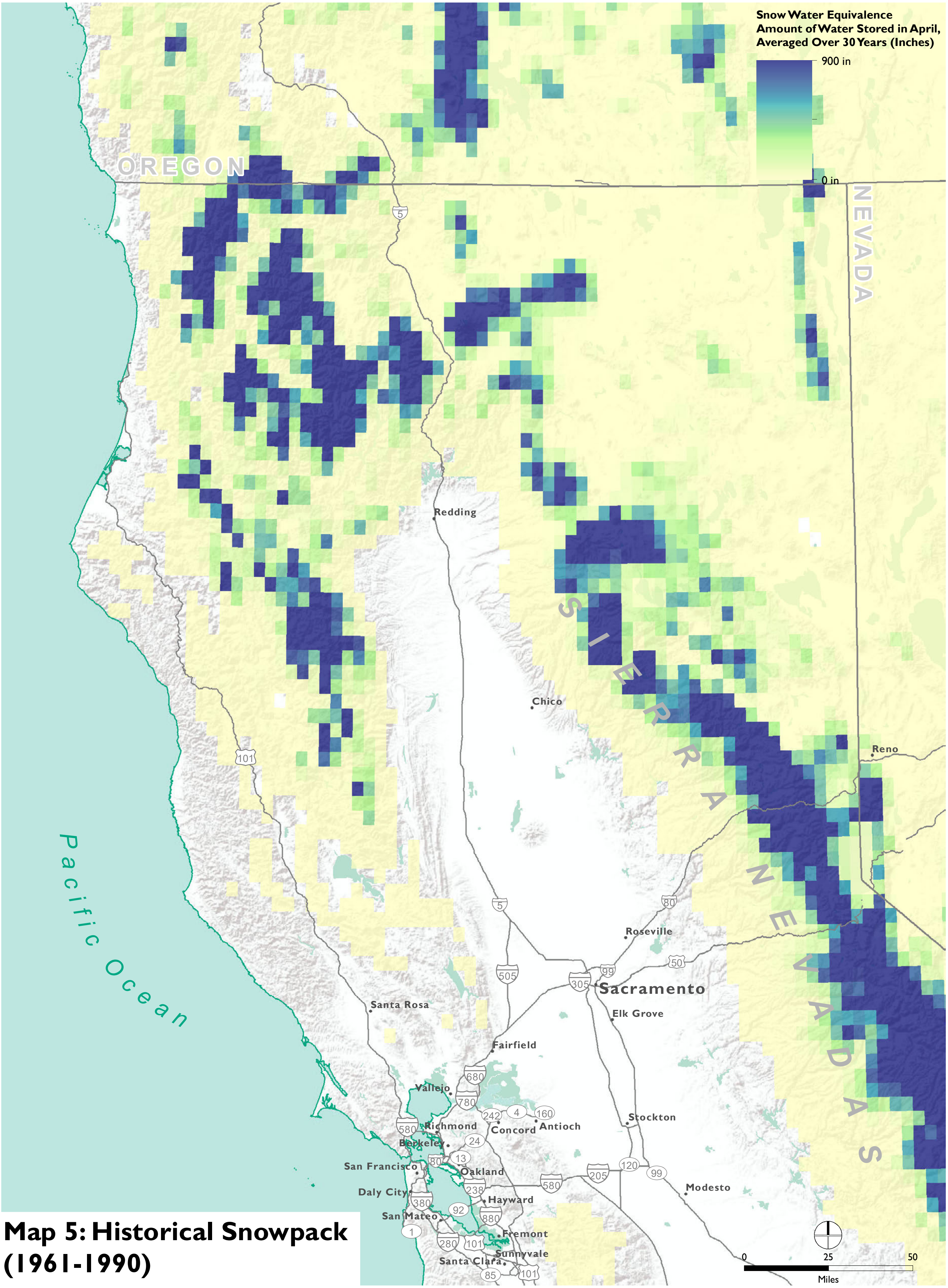
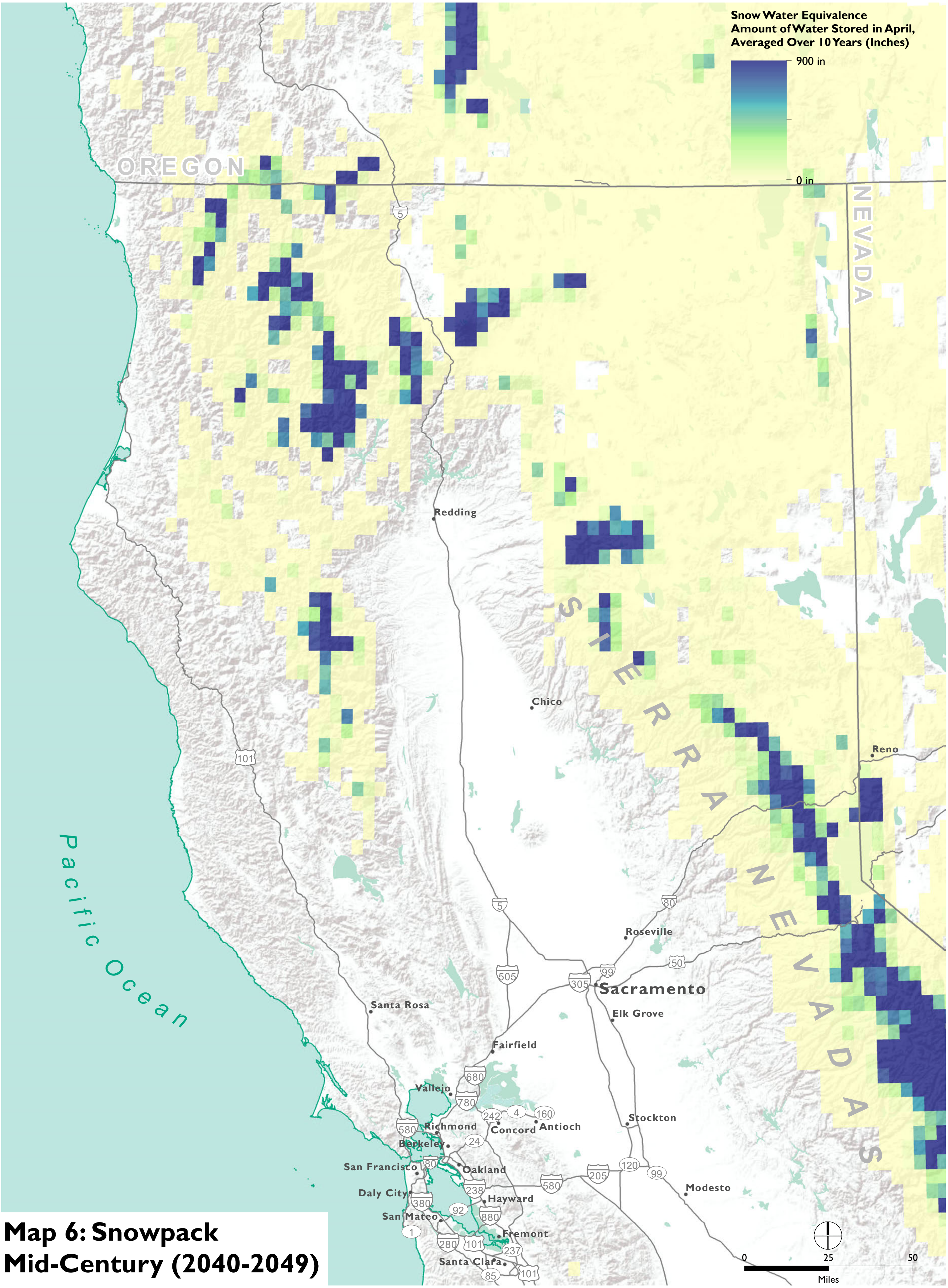
[120] Gergel DR, Nijssen B, Abatzoglou JT, Lettenaier DP, Stumbaugh MR. "Effects of Climate Change on Snowpack and Fire Potential in the Western USA. *Climatic Change* Feb 1 2017. May 6 2020: https://link.springer.com/article/10.1007/s10584-017-1899-y.

[121] Meisen P and Phares N., 2011.



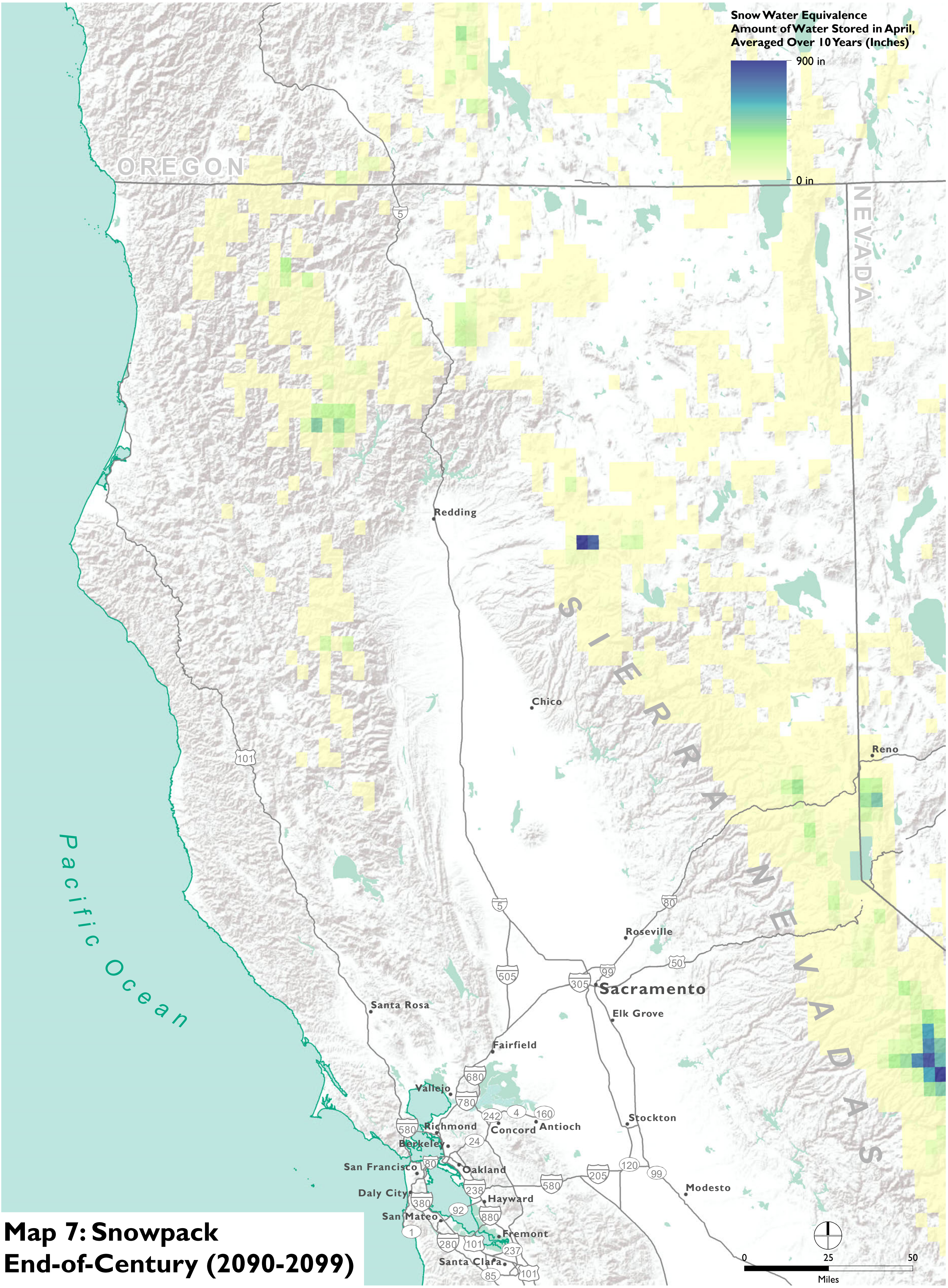
Map 5: Historical Snowpack (1961-1990)

Source: CalAdapt/UC Berkeley, 2016; Esri, USGS, NOAA, City of Sacramento, 2019; Dyett and Bhatia, 2019



Map 6: Snowpack Mid-Century (2040-2049)

Source: CalAdapt/UC Berkeley, 2016; Esri, USGS, NOAA, City of Sacramento, 2019; Dyett and Bhatia, 2019



Map 7: Snowpack End-of-Century (2090-2099)

Source: CalAdapt/UC Berkeley, 2016; Esri, USGS, NOAA, City of Sacramento, 2019; Dyett and Bhatia, 2019

Drought

Drought is a complex phenomenon that results from the long-term interaction of temperature, precipitation, snowpack retention, and other climate factors. Drought is associated with a number of ecosystem effects, including reduced soil moisture, increased risk of wildfire, and reductions in streamflow.[122] Other environmental and health impacts of drought include dust storms, flash flooding, lower crop yields, and reduced water quality.[123] [124] [125] Periods of surface water scarcity also increase demand for groundwater, with attendant environmental consequences as described below. Meanwhile, drought can increase the concentrations of industrial chemicals, heavy metals, and agricultural runoff contaminants in groundwater, increasing the risk of exposure among communities that rely of groundwater resources.[126]

Drought conditions have profound impacts on water availability across California. Industries and communities especially vulnerable to the effects of drought include the agricultural sector, hydropower industry[127], rural populations, and those dependent on wells.[128] The soil drying and weakening caused by long-lasting droughts can also comprise levee integrity.[129]

A combination of drier soils and increased wildfire activity, which removes vegetation and other natural soil stabilizers, increases wind erosion and causes unhealthy dust to be released into the air. Small dust particles can travel deep into the lungs and enter the bloodstream, where they can cause or exacerbate conditions such as asthma and bronchitis. Dust can also carry pesticides and heavy metals as well as viral, bacterial, and fungal pathogens.[130]

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122 Williams AP, Seager R, Abatzoglou JT, Cook BI, Smerdon JE, Cook ER. "Contribution of Anthropogenic Warming to California's Drought 2012-2014." *Geophysical Research Letters*, Aug 20 2015. May 7 2020: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015GL064924%4010.1002/%28ISSN%291944-8007.CALDROUGHT1.

123 CalBRACE, Climate Change and Health Profile Report Sacramento County (2017).

124 Sacramento Municipal Utility District, 2018.

125 Rudolph L, Harrison C, Buckley L, North S. "Climate Change, Healthy, and Equity: A Guide for Health Departments." Public Health Institute, American Public Health Association (2018). May 11 2020: https://www.apha.org/-/media/files/pdf/topics/climate/climate_health_equity.ashx?la=en&hash=14D2F64530F1505EAE7AB16A9F9827250EAD6C79.

126 Rudolph L, et.al., 2018.

127 Sacramento Municipal Utility District, 2018.

128 Sacramento Municipal Utility District, 2018.

129 Maxwell, K., et.al., 2018..

130 Constible J, et.al., 2020.

The exact timing, location, and duration of future droughts is difficult to predict. However, studies have shown that statewide shifts in precipitation patterns towards wetter winters and drier summers make drought-like conditions more likely.[131] [132]

California recently experienced a major drought from 2012 to 2016, and statewide efforts have since made several improvements to become less vulnerable to drought such as through the Sustainable Groundwater Management Act, establishing new water use standards, funding drought response and long-term water resilience projects, and preparing a Water Resilience Portfolio. Yet, two consecutive years of dry conditions have resulted in drought or near-drought conditions throughout the state, and the combination of exceptionally low precipitation, warm temperatures, and dry soils have resulted in record low runoff from the Sierra-Cascade snowpack, leading to significantly reduced water supply and extremely low reservoir storage levels. On May 10, 2021, Governor Newsom declared a drought emergency for 41 counties, including those within the Sacramento-San Joaquin Delta, and outlined water conservation and water supply contingency actions that the State Water Board, urban water suppliers, and other agencies should take or consider.[133] On October 19, 2021, the drought emergency was expanded statewide, and the State Water Board was empowered to prohibit wasteful uses of potable water such as washing sidewalks/driveways, filling decorative fountains/ponds, watering lawns during and right after rain, and using hoses without automatic shutoff nozzles. California residents are also encouraged to voluntarily reduce water consumption by 15 percent.[134]

Groundwater Supply

Sacramento County lies over the north central portion of California's Great Valley Groundwater Basin, which provides groundwater to the City and County of Sacramento. Groundwater recharge occurs primarily from the American and Cosumnes rivers, with additional recharge from the Sacramento River and local streams. Groundwater currently comprises about one-third of the region's water use.[135] This rate of usage is by design in the City of Sacramento, where policies in the City's General Plan and regional groundwater sustainability plans implement a standing water management objective to rely on groundwater during surface water scarcity and rely on surface water during excess, a balance that allows groundwater supply to recharge.

Streamflow declines and changes in precipitation patterns anticipated under continued global climate change may increase demand for groundwater. Groundwater overdraft is associated with

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131 Swain DL., Langenbrunner B., Neelin JD., Hall A., "Increasing precipitation volatility in twenty-first-century California." *Nature Climate Change* (2018).

132 Mann ME, Gleick PH. "Climate Change and California Drought in the 21st Century." *PNAS* Mar 31 2015. May 7 2020: https://www.pnas.org/content/112/13/3858.short.

133 California Water Boards, "Sacramento-San Joaquin Delta Watershed Drought & Curtailment Information," last updated September 29, 2022, accessed October 3, 2022: https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/delta/.

134 State of California, "State drought response," accessed October 3, 2022: California Drought Action, https://drought.ca.gov/state-drought-response/#regional-drought-response.

135 "Fact Sheet: The State of Sacramento Valley Groundwater." *Northern California Water Association* Jul 1, 2017. May 7 2020: https://norcalwater.org/wp-content/uploads/Groundwater_factsheet.pdf

numerous economic and ecosystem effects, including higher groundwater pumping costs, decreased streamflow, land surface subsidence, and loss of wetland ecosystems.[136] [137] Reduced snowpack in the upper watershed of the American River Basin, for instance, will directly impact water supply reliability in Sacramento. Increased flood risk in the winter (as discussed above) will prompt more flood releases from Folsom Reservoir. Along with decreased runoff in the spring, this will reduce water available in Folsom Reservoir during summer and fall for drinking water, hydropower, irrigation, and recreation, making the region more vulnerable to shortages. However, the City's groundwater supplies are currently being managed sustainably, including through key partnerships such as the Regional Water Authority, and major overdrafts are not anticipated.[138] [139]

WILDFIRE

Historically, wildfire has exhibited a cyclical pattern within California – some years may see intense wildfire while others may not. Additionally, there used to be what was considered a "fire season" in California from mid-summer to fall; however, now fires are increasingly occurring year-round. As wildfire emerges from a variety of climate conditions including type of vegetative cover, precipitation, and temperature, wildfire severity will continue to fluctuate over time. However, climate change will favor many of the climatic conditions that make wildfire more likely, meaning that average wildfire intensity will gradually increase. Wildfire is associated with secondary impacts such as smoke production and air quality reductions, reductions in soil and water quality, landslides and erosion, and impacts to health, energy, and transit systems, as discussed below and in Table 2-5.

Table 2-5: Wildfire

Temporal Extent	• Wildfire extent and severity is projected to exhibit high levels of variability, but generally increase over time • Historically, fire season has extended from early summer through late fall. Fire season may continue to expand in the future
Spatial Extent	• A wildfire is unlikely to break out within Sacramento City limits. However, the entire City may be subject to wildfire smoke originating from across the Sacramento Valley • Storm events will mobilize the debris from these events into the waterways and become a concern for source water protection.
Permanence	• The overall trend of increase wildfire intensity is fairly certain, although there will be year-to-year variability • Impacts of contamination to air, water, and soil quality may be irreversible.

[136] Famigletti JS. "The Global Groundwater Crisis." *Nature Climate Change* Oct 29 2014. May 7 2020: https://www.nature.com/articles/nclimate2425

[137] Lund JR, Harter T. "California's Groundwater Problems and Prospects." *California Water Blog* Jan 30 2013. May 7 2020: https://californiawaterblog.com/2013/01/30/californias-groundwater-problems-and-prospects/.

[138] Northern California Water Association, "Fact Sheet: The State of Sacramento Valley Groundwater," July 1, 2017. May 7 2020: https://norcalwater.org/wp-content/uploads/Groundwater_factsheet.pdf

[139] West Yost Associates. "2015 Urban Water Management Plan." City of Sacramento (2016). May 7 2020: https://www.cityofsacramento.org/~/media/Corporate/Files/DOU/Reports/City%20of%20Sacramento%20Final%202015%20UWMP%20June%202016.pdf

Table 2-5: Wildfire

Level of Disruption	• Moderate
Nature of Disruption	• The wildfire impact most likely to have a significant impact on the city is air pollution from wildfire smoke
Level of Uncertainty	• Moderate

California has an extensive history of wildfires, with large-scale, highly damaging fires becoming increasingly common. Fourteen of California's twenty largest fires have occurred since the year 2000, damaging 3,095,457 acres of land and 26,531 structures. Three of these largest fires occurred in 2018. The Camp Fire, occurring in November 2018, resulted in 18,804 structures damaged or destroyed and 85 deaths—the highest amount of any fire recorded.[140] This fire occurred in Butte County, less than 100 miles from the City of Sacramento. Within Sacramento County itself, three wildfires have occurred since 2014, causing a total of three million dollars in property damage.[141] Indeed, the Sacramento metropolitan area has among the highest number of homes at risk of damage from wildfires in the United States[142] [143], posing a significant risk to structures within the region. While a wildfire may be unlikely to break out within city limits, these major wildfires have profound impacts on economies, health, and ecosystem function throughout the region.

Wildfire risk is influenced by a number of climatic factors, including topography, fuel type and availability, temperature, soil moisture, as well as local typography and wind and precipitation patterns.[144] [145] Climate change is expected to increase wildfire risk and intensity by increasing temperatures, reducing snowpack, and altering precipitation patterns.

Large swings in rainfall from season to season can encourage vegetation growth in rainy periods, allowing more vegetation to accumulate.[146] Meanwhile, high temperatures increase the rate of evapotranspiration in plants, making vegetation drier and more prone to catching fire.[147] [148] High temperatures also reduce winter snowpack by encouraging precipitation to fall as rain instead of

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140 Cal Fire, "Top 20 Largest California Wildfires." 2019. Oct 29 2019: https://www.fire.ca.gov/media/5510/top20_acres.pdf.

141 Sacramento County, 2016.

142 CoreLogic, "2019 Wildfire Risk Report." 2019. May 8 2020: https://www.corelogic.com/downloadable-docs/wildfire-report_0919-01-screen.pdf.

143 Milne S. "Sacramento Metro Area Ranks No. 4 On National Wildfire Risk Report." *Capradio* Sep 12 2019. May 8 2020: https://www.capradio.org/articles/2019/09/12/sacramento-metro-area-ranks-no-4-on-national-wildfire-risk-report/.

144 Sacramento Municipal Utility District, 2018.

145 Sacramento County, 2016.

146 Sacramento Municipal Utility District, 2016.

147 Sacramento County, 2016.

148 Sacramento Area Council of Governments, 2015.

snow and prompting earlier snowmelt.[149] These changes lead to longer and drier summers, during which wildfires may be more likely to occur.

Across the state of California, approximately 170,345 hectares of land succumbed to wildfire per year between 1961 and 1990, as shown in Map 8. This figure is projected to increase to 203,587 hectares per year by midcentury and may climb as high as 309,921 hectares per year by the end of the century, an 82 percent increase over historic levels. Within the Sacramento-Delta Climate Region, approximately 12,074 hectares were burned in wildfire per year between 1961 and 1990. This value is projected to increase to between 12,171 and 12,306 hectares by midcentury and between 12,516 and 13,037 hectares per year by the end of the century, an 8 percent increase. Maps 9 and 10 illustrate the projected increase in wildfire extent and severity that is projected to take place in Northern California as climate change progresses. A notable increase in the annual area affected by wildfire is projected to occur to the northwest of Sacramento. Wildfires occurring in the Sierra Nevada are projected to increase in intensity.

Wildfires may pose a threat to the homes of those who live in the urban-wildland interface (UWI), areas where homes are built near or among lands prone to wildland fire outside the city limits.[150] At the UWI, structures and vegetation are sufficiently close that a wildfire could spread to a structure, or a structure fire could ignite vegetation.[151] Numerous factors can contribute to wildfire risk within the UWI, including type and distribution of vegetation, structure flammability, proximity to fire-prone vegetation, weather patterns, topography, lot size and structure density, and road construction.[152] The Sacramento Metropolitan Fire District has found that almost all the wildfires that occur within its territory are caused by humans and occur closer to developed areas.[153] Areas characterized as UWI by the Sacramento Metropolitan Fire District occur along the eastern and northern edges of the city.

While the UWI area within the city is not extensive, the city will be impacted by wildfires occurring throughout the metropolitan region via impacts on air, water, and soil quality; damage to energy infrastructure and roads; and strain on local firefighting resources as the fire department is called to respond to fires across the region and State.

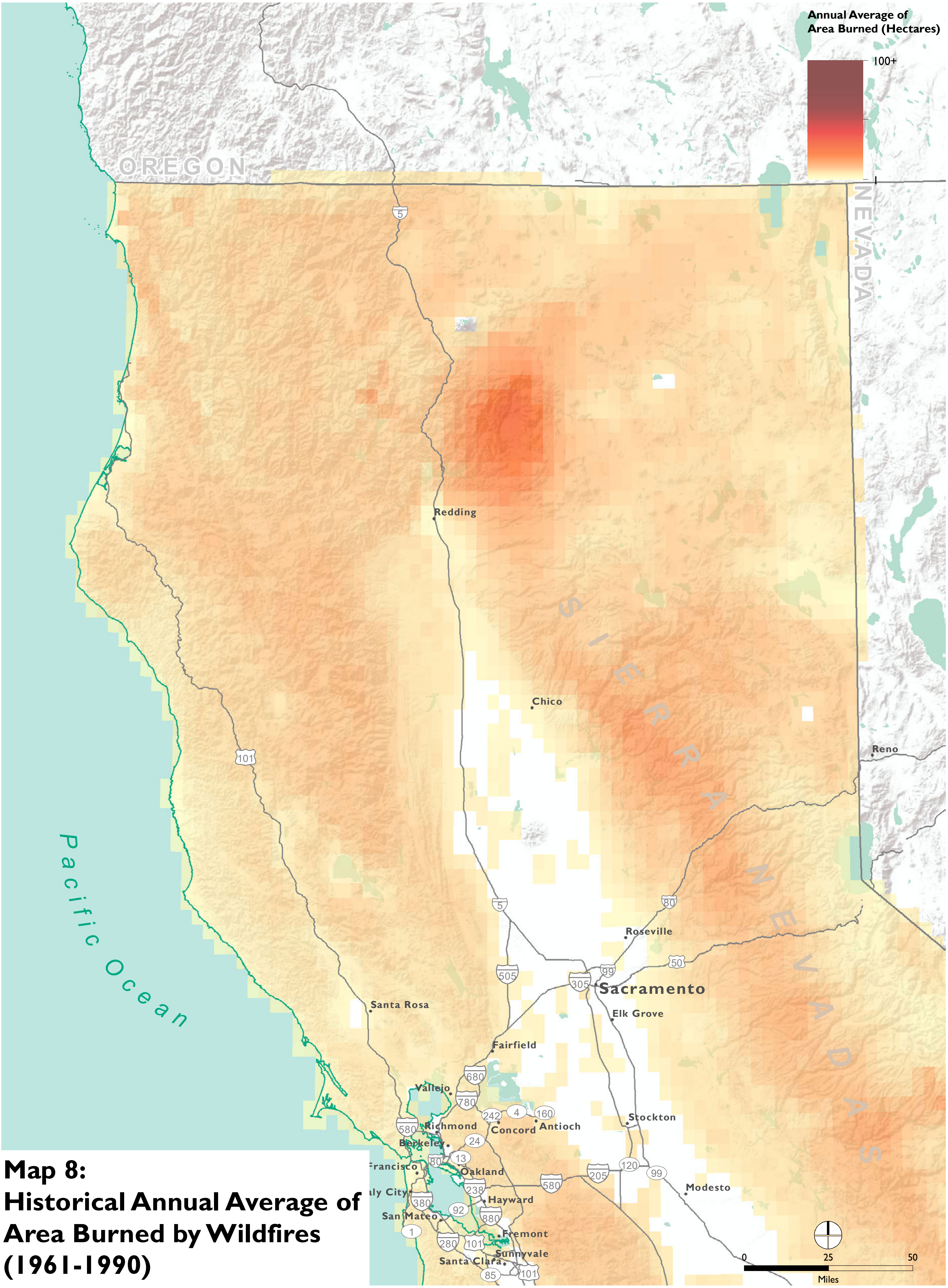
[149] Sacramento Area Council of Governments, 2015.

[150] International Association of Fire Chiefs, "Wildland Urban Interface." Oct 29 2019: https://www.wildlandfirersg.org/About/Wildland-Urban-Interface.

[151] Ascent Environmental, "Sacramento Metropolitan Fire District Community Wildfire Protection Plan." (2014). Oct 29 2019: https://metrofire.ca.gov/phocadownloadpap/CWPP/appacwpp.pdf.

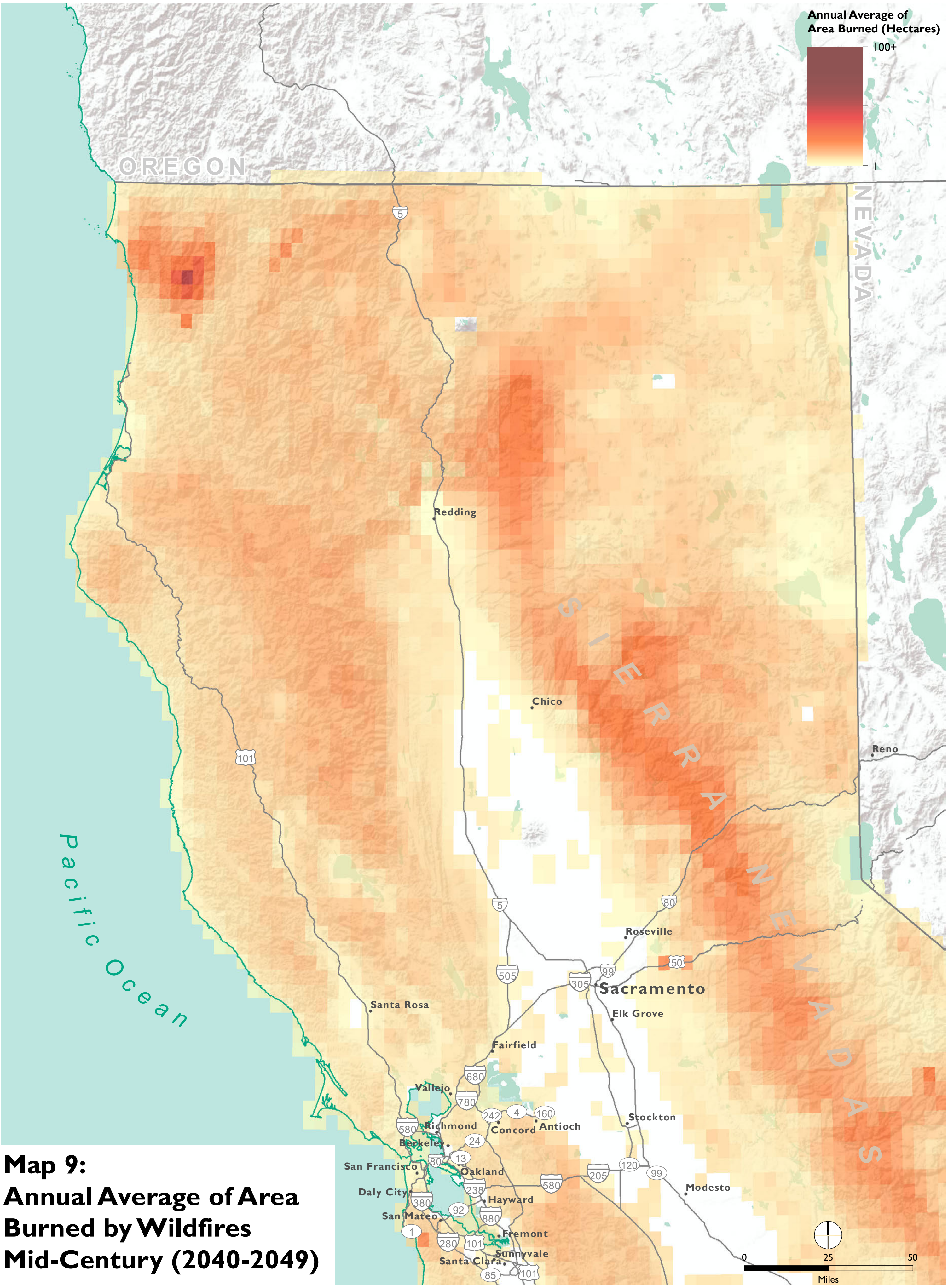
[152] International Association of Fire Chiefs, "Wildland Urban Interface." Oct 29 2019: https://www.wildlandfirersg.org/About/Wildland-Urban-Interface.

[153] Ascent Environmental, 2014..



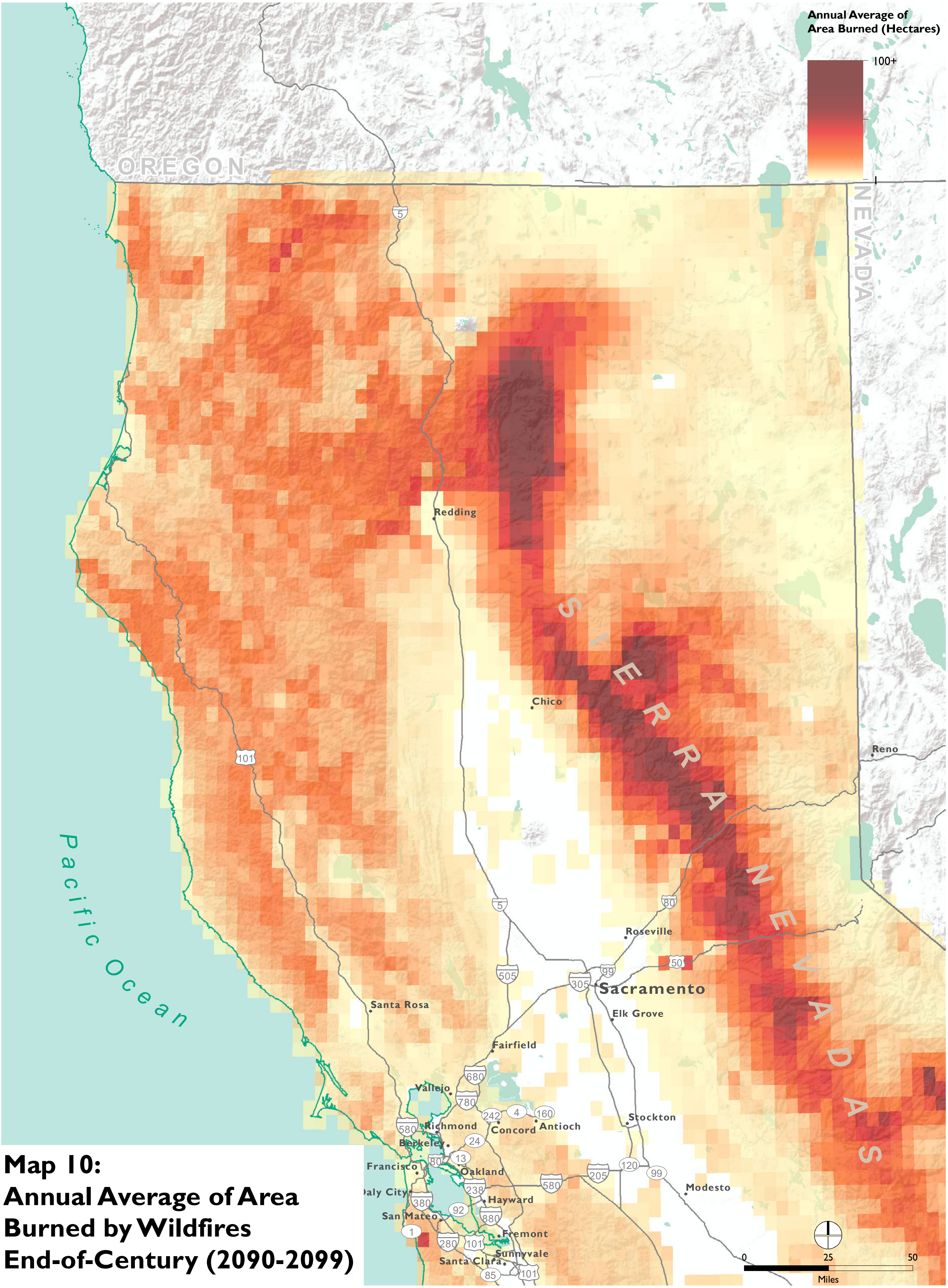
Map 8: Historical Annual Average of Area Burned by Wildfires (1961-1990)

Source: CalAdapt/UC Berkeley, 2016; Esri, USGS, NOAA, City of Sacramento, 2019; Dyett & Bhatia, 2019



Map 9: Annual Average of Area Burned by Wildfires Mid-Century (2040-2049)

Source: CalAdapt/UC Berkeley, 2016; Esri, USGS, NOAA, City of Sacramento, 2019; Dyett & Bhatia, 2019



Map 10: Annual Average of Area Burned by Wildfires End-of-Century (2090-2099)

Source: CalAdapt/UC Berkeley, 2016; Esri, USGS, NOAA, City of Sacramento, 2019; Dyett & Bhatia, 2019

Secondary Impacts

Air Quality

Residents and employees of Sacramento's urban environment may not experience the direct impacts of wildfire the same way they might directly feel the immediate effects of heat waves, extreme rain events, and floods. However, wildfires are projected to increase in severity across Northern California, and their health impacts are not easily contained within city limits. In fact, particulate matter from wildfire can dissipate throughout the Central Valley and degrade air quality for extended periods of time.[154]

Wildfires emit substantial quantities of particulate matter, carbon monoxide, nitrogen oxides, and volatile organic compounds.[155] The effects that wildfire smoke can have on Sacramento's air quality are immense. During the 2018 Camp Fire, Sacramento's PM 2.5 (particulate matter) concentrations exceeded 300 $\mu g/m^3$, among the highest in the world.

Wildfire smoke can cause adverse health effects including restricted breathing; eye irritation; aggravation of respiratory and cardiovascular diseases including asthma, chronic obstructive pulmonary disease (COPD), bronchitis, and pneumonia; and may increase cancer risk and impair immune function.[156] [157] [158]

Many of the chemicals released during wildfires are ozone precursors, chemicals that can interact to form ground-level ozone.[159] Populations exposed to ozone air pollution are at greater risk of dying prematurely, experiencing respiratory-related hospital admission, and contracting asthma.[160] The health impacts associated with air pollution exposure may be compounded by exposure to additional climate stressors such that, for example, the risk of dying from exposure to a given level of ozone pollution may increase on warmer days.[161] [162] In addition to wildfire, conditions that favor

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[154] Sacramento County, 2016.

[155] Centers for Disease Control and Prevention, "Wildfires." (2019). Oct 29 2019: https://www.cdc.gov/climateandhealth/effects/wildfires.htm.

[156] Finlay SE., Moffat A., Gazzard R., Baker D., Murray, V. "Health Impacts of Wildfires." *PLos Currents*, Nov 2, 2012. Oct 29 2019: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3492003/.

[157] U.S. Global Change Research Program, The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. (Washington, DC: 2016). Oct 29 2019: https://health2016.globalchange.gov/air-quality-impacts.

[158] Cascio, WE. "Wildland Fire Smoke and Human Health." *Science of the Total Environment*, Dec 27, 2017. Apr 30, 2020: https://www.sciencedirect.com/science/article/pii/S004896971733512X.

[159] United States Department of Agriculture, "Ozone Precursors." (2012). Oct 29 2019: https://www.climatesignals.org/sites/default/files/resources/ozone%20precursors.pdf.

[160] U.S. Global Change Research Program, 2016..

[161] U.S. Global Change Research Program, 2016..

[162] Orru H., Ebi KL., Forsberg. "The Interplay of Climate Change and Air Pollution on Health." *Current Environmental Health Reports*, Oct 28, 2017. Oct 29 2019: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5676805/.

high ozone levels include high temperatures, sunny skies, low humidity, and periods of low wind.[163] [164]

Young children; middle-aged and older adults; pregnant women; those with hypertension, diabetes, and COPD; and smokers are particularly sensitive to the health effects of smoke.[165] [166] African Americans have been found to experience higher rates of cardiovascular disease and asthma, which increase sensitivity to the health effects of smoke.[167] Some studies have also found associations between low socioeconomic status and health effects related to wildfire smoke exposure.[168] Low socioeconomic status is associated with a higher prevalence of preexisting diseases, limited access to medical care, and limited access to fresh food, all of which may contribute to susceptibility to the health effects of particulate matter exposure.[169] Members of the community such as outdoor workers and the homeless, who may not be able to remain indoors in order to reduce smoke exposure, are also at elevated risk for health impacts.

Many Sacramento residents may be required to make behavioral or lifestyle changes in order to minimize exposure to poor air quality during wildfires. These changes, such as avoiding active transportation, spending less time outdoors, or avoiding public transit if facilities are not adequately ventilated, may have ripple effects on community health, energy use, and transportation-related emissions as residents may not be able to partake in daily exercise or may choose to replace alternative transportation with the use of private vehicles.

Map 11 shows current air quality across the City of Sacramento. As can be seen in Map 11, areas with poor ambient air quality tend be clustered in the center of the city and along major roadways Interstate 50, SR 99, and Interstate 80. In the event of a wildfire, the distribution of smoke-related air pollution will likely not be concentrated in separate neighborhoods as seen in Map 11 but will be dispersed across the City.

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163 U.S. Global Change Research Program, 2016.

164 Orru H., et.al., 2017..

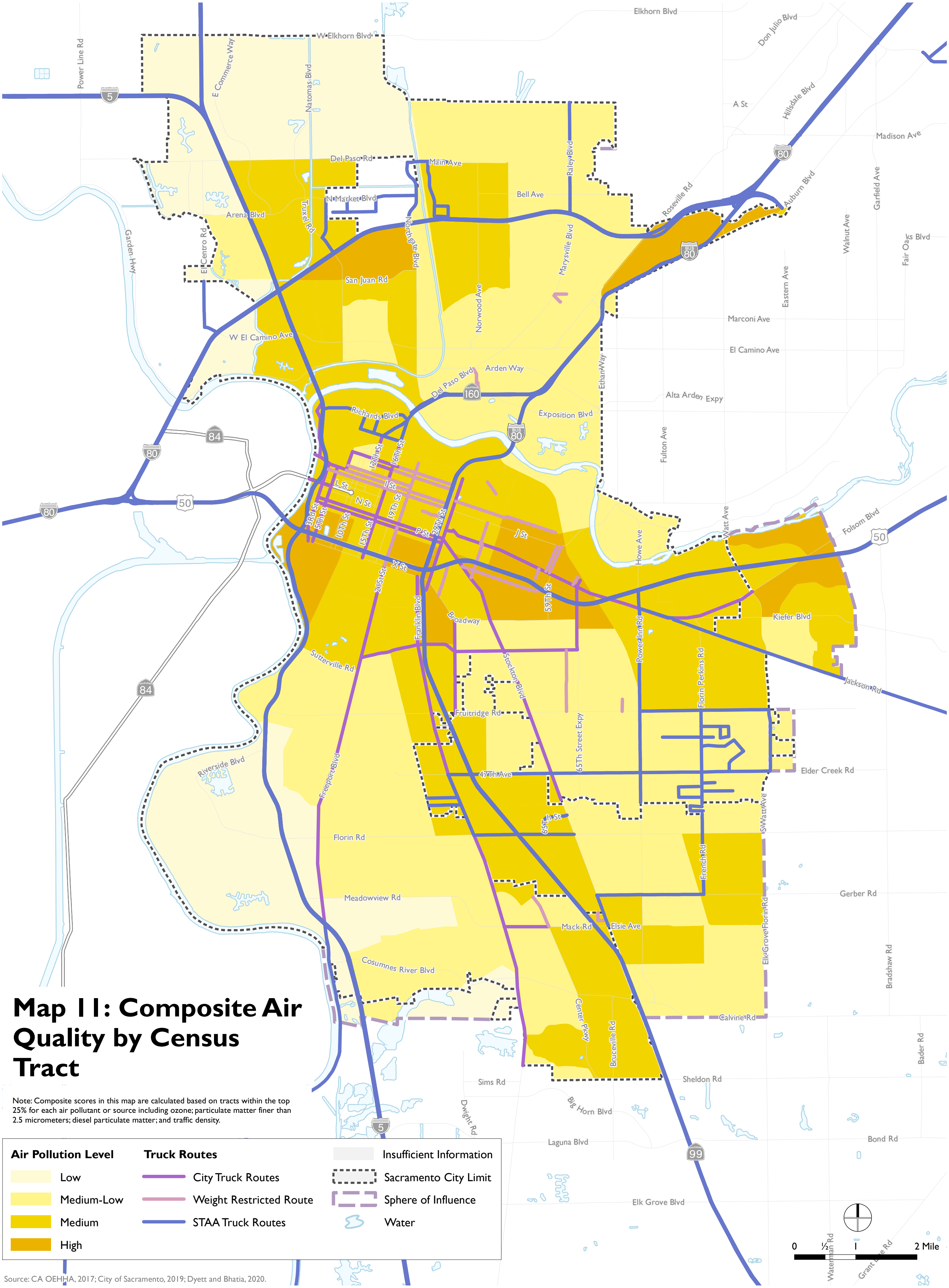
165 Finlay SE., et.al., 2012..

166 Cascio, WE. "Wildland Fire Smoke and Human Health." *Science of the Total Environment*, Dec 27, 2017. Apr 30, 2020: https://www.sciencedirect.com/science/article/pii/S004896971733512X.

167 Rudolph L, et.al., 2018.

168 Cascio, WE., 2017.

169 Sacks JD, Wichers Stanek L, Luben TJ, Johns DO, Buckley BJ, Brown JS, Ross M. "Particulate Matter-Induced Health Effects: Who is Susceptible?" *Environmental Health Perspectives,* Apr 1, 2011. Apr 30, 2020: https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.1002255



Map 11: Composite Air Quality by Census Tract

Note: Composite scores in this map are calculated based on tracts within the top 25% for each air pollutant or source including ozone; particulate matter finer than 2.5 micrometers; diesel particulate matter; and traffic density.

Air Pollution Level
- Low
- Medium-Low
- Medium
- High

Truck Routes
- City Truck Routes
- Weight Restricted Route
- STAA Truck Routes

- Insufficient Information
- Sacramento City Limit
- Sphere of Influence
- Water

Source: CA OEHHA, 2017; City of Sacramento, 2019; Dyett and Bhatia, 2020.

Water and Soil Quality

Even after a fire is put out, it can continue to have detrimental effects on the environment and surrounding communities. The infiltration capacity of soil is reduced following wildfire, increasing the risk of landslides and waterbody contamination.[170] [171] [172] Ash debris from wildfires may contain high levels of heavy metals such as arsenic, cadmium, copper, and lead, potentially causing long-term effects to soil and water quality.[173]

Infrastructure Damage

Energy production and distribution are threatened by heat and wildfires. Physical infrastructure such as power lines or pipes in the direct path of a fire can suffer extensive damage. Transmission capacity is affected by high heat, smoke, and particulate matter, and lines may be shut down as a firefighting measure.[174] [175] [176] Wildfire in the Sierra Nevada may damage water and energy infrastructure upon which the Sacramento region relies.[177]

Extreme heat and wildfire also threaten water production and distribution. Water treatment and utility services depend on the electric utility to operate, and rely on diesel generators for back-up. Increased incidents of power outages may increase reliance on diesel and other fossil fuel as well as the possibility of water shortages.

Wildfire affects transportation infrastructure by causing road and airport blockages, closures, and reducing road visibility.[178] [179] Transportation services such as electric rail lines and traffic signals may also be affected by the disruptions to power service described above. Transportation infrastructures such as roads and rail lines can also be damaged by wildfires that result in high heat.[180]

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170 Sacramento Municipal Utility District, "Climate Readiness Assessment and Action Plan." (2016).

171 Sacramento Municipal Utility District, "2018 Local Hazard Mitigation Plan." (2018).

172 United States Environmental Protection Agency, "Wildfires: How Do They Affect Our Water Supplies?" (2019). Oct 28 2019: https://www.epa.gov/sciencematters/wildfires-how-do-they-affect-our-water-supplies.

173 Finlay SE., Moffat A., Gazzard R., Baker D., Murray, V. "Health Impacts of Wildfires." *PLos Currents*, Nov 2, 2012. Oct 29 2019: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3492003/.

174 Sacramento Municipal Utility District, "Climate Readiness Assessment and Action Plan." (2016).

175 Maizlish N., English D., Chan J., Dervin K., English, P. "Climate Change and Health Profile Report Sacramento County." Sacramento County Office of Health Equity, California Department of Public Health (2017).

176 Sacramento Municipal Utility District, "2018 Local Hazard Mitigation Plan." (2018).

177 Maizlish N., English D., Chan J., Dervin K., English, P. "Climate Change and Health Profile Report Sacramento County." Sacramento County Office of Health Equity, California Department of Public Health (2017).

178 Sacramento Area Council of Governments, 2015.

179 Finlay SE., Moffat A., Gazzard R., Baker D., Murray, V. "Health Impacts of Wildfires." *PLos Currents*, Nov 2, 2012. Oct 29 2019: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3492003/.

180 Sacramento Area Council of Governments, 2015.

Higher Demand for Fire Fighting and Support Services

The Sacramento Fire Department maintains automatic aid agreements with all of its neighboring agencies and participates in the California Fire and Rescue Mutual Aid System, which provides Type I and Type III engine companies at the request of the California Office of Emergency Services (Cal OES). The department regularly provides overhead personnel for the Federal Emergency Management Administration (FEMA) Incident Support Teams (IST). In 2017, the department responded to 47 incidents with overhead personnel or resources, both throughout the state and internationally, and provided mutual aid for 8,114 incidents outside of the department's service area.[181] As the severity and frequency of wildfire increase across the Sacramento region and beyond, municipalities throughout the state will experience increased demand for fire protection services and the City may experience increased demand for its fire protection services.

Increased levels of homelessness and higher housing costs have been reported following major California wildfires.[182] [183] Displaced residents from neighboring communities have the potential to increase demand for social support services in Sacramento. Meanwhile, reductions in housing stock and increases in local demand may lead to elevated housing prices and exacerbate housing insecurity among lower income individuals and families.

SEA LEVEL RISE

Climate models anticipate some degree of sea level rise in all areas that are connected to ocean bodies. Sea level rise exacerbates flood risk and can affect the health of aquatic ecosystems and threaten the integrity of the levee system that protects the City of Sacramento. The key characteristics of sea level rise's impact on the Sacramento area are summarized in Table 2-6.

Table 2-6: Sea Level Rise

Temporal Extent	• Projected to gradually increase over the course of the century
Spatial Extent	• Areas near the Delta are most at risk
Permanence	• High • Flooding may impact low lying areas of the City. • Saltwater intrusion may affect ability to treat and receive drinking water.
Level of Disruption	• Moderate
Nature of Disruption	• Saltwater intrusion into areas where water is pumped for agricultural or municipal uses • Increase flood risk of stormwater or wastewater systems • Effects may be more severe when coinciding with flooding
Level of Uncertainty	• Low

181 City of Sacramento Fire Department, "2017 Annual Report." (2016).

182 Raphelson S. "Wildfires Exacerbate Chronic Homelessness In Northern California." *NPR*, Dec 6, 2017. Apr 30 2020: https://www.npr.org/2017/12/06/568857057/wildfires-exacerbate-chronic-homelessness-in-northern-california.

183 Levine AS. "After a California Wildfire, New and Old Homeless Populations Collide." *The New York Times*, Dec 3, 2018. Apr 30, 2020: https://www.nytimes.com/2018/12/03/us/california-fire-homeless.html.

The Sacramento-San Joaquin Delta has been a tidal freshwater marsh, with a vast network of channels, sloughs, and islands, for more than 6,000 years.[184] The Delta's characteristic intertidal conditions have created a unique and vibrant ecosystem that serves as a home for nearly 750 species.[185] While Sacramento is not a coastal city, the Sacramento-San Joaquin Delta's connection to the Pacific Ocean means that this delicate ecosystem stands to be impacted by rising seas. Ecosystem effects likely to result from sea level rise include saltwater intrusion[186] [187], with subsequent effects on freshwater quality, agricultural production[188], and the wellbeing of aquatic species such as the delta smelt.[189] In 2014, the U.S. Department of Interior Bureau of Reclamation predicted that Delta salinity may increase by 33% by the end of the century.[190]

Sea level rise can reduce the structural integrity of the delta's elaborate levee system in a variety of ways. Higher water levels in the delta increase the likelihood of levee overtopping and seepage.[191] Research has indicated that rising sea levels may accelerate levee compaction which, especially when coupled with nearby land sinking, may reduce the levee system's ability to prevent flooding.[192] Flood risk may be further exacerbated by the fact that, as sea level rises, it may become harder for water to drain out of the Sacramento Valley.[193]

Saltwater intrusion may affect ability to treat and receive drinking water. As upstream flows from the high Sierras decreases with reduced snowpack, so too will the amount of freshwater used to push back saltwater from higher sea levels, resulting in infiltration of saltwater further west into the Sacramento-San Joaquin Delta. The delta is an important water source for local farmers and water agencies, and it also provides fresh water through the State Department of Water Resources (DWR) via the California aqueduct and the rest of the State Water Project's water delivery system. As sea level rise increases salinity of Delta waters, extra outflow of fresh water will be needed to meet

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[184] Mount J, Twiss R. "Subsidence, sea level rise, seismicity in the Sacramento-San Joaquin Delta." *San Francisco Estuary and Watershed Science* (2005).

[185] Meisen P and Phares N., 2011.

[186] Sacramento County, 2016.

[187] Sacramento County, Sacramento County Climate Action Plan (2011).

[188] Medellín-Azuara J, Howitt RE, Hanak E, Lund JR, Fleenor WE. "Agricultural Losses from Salinity in California's Sacramento-San Joaquin Delta." *San Francisco Estuary and Watershed Science* (2014). May 9 2020: https://escholarship.org/uc/item/4b7295m9

[189] Brown LR, Bennett WA, Wagner RW, Morgan-King T, Knowles N, Feyrer F, Schoellhamer DH, Stacey MT, Dettinger M. "Implications for Future Survival of Delta Smelt from Four Climate Change Scenarios for the Sacramento-San Joaquin Delta, California." *Estuaries and Coasts* (2013). May 9 2020: https://link.springer.com/article/10.1007/s12237-013-9585-4.

[190] United States Department of the Interior Bureau of Reclamation, Reclamation Managing Water in the West. West-Wide Climate Risk Assessment Sacramento and San Joaquin Basins Climate Impact Assessment (2014). Nov 8 2019: https://www.usbr.gov/watersmart/baseline/docs/ssjbia/ssjbia.pdf.

[191] Suddeth RJ, Mount J, Lund JR. "Levee Decisions and Sustainability for the Sacramento-San Joaquin Delta." *San Francisco Estuary and Watershed Science* (2010). May 9 2020: https://escholarship.org/uc/item/9wr5j84g.

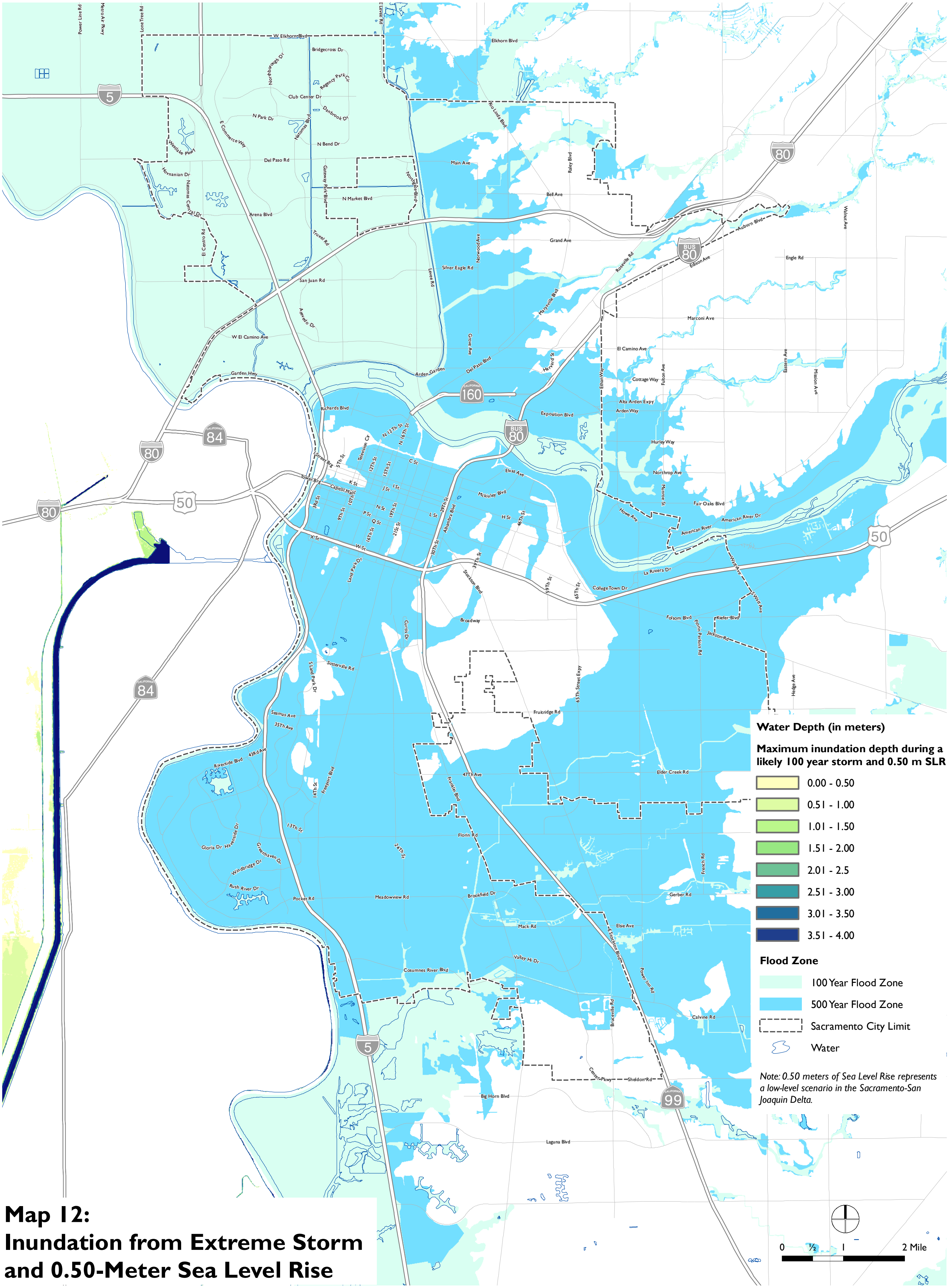
[192] Oliver K. "How rising sea levels could impact Delta, Sacramento Valley." *KCRA* Mar 20 2019. May 9 2020: https://www.kcra.com/article/how-rising-sea-levels-could-impact-delta-sacramento-valley/26888359.

[193] Oliver K., 2019.

environmental standards - an increasing issue that has conflicting tradeoffs during periods of water shortages.[194]

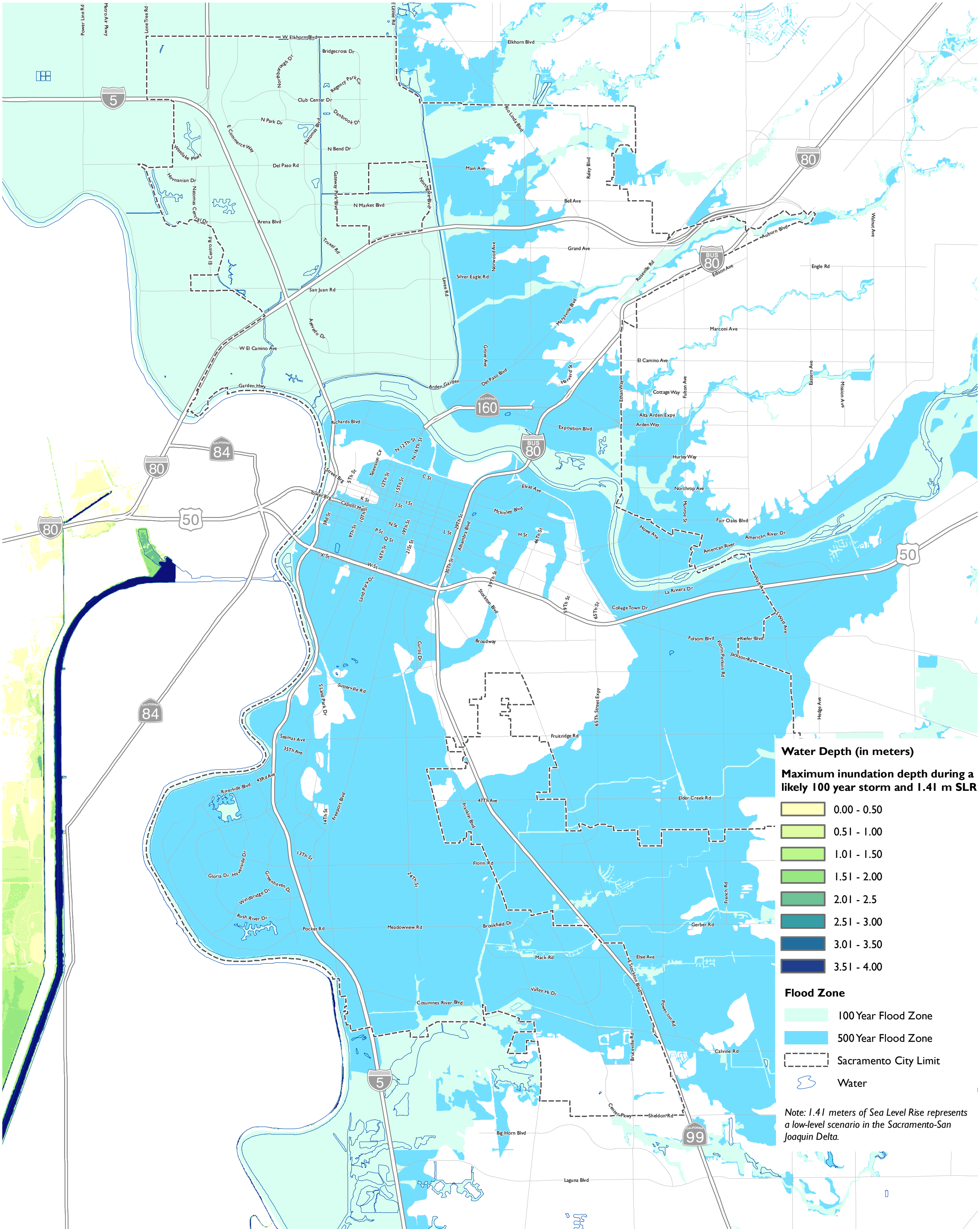
Maps 12 and 13 illustrate the amount of sea level rise projected to occur in the Sacramento region over the course of the century. As can be seen in these images, sea level rise is projected to progress gradually, affecting first the areas immediately surrounding the Sacramento River and Sacramento River Deep Water Ship Channel. As the century progresses, the areas immediately around the American River may also be affected. The most dramatic increases in sea level are projected to occur outside of the city, in the agricultural areas west of the Sacramento River. The area surrounding Washington Lake in West Sacramento is also projected to be affected by the century's end.

[194] California Department of Water Resources, "Could Sea Level Rise Threaten the Water Coming Out of Some California Taps?", September 17, 2019: https://water.ca.gov/News/Blog/2019/Sept-19/Sea-Level-Rise-Climate-Change



Map 12: Inundation from Extreme Storm and 0.50-Meter Sea Level Rise

Source: CalAdapt/UC Berkeley, 2016; FEMA, 2015; City of Sacramento, 2019; Dyett & Bhatia, 2019



Map 13: Inundation from Extreme Storm and 1.41-Meter Sea Level Rise

Source: CalAdapt/UC Berkeley, 2016; FEMA, 2015; City of Sacramento, 2019; Dyett & Bhatia, 2019

3 Vulnerability

This chapter identifies vulnerabilities to climate change which involve areas at risk, vulnerable populations, and areas at the intersection of these vulnerabilities in Sacramento. This analysis is meant to guide adaptation interventions to areas that are most susceptible and less likely to recover from the impacts of climate hazards.

3.1 Vulnerable Populations

Certain populations are particularly vulnerable to the effects of climate change and may require additional health interventions. The following section describes the different groups who are at risk, which include children (aged 14 and below), older adults (aged 65 and over), individuals with disabilities, low-income households, outdoor workers, cost-burdened households, households living in substandard housing conditions, linguistically isolated households, and communities of color.

DEMOGRAPHIC CHARACTERISTICS

Children

Children's vulnerability to climate change arises primarily from their physiological characteristics and lifestyles, as well as their position of dependency on adults and increased sensitivity to the mental health impacts of climate change. Different contributors to vulnerability may be especially prominent at different ages and under different circumstances.

Increased time spent outdoors increases children's exposure to high temperatures. This is especially true for student athletes.[195] Newborns are also highly susceptible to temperature extremes because their capacity for body temperature regulation is limited.[196] Children also have fewer opportunities than the average adult to make independent choices with regard to housing conditions, transportation, money management, medical treatment, and political representation. This means that children generally have fewer opportunities to take independent actions that might reduce their vulnerability.

Climate disruptions can be traumatic events which may result in injury, death, or displacement. Exposure to traumatic events can impact children's ability to regulate emotions, undermine cognitive development, and contribute to PTSD, anxiety, depression, and other psychiatric disorders, to which children are highly susceptible.[197] [198] Poverty can exacerbate the effect of these traumatic exposures, as children in poverty may encounter financial barriers to receiving proper medical care and social-emotional support and may be less able to escape or recover from extreme

[195] U.S. Global Change Research Program, 2016.

[196] U.S. Global Change Research Program, 2016.

[197] U.S. Global Change Research Program, 2016.

[198] CalBrace, "Children <5 years." Nov 8 2019: https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/Children0to4_788_Narrative.pdf

weather events.[199] Furthermore, children's ongoing lung development, airway size, level of physical activity, and body weight increase their susceptibility to respiratory hazards including ozone and wildfire smoke.[200] During days with poor air quality, it is especially important to keep children inside of buildings with adequate air-conditioning and filtration, as their developing lungs and inability to appropriately use protective equipment such as N95 masks, put children at greater risk during air quality concerns.

About 6.8 percent of Sacramento's population is under five years of age, 19.8 percent are 14 years of age or younger, and 23.5 percent are younger than 18.[201] Of those children aged 18 years and younger, about 27 percent are members of a household that participates in a public assistance program such as the Supplemental Nutrition Assistance Program (SNAP), 17 percent live in a household whose annual income is at or below the poverty level, and three percent have some form of disability.[202]

Within the City of Sacramento, Map 14 illustrates that particularly high concentrations of young children occur in neighborhoods such as Valley Hi/ North Laguna, Meadowview, Del Paso Heights, Strawberry Manor, and Gardenland. These are primarily single-family neighborhoods in close proximity to schools such as Grant Union High School, Castori Elementary School, Fairbanks Elementary School, Smythe Academy of Arts and Sciences, Jefferson Elementary School, Valley High School, John Reith Elementary School, Samuel Jackman Middle School, and Prairie Elementary School.

Older Adults

Older adults are a diverse population whose potential vulnerability to climate change is influenced by such factors as underlying health status, economic situation, and level of social isolation.[203] [204] [205]

The body's natural aging processes and the effects of mental illness may interact to make the elderly especially vulnerable to the effects of heat. Aging can impair the body's ability to regulate internal temperature.[206] [207] This is especially true for individuals taking medication that interferes with internal temperature regulation, including medications used to treat mental illnesses such as depression, anxiety,

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199 U.S. Global Change Research Program, 2016.

200 U.S. Global Change Research Program, 2016.

201 2013-2017 American Community Survey 5-Year Estimates

202 2013-2017 American Community Survey 5-Year Estimates

203 U.S. Global Change Research Program, 2016.

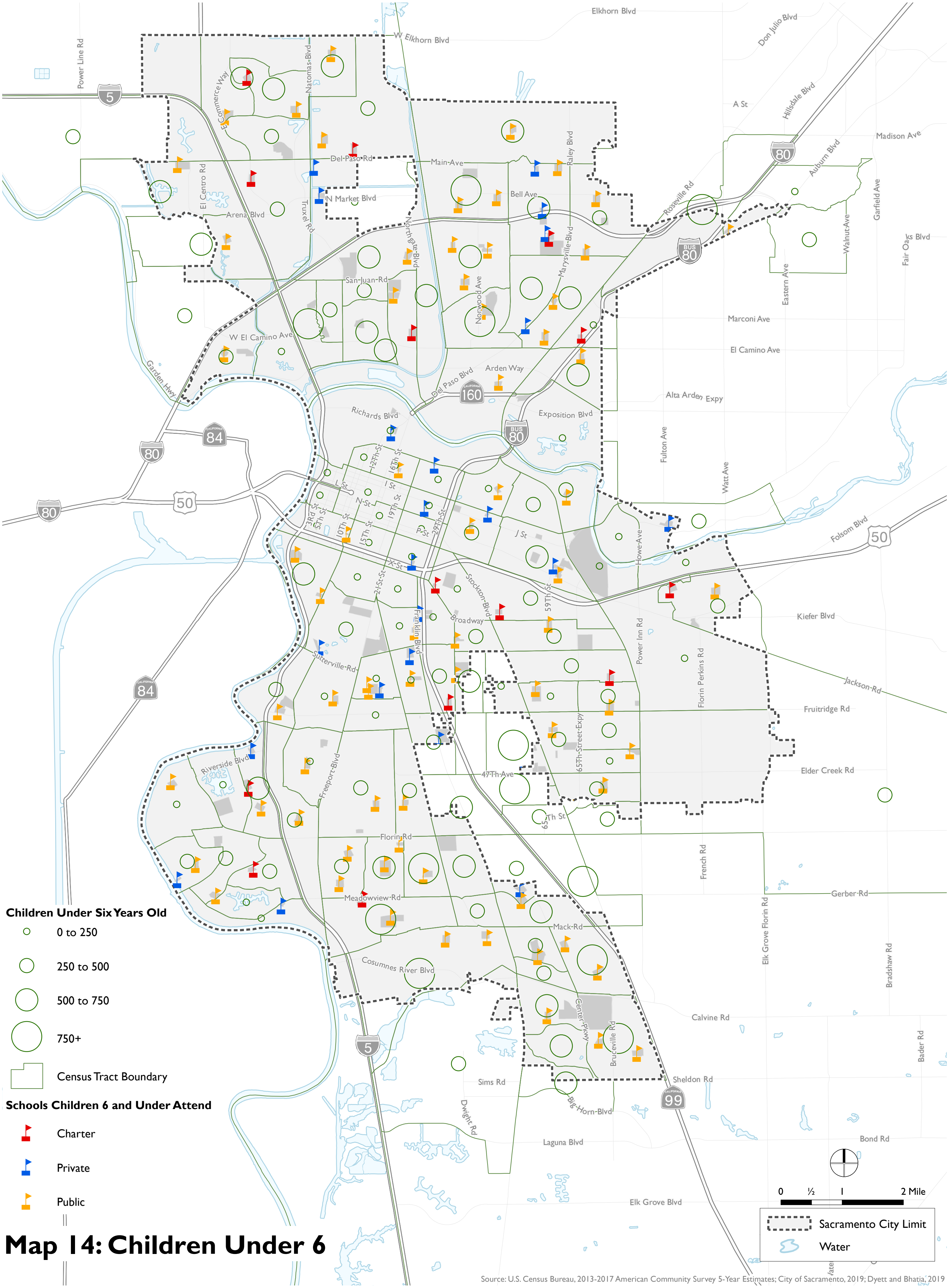
204 Benevolenza MA, DeRigne L. "The impact of climate change and natural disasters on vulnerable populations: A systematic review of literature." *Journal of Human Behavior in the Social Environment* (2019). Nov 8 2019: https://www.tandfonline.com/doi/abs/10.1080/10911359.2018.1527739?journalCode=whum20.

205 Gamble JL, Hurley BJ, Schultz PA, Jaglom WS, Krishan N, Harris M. "Climate Change and Older Americans: State of the Science." *Environmental Health Perspectives* Jan 1 2013. May 11 2020: https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.1205223.

206 U.S. Global Change Research Program, 2016.

207 CalBrace, "Population aged ≥ 65." Nov 9 2019: https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/Elderly_789_Narrative.pdf.

Map 14: Children Under 6



and psychosis.[208] In addition, many older adults may be especially affected by increases in costs for energy during high heat events because they live on fixed incomes.[209]

Older adults with cognitive or functional impairments may have difficulty responding to and recovering from extreme events, such as flooding.[210] These effects may be confounded by social isolation as older adults in isolation, especially those with cognitive impairments, may not receive emergency information or may underestimate the severity of warnings[211]. Elders residing in assistive care facilities or with limited mobility also face additional complications during evacuations and may be adversely affected by interruptions in care for chronic medical conditions.[212] [213] [214] In addition, older adults are more sensitive to certain diseases, such as West Nile Virus[215], which may expand in range as precipitation patterns change.

Air pollution can exacerbate asthma and Chronic Obstructive Pulmonary Disease (COPD) and increase the risks of heart attack in older adults, especially those who are diabetic or obese.[216] Respiratory function often declines with age. The elderly thus may be more sensitive to the effects of air pollution, airborne pathogens, and allergens than the general population.[217]

As depicted in Map 15, Sacramento's older adult population is highly concentrated in four small areas: the northern portion of the Pocket neighborhood, Little Pocket, the Central City, and Sierra Oaks. With the exception of the Central City, these are suburban neighborhoods that neighbor parks and other scenic resources but may render seniors socially isolated from the broader community.

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[208] U.S. Global Change Research Program, 2016.

[209] Gamble JL, et.al., 2013.

[210] U.S. Global Change Research Program, 2016.

[211] Gamble JL, et.al., 2013.

[212] U.S. Global Change Research Program, 2016.

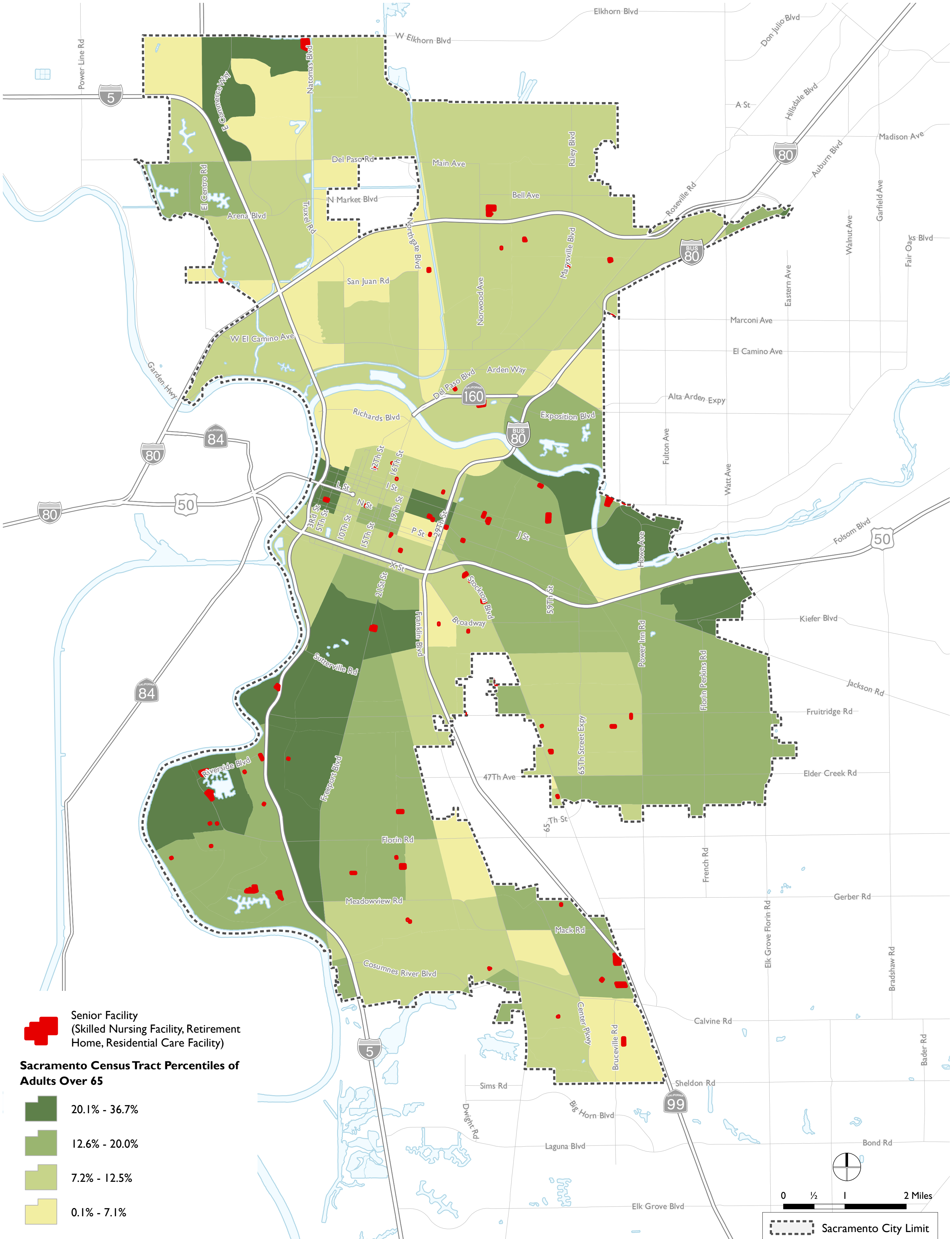
[213] CalBrace, "Population aged ≥ 65."

[214] Gamble JL, et.al., 2013.

[215] CalBrace, "Population aged ≥ 65."

[216] U.S. Global Change Research Program, 2016.

[217] Gamble JL, et.al., 2013.



Map 15: Percentage of Adults Over 65

Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates; City of Sacramento, 2019; Dyett & Bhatia, 2021

Disabled People

Disability is a broad term that refers to any condition or impairment of the body or mind that limits a person's ability to do certain activities. Limited mobility and reliance on medical equipment can also contribute to vulnerability, particularly during times of emergency evacuation and power interruption.[218] [219] Climate-related displacement can interrupt medical treatment, with health implications for those with chronic conditions. Further, mental health issues tend to increase following disasters. Rates of depression, anxiety disorders, post-traumatic stress disorders, substance abuse, and suicide are all projected to increase as the effects of climate change become more intense.[220] Use of certain medications, especially those used to treat mental health disorders, can increase sensitivity to high heat by interfering with the body's ability to regulate internal temperature.[221] In addition, the compounded effect of high poverty levels and low levels of educational attainment and employment among populations with disabilities can heighten climate change vulnerability.[222]

Risk communication materials are not always designed or delivered with accessibility in mind, potentially limiting knowledge accessibility for those who are deaf or have hearing loss, who are blind or have low vision, or those with diminished cognitive skills.

About 12.4 percent of Sacramento's population has some form of disability; 4.7 percent are both disabled and elderly. About 27.7 percent of Sacramento's total disabled population reported yearly income at or below the poverty level; about 69 percent of working-age disabled individuals living in Sacramento are either unemployed or do not participate in the labor force. Map 16 illustrates that the incidence of disability is particularly strong at the southern end of the city, the areas around Freeport and Meadowview. Valley Hi / North Laguna, Pocket, East Sacramento, and the northern neighborhoods of Raley Industrial Parkway, Del Paso Heights, North Sacramento, and South Natomas also contain large numbers of disabled individuals.

Race/Ethnicity

Structural racism, meaning the "totality of the social relations and practices that reinforce white privilege", contributes to the climate change vulnerability of communities of color.[223] Structural racism manifests in a number of policy-making decisions, including race-based housing segregation, lack of investment in public transit, and exclusionary zoning practices, whose legacy continues to have impacts on climate change vulnerability. Redlining is an example of structural racism. The term 'redlining' is often used to describe the discriminatory practices of delineating

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218 U.S. Global Change Research Program, 2016.

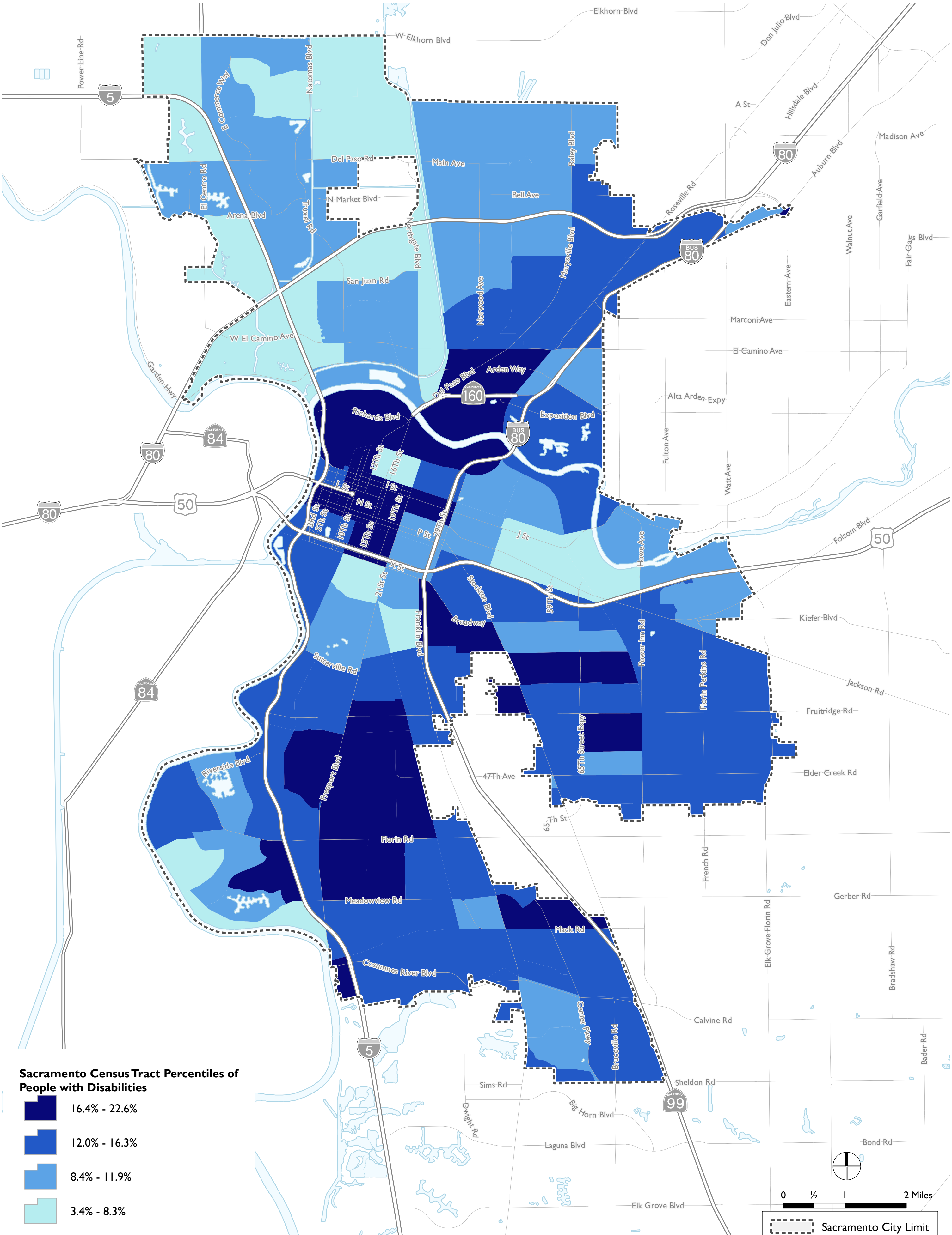
219 CalBrace, "Disability." Nov 8 2019: https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/BRACE_Disability_Narrative_795_11-16-2016.pdf.

220 CalBrace, "Disability."

221 U.S. Global Change Research Program, 2016.

222 U.S. Global Change Research Program, 2019.

223 Thomas, K., et.al., 2018.



Map 16: Disability

Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates; City of Sacramento, 2019; Dyett and Bhatia, 2019

areas where banks would avoid investments based on the racial makeup of certain communities; this was common practice in the United States for decades, starting in the 1930s. Structural racism's entrenched position in American life means that this race-based source of vulnerability manifests in a number of interacting ways, including inequities in housing quality and location, household wealth, and educational and employment opportunities.[224] [225] [226] Historically, public policy has reinforced and compounded these inequalities as white and affluent residents have accrued disproportionate levels of wealth and influence in the political process.[227]

When analyzing the effect that race or ethnic group identity has on climate change vulnerability, it is important to keep this extensive history of race-based discrimination in mind. Race or ethnicity, considered in a historical and societal vacuum, may not contribute significantly to vulnerability. What matters in this case is the fact that factors such as race, immigration status, income level, educational attainment, and housing and employment opportunities have and continue to intersect to systematically affect access to resources, societal advantages, and environmental exposures in ways that are consistently associated with race.[228] As a result, being a racial or ethnic minority in the United States is correlated with lower income, poorer physical health, living in an area with sparse vegetation and more heat-absorbing surfaces, lower air conditioning ownership, and higher rates of participation in outdoor and farming work[229], all factors which increase vulnerability to climate change.

Communities of color are disproportionately impacted by poor air quality, such as that which may arise from wildfire, industrial and transportation emissions, and the urban heat island effect, due to both disproportionate levels of exposure to air pollutants and elevated rate of diseases such as asthma and COPD, whose symptoms are exacerbated by climate change.[230]

Sacramento is one of America's most racially diverse cities. Approximately 48.5 percent of the city is white, 18.7 percent Asian, 13.4 percent Black or African American, 1.6 percent Native Hawaiian or Pacific Islander, and 0.7 percent Native American. Approximately 17.1 percent identified as belonging to two or more races or a race not identified in the U.S. Census.

As can be seen in Maps 17 and 18, communities of color are clustered primarily at the northern and southern ends of the city, which, as demonstrated in the series of maps above, contain several neighborhoods that experience elevated levels of climate change vulnerability along several different axes.

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[224] Thomas, K., et.al., 2018.

[225] U.S. Global Change Research Program, 2016.

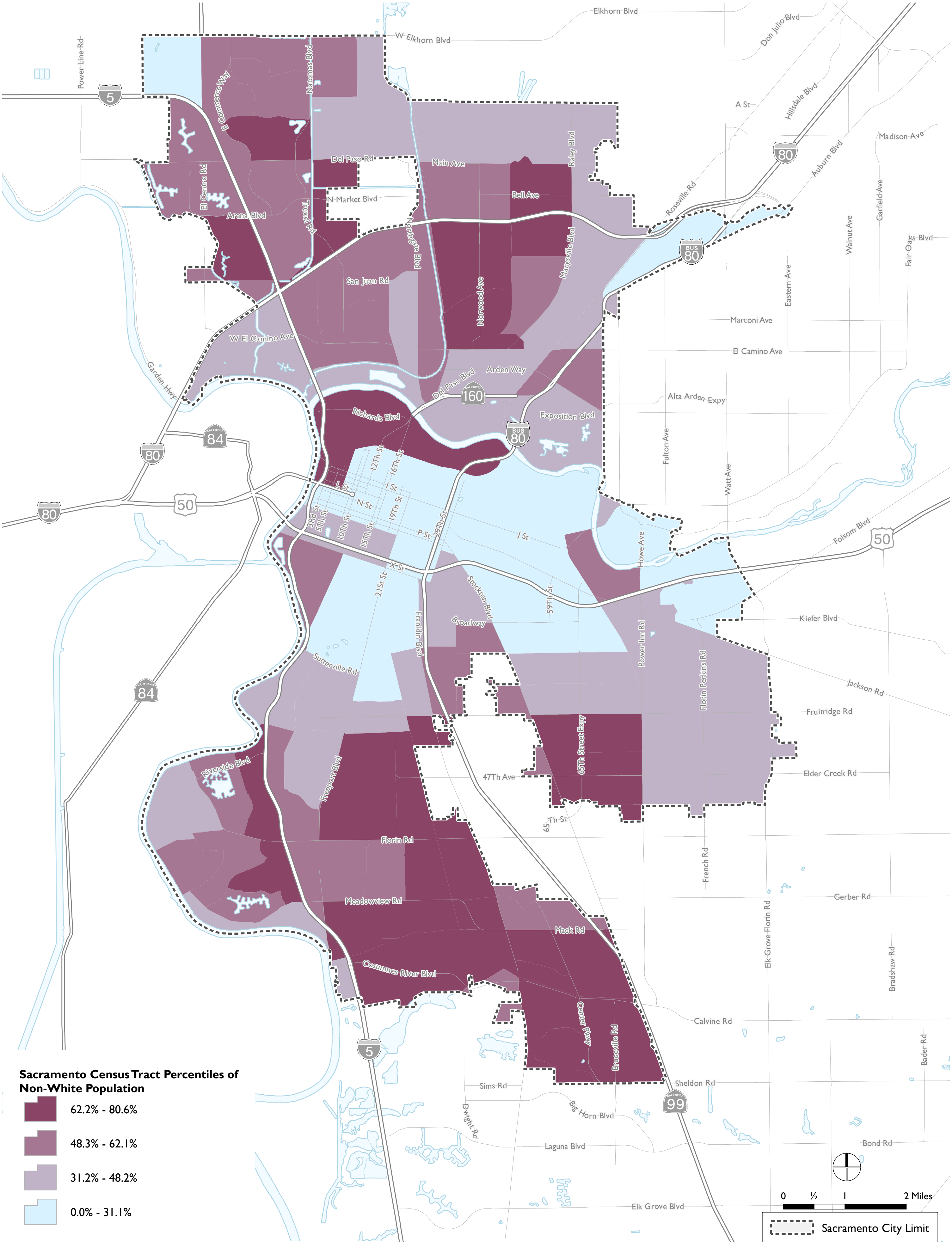
[226] Bolin B and Kurtz LC, 2017.

[227] Deas M, et.al.,. "Opportunities for Equitable Adaptation in Cities: A Workshop Summary Report." Georgetown Climate Center (2017). Nov 8 2019: www.georgetownclimate.org/files/report/GCC-Opportunities_for_Equitable_Adaptation-Feb_2017.pdf.

[228] Bolin B and Kurtz LC, 2017.

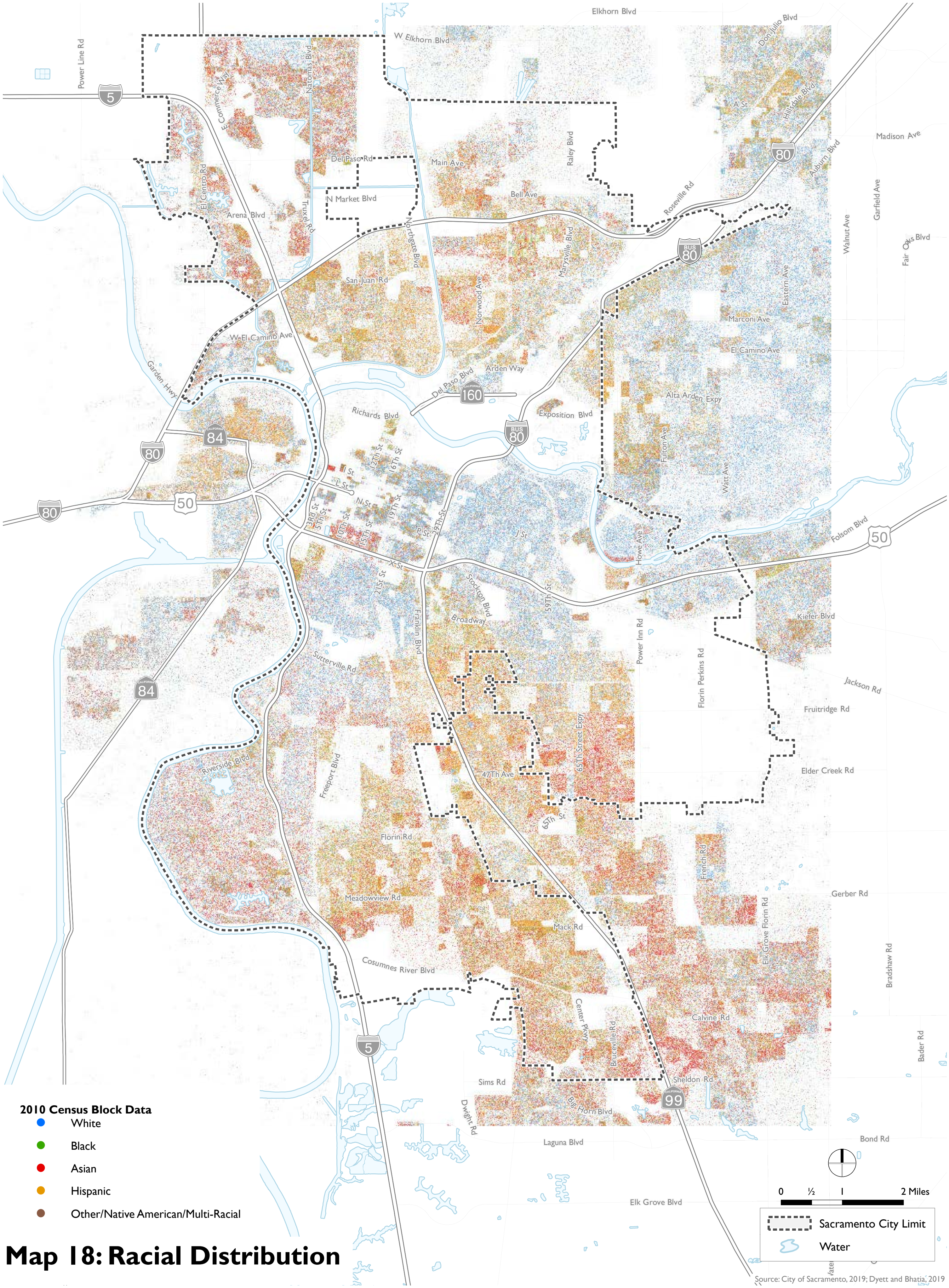
[229] Gronlund CJ, 2014.

[230] U.S. Global Change Research Program, 2016.



Map 17: Communities of Color

Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates; City of Sacramento, 2019; Dyett and Bhatia, 2019



Map 18: Racial Distribution

SOCIOECONOMIC CHARACTERISTICS

Low-Income and Poverty

Low-income people can be more vulnerable to climate change as a result of pre-existing health conditions, reduced mobility options, reduced access to health care, and limited ability to purchase the goods and services that could mitigate the negative effects of climate change.[231] [232] [233] Anticipated increases in food, water, and utility prices under climate change may also be especially problematic for low-income households.[234] [235]

Poverty is also associated with societal exclusion and mental illness, and low-income individuals and families are more likely to work or live in environments that expose them to pesticides, lead, and outdoor air pollution.[236] During high heat events, concerns about utility costs may inhibit a low-income household's ability to stay cool and receive necessary medical care.[237] Lower income households are also more likely to suffer from chronic illnesses such as diabetes, heart disease, and stress.[238] Moreover, studies have shown that lower-income residents tend to have less access to working home air conditioners, transportation, and cool environments (e.g., shopping mall, library) during prolonged heat events, leading to substantially higher risk of heat-related deaths. Housing quality may also be a factor compounded with low income levels that affects disparities in heat-related mortality; those with lower income are more likely to live in overcrowded or substandard housing conditions where ventilation is inadequate.[239]

About 15 percent of Sacramento families (about 20 percent of all people) live in poverty.[240] Some types of families are more likely to be in poverty than others. These include families headed by a single female, those whose heads are non-white, those whose heads have not attended college, and those that include multiple children.[241]

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231 U.S. Global Change Research Program, 2016.

232 CalBrace, "Poverty Rate." Nov 8 2019: https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/HCI_PovertyRate_754_Narrative_Examples11-5-13rev3-12-14.pdf.

233 Wilson SM, Richard R, Joseph L, Williams E. "Climate Change, Environmental Justice, and Vulnerability: An Exploratory Spatial Analysis." *Environmental Justice* Mar 17 2010. May 11 2020: https://www.liebertpub.com/doi/abs/10.1089/env.2009.0035.

234 Tacoli C. "Urban poverty, food security, and climate change." International Institute of Environment and Development (2013). May 11 2020: https://pubs.iied.org/pdfs/17149IIED.pdf.

235 Shonkoff SB, Morello-Frosch R, Pastor M, Sadd J. "The climate gap: environmental health and equity and implications of climate change and mitigation policies in California – a review of the literature." *Climatic Change* Nov 24 2011. May 11 2020: https://link.springer.com/article/10.1007/s10584-011-0310-7.

236 CalBrace, "Poverty Rate."

237 Gronlund CJ, 2014..

238 CalBrace, "Poverty Rate."

239 Glen P. Kenny et al., "Heat Stress in older individuals and patients with common chronic diseases," *Canadian Medical Association Journal*, July 13, 2010, 182(10): 1053-1060, doi: 10.1503/cmaj.081050.

240 2013-2017 American Community Survey 5-Year Estimates

241 2013-2017 American Community Survey 5-Year Estimates

Map 19 reveals that poverty rates are particularly high in the neighborhoods of North Sacramento, Del Paso Heights, Village Green, South Hagginwood, and Woodlake, as well as in Southern Pacific Richards, Tokay Meadows, Avondale, Central Oak Park, Woodbine, Brentwood, and South City Farms. A number of these neighborhoods are sparsely populated areas that contain or adjoin industrial land uses.

Unemployment and Occupation

Employment is considered a key social determinant of health because wages and benefits such as health insurance are an important factor in determining workers' ability to pay for safe housing, nutritious food, and medical care.[242] However, individuals who engage in certain occupations may also have elevated climate change vulnerability. Outdoor workers are often among the first to be exposed to the effects of climate change such as increased ambient temperature and degraded air quality.[243] [244] There is emerging evidence that extreme heat can increase the risk of on-the-job injuries by making workers irritable or confused or by interfering with balance, motor control, and vision.[245] Specific occupations that may experience heightened vulnerability include agricultural workers, groundskeepers, emergency responders, utility repair crews, and construction workers.[246] Statistics show that these occupations tend to have a higher percentage of Blacks or African Americans, Hispanics or Latinos, and low-wage workers[247] than the population as a whole, many of whom enjoy little job security and do not receive health insurance or paid sick leave. [248] [249] For some groups, such as migrant laborers and day laborers, occupational-related vulnerability may be compounded by additional sources of vulnerability such as lack of access to quality housing[250], low income, linguistic isolation, pesticide exposure, and legal precariousness that introduces barriers to the use of emergency and legal protective services.[251] Fear of discrimination or deportation dissuades some immigrant workers from reporting unsafe conditions or injuries and illnesses sustained on the job.[252] Additionally, immigrant workers may be unaware of their workplace rights

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242 Constible J, Chang B, Morganelli C, Blandon N. "On the Front Lines: Climate Change Threatens the Health of America's Workers." Natural Resources Defense Council Jun 2020. July 31 2020: https://www.nrdc.org/sites/default/files/front-lines-climate-change-threatens-workers-report.pdf.

243 U.S. Global Change Research Program, 2016.

244 CalBrace, "Outdoor Workers." Nov 8 2019: https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/BRACE_OutdoorsWorkers_Narrative_790_12-5-2016.pdf.

245 Constible J, et.al., 2020.

246 U.S. Global Change Research Program, 2016.

247 Constible J, et.al., 2020.

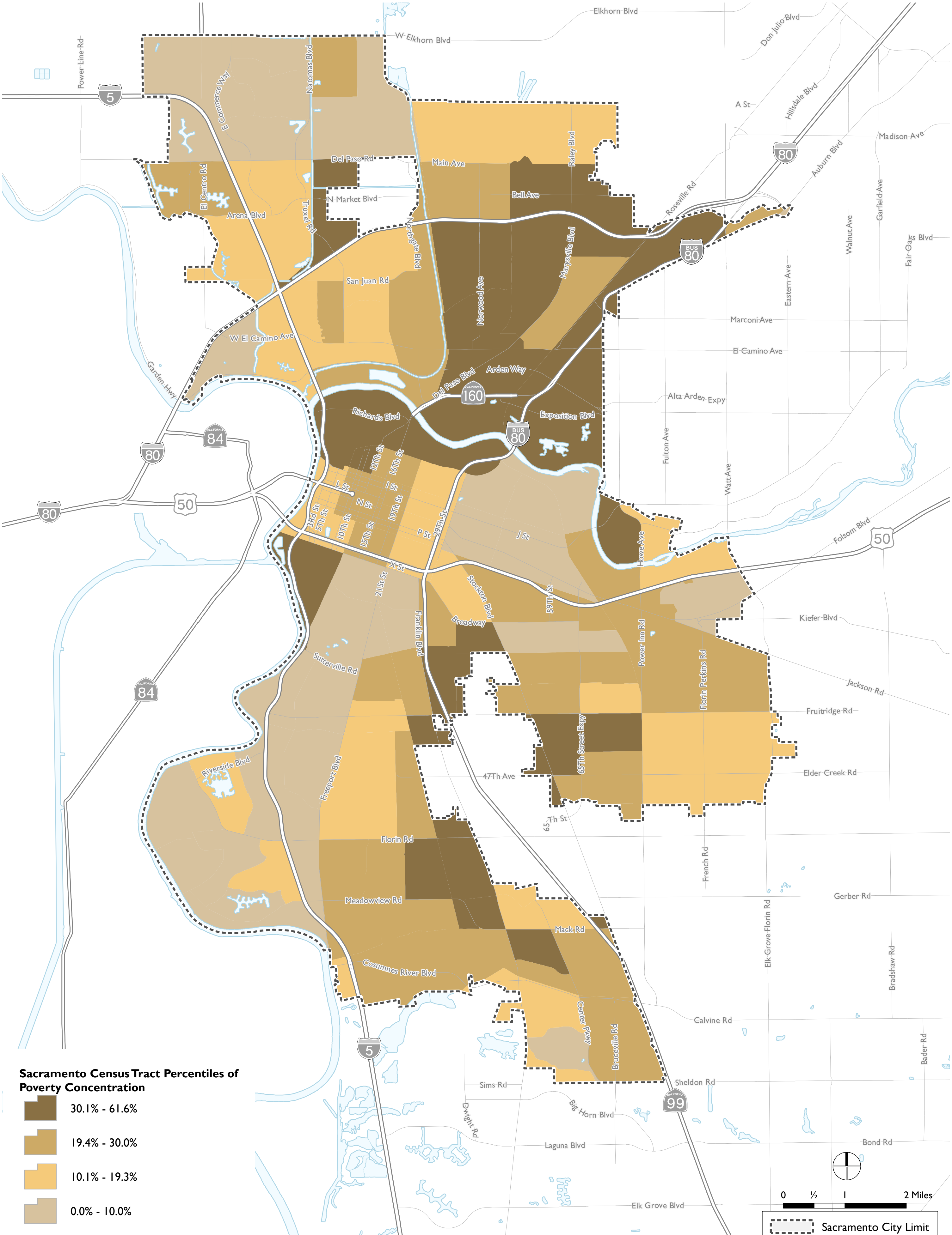
248 Shonkoff SB, et.al., 2011.

249 Constible J, et.al., 2020.

250 U.S. Global Change Research Program, 2016.

251 CalBrace, "Outdoor Workers."

252 Constible J, et.al., 2020.



Map 19: Concentration of Poverty

Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates; City of Sacramento, 2019; Dyett and Bhatia, 2019

or ineligible for workers' compensation. Temporary and informally employed workers are more susceptible to occupational injuries and illnesses than are permanent employees because they often have less work experience, are unfamiliar with their workplaces, receive inadequate health and safety training, are assigned the most dangerous jobs, and may be fired or penalized for taking time off.[253] In addition, outdoor workers are often among the first to be exposed to the effects of wildfires, such as degraded air quality.[254] [255]

Housing Conditions

The availability of high-quality, stable, and affordable housing helps reduce exposure to extreme climate events and enables recovery. High housing costs may increase vulnerability by monopolizing financial resources, while lack of stable or high-quality housing may increase vulnerability by increasing exposure to environmental impacts.

The US Department of Housing and Urban Development (HUD) defines housing cost burdened households as those who pay more than 30 percent of their income on housing. Housing cost-burdened households may struggle to afford other necessities such as food, transportation, medical care[256], and—in the case of extreme climate events—emergency supplies and the ability to access a safe area. About 15 percent of households in Sacramento are housing cost-burdened.[257]

In the absence of high-quality affordable housing options, the locations in which low-income households and individuals reside are often less resilient in the face of the impacts of weather and climate change[258] and may be farther from workplaces, shopping districts, and public transit—increasing the costs associated with transportation. Patterns of settlement in which lower-income households locate in especially vulnerable areas could be exacerbated in the future as the real estate market begins to take exposure to climate change affects into account when setting housing prices.[259] As seen in Map 20, those neighborhoods where residents may experience particularly high housing cost burdens include North Sacramento, Del Paso Heights, South Hagginwood, Point West, Cal Expo, Southern Pacific/ Richards, Tokay Meadows, Weyand Industrial, North City Farms, Woodbine, Valley Hi/ North Laguna, and Central City.

A variety of housing types have been found to be correlated with higher sensitivity to climate change impacts. Poor quality home construction can also increase vulnerability to climate change impacts.[260] Manufactured or mobile homes are especially vulnerable to storm and flooding

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[253] Constible J, et.al., 2020.

[254] U.S. Global Change Research Program, 2016.

[255] CalBrace, "Outdoor Workers."

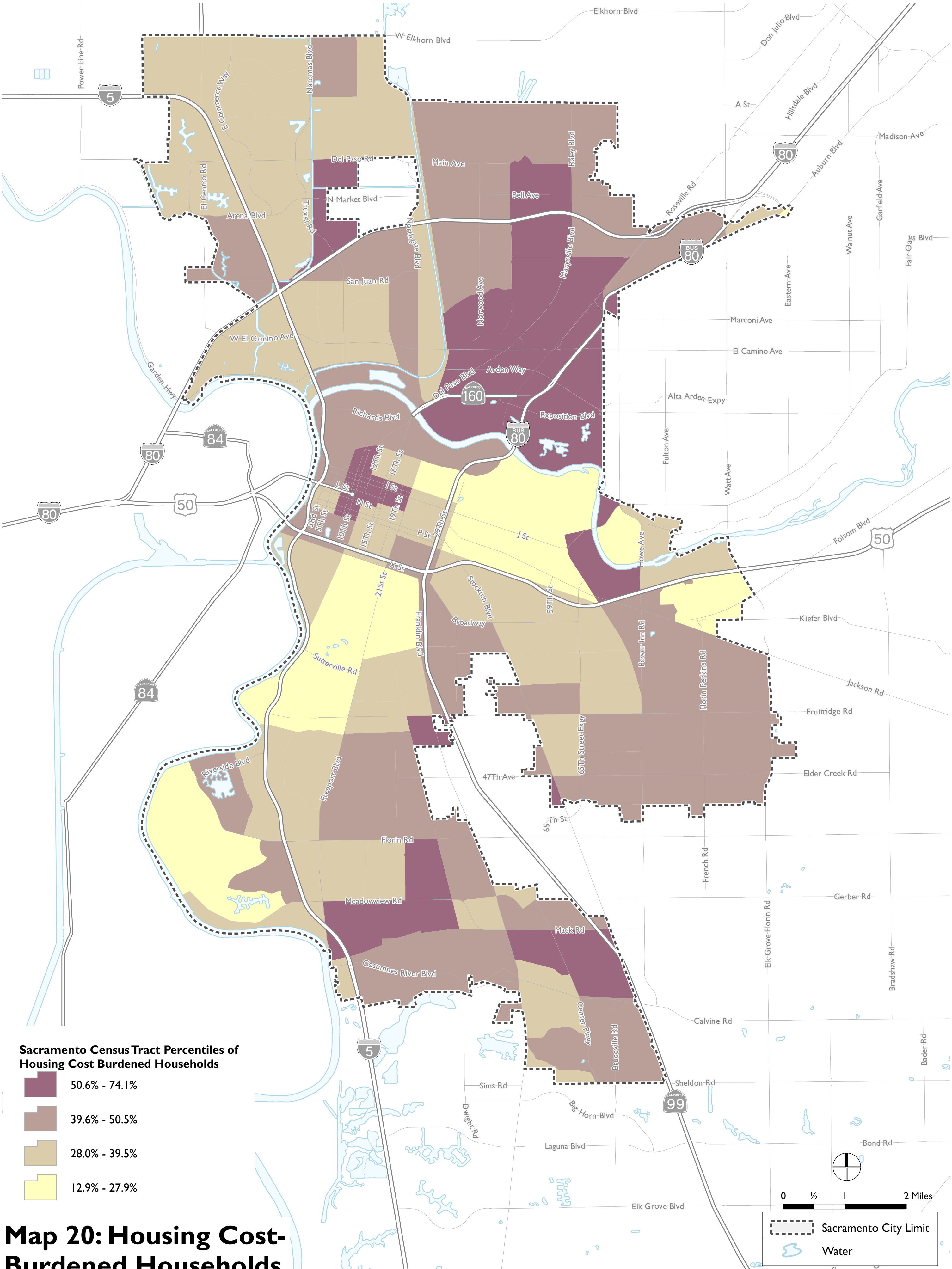
[256] "Rental Burdens: Rethinking Affordability Measures." *PD&R Edge Home.* Nov 8 2019: https://www.huduser.gov/portal/pdredge/pdr_edge_featd_article_092214.html.

[257] 2013-2017 American Community Survey 5-Year Estimates

[258]Thomas, K., et.al., 2018..

[259] Deas M, etl.al., 2017.

[260] Thomas, K., et.al., 2018.



Map 20: Housing Cost-Burdened Households

Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates; City of Sacramento, 2019; Dyett and Bhatia, 2019

damage.[261] Similarly, rental housing, manufactured housing, and subsidized housing are often located in neighborhoods where there are higher concentrations of populations who are sensitive to heat.[262] Thirty-one percent of Sacramento county's subsidized housing units are located in high-heat census tracts, one of the highest rates of the state.[263]

Low-income households may struggle to afford to invest in home upgrades that reduce climate exposure. Additionally, in the aftermath of an extreme climate event, it can be especially difficult for low-income individuals to cover costs associated with home repairs or relocation[264], potentially perpetuating the vulnerability of low-income and housing cost burdened households.

Whether a resident owns or rents their housing unit may also affect climate vulnerability. Renters may have less control than homeowners when it comes to making home upgrades to reduce climate exposure or increase resiliency. Across the Sacramento region, renters are less likely to have access to air conditioning; when they do use air conditioning, renters are more likely than homeowners to use window conditioning units, which are less effective at cooling and more energy-intensive, and thus more likely to place an energy burden on residents.[265] Additionally, areas with high rates of homeownership are associated with stronger local social networks, greater community involvement, and longer resident tenure. In past studies, a neighborhood's proportion of renter-occupied housing units was shown to be positively correlated with higher mortality rates among the elderly population during extreme heat events, perhaps reflecting a lack of stability, coping capacity, and strong community ties in these neighborhoods.[266] About 52.7 percent (95,780) of Sacramento's occupied housing units are renter-occupied.[267] As can be seen in Map 21, high concentrations of renter-occupied housing occur in downtown and the Natomas neighborhood.

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[261] Gamble JL, et.al., 2013..

[262] Gabbe CJ, Pierce G. "Extreme Heat Vulnerability of Subsidized Housing Residents in California." *Housing Policy Debate*. (Jul 2020). July 27 2020: https://www.tandfonline.com/doi/full/10.1080/10511482.2020.1768574

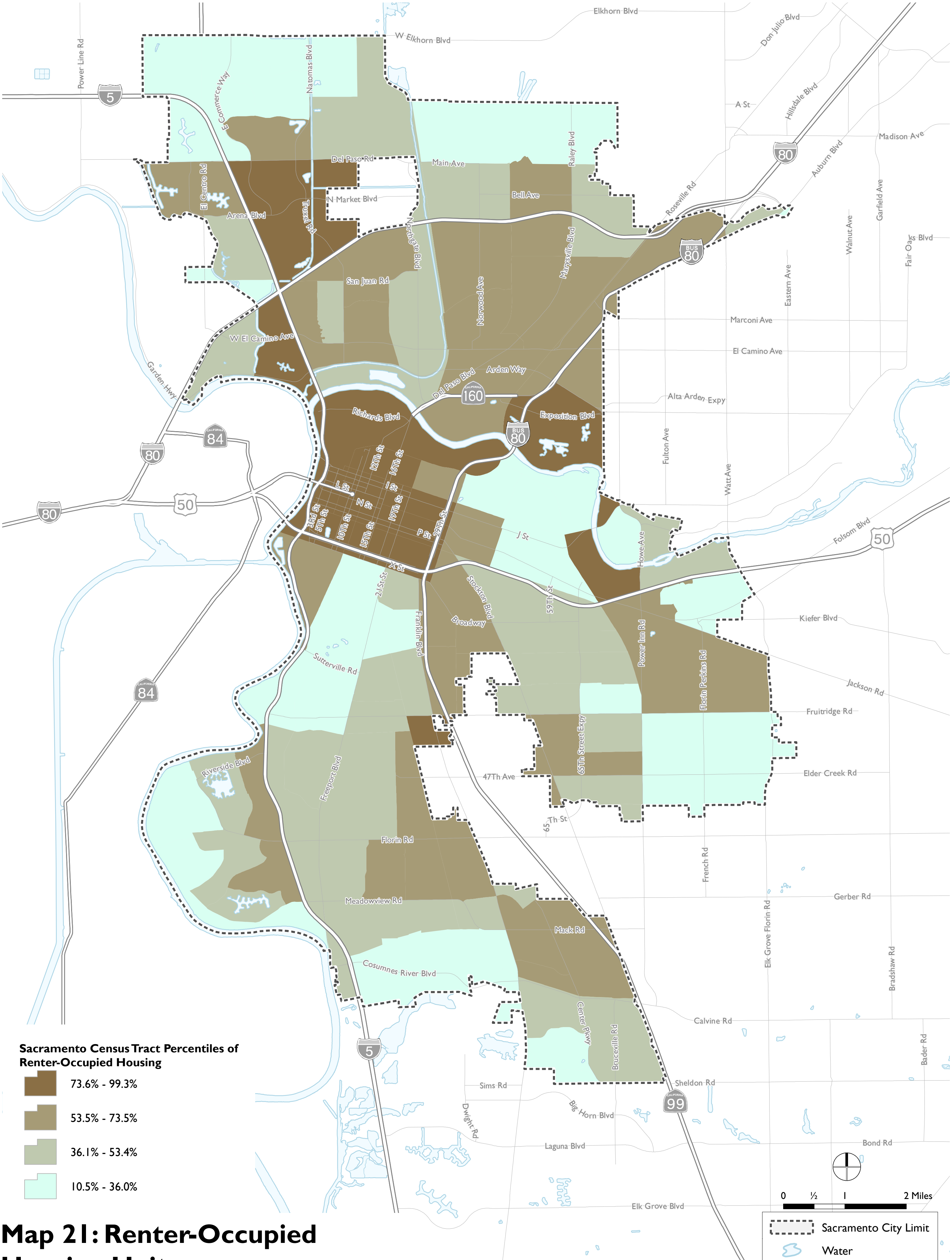
[263] Gabbe CJ and Pierce G., 2020.

[264] Thomas, K., et.al., 2018.

[265] Sacramento Metropolitan Air Quality Management District, 2020.

[266] Klein Rosenthal J, Kinney PL, Metzger KB. "Intra-urban vulnerability to heat-related mortality in New York Coty, 1997-2006." *Health & Place* (2014). May 11 2020: https://www.sciencedirect.com/science/article/pii/S1353829214001087.

[267] 2013-2017 American Community Survey 5-Year Estimates



Map 21: Renter-Occupied Housing Units

Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates; City of Sacramento, 2019; Dyett and Bhatia, 2019

Homelessness

People experiencing homelessness may be especially vulnerable to climate change impacts. Homeless individuals, who already experience elevated levels of exposure to environmental stressors such as high heat, poor air quality from wildfire smoke, and flooding, may lack a secure place to shelter in the event of a climate emergency and experience especially high levels of exposure to extreme weather. For example, there have been recent reports that homeless individuals in the Sacramento area are establishing shelters among the Delta's levee networks. Human interference with the levee system may threaten the structural integrity of the levees.[268] [269] Meanwhile, individuals who take up residence among the levees are at particularly high risk for suffering flood-related damages.

The needs of homeless individuals may be overlooked in disaster planning initiatives, and they are often more difficult to contact via emergency alert systems.[270] Additionally, homeless communities often lack the legal standing that would help ensure their legitimacy and protection in times of emergency.[271]

As of 2017, it was estimated that approximately 3,665 individuals experienced homelessness in Sacramento each night. About 78 percent of these individuals were single adults over the age of 25, 16 percent were in family units, and 6 percent were unaccompanied youth.[272] Sacramento County's 2019 Point-In-Time Count revealed a 19 percent increase in nighttime homelessness since 2017, to a total of 5,570 individuals.[273] This figure corresponds to a range of between 10,000 and 11,000 individuals experiencing homelessness over the span of the year.[274] The Point-In-Time Count also found that approximately 30 percent of individual sleeping outside in Sacramento County are adults over the age of 50. Black and American Indian or Alaska Native people are also significantly overrepresented in the homeless population, especially within unsheltered families.[275]

Linguistic Isolation

Linguistically isolated households are those in which there is no one aged 14 years or older who speaks English fluently.[276] Linguistic isolation may delay or prevent access to information such as

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[268] Heap, B. "'Could be catastrophic': Homeless camps on Sacramento-area levees cause concern," KCRA (May 10 2019). Nov 8 2019: https://www.kcra.com/article/could-be-catastrophic-homeless-camps-on-sacramento-area-levees-cause-concern/27440429#.

[269] CBS Sacramento, "Homeless People Damaging Flood Levees, Putting Thousands of Sacramento Homes In Danger." (May 9 2019). Nov 8 2019: https://sacramento.cbslocal.com/2019/05/09/homeless-digging-flood-levees/.

[270] Thomas, K., et.al., 2018.

[271] Thomas, K., et.al., 2018.

[272] City of Sacramento, "Homelessness in Sacramento." (2017).

[273] Baiocchi A, Curry S, Williams S, Argüello T, Price Wolf J, Morris J. "Homelessness in Sacramento County: Results from the 2019 Point-in-Time Count." (Sacramento, CA: Institute for Social Research and Sacramento Steps Forward, 2019). Nov 8 2019: https://sacramentostepsforward.org/wp-content/uploads/2019/06/2019-Final-PIT-Report-1.pdf.

[274] Baiocchi A, et.al., 2019.

[275] Baiocchi A, et.al., 2019.

[276] CalBRACE, "Linguistic Isolation." Nov 8 2019:

public notices, job opportunities, and healthcare services. Linguistic isolation may hinder protective behaviors during extreme weather events or disasters by limiting access to or understanding of health and safety warnings and health information[277], such as the City's own emergency response materials, the majority of which are only available in English. Studies have shown that people who live in linguistically isolated households are more likely to make heat-related calls to 911 during extreme heat events. In the aftermath of an extreme event, language barriers can present barriers to proper care and recovery services.[278] Language barriers can be a contributor to vulnerability for new immigrants, older first-generation immigrants, asylum seekers, and young children.[279] Additionally, lack of familiarity with American government and planning processes may present barriers to engaging in planning processes and accessing key government-provided resources.[280]

Sacramento is a place of great linguistic diversity. Approximately 37.8 percent of Sacramento residents speak a language other than English at home.[281] Of those who speak a language other than English at home, 41.2 percent have limited English proficiency.[282] Eighteen percent speak Spanish at home[283], with other frequently spoken languages including Chinese (including Cantonese and Mandarin), Tagalog (including Filipino), and Vietnamese.

Within the City of Sacramento, neighborhoods where residents experience high rates of linguistic isolation show a significant amount of overlap with those neighborhoods that are high in poverty, residents with disabilities, and high-cost, reduced quality housing. As described above, a number of these neighborhoods are low-density, contain or are adjacent to industrial land uses, and relatively isolated from core City activities. However, many linguistically isolated residents are also located downtown in the City's core. When compared with Map 18 (Racial Distribution), Map 22 shows how this area corresponds to a high density of the City's Asian population.

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https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/BRACE_LinguisticIsolation_Narrative_11-15-2016.pdf.

277 CalBRACE, "Linguistic Isolation.".

278 U.S. Global Change Research Program, 2016.

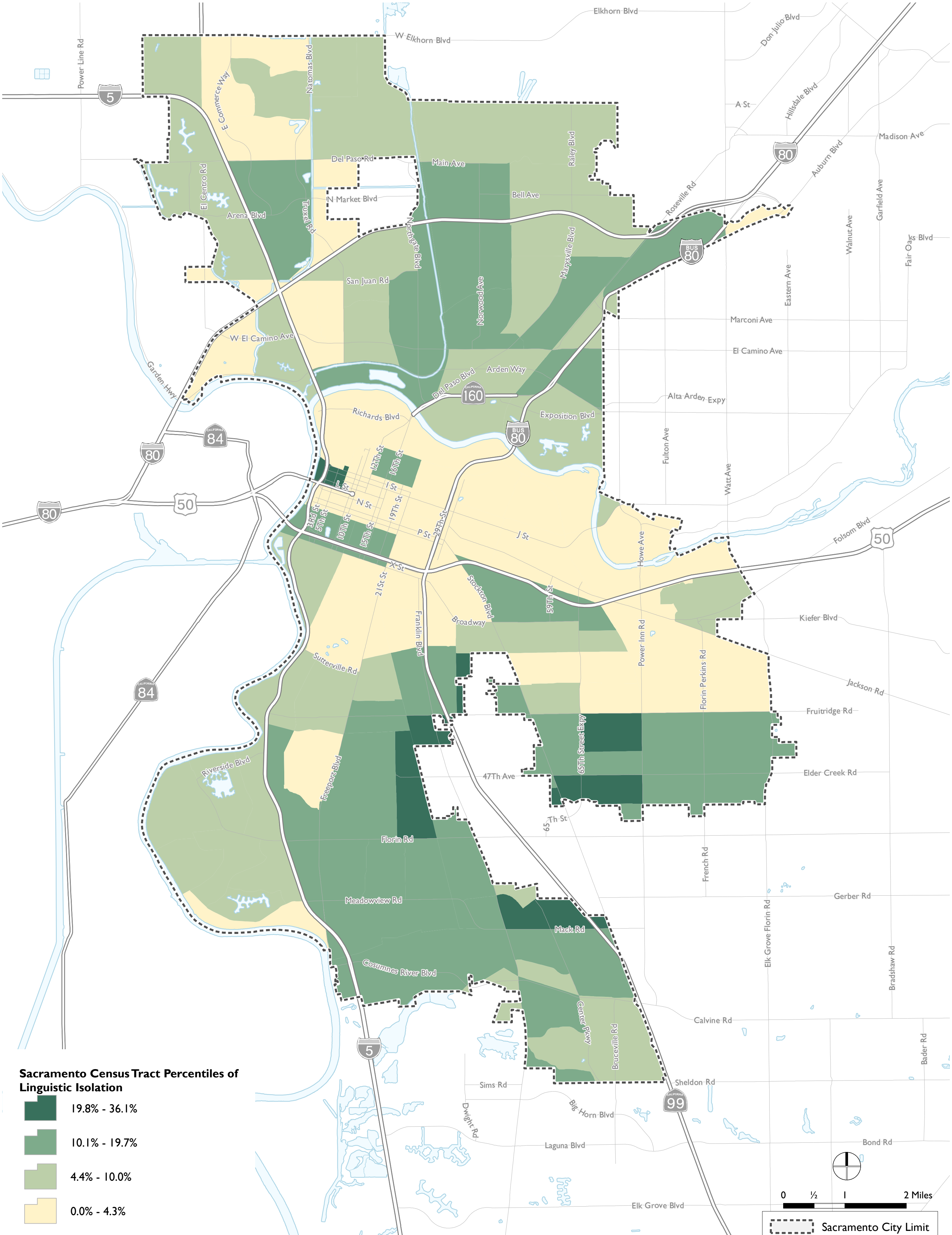
279 CalBRACE, "Linguistic Isolation.".

280 Deas M, et.al., 2017..

281 2013-2017 American Community Survey 5-Year Estimates

282 2013-2017 American Community Survey 5-Year Estimates

283 2013-2017 American Community Survey 5-Year Estimates



Map 22: Rate of Linguistic Isolation

Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates; City of Sacramento, 2019; Dyett and Bhatia, 2019

AT-RISK VULNERABLE POPULATIONS

This section discusses and maps the overlay of areas that are impacted by each of the climate change effects with the vulnerable populations described above.

Urban Heat

Urban heat island effects in Sacramento are most prevalent in North Sacramento, Fruitridge-Broadway, the South Area, parts of the Central City, and in industrialized areas (see Map 1). Populations vulnerable to urban heat include children (aged 14 and below), older adults (aged 65 and over), individuals with disabilities, low-income households, outdoor workers, cost-burdened households, households living in substandard housing conditions, linguistically isolated households, and communities of color.

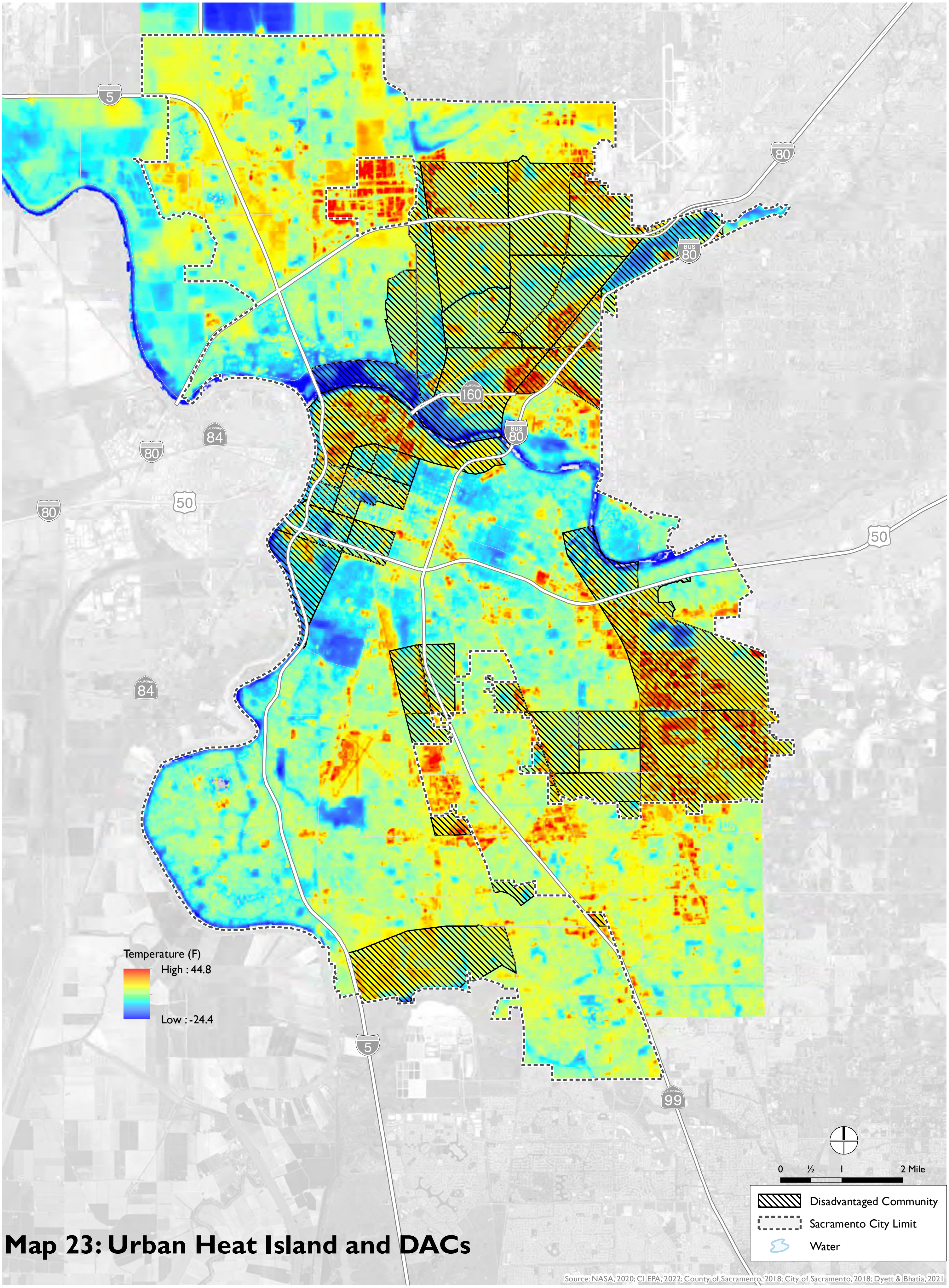
Map 23: Urban Heat Island and DACs illustrates an overlay of areas that are impacted by the urban heat island effect as well as house a high proportion of disadvantaged communities (DACs). DACs are defined as the areas in the top 25 percent of CalEnviroScreen scores, which take into account census tracts' pollution burdens and population socioeconomic characteristics. Northeast and southeast Sacramento largely contain areas that are vulnerable to urban heat island effects and house DACs. While many of these areas represent industrial and large commercial areas, many adjacent neighborhoods were developed without street tree canopy, have large unshaded parking lots, and represent neighborhoods with fewer trees on private property. The City's Urban Forest Plan will focus on high-risk neighborhoods that contain vulnerable populations that should be prioritized for urban heat island mitigation and adaptation strategies.

Flooding

As described in Chapter 2, flooding is the most common climate hazard event to occur within the city limits. The majority of the city lies within the 100-year Magpie Creek floodplain, the 100-year flood zone, or the 500-year flood zone. In addition, areas of repetitive flooding include, South Natomas, Downtown East, Downtown West, Southeast Sacramento, and Sutterville/Meadowview as illustrated in Map 4: Repetitive Loss Areas and FEMA Flood Zones.

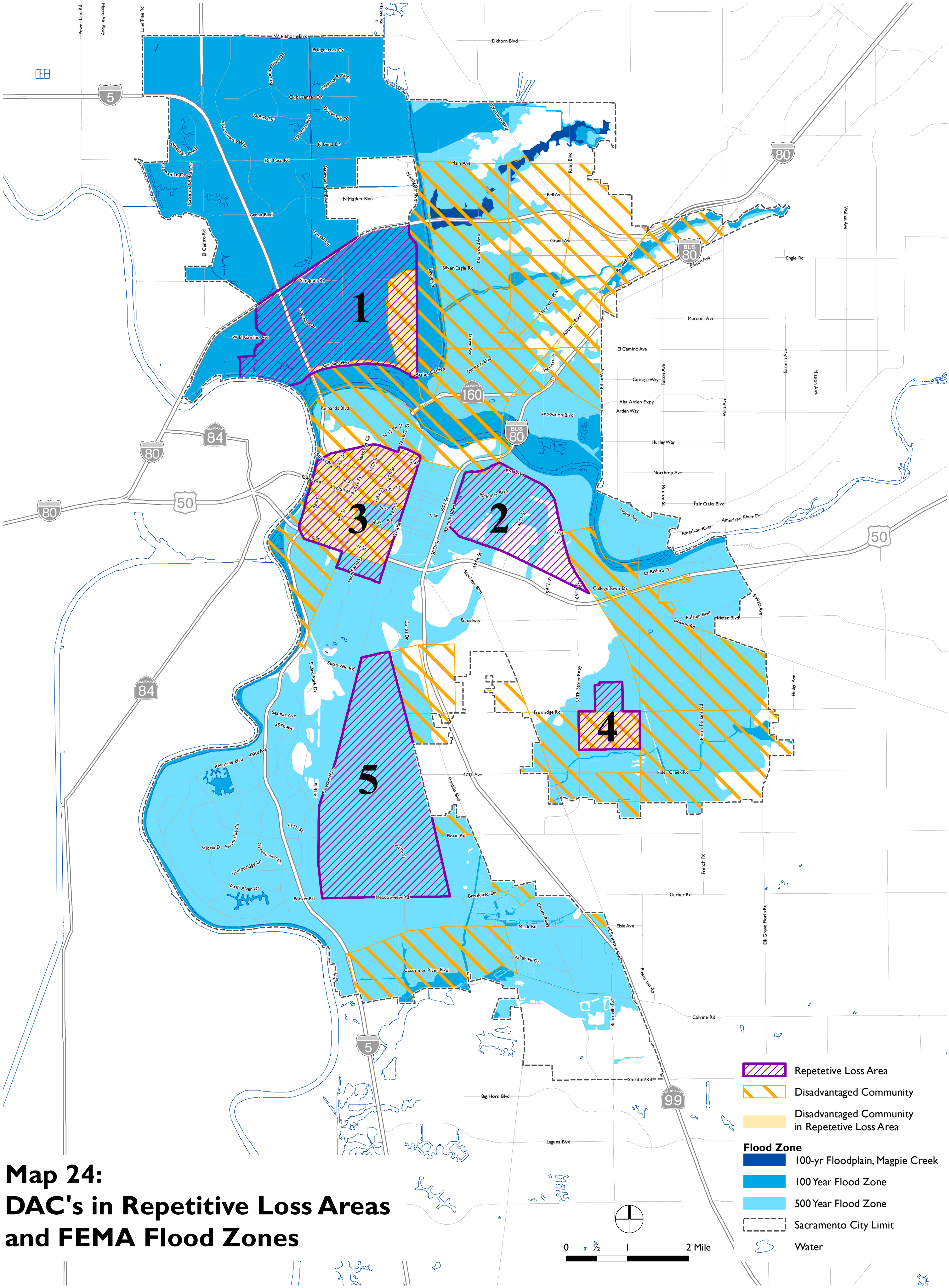
Numerous populations are particularly vulnerable to the effects of flooding and may require additional health interventions. As described above, groups who are at risk include older adults (aged 65 and over), individuals with disabilities, low-income households, cost-burdened and poor-quality households, linguistically isolated households, and communities of color.

Map 24: DACs in Repetitive Loss Areas (RLAs) and FEMA Flood Zones illustrates an overlay of areas that are impacted by flooding in Sacramento as well as house a high proportion of disadvantaged communities (DACs). Areas at particular risk include portions of RLAs 1, 3, and 4. Specific neighborhoods in these high-risk areas include Northgate, Downtown, Southside Park, Richmond Grove, Alkali Flat, Mansion Flats, and Avondale.



Map 23: Urban Heat Island and DACs

Source: NASA, 2020; CI EPA, 2022; County of Sacramento, 2018; City of Sacramento, 2018; Dyett & Bhatia, 2021



Map 24:
DAC's in Repetitive Loss Areas and FEMA Flood Zones

Source: CalEPA, 2022; CalAdapt/UC Berkeley, 2016; FEMA, 2015; City of Sacramento, 2019; Dyett and Bhatia, 2019

Drought

Communities especially vulnerable to the effects of drought include those working in the agricultural sector, rural populations, and those dependent on wells.[284] The state's agricultural output for 2019 was more than $50 billion, over $460 million of which was produced by Sacramento County.[285] A significant drought can jeopardize crop production, livelihoods, and the financial stability of those working in the agricultural industry in the Sacramento region. With around 6,400 jobs, the agribusiness and food manufacturing sector represent a $3 billion industry in the region.[286]

Of those Sacramento residents who are employed, about 11.5 percent (25,418 individuals) work in construction or agricultural industries.[287] Some of the largest employers in Sacramento County include educational institutions such as American River College and California State University; government and utility services such as the Department of Transportation, Environmental Protection Agency, the Water Resources Department, and SMUD; and healthcare providers such as Kaiser Permanente and Mercy General Hospital[288]. The extent to which employees within these industries will be vulnerable to climate change impacts will depend on the nature of the individuals in question as well as their professional duties. However, the large scale of these sectors in the Sacramento region means that any climate event that disrupts their functioning may impact the financial stability of a large number of Sacramento residents.

Food insecurity along with the financial instability of the agricultural sector is a growing concern during prolonged periods of drought. The scarcity of water factors into the costs of food throughout the system. Food prices in grocery stores may increase during a drought which could make it too costly for low-income households to purchase fresh produce, meats, and poultry.

Unless groundwater resources are successfully managed, consistent droughts would likely result in significant groundwater depletion over time due to an increased reliance on the water source. Groundwater currently comprises about one-third of the region's water use; studies have shown that regional rates of groundwater extraction increase under drought conditions.[289] [290] The City's groundwater supplies are currently being managed sustainably and major overdrafts are not anticipated.[291] [292] However, climate change effects such as drought and shifting precipitation

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[284] Sacramento Municipal Utility District, 2018.

[285] California Department of Food and Agriculture, California Agricultural Statistics Review (2020). August 25 2021: https://www.cdfa.ca.gov/Statistics/PDFs/2020_Ag_Stats_Review.pdf.

[286] City of Sacramento, Agricultural Hub and Research and Development (2021). September 1 2021: https://www.cityofsacramento.org/Economic-Development/Key-Industries/Agriculture-Hub-and-Research-and-Development.

[287] 2013-2017 American Community Survey 5-Year Estimates

[288] State of California Employment Development Department, "Major Employers in Sacramento County." Nov 8 2019: https://www.labormarketinfo.edd.ca.gov/majorer/countymajorer.asp?CountyCode=000067.

[289] Northern California Water Association, 2017.

[290] Xiao M, et.al., 2017.

[291] Northern California Water Association, 2017.

[292] West Yost Associates. "2015 Urban Water Management Plan." City of Sacramento (2016). May 7 2020: https://www.cityofsacramento.org/~/media/Corporate/Files/DOU/Reports/City%20of%20Sacramento%20Final%202015%20UWMP%20June%202016.pdf

patterns could impact groundwater supply over the course of the century. Meanwhile, drought can increase the concentrations of industrial chemicals, heavy metals, and agricultural runoff contaminants in groundwater, increasing the risk of exposure among communities that rely of groundwater resources.[293] Thus, residents that rely on groundwater wells may be particularly vulnerable to overdraft and pollutant exposure as droughts become more common and severe.

When compounded with other climate change effects, droughts can exacerbate water quality issues. For instance, as sea levels rise, saltwater intrusion will become more common, contaminating inland freshwater sources. The Sacramento-San Joaquin Delta is already feeling these side effects, as high tides bring saltwater further inland each passing year.[294] Areas that rely on Delta waters for municipal and agricultural use are particularly vulnerable to changes in water quality.

Wildfire

While a wildfire may be unlikely to break out within Sacramento city limits, wildfires can have profound secondary impacts on the health of vulnerable populations. Wildfire smoke can cause adverse health effects including restricted breathing; eye irritation; aggravation of respiratory and cardiovascular diseases including asthma, COPD, bronchitis, and pneumonia; and may increase cancer risk and impair immune function. Vulnerable populations include children (aged 14 and below), older adults (aged 65 and over), individuals with disabilities, low-income households, outdoor workers, linguistically isolated households, and communities of color. Some studies have also found associations between low socioeconomic status and health effects related to wildfire smoke exposure.

While Sacramento itself may not be at a very high risk to wildfires within city limits, its secondary air quality impacts can have harmful health effects on the city's vulnerable populations. Even though Sacramento and the State of California have a plethora of resources on wildfire emergency preparedness, it is essential to ensure that all community members are well-informed and well-equipped to respond to a climate-related event.

Climate Disaster Preparedness

If evacuation is necessary due to a climate disaster event, several barriers may prevent residents from evacuating. Some residents, such as the elderly, the hospitalized, prisoners[295], the low-income[296], individuals with mobility issues, those who lack access to reliable transportation[297], those whose do not receive language-appropriate warning and evacuation information, and those with pets,[298] may not be able to evacuate in a timely manner even if they desire to do so. When a large-scale evacuation is taking place, the elderly may be left behind by caretakers and families, and their

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293 Rudolph L, et.al., 2018.

294 Meisen P and Phares N., 2011.

295 Benevolenza MA, DeRigne L. "The impact of climate change and natural disasters on vulnerable populations: A systematic review of literature." *Journal of Human Behavior in the Social Environment* (2019). Nov 8 2019: https://www.tandfonline.com/doi/abs/10.1080/10911359.2018.1527739?journalCode=whum20.

296 U.S. Global Change Research Program, 2016.

297 Nutters, H., 2012.

298 Porter K., et al., 2010..

specific conditions and medical needs may be overlooked. Income influences the ability to evacuate by affecting ability to afford access to private transportation and services such as hotels. Additionally, research has shown that residents of high-density areas may require additional assistance while evacuating.[299]

Even in the absence of an evacuation event, disruptions to the transportation network can occur as a result of localized flooding, and can disproportionately affect low-income individuals and older adults who may have limited mobility as well as those with limited English proficiency who may not understand notices communicated only in English. These disruptions also affect those who commute into or out of the city for work, who may suffer economic losses as a result.[300] Car ownership is an important marker of social vulnerability to storms and floods. During a sudden flood event, households in or near a flood zone without a personal vehicle may be at greater risk of harm because they have reduced capacity to evacuate.[301] Approximately 10 percent of Sacramento's households lack access to a household vehicle.[302]

3.2 Critical Facilities

A critical facility is any facility whose damage or disruption would result in severe consequences to public health and safety or interrupt essential services for the community. The following section details critical facilities in Sacramento and their essential services which can consist of water utilities, wastewater services, energy infrastructure, communication infrastructure, power generation facilities, levees, roads and bridges, and medical services.

WATER SUPPLY

The City provides domestic water service to the area within the city limits, as these limits change from time to time, and to several small areas within the County of Sacramento. A small area in the northeastern portion of the city (Swanston Estates) is served by the Sacramento Suburban Water District, although City and District staff have held discussions relative to the City taking this service area over at some point in the future. Areas adjacent to the city limits are served by the Natomas Central Mutual Water Company, Rio Linda Elverta Community Water District, Sacramento County Water Agency, Sacramento Suburban Water District, California-American Water Company, Tokay Park Water District, Elk Grove Water Service, and the Florin County Water District.

The City supplies domestic water from a combination of surface water and groundwater sources. Two water treatment plants supply domestic water by diverting water from the American River and Sacramento River. In addition to the surface water diverted from the two rivers, the City operates groundwater supply wells. Emergency connections to adjacent water systems exist in various locations.

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[299] Porter K., et al., 2010..

[300] Maxwell, K., et.al., 2018.

[301] Nutters, H., 2012.

[302] 2013-2017 American Community Survey 5-year estimates

WASTEWATER

Portions of the City of Sacramento are currently served by a combined sewer and storm water system, while other parts of the city have separated sewer and storm drainage systems. The area served by the combined system generally extends from the Sacramento River on the west, to the vicinity of Sutterville Road and 14th Avenue on the south, to about 65th Street on the east, and to North B Street and the American River on the north. The remainder of the city is served by separated sewer and storm drainage systems.

Three separate entities are involved in the collection, conveyance, treatment, and disposal of wastewater in the city. The City of Sacramento Department of Utilities (DOU) provides collection through its separated system and its combined system to about 65 percent of the population of Sacramento. The Sacramento Area Sewer District (formerly County Services District CSD-1) provides collection through its separated system to the remaining 35 percent of the population, primarily in the northwest and southeast sections of the city. The City's separated system and Sacramento Area Sewer District's system, as well as the dry-weather flow from the city's combined system, and a majority of the wet weather flows from the city's combined sewer system, drain into interceptors owned and operated by the Sacramento Regional County Sanitation District (Regional San) which in turn convey all flows to the Sacramento Regional Wastewater Treatment Plant (Sacramento Regional WWTP) also owned by Regional San. When a storm event results in flows exceeding 60 million gallons per day, the City collects and treats the excess flows before discharging to the Sacramento River.[303]

The City collects fees for 54 sewer basins that serve the community plan areas of North Sacramento, and portions of Arden-Arcade, most of South Sacramento (e.g., Pocket, Airport, Meadowview, South Land Park), and most of East Sacramento. Fourteen of those basins are part of the combined sewer system. Four out of the other forty separated basins flow directly into the downtown area's combined system, where the flow joins the combined flow before being conveyed to the Sacramento Regional WWTP. The other 50 separated basins flow into the Regional San interceptors which convey flows to the Sacramento Regional WWTP. Out of these 50 basins, 40 are pumped through their own individual pump stations, while the other 10 basins flow by gravity.

The older Central City area is served by a system in which both sanitary sewage and storm drainage are collected and conveyed in the same system of pipelines, referred to as the Combined Sewer System (CSS). There are 14 combined sewer basins. The area served by the CSS constitutes approximately 7,545 acres or 12 percent of the total area within the current city limits. There are some local areas within this larger area that have separate sewer and storm drainage systems, but the bulk of the area is served by the combined system. Additionally, there are some peripheral areas that have separate sewer and storm drainage that contribute sewage to the CSS, including the four separated sewer basins described above.

[303] City of Sacramento Department of Utilities, Where does it go? A Snapshot of the City's Combined Sewer System, https://www.cityofsacramento.org/-/media/Corporate/Files/DOU/McKinley/How-it-works.pdf?la=en

FLOOD PREVENTION

The City of Sacramento is located in the heart of California's Central Valley at the confluence of the Sacramento and American Rivers. The Central Valley is a flat alluvial plain approximately 50 miles wide and 400 miles long in central California. The northern part is the Sacramento Valley drained by the Sacramento River, and the southern part is the San Joaquin Valley drained by the San Joaquin River. It is surrounded by the Sierra Nevada Mountains to the east, the Tehachapi Mountains to the south, Coastal Range to the west, and Cascade Range to the north. The topography of the area is relatively flat. There is a gradual slope rising from elevations as low as sea level in the southwestern portion of the Valley up to approximately 75 feet above sea level in the northeastern portion.

Given this geographic context, the City of Sacramento is susceptible to various types of flood events: riverine, flash, and localized stormwater flooding; and levee and dam failure flooding. Regardless of the type of flood, the cause is most often the result of severe weather patterns and excessive rainfall, either in the flood area or upstream reach. Flooding is the most significant natural hazard that the City faces.

The Sacramento region's extensive network of levees, dams, and weirs protect vast portions of the city and its critical facilities from flooding. If this infrastructure were to fail from major floods, significant numbers of people could be injured, killed, or forced to evacuate. Thus, high-intensity storms may produce higher volumes of runoff, contribute to increased flood risk and contribute to levee failure. Moreover, sea level rise would exacerbate flood risk in Sacramento and threaten the structural integrity of the levee system that protects the city.

ENERGY SUPPLY

Climate change can disrupt energy supply and delivery via increased temperatures, changes in the hydrological cycle, wildfire, and heavy storms. Heat both increases demand for energy and reduces the efficiency of energy transmission, making the city more susceptible to interruptions. Changes in seasonal snowmelt reduces the generating capacity of SMUD's hydroelectric facilities. Both wildfire and heavy storms, including winds, can damage infrastructure, leading to electricity and telecommunications service outages.[304] [305] This may make it difficult or impossible for vulnerable populations, such as the elderly or persons with disabilities, to receive necessary medical care during a climate hazard event.

Energy production and distribution are threatened by heat and wildfires. Physical infrastructure such as power lines or pipes in the direct path of a fire can suffer extensive damage. Transmission capacity is affected by high heat, smoke, and particulate matter, and lines may be shut down as a firefighting measure. Wildfire in the Sierra Nevada may damage water and energy infrastructure upon which the Sacramento region relies.

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[304] Lane K, Charles-Guzman K, Wheeler K, Abid Z, Graber N, Matte T. "Health Effects of Coastal Storms and Flooding in Urban Areas: A Review and Vulnerability Assessment." *Journal of Environmental and Public Health* May 30 2013. May 11 2020: https://www.hindawi.com/journals/jeph/2013/913064/.

[305] Porter K., et al., 2010..

High temperatures can impact key infrastructure including energy generation and distribution. High temperatures decrease the efficiency of power lines while increasing the demand for energy-intensive uses such as air conditioning and cooling equipment. This results in a higher risk of energy blackouts and increases energy bills. These impacts can strain household budgets, increase exposure to heat, and negatively impact the provision of medical and social services.

The Sacramento Municipal Utility District (SMUD) is responsible for the acquisition, generation, transmission and distribution of electrical service to customers for the City of Sacramento. SMUD's 900 square mile service territory also includes most of Sacramento County and a portion of Placer County. SMUD serves a population of approximately 1.5 million with a total annual retail load of approximately 12.565 million megawatt-hours. SMUD generates 1,771 megawatts (MW) of power and buys 1,483 MW of power to meet the region's power demands. SMUD supplies power through a distribution grid that is a looped system, which provides for more reliable power.

TRANSPORTATION

Extremely high temperatures can cause physical damage to roadways, railways, and bridges, as well as reduce the comfort and feasibility of walking, biking, and taking public transit.

Roads and sidewalks absorb and radiate heat, subjecting those nearby, including people walking and those using transit, to increased heat burdens.

Sacramento Regional Transit (SacRT) powers their light rail system with overhead catenary systems lines, which can stretch with heat and may lead to severing of the connection with the rail car.

Wildfire affects transportation infrastructure by causing road and airport blockages, closures, and reducing road visibility. Transportation services such as electric rail lines and traffic signals may also be affected by the disruptions to power service described above. Transportation infrastructures such as roads and rail lines can also be damaged by wildfires that result in high heat. Flooding can also result in roadways under water, critical facilities washed out, and damage to traffic signals, signs, and bridges.

The State highway system will also be affected. Caltrans owns or controls 350,000 acres of right of way, maintains 15,133 centerline miles of highway and 13,063 miles of state highway, and inspects more than 12,200 local bridges statewide. Caltrans engages in a number of climate-related initiatives to protect these critical assets. It conducts climate change vulnerability assessments to identify segments of the State Highway System vulnerable to climate change impacts including precipitation, temperature, wildfire, storm surge, and sea level rise. The results of these assessments are used to guide analysis of at-risk assets and develop adaptation plans and evacuation routes.

MEDICAL FACILITIES

A number of climate change effects, including higher ambient temperature, reduced ambient air quality, flooding, and wildfire will increase demand for medical services, potentially straining the City's medical services infrastructure. There are six hospitals within the Sacramento area that serve the region:

- Kaiser Permanente South Sacramento Medical Center (6600 Bruceville Road);
- Mercy General Hospital (4001 J Street);
- Methodist Hospital of Sacramento (7500 Hospital Drive);
- Shriners Hospital for Children – Northern California (2425 Stockton Boulevard);
- Sutter Medical Center, Sacramento (2825 Capitol Avenue); and
- UC Davis Medical Center (2315 Stockton Boulevard).

All of these facilities are designed and equipped to handle multiple, simultaneous patients during everyday activities and emergency situations.

The Kaiser Permanente South Sacramento Medical Center and UC Davis Medical Center are certified trauma centers serving the Policy Area. These facilities provide an enhanced level of life-saving care to victims of traumatic injuries. These facilities are staffed 24 hours per day with physicians, nurses, and other health care professionals who have special training in treating critical injuries to the head, spine and vital organs. Kaiser Permanente's hospital is a Level II Trauma Center. The UC Davis Medical Center is a Level I trauma center and a Level I pediatric trauma center.

Various groups offer health clinics designed to address the needs of specific underserved populations throughout the Sacramento area. Many of these clinics are operated in coordination with the UC Davis Medical Hospital, including the Joan Viteri Clinic, the Center for Aids Research and Education (CARES), the Paul Hom Asian Clinic, ClinicaTepati, Imani Clinic, and Shita Clinic. The County also provides CIMSP services at the following public clinics:

- Primary Care Center (4600 Broadway)
- Del Paso Health Center (3950 Research Drive)
- Capitol Health Center (1500 C Street)
- Oak Park Clinic - Oak Park Neighborhood Multiservice Center Health Clinic (3425 Martin Luther King, Jr. Boulevard)

The Department of Health and Human Services also operates the Sacramento County Mental Health Treatment Center (SCMHTC), located on 2150 Stockton Boulevard. The Minor Emergency Response Team unit also provides crisis intervention and stabilization for children and youth who are experiencing a psychiatric emergency. Inpatient hospitalization is available as a last resort when other treatment options are unsuccessful.

AT-RISK CRITICAL FACILITIES

Some climate hazards, such as floods, pose a direct physical threat to critical infrastructure and facilities, while others, like rising temperatures, are associated with multiple effects that will increase burden on or even threaten capacity of these critical facilities. Moreover, the extent to which key transportation, power, communication, health, and safety systems are central to the operation of the City makes risk factors even more significant. For instance, the majority of Sacramento's urban center, as well as vital public utilities, are dependent on levee protection.[306] [307] Damage or disruption from flooding due to levee failure may interfere with the operation of key transportation, power, communication, health, and safety systems. In addition, secondary hazards such as industrial facilities that store hazardous materials can be potentially harmful to the public and expose residents to significant health and safety risks if damaged during a climate hazard event.

Similarly, secondary climate change effects pose a threat to stormwater and wastewater systems, which can be overwhelmed and/or damaged by floods or storm events. A combined sewer overflow (CSO) can occur when a CSS becomes flooded and the volume of wastewater exceeds its storage capacity. This, in turn, can cause untreated stormwater and wastewater to be discharged into nearby streams, rivers, and other water bodies, threatening public and ecosystem health. This occurred three times between 2004 and 2012.[308]

Maps 25, 26, 27, and 28 illustrate critical facilities overlayed with FEMA flood zones. Critical facilities featured in the maps include emergency evacuation shelters, industrial facilities, public safety facilities, and transportation facilities. According to the maps, the vast majority of critical facilities are located within a flood zone. Areas with a higher probability of annual flooding, like the 100-year flood zone, may be unsuitable locations for existing critical facilities and may require relocations in the future.

Areas designated as Disadvantaged Communities by SB 535 (Chapter 830, Statutes of 2012) are specifically targeted for investment of proceeds from the State's Greenhouse Gas Reduction Fund (pursuant to AB 32), which the State appropriates to improve infrastructure, public health, quality of life, and economic opportunity, while also reducing pollution that causes climate change. Under SB 535, areas identified by CalEPA as Disadvantaged Communities—those that are disproportionately affected by environmental pollution and other hazards that can lead to negative health effects, exposure, or environmental degradation; or those with concentrations of people that are of low income, high unemployment, low levels of homeownership, high rent burden, sensitive populations, or low levels of educational attainment—represent opportunities to leverage funding for making improvements to existing critical facilities or providing new ones within the communities that need them most. Similarly, California Opportunity Zones, established in the Tax Cuts and Jobs Act of 2017, provide tax incentives for investment in designated census tracts. California Opportunity Zones support new investments in environmental justice, sustainability, climate change, and affordable housing.

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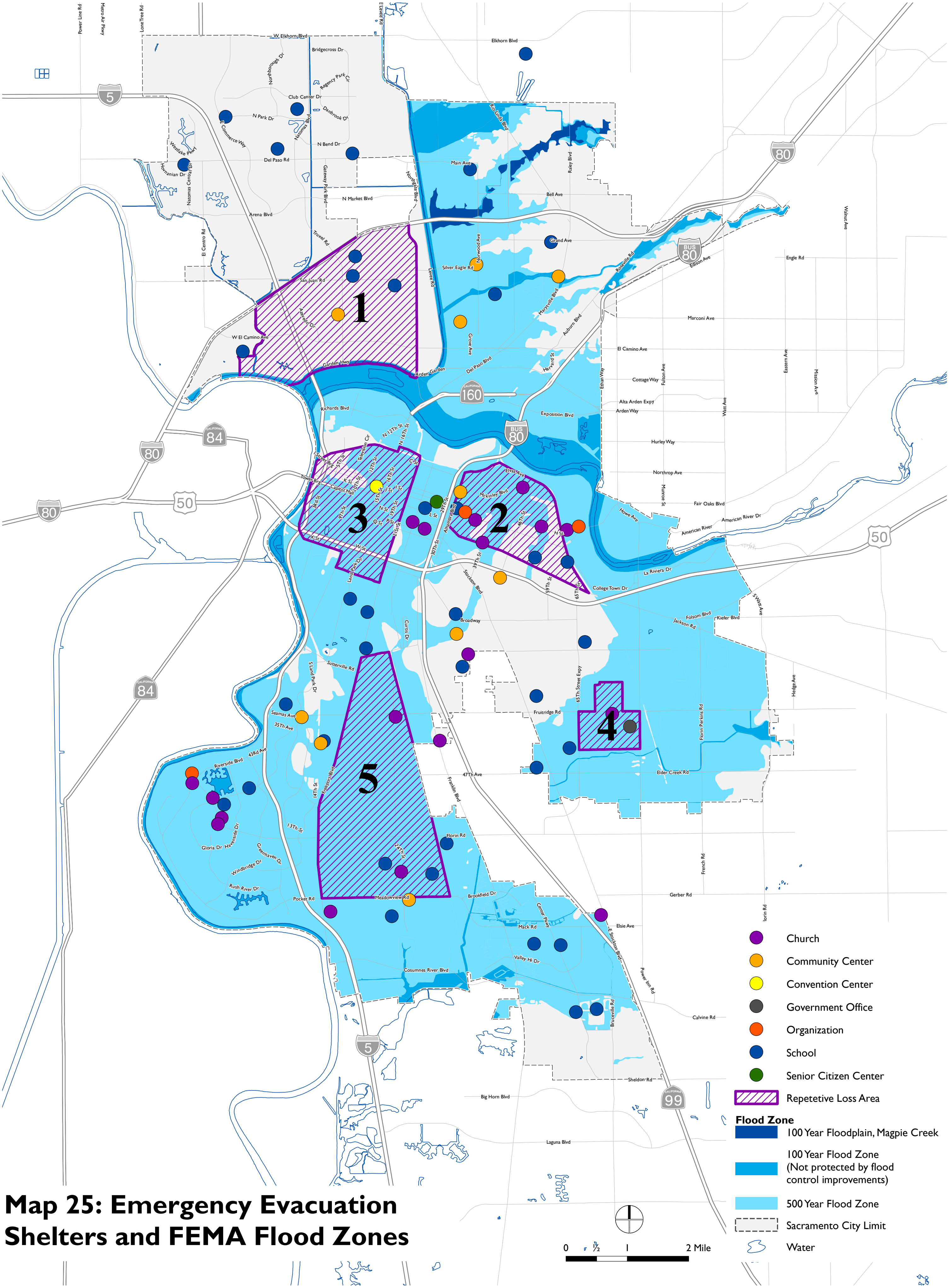
[306] Sacramento Municipal Utility District, 2018.

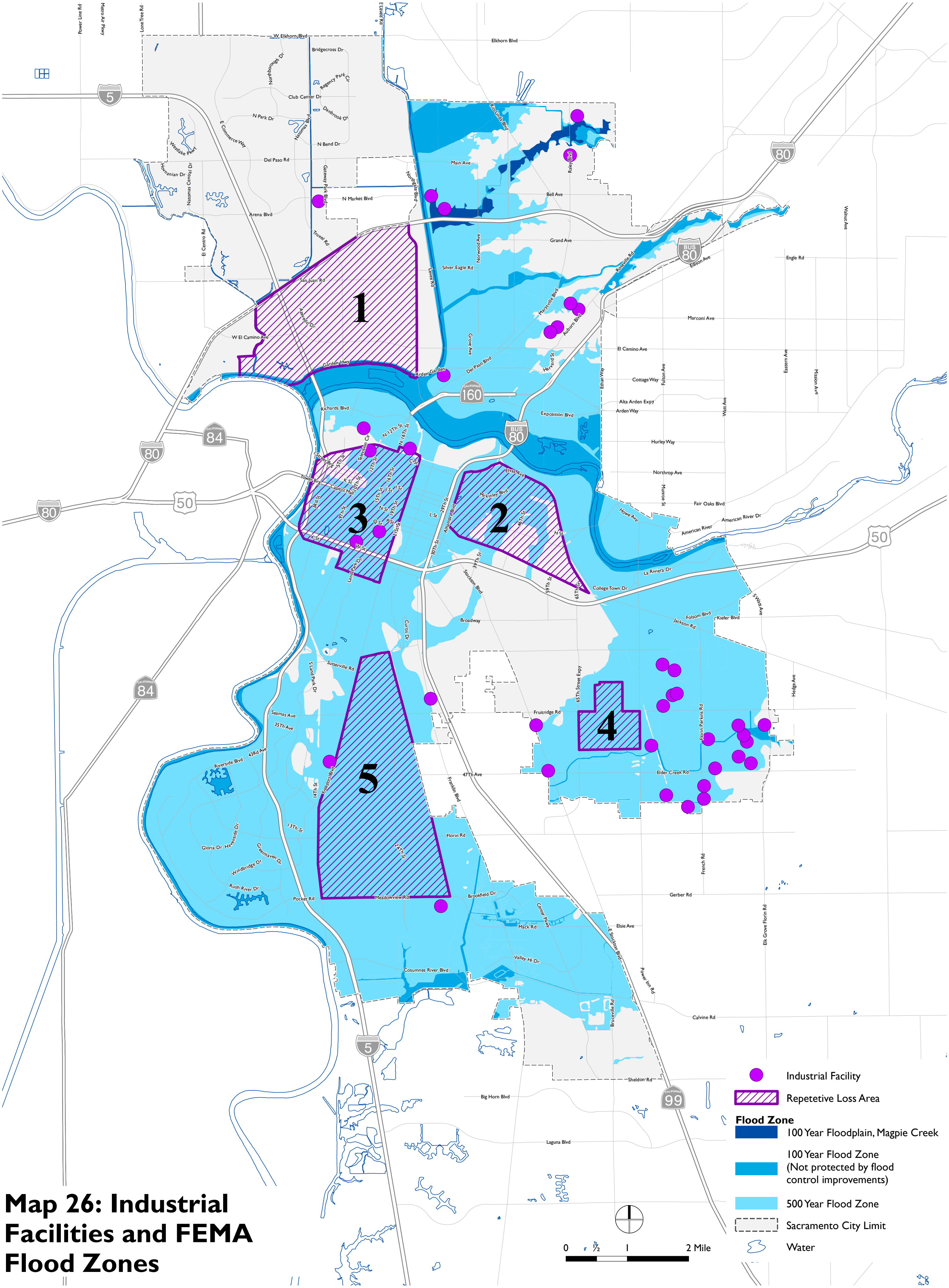
[307] Water Education Foundation, "Sacramento-San Joaquin Delta Levees." Nov 9 2019: https://www.watereducation.org/aquapedia/sacramento-san-joaquin-delta-levees.

[308] City of Sacramento Department of Utilities, Where does it go? A Snapshot of the City's Combined Sewer System.



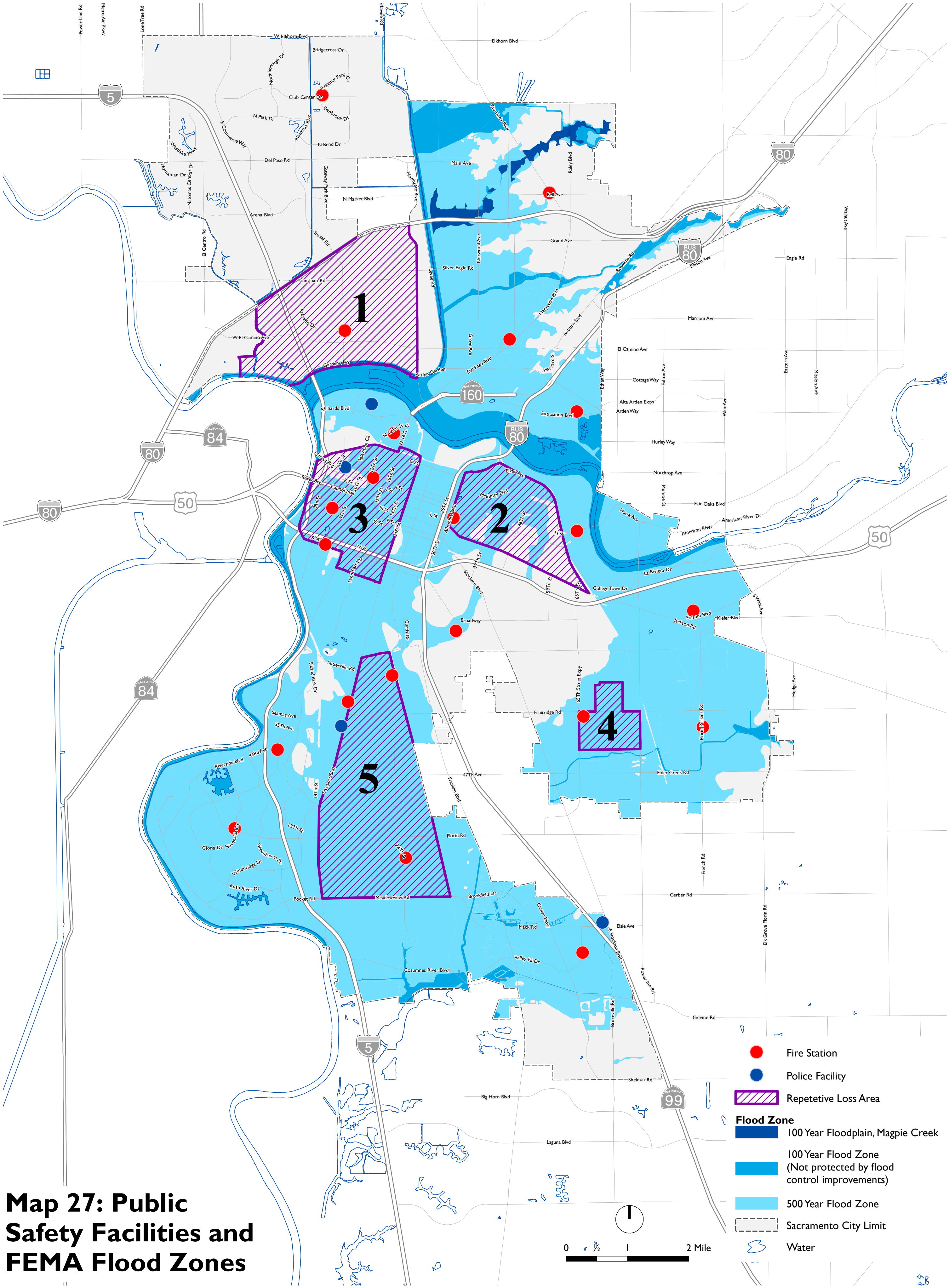
Map 25: Emergency Evacuation Shelters and FEMA Flood Zones

Source: CalAdapt/UC Berkeley, 2016; FEMA, 2015; City of Sacramento, 2019; Dyett & Bhatia, 2021



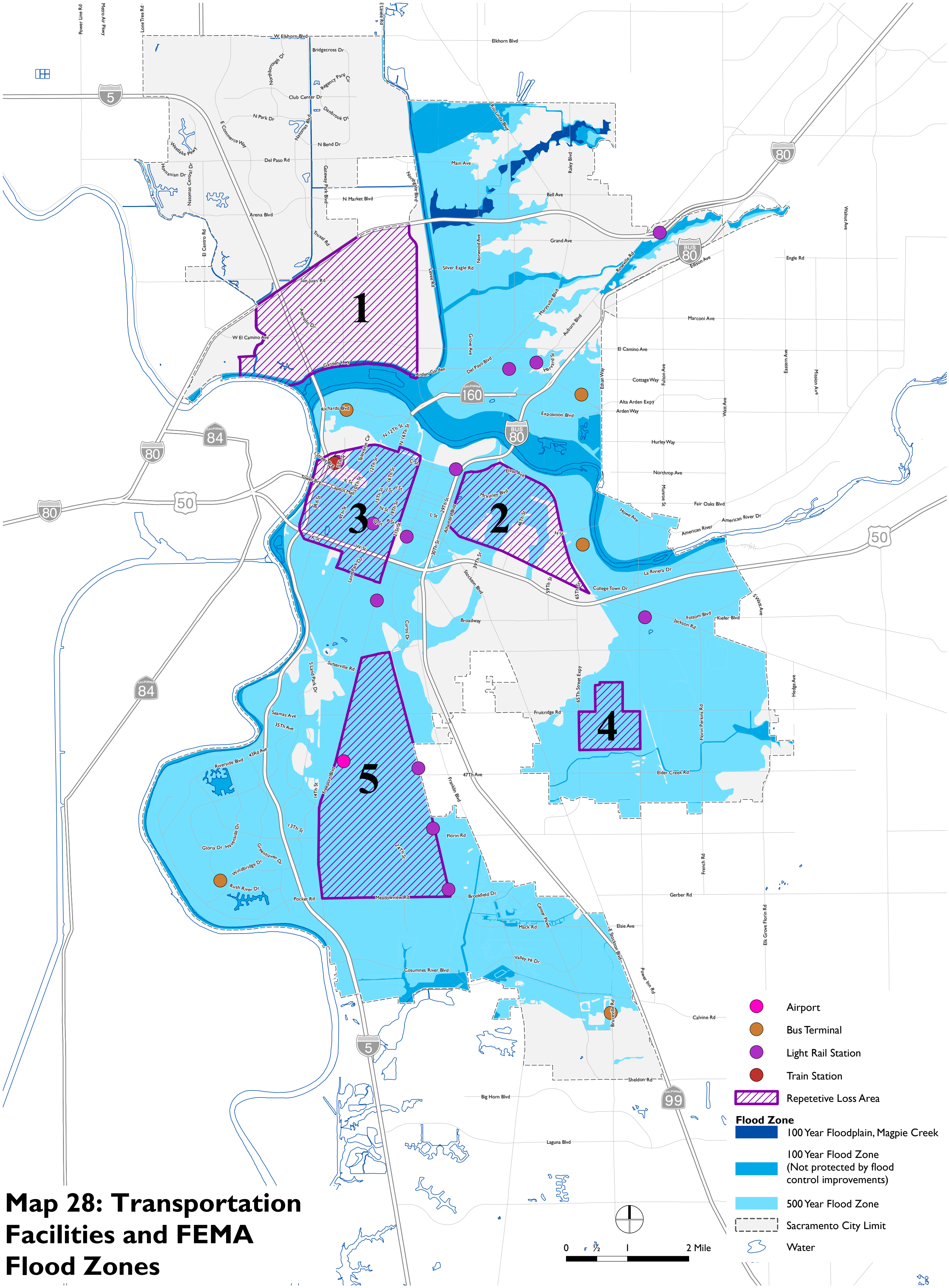
Map 26: Industrial Facilities and FEMA Flood Zones

Source: CalAdapt/UC Berkeley, 2016; FEMA, 2015; City of Sacramento, 2019; Dyett & Bhatia, 2021



Map 27: Public Safety Facilities and FEMA Flood Zones

Source: CalAdapt/UC Berkeley, 2016; FEMA, 2015; City of Sacramento, 2019; Dyett & Bhatia, 2021



Map 28: Transportation Facilities and FEMA Flood Zones

Source: CalAdapt/UC Berkeley, 2016; FEMA, 2015; City of Sacramento, 2019; Dyett & Bhatia, 2021

Sacramento's designation in 2015 as a "promise zone" by the U.S. Department of Housing and Urban Development is the catalyst for service expansion in Sacramento's most economically distressed neighborhoods. Through the Promise Zone Initiative, the federal government works with local leaders and organizations in high poverty communities to increase economic activity, improve educational opportunities, leverage private investment, reduce violent crime, enhance public health, and address other priorities identified by the community. Promise Zone funding has supported expanded access to critical facilities and services including a new hospital and a new community health clinic. Additionally, improvements in communitywide health and wellness and strengthened community capacity can help reduce the factors that make certain populations more vulnerable to climate-related risks. Sacramento's Promise Zone encompasses 22 square miles from Del Paso Heights in the north to Oak Park and part of Fruitridge Manor neighborhood in the south. Sacramento's Disadvantaged Communities, Opportunity Zones, and federal Promise Zone are shown in Map 29.

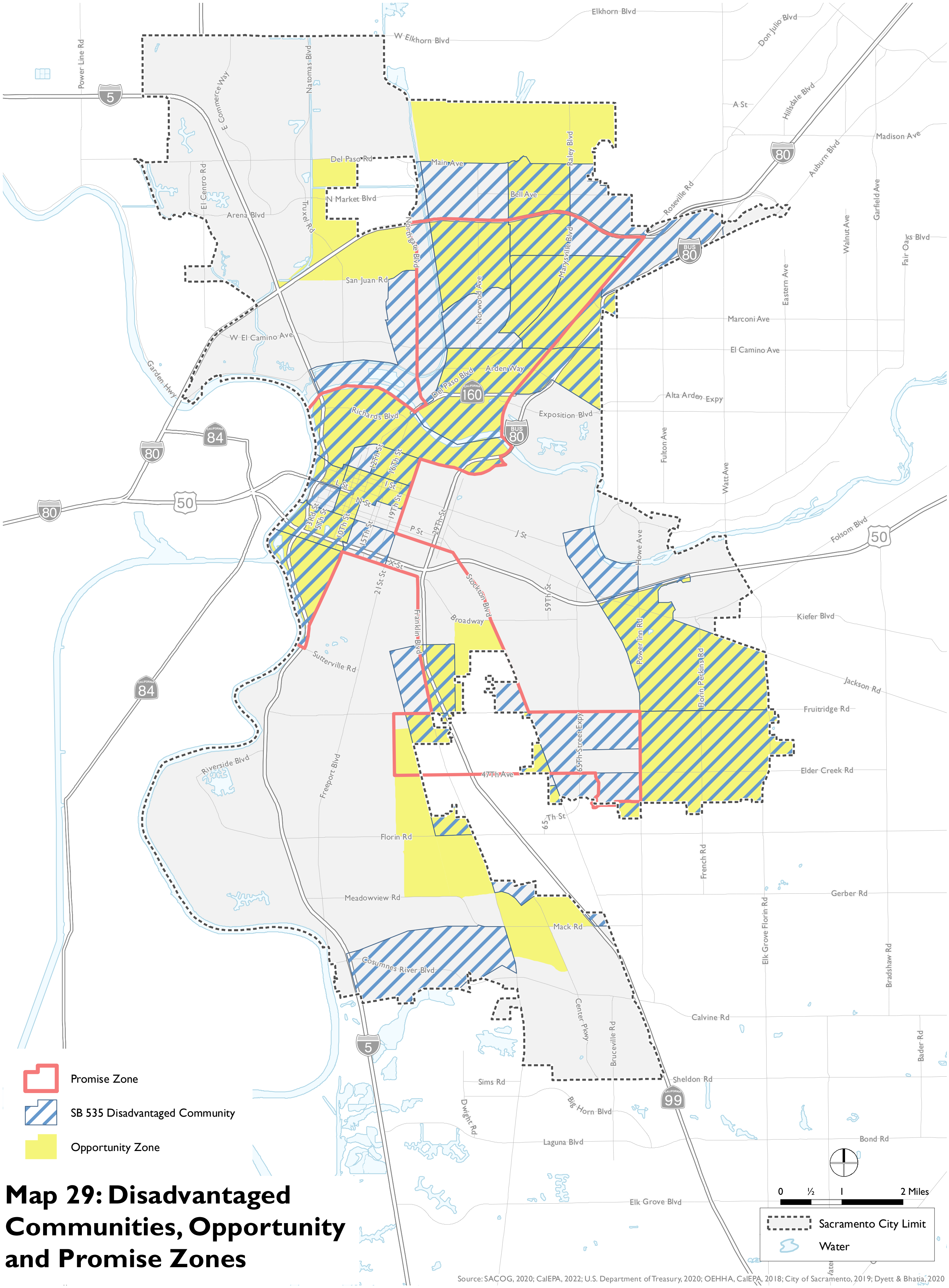
Emergency Evacuation and Response

As the severity and frequency of floods and wildfire increase across the Sacramento region and beyond, municipalities throughout the state will increasingly rely on emergency evacuation and response systems. Municipalities can expect an increased demand for emergency response/staff and social services, the need for more cooling/clean air/evacuation centers, and the need for expanded roadway capacity in the event of an evacuation.

Sacramento may experience increased demand for its fire protection services. While the urban-wildland interface in the city is not extensive, there will likely be an added strain on local Sacramento firefighting resources as the fire department is called to respond to fires across the region and State. Wildfires also exacerbate the poor air quality conditions already experienced in California's Central Valley. Smoke and other air pollutants generated by wildfires can lead to increased need for medical attention and services among affected vulnerable populations, such as those with pre-existing medical conditions like asthma or populations that spend a lot of time outdoors including outdoor workers and unsheltered homeless people.

Climate change is expected to bring more frequent and severe heatwaves, flooding, drought, and wildfires to the Sacramento region. This in turn requires more social and medical support services which include public cooling and clean air centers and evacuation centers. Additional social support infrastructure will require more public dollars from the City to operate, maintain, and properly engage with residents to advertise services. Public cooling centers are crucial facilities that provide cool shelter to prevent heat-related illness. Similarly, healthy air centers provide respite when there is poor ambient air quality, particularly when there are active wildfires nearby. Finally, pre-designated evacuation facilities are essential to ensure the safety of Sacramento's population in an event of a flood or wildfire.

Increased levels of homelessness and higher housing costs have been reported following major California wildfires. Displaced residents from neighboring communities also have the potential to increase demand for social support services in Sacramento. Reductions in housing stock and increases in local demand may increase housing prices and exacerbate housing insecurity, evictions, and homelessness among lower income individuals and families.



Map 29: Disadvantaged Communities, Opportunity and Promise Zones

The primary natural hazard that would cause the City to begin a large-scale evacuation is a flood. Evacuation during a natural hazard event may result in the evacuation of hundreds or hundreds of thousands in Sacramento. Realtime information and GIS-operated mapping is posted to numerous public-facing sites during large-scale evacuation events, following procedures established in the City's Evacuation Plan (an annex of the City of Sacramento Emergency Operations Plan). If available to public safety officials, evacuation information may be provided in multiple languages. Emergency preparedness resources are available to the public both online and distributed during community events. The movement of evacuating vehicles during a large-scale evacuation requires extensive traffic control to maximize the use of roadway capacity and expedite safe escape from hazards. A transportation analysis identifies critical roadway segments and intersections that are not expected to flood and recommend specific traffic control measures and/or roadway modifications to help alleviate the anticipated problems in these areas. Special care should be given to transport vulnerable populations, such as the elderly or persons with access and functional needs.

4 Adaptive Capacity

The chapter describes the climate change readiness landscape in California and addresses the vulnerabilities discussed in Chapter 3 by identifying responsible agencies at the federal, state, regional, and local levels and potential gaps in existing adaptation strategies. This chapter also includes a discussion of Sacramento's capacity to adapt and respond to those risks caused by climate change in an effort to improve resilience.

4.1 Climate Change Readiness Landscape

STATE LEGISLATION AND GUIDANCE

The State of California has adopted several legislative actions to mitigate the onset of climate change and prepare for its impacts. Passed in 2016, SB 379 requires that, beginning January 1, 2017, all cities and counties in California include climate adaptation and resiliency strategies in the safety element of their general plan as part of the general plan revision process. The climate adaptation update must include community goals, policies, and objectives that are informed by a climate change vulnerability assessment[309], as well as measures for addressing climate vulnerabilities. To assist with these requirements, the State of California has also established programs and guidance for climate change adaptation. These include the California Adaptation Planning Guide and Adaptation Clearinghouse[310], SB 246[311], and AB 1482.[312] Collectively, these plans and policies identify the key climate impacts most likely to affect California, provide guidance on how to analyze climate change vulnerabilities and adaptation opportunities as part of the community planning process, and help local and regional governments and agencies collaborate to identify and implement equity-promoting adaptation strategies.

Additionally, in 2018 the State of California published the Fourth Climate Change Assessment, including the Sacramento Valley Regional Report.[313] Primary climate impacts discussed in the report include warming air and water temperatures, more extreme heat waves, drier landscapes, less snow, variable precipitation and seasonal shifts, more intense droughts and floods, higher delta water levels, increased risk of wildfire, and loss of ecosystem habitat. The report concludes that public health challenges will arise in the form of an increased number of extremely hot days, the spread of infectious diseases, and reductions in air quality, with the young, elderly, and members

[309] ResilientCA, SB 379. Oct 29 2019: https://resilientca.org/projects/bf4c7799-3157-4cf0-ba4d-894f1ddcdf7a/.

[310] Adaptation Clearinghouse, California Climate Adaptation Planning Guide. June 2020 https://resilientca.org/apg/

[311] Adaptation Clearinghouse, California SB 246 – Integrated Climate Adaptation and Resiliency Program. Oct 29 2019: https://www.adaptationclearinghouse.org/resources/california-sb-246-integrated-climate-adaptation-and-resiliency-program.html.

[312] Adaptation Clearinghouse, California AB 1482: Climate adaptation strategy. Oct 29 2019: https://www.adaptationclearinghouse.org/resources/california-ab-1482-climate-adaptation-strategy.html.

[313] Benjamin Houlton and Jay Lund, California's Fourth Climate Change Assessment - Sacramento Summary Report (University of California, Davis: 2018), accessed October 3, 2022: https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-002_SacramentoValley_ADA.pdf

of disadvantaged communities most vulnerable. The report includes recommendations for reducing climate change risks, including developing climate-smart buildings and more accessible public cooling centers, fire reduction practices, enhanced emergency preparedness with a focus on disadvantaged communities, and land use planning practices that focus on extreme floods and drought.

REGIONAL AGENCY PLANS AND EFFORTS

Many agencies in the Sacramento region have already taken concrete steps toward addressing climate change vulnerability and implementing mitigation and adaptation strategies. Key regional climate change plans, assessments, and programs are summarized below.

Sacramento Area Council of Governments (SACOG)

- **Sacramento Region Transportation Climate Adaptation Plan (2015).** Highlights key climate change phenomena likely to influence the transportation system throughout the Sacramento region, as well as strategies and actions that Sacramento-area governments can take to ensure that transportation assets are adaptable. Transportation sectors and infrastructure types considered include roadways, railways, bridges, walking and biking, drainage, traffic flow, public transit, buildings and facilities, and traffic controls.[314]
- **SACOG Vulnerability and Criticality Assessment (2020)**. Establishes a better understanding of extreme weather and climate change threats to the region's transportation system. Expected changes in wildfire, riverine flooding, sea level rise, storm surge in the Sacramento-San Joaquin River Delta, and extreme heat are identified as hazards that pose significant risks to portions of the regional transportation system.[315]
- **SACOG Project-Level Adaptation Strategies Guidance Document (2020).** Building on the findings of the Vulnerability and Criticality Assessment (above), this study examines risks facing individual transportation assets in greater detail and evaluates potential adaptation strategies at an asset-scale.[316]

County of Sacramento

- **Sacramento County Climate Action Plan Strategy and Framework Document (2011).** Describes actions that the County has already taken or has planned to take in order to reduce greenhouse gas emissions and adapt to climate change. The Plan discusses climate actions in terms of five sectors: transportation and land use, energy, water, waste management and recycling, and agriculture and open space.[317]

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[314] Sacramento Area Council of Governments, 2015.

[315] Sacramento Area Council of Governments, Vulnerability and Criticality Assessment, June 2020, Accessed August 25, 2022: https://www.sacog.org/sites/main/files/sacog_vulnerability_and_criticality_assessment_report.pdf

[316] Sacramento Area Council of Governments, Project-Level Adaptation Strategies Guidance Document, June 2020, Accessed August 25, 2022: https://www.sacog.org/sites/main/files/sacog_project-level_climate_adaptation_strategies_for_transportation_guidance_report.pdf.

[317] County of Sacramento, Climate Action Plan: Strategy and Framework Document, November 9, 2011. Accessed May

- **Climate Change Vulnerability Assessment for the Sacramento County Climate Action Plan: Communitywide Greenhouse Gas Reduction and Climate Change Adaptation (Communitywide CAP) (2017).** Provides an overview of the primary and secondary threats associated with climate change and identifies the ones most likely to affect Sacramento County. The assessment identifies population subgroups, community functions, and structures that are most sensitive to each of the climate impacts.[318]
- **Sacramento County Multi-Jurisdictional Local Hazard Mitigation Plan Update (2021).** The County's 2021 Local Hazard Mitigation Plan (LHMP) updates 2016 LHMP and addresses hazards posed by climate change. The Plan identifies drought and water shortage, extreme heat, and wildfire as hazard sources that are highly influenced by climate change; dam failure, flooding, levee failure, and wildfires are identified as hazards of high significance (widespread potential impact). The LHMP recommends County- and City-level hazard mitigation actions to address these hazards.[319]
- **Sacramento County Climate Action Plan (2022).** The Sacramento County Climate Action Plan details specific measures that will be implemented in Sacramento County by 2030 to reduce communitywide GHG emissions and also includes an adaptation plan that recommends actions to reduce the community's vulnerability to the anticipated impacts of climate change.[320] The County's CAP is based on the 2011 Framework Document (above).

Sacramento Metropolitan Fire District

- **Community Wildfire Protection Plan (2014).** Addresses wildfire risk within the district's service territory by providing community education materials to reduce residential wildfire risk. [321]

Sacramento Municipal Utility District (SMUD)

- **Climate Readiness Assessment and Action Plan (2016).** Highlights the key steps that SMUD has taken to respond to climate change threats, including a climate vulnerability assessment for SMUD's critical assets such as power plants, substations, and transmission and distribution lines.[322]

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12 2020: https://planning.saccounty.net/PlansandProjectsIn-Progress/Documents/Climate%20Action%20Plan/CAP%20Strategy%20and%20Framework%20Document.PDF.

318 Ascent Environmental, 2017.

319 County of Sacramento, Sacramento County Multi-jurisdictional Local Hazard Mitigation Plan Update, September 2021, Accessed August 25, 2022: https://waterresources.saccounty.gov/stormready/Documents/LHMP%202021/Executive%20Summary%20and%20TOC.pdf.

320 County of Sacramento, Climate Action Plan, February 2022, Accessed August 25, 2022: https://planning.saccounty.net/PlansandProjectsIn-Progress/Documents/Climate%20Action%20Plan/Revised%20Final%20Draft%20CAP_February%202022.pdf

321 Sacramento Metropolitan Fire District, "Community Wildfire Protection Plan," 2014. Accessed August 25, 2022: https://metrofire.ca.gov/community-wildfire-protection-plan.

322 Sacramento Municipal Utility District, 2016..

- **Local Hazard Mitigation Plan (2018).** Identifies and introduces strategies for reducing environmental and man-made hazards that have the potential to impact SMUD's customers and energy delivery infrastructure. The hazard mitigation plan discusses climate change hazards explicitly, as well as hazards associated with secondary climate change impacts such as fire and flooding.[323]

- **Wildfire Mitigation Plan (2022).** The 2022 wildfire mitigation plan (WMP) is the comprehensive update to the initial plan adopted in 2019 to construct, maintain, and operate SMUD's electrical facilities to minimize the risk of wildfire posed by those facilities. The plan includes vegetation management programs, inspection and maintenance programs, protocols for deactivating automatic reclosers and for de-energizing power lines in severe weather conditions. It also identifies priority customers, including first responders and local agencies, healthcare providers, water and telecommunication facilities, and groups that assist vulnerable populations.[324]

Sacramento Metropolitan Air Quality Management District (SMAQMD)

- **Sacramento Metropolitan Air District Climate Change Protection Program.** Provides outreach and support for local, regional, state, and federal initiatives addressing climate change. Program efforts focus on reducing greenhouse gas emissions and helping the Sacramento region prepare for the effects of climate change. SMAQMD assesses new construction and development projects for greenhouse gas emissions and other air pollutants, provides financial assistance for residents to replace wood burning stoves, and has partnered with ZipCar, Mutual Housing California, and the Sacramento Housing and Redevelopment Agency to bring electric vehicle car sharing to multifamily and low-income housing communities as part of the first low-income EV-share program in the State.[325]

Regional Water Management

Water Forum

The Water Forum was created in 1993 by the City and County of Sacramento in response to increasingly conflicting water demand and environmental needs. In 2000, stakeholders came together to sign the Water Forum Agreement, forming a partnership between local governments, water managers, business and agricultural leaders, citizen groups, and environmentalists collaborating to provide a reliable and safe water supply for the region's economic health and planned development through the year 2030, in addition to preserving the fishery, wildlife, recreational, and aesthetic values of the lower American River. The Water Forum helps guide

[323] Sacramento Municipal Utility District, 2018.

[324] Sacramento Municipal Utility District, Wildfire Mitigation Plan, 2022, Accessed August 25, 2022: https://www.smud.org/-/media/Documents/In-Our-Community/Safety/2022-SMUD-Wildfire-Mitigation-Plan.ashx.

[325] Sacramento Metropolitan Air Quality Management District, "Keeping Cool in the Capital Region: Capital Region Urban Heat Island Mitigation Project," 2020, accessed October 3, 2022: https://urbanheat-smaqmd.hub.arcgis.com/

cohesive regional groundwater management across the North, Central, and South subbasins in the Sacramento area.[326]

There are seven elements of the Water Forum Agreement that are endorsed and implemented by signatories of the Water Forum Agreement: increased surface water diversions, actions to meet customers' needs while reducing diversion impacts in drier years, support improved fishery flow releases from Folsom Reservoir, habitat management, water conservation, the groundwater management, and the Water Forum Successor Effort.

Regional Water Authority

The Regional Water Authority (RWA) is a joint powers authority formed in June 2001, representing 24 water providers and agencies in the greater Sacramento region that seek to serve, represent, and align the interests of regional water providers and stakeholders to improve water supply reliability, availability, quality, and affordability.[327]

RWA's Strategic Plan 2018+, published in 2013, established goals to guide effective regional water resources management, including developing a Regional Water Reliability Plan, implementing the American River Basin Integrated Regional Water Management Plan, increasing education and outreach, and expanding regional water regulatory efforts to protect water supply reliability.[328] RWA has since had recent success including participating in the regional conjunctive use program that supports reduced diversions from the American River in dry years, undertaking preparation of the American River Basin Integrated Regional Water Management Plan, developing the Regional Water Efficiency Program, providing assistance for local water suppliers to implement the Water Forum Agreement, and funding water supply, water quality, and environmental restoration projects through more than $68 million of state and federal grant funds.[329]

Sacramento Groundwater Authority

The Sacramento Groundwater Authority (SGA) is a joint powers authority that manages the groundwater basin in Sacramento County north of the American River, encompassing the southern one-third of the North American Subbasin. SGA is an essential partner of the Water Forum Agreement of 2000, a key component of which is a regional program to manage and conjunctively use groundwater and surface water to help meet water needs through 2030, while reducing diversions from the lower American River during environmentally sensitive times such as droughts.

In 2021, SGA and other groundwater sustainability agencies of the North American Subbasin prepared a groundwater sustainability plan, pursuant to the State's Sustainable Groundwater Management Act. Based on a water budget of the Cosumnes-South American-North American

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[326] Water Forum, "About Us," accessed October 3, 2022: https://www.waterforum.org/stakeholders/about-the-water-forum/

[327] Regional Water Authority, "About," accessed October 3, 2022: https://rwah2o.org/about-rwa/

[328] Regional Water Authority, Strategic Plan 2018+, 2013, accessed October 3, 2022: https://rwah2o.org/wp-content/uploads/2016/02/RWA-Strategic-Plan-2018.pdf

[329] Regional Water Authority, "Regional Water Authority Success," accessed October 3, 2022: https://rwah2o.org/about-rwa/regional-water-authority-success/

subbasins, there is a current surplus of water, which is projected to continue into the future but in lesser amounts. However, future conditions modeled with a moderate climate change scenario estimate a future deficit of about 3,500 acre-feet per year. To address this deficit, the North American Subbasin Groundwater Sustainability Plan evaluated a conjunctive use project that has a net benefit of reducing groundwater pumping by 5,000 acre-feet per year, using primarily existing infrastructure and funding by public water suppliers. The planned Natomas Cross Canal project will also improve flood protection and provide habitat for aquatic species. There are five management actions in the plan: continue developing the Sacramento Regional Water Bank; improve well permitting programs throughout the subbasin to protect domestic wells, groundwater-dependent ecosystems, and interconnected surface water; proactively coordinate with land use agencies; improve data collection and communication with domestic and other shallow well owners; and continue monitoring and assessment of groundwater-dependent ecosystems.[330]

Sacramento Central Groundwater Authority

The Sacramento Central Groundwater Authority (SCGA) is one of six groundwater sustainability agencies that manages the long-term sustainable groundwater yield of the South American Subbasin in Sacramento County between the American and Cosumnes Rivers. In 2006, the SCGA developed the Central Sacramento County Groundwater Management Plan, which assesses water supply and demand, incorporating water conservation measures from the Water Forum Agreement to reduce demand, in addition to assessing risks to groundwater quality.[331] This plan establishes a groundwater extraction threshold of 273,000 acre-feet per year, sets minimum groundwater elevations within all areas of the subbasin consistent with the Water Forum, protects against potential subsidence and adverse impacts to surface water, and identifies water quality objectives for constituents of concern. As of 2018, SCGA continues to be under the groundwater yield threshold.[332]

The South American Subbasin Groundwater Sustainability Plan, published in October 2021, found that groundwater usage will continue to be sustainable over the next twenty years as long as planned recycled water, recharge, and other projects are implemented. These projects will raise groundwater levels above current levels, maintain storage volumes, and protect ecosystems, interconnected surface water, and shallow well users despite projected climate change conditions that will increase groundwater use. Implementing activities identified in the plan include: ongoing monitoring and annual reporting on conditions in the subbasin; public engagement and outreach; regional coordination; development and implementation of a shallow well protection and monitoring program; development of a regional water bank; coordination with land use and water supply

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330 Sacramento Groundwater Authority, North American Subbasin Groundwater Sustainability Plan, December 2021: https://sgma.water.ca.gov/portal/service/gspdocument/download/6197

331 Sacramento Central Groundwater Authority, Central Sacramento County Groundwater Management Plan, February 2006, accessed October 3, 2022: https://scgah2o.saccounty.gov/documents/CSCGMP_final.pdf

332 Sacramento Central Groundwater Authority, 2018 Sustainable Groundwater Management Act Annual Report – South American Subbasin (5-021.65), March 2019, accessed October 3, 2022: https://scgah2o.saccounty.gov/Documents/2018%20SCGA%20Annual%20Report%20South%20American%20Subbasin%205-021.65_20180329.pdf

agencies to promote consistency with the plan; coordination with regional agencies to develop updated climate change projections; and preparation of a five-year update to the plan (in 2027).[333]

Regional San

Originally formed in 1973, Regional San today is a partnership between the Sacramento Area Sewer District and the cities of Sacramento, Folsom, and West Sacramento to manage regional wastewater treatment. Located in Elk Grove, the Sacramento Regional Wastewater Treatment Plant is connected to approximately 111 miles of interceptor pipelines and cleans about 124 million gallons of the region's wastewater each day and safely discharges the treated effluent to the Sacramento River.[334]

Regional San's Harvest Water Program (formerly known as the South County Ag Program) is designed to provide safe, reliable supply of tertiary-treated water for crop irrigation, reducing groundwater pumping, supporting habitat protection efforts, and providing near-term benefits to the Sacramento-San Joaquin Delta. This program supports regional and State water supply reliability through groundwater storage and conjunctive use, with the potential to deliver up to 50,000 acre-feet per year of drought-resistant recycled water in lieu of pumping groundwater, resulting in an increase in groundwater storage by approximately 225,000 acre-feet within 10 years and up to 370,000 acre-feet over the course of the project. Such efforts will also serve to improve water quality by increasing in-stream flows in the Cosumnes River.[335]

Sacramento Area Flood Control Agency (SAFCA)

The Sacramento Area Flood Control Agency (SAFCA) was formed at the directive of the State Legislature in 1989 to address the Sacramento area's vulnerability to catastrophic flooding. This vulnerability was exposed during the record flood of 1986 when Folsom Dam exceeded its normal flood control storage capacity and several area levees nearly collapsed under the strain of high water pressure on levees from the storm. Formed under a Joint Exercise of Powers Agreement, SAFCA's board is comprised of the City of Sacramento, County of Sacramento, County of Sutter, American River Flood Control District and Reclamation District No. 1000.

SAFCA is responsible for the planning and implementation of major capital flood control improvements in the Sacramento area by providing the local cost-share to support construction of those projects. Day-to-day operations and maintenance of the flood control system is provided by various Local Maintaining Agencies (LMAs).

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[333] South American Subbasin Groundwater Sustainability Agencies, South American Subbasin Groundwater Sustainability Plan – Final, October 29, 2021, accessed October 3, 2022: http://www.sasbgroundwater.org/assets/pdf/resources/complete/FinalPDFs/SASbGSP_FrontEnd-ExecSumm_FINAL_10292021.pdf

[334] Regional San, "About Us," accessed October 4, 2022: https://www.regionalsan.com/about-us

[335] Regional San, "Harvest Water", accessed October 4, 2022: https://www.regionalsan.com/harvest-water

Central Valley Flood Protection Plan

The Central Valley Flood Protection Plan (CVFPP) is DWR's flood risk management plan for the Central Valley, developed in accordance with the Central Valley Flood Protection Act of 2008. Although flood management in the valley has improved considerably since 2008, climate change will exacerbate flood risk in the region. The 2022 CVFPP Update[336] evaluates progress made since major State bonds in 2007 and recommends future management actions, focusing on climate resilience, performance tracking, and alignment with other State efforts. The update continues to develop priorities to improve flood risk management in the Central Valley in the face of climate change, using new information, updated science, and innovative tools.[337]

LOCAL CLIMATE CHANGE READINESS

Greenhouse Gas Reduction Efforts

The City of Sacramento has a long-standing commitment to foster sustainability in government operations and community activities. Since adoption of the City's first Sustainability Master Plan in 2007, the City has led by example with internal projects that reduce reliance on fossil fuels while reducing operating costs and greenhouse gas (GHG) emissions. General Plan policies commit the City to continue striving for ongoing reductions in municipal and community GHG emissions through regular reviews and updates of the City's GHG emissions inventory at least once every five years to track Sacramento's progress towards its climate action goals. To date, GHG inventories have been completed for 2005, 2011, and 2016, as described further below.

In 2010, the City completed its first Climate Action Plan for Internal Operations (IO CAP) with strategies to reduce GHG emissions in City operations 22 percent below 2005 levels by 2020. In 2012, the City adopted its first community-wide Climate Action Plan (CAP), which included a target and strategies to achieve a 15 percent reduction below 2005 levels by 2020 for all sources of GHG emissions within the community as a whole. The IO CAP was later updated in 2016. The 2016 inventory counted emissions produced from residential and commercial electricity and natural gas usage, transportation, water delivery, wastewater treatment, and solid waste within City limits.

In March 2015, the City adopted the 2035 General Plan Update, which included new sustainability targets and an updated community-wide CAP integrated with the General Plan. The targets included reducing GHG emissions from internal operations by 22 percent below 2005 levels by 2020 (consistent with the 2010 IO CAP target), along with a long-term objective of achieving GHG

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336 California Department of Water Resources, Central Valley Flood Protection Plan 2022 Update Public Draft, April 2022, accessed October 3, 2022: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Flood-Management/Flood-Planning-and-Studies/Central-Valley-Flood-Protection-Plan/Files/CVFPP-Updates/2022/2022updateCVFPP22_layout_v9_plus_Append_BC.pdf

337 California Department of Water Resources, "Central Valley Flood Protection Plan," accessed October 3, 2022: https://water.ca.gov/Programs/Flood-Management/Flood-Planning-and-Studies/Central-Valley-Flood-Protection-Plan

reductions of 83 percent below 2005 levels by 2050. Reduction targets were established in the 2035 General Plan Policy ER 6.1.6, which also calls for maintenance and implementation of the IO CAP.

Current Climate Action, Sustainability and Resilience Efforts

The City of Sacramento already engages in a number of activities to reduce climate change vulnerability and promote adaptation across the city. These climate action efforts are in accordance with the City's vision statement to become a national model of sustainable, equitable growth, and community development. Guiding principles to aid the City of Sacramento in becoming leader in the field include sustainable and responsible growth, resilience and climate action.

Key to these efforts is the Mayors' Commission on Climate Change, which began in November 2018 as an effort between the City of Sacramento and City of West Sacramento to achieve carbon neutrality by 2045, in line with State GHG reduction goals. The final report from the Commission was published in June 2020 and recommended climate actions address the climate risks that threaten public health and safety in the two cities, with a focus on equity as well as foundational principles and strategies including urgency, advocacy, accountability, education, and financial and economic sustainability.[338]

In 2019, the City of Sacramento adopted Resolution No. 2019-0465, Declaring a Climate Emergency and Proposing Mobilization Efforts to Restore a Safe Climate Background.[339] In addition to recognizing the importance of the Mayors' Commission on Climate Change, this resolution underlined the role that the 2040 General Plan Update and CAP would play in achieving the City's goal of carbon neutrality by 2045 and emergency actions needed toward emissions elimination by 2030 as mandated by SB 32, the California Global Warming Solutions Act of 2016. Building on the recommendations from the Mayors' Commission on Climate Change, the City's Climate Emergency Declaration, and the previous (2012) CAP, the findings from this Vulnerability Assessment have informed development of the Adaptation chapter of the CAAP and the goals, policies, and implementing actions of the Safety Element of the 2040 General Plan.

In addition to these recent and ongoing efforts, the following City departments and local agencies provide services that generally address the risks posed by climate change effects identified in Chapter 2:

- **The City of Sacramento Community Development Department** has adopted a number of tasks and responsibilities related to climate change adaptation and hazard mitigation. These include coordinating with relevant organizations and agencies to consider the

[338] Mayors' Commission on Climate Change (Local Government Commission), Achieving Carbon Zero in Sacramento and West Sacramento: Final Report, June 2020, Accessed August 28, 2022: http://www.cityofsacramento.org/-/media/Corporate/Files/CDD/Planning/Long-Range/Climate-Action-Plan/Mayors-Commission-on-Climate-Change-Final-Report.pdf?la=en

[339] City of Sacramento, Resolution No. 2019-0465 "Declaring a Climate Emergency and Proposing Mobilization Efforts to Restore a Safe Climate Background, Adopted December 10, 2019, Accessed August 29, 2022: https://www.cityofsacramento.org/-/media/Corporate/Files/CMO/Climate-Change/R2019-0465-Declaring-a-Climate-Emergency-and-Proposing-Efforts-to-Restore-a-Safe-Climate-Background.pdf?la=en

impacts of urbanization and climate change on long-term natural hazards and safety, and engaging in land use planning and development.

- **The City of Sacramento Department of Utilities** engages in many activities related to flood management and response, including the development of the Flood Recovery Plan and providing public information about flood response planning. The Department has participated in efforts to map and assess vulnerability to sea level rise, study climate change effects on drinking water quality, address aquifer shortage, study groundwater recharge, and monitor and respond to algal blooms. The Department maintains floodplain development standards and has conducted drainage improvement projects to address the presence of repetitive loss properties. The Department also monitors upstream snowpack and river water supply and use. This information is used to determine when to draw from the Sacramento River, the American River, and/or groundwater wells. The Department is also active in the City's response to drought. The Department's Water Conservation Office provides residents and businesses with information and rebates on drought tolerant landscaping, irrigation upgrades, and leak repairs. The Department also engages in education and outreach activities.
- **The Office of Emergency Management** conducts emergency preparedness outreach to the public through community engagement events and online resources. The office has led the development of the Emergency Operations Plan, Recovery Plan, Joint Information Center Addendum to the Operational Area Joint Information System Plan, and proactive emergency planning and coordination for access and functional needs populations within the City of Sacramento. Other recent activities include the development of a new emergency operations center and conducting emergency and disaster preparedness exercises.
- **The City of Sacramento Department of Public Works** has many responsibilities, including the planning, building, and maintenance of most transportation infrastructure and street landscaping, providing recycling services, managing the City's vehicle fleet and buildings, and leading the City's electric vehicle initiatives. The Department builds walking and bicycling facilities and collaborates with transit providers to ensure that Sacramento's transportation landscape is robust, accessible, and sustainable. The Department also manages the city's urban forest through planting, protecting, and maintaining trees in the city right-of-way, parks and public spaces.
- **The Sacramento City Fire Department** implements a fire education and information program, participates in fuel reduction along the American River Parkway, and conducts outreach on the effects of smoke on air quality. Spare the Air Sacramento and the City of Sacramento Public Information Office engage in similar educational activities regarding the effects of smoke on air quality.

Community Climate Programs and Projects

The Sacramento region is home to a number of organizations that are actively involved in addressing climate issues in Sacramento. These organizations include community-based groups, larger non-profit organizations with Sacramento offices, and regional coalitions. These organizations are involved in a range of climate-related efforts include tree planting, air quality monitoring and education, urban agriculture, research, and disaster preparedness and recovery.

Sacramento is also home to the Sacramento Community Emergency Response Team, an all-risk, all-hazard training program that educates volunteer community members about disaster preparedness and trains them in basic disaster response skills, in partnership with the City of Sacramento Fire Department.

4.2 Existing Adaptive Capacity

This section highlights the federal, State, regional, and local responsible agencies and ongoing actions that they are taking to help communities mitigate and adapt to each of the climate change effects identified in Chapter 2 in relationship with the vulnerabilities presented in Chapter 3.

EMERGENCY EVACUATION AND RESPONSE

Emergency management is an essential component of the City's preparedness for a climate-change-induced emergency. Indeed, many risks and vulnerabilities are directly tied to the ability of service providers to adequately protect public safety and wellbeing in the face of an emergency event. The City of Sacramento has a comprehensive emergency management system that supplements the services and programs already set in place by the State. Together, these efforts build a strong foundation for the City's existing adaptive capacity.

State

The California Department of Transportation (Caltrans) manages more than 50,000 miles of State highway and freeway lanes and oversees programs for highway transportation, mass transportation, and transportation planning, among others. In 2021, Caltrans published the California Transportation Plan 2050 (CTP 2050), which recognizes the increasing risk that climate change poses on the State's transportation system. In particular, the State recognizes that climate change preparedness will require resilient infrastructure, reliable emergency response systems, and clean transportation options. One of the main safety objectives of the plan is to improve emergency preparedness, response, and recovery on the transportation system as these incidents become more frequent and severe. Enhancing transportation system resiliency is also tied with equity, and CTP 2050 utilizes vulnerability assessments to identify and manage the specific risks posed by climate change. It also calls for expanded funding for implementing State, local, and regional climate mitigation and adaptation plans; increasing multi-jurisdictional collaboration on resiliency and adaptation efforts; creating a statewide transportation risk management plan; and increasing access to data, technical tools, and information sharing to make communities stronger and more resilient to future disruptions.[340]

Originally developed in 2005 and last updated in 2022, Caltrans' Strategic Highway Safety Plan (SHSP) is a statewide, coordinated traffic safety plan that also addresses emergency response, which has been identified as one of 16 stakeholder-identified "challenge areas" where State resources and efforts will be focused. The Emergency Response strategy seeks to improve emergency response times and actions to address this challenge area. Past accomplishments toward this goal include

[340] California Department of Transportation, Califonira Transportation Plan 2050, February 2021, Accessed August 31, 2022: https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/ctp-2050-v3-a11y.pdf

increasing emergency medical services and fire personnel taking traffic incident management training and revising the California Emergency Medical Services Authority (EMSA) Manual #145 with the latest information. The SHSP also seeks to improve emergency response by leveraging co-benefits from actions addressing the emerging technologies challenge area.[341]

In California, day-to-day emergency medical services system management is the responsibility of local and regional agencies. However, the State EMSA is charged with providing leadership in developing and implementing statewide emergency medical services systems and standards. EMSA also is responsible for promoting disaster medical preparedness and, when required, coordinating and supporting the state's medical response to major disasters. Some of EMSA's primary program responsibilities include emergency medical services systems planning and development, emergency medical services for children, emergency medical dispatcher standards and emergency medical services communications systems, and disaster medical services preparedness and response.[342]

The California Governor's Office of Emergency Services (Cal OES) responds to and aids in the recovery from emergencies within the State of California under the authority of the California Services Act, California Disaster Assistance Act, and the Stafford Act. Cal OES is responsible for managing disaster recovery and providing assistance to local governments, special districts, certain nonprofit organizations, individuals, and businesses and agricultural communities impacted by disasters. It provides technical support to reduce the costs and streamline the process of recovery efforts and serves as a liaison with local, State, and federal agencies, legislators, nonprofit organizations, and the general public. It develops and maintains state-level emergency plans, assists local governments in developing their own plans, and is also responsible for the design, installation, and repair of the statewide public safety radio communication system.

The California Environmental Protection Agency (CalEPA) contains the CalEPA Emergency Response Management Committee, which coordinates preparedness for and responses to environmental emergencies in California. CalEPA's climate-related work includes analysis of the State's cap-and-trade program, studying urban heat islands, and operating the CalEPA Environmental Justice Task Force. The Environmental Justice Task Force coordinates the compliance and enforcement work of CalEPA's boards, departments, and offices in areas of California that are burdened by multiple sources of pollution and are disproportionately vulnerable to its effects.

The California Department of Public Health contains the Emergency Preparedness Office, which maintains and manages the Medical and Health Coordination Center, distributes funds to local health departments for disaster planning, and operates the California Health Alert Network. The Department also manages the Climate Change & Health Equity Program, whose goal is to systematically integrate work from climate change planning and public health planning with policies and principles that promote equity. The Department works with local, State, and national

[341] California Department of Transportation, California Safe Roads: Strategic Highway Safety Plan, Accessed August 31, 2022: https://dot.ca.gov/-/media/dot-media/programs/safety-programs/documents/shsp/2022-shsp-full-report-2020-2024-a11y.pdf

[342] California Emergency Medical Services Authority, "About the EMS Authority," Accessed August 31, 2022: https://emsa.ca.gov/about_emsa/#Dept_Description

partners to assure that climate change mitigation and adaptation activities have beneficial effects on health while not exacerbating preexisting health disparities.

Local

The City of Sacramento participates in the County's Local Hazard Mitigation Plan (LHMP) which serves to reduce or eliminate long-term risk to people and property form hazards. In addition to providing representation to the Sacramento County Hazard Mitigation Planning Committee, the City formulated their own internal planning team to support broader planning process requirements. The City participated in developing their community profile and hazard profile and vulnerability assessment to develop strategies. Key mitigation actions specifically designated to the City of Sacramento are to integrate the LMHP into the City's General Plan, enhance community outreach and education around hazard preparation and mitigation, consider impacts of long-term natural hazard safety, maintain a critical facility database, evaluate and mitigate critical facility risks, retrofit repetitive loss properties and historical buildings, construct a new Emergency Operation Center (EOC), protect transportation infrastructure, develop regional emergency and disaster preparedness exercises, establish heating and cooling centers in high priority areas, and adopt floodplain development standards. LHMP suggests a variety of plans to develop and adopt that include a generation plan for pump stations, disaster housing plan, disaster resistant business plan, enhanced emergency plan for special needs populations, and a post-disaster action plan.

The City's Office of Emergency Management (SacOEM) provides comprehensive emergency management services for the City of Sacramento, including coordination of City-wide preparedness, planning, response, recovery, and mitigation activities. It is the mission of SacOEM to prepare City government and the community for potential natural, human-caused, and technological emergencies. Programs facilitated by the Office include Flood Ready, which strives to build a flood resilient community through preparedness and mitigation. Resources provided to residents include floodplain information, flood warning systems, flood insurance information, and floodplain construction requirements. Similarly, the Sacramento Ready program, which was renewed in 2022, provides downloadable guides for quick evacuation, family disaster communications, and a personal safety plan. Residents can also sign up for Sacramento Alert, which is an emergency alerts notification system to disseminate public safety information rapidly and efficiently.

SacOEM also manages the City's Emergency Operations Center (EOC) which is staffed with City personnel who are trained to support first responders and community members in the event of a disaster. EOC also will assign paratransit and other transportation resources for the disabled or medically frail to the areas with greatest needs. In addition, EOC will designate task forces of buses, paratransit, and/or animal care vans as emergency vehicles able to enter evacuation zones.[343] These programs in turn can help maximize roadway capacity.

The City's 2023 Emergency Operations Plan (EOP) addresses planned response to emergency situations associated with natural disasters and human-caused incidents. The Plan outlines

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[343] City of Sacramento Office of Emergency Services, City of Sacramento Evacuation Plan for Floods and Other Emergencies (2008). August 26 2021: https://sacramentoready.saccounty.net/Documents/sac_018943.pdf.

emergency management operations, including personnel and departments responsible for managing an incident in the city. Operations in response to a disaster include preparedness and monitoring activity, alert and warning, proclaiming an emergency, city-wide coordination, and consideration of people with access and functional needs.

To facilitate the coordination and flow of mutual aid, the State has been divided into six OES Mutual Aid Regions (and three administrative regions). The City of Sacramento is in Mutual Aid Region IV. The City maintains an Automatic Aid agreement with Sacramento County and the City of West Sacramento. Under the automatic aid agreement, all emergency calls are routed through a central dispatch center and the nearest resource responds to the call. Statewide, California's mutual aid system is designed to ensure that adequate resources, facilities, and other support are provided to jurisdictions whenever their own resources prove to be inadequate to cope with a given situation. Local jurisdictions have the discretion to give and receive aid when needed, while state government is obligated to provide available resources to assist local jurisdictions in emergencies.

Sacramento's emergency alert and assistance systems include the Emergency Alert System, fire and law enforcement vehicle loudspeakers, Reverse 9-1-1, Sacramento 2-1-1, and agency websites. The Emergency Alert System is designed to provide emergency information via radio and television. The City of Sacramento's Reverse 9-1-1 system can send pre-recorded messages to individual households and businesses with phone numbers listed in the 9-1-1 database. The Community Services Planning Council, a non-profit organization, operates 2-1-1 in Sacramento County. Individuals can call into the system to request information on an emergency situation.

Evacuation procedures are most effective when residents are aware of the emergencies that are most likely to affect them and have ample time and support to prepare their own emergency plans. The City of Sacramento, in conjunction with Sacramento County, has a variety of systems and procedures in place to protect residents and visitors and to plan for, avoid, and respond to a hazard event. These include the provision of pre-disaster public awareness programs including a local emergency alert program, Community Emergency Response Training (CERT) program, and Crisis Action Team (CAT). Sacramento County's Office of Emergency Services maintains countywide emergency evacuation, operations plans, mass shelter, hazard mitigation, and severe weather plans and provides guidance to residents creating personal emergency preparedness plans. The City Manager's Office of Emergency Management coordinates communication, planning, preparedness, response, and recovery pertaining to emergency events and manages the City's Emergency Operations Center (EOC).

TEMPERATURE INCREASE

Increasing temperatures will result in more frequent and severe heat waves and warm nights that will be felt especially in urban heat islands. Given the high level of impact, vulnerable populations including children, older adults, individuals with disabilities, low-income households, outdoor workers, cost-burdened households, households living in substandard housing conditions, linguistically isolated households, and communities of color will be particularly at-risk. Critical facilities such as energy, transportation, and utility infrastructure as well as medical services may also be strained or physically damaged as a result of extreme heat.

General Mitigation and Adaptation Efforts

The County of Sacramento has engaged in a variety of climate-preparedness activities, some of which were initiated in partnership with the City. The Sacramento County Office of Emergency Services provides emergency-related information to the public. The Department of Public Health provides community-wide information for how to stay safe during periods of extreme heat. This includes warning signs of heat stroke and heat exhaustion, how to protect against heat-related illness, descriptions of heat-related illness among older adults, and how to help someone with a heat-related illness. Through the Sacramento Ready Program, the County has also designated public cooling centers in the event of a heat emergency. The Sacramento County General Plan also contains policies to promote cool communities in order to reduce urban heat island effects. Some of these policies include streetscaping, preserving habitats and open space, restoring natural areas, and reducing urban sprawl.

The City of Sacramento is also in the process of preparing an Urban Forest Plan. This Plan will address the protection, maintenance, sustainability, and enhancement of Sacramento's tree canopy. The City's longstanding emphasis on the importance of its beautiful tree canopy will aid its adaptation to the worsening effects of urban heat. In 2003, the City published parking lot tree shading and maintenance guidelines. These guidelines are meant to help achieve the City's parking lot tree shading ordinance which requires that all new parking lots include tree plantings designed to result in 50 percent shading of parking lot surfaces within 15 years. Guidelines include information about tree planting practices, drainage and water quality options, irrigation plans, landscape plans, grading, and maintenance.

The Sacramento Tree Foundation is a community-based non-profit organization working to support a healthy tree canopy for Sacramento. Ongoing programs include the Shade Tree Program in partnership with SMUD, which provides free shade trees to residents and businesses, which can help cool buildings and reduce air-conditioning use in summer. All Sacramento County residents and SMUD customers can qualify for a free landscape assessment and up to 10 free shade trees. An additional program formed from the Foundation's partnership with SMUD is Trees for Community Spaces. This program provides free consultation and trees to qualifying public spaces, such as schools and parks. The Shady Eighty tool provided by the foundation is a tree guide to help residents choose the best trees for their yard. Users can input characteristics such as size, water needs, shape, growth rate, and flowers to determine the species that best work for their property.

Vulnerable Populations

The California Department of Community Services and Development (CSD) administers the federally funded Low-Income Home Energy Assistance Program (LIHEAP). This program provides two types of assistance: Home Energy Assistance and Energy Crisis Intervention. The first type of assistance is a direct payment to utility bills for qualified low-income households. The second type of assistance is available to low-income households that are in a crisis. CSD also offers free weatherization assistance, such as cooling system repairs to low-income households.[344] These

[344] City of Sacramento, City of Sacramento Housing Element Appendix H-6 Opportunities for Energy Conservation. September 7 2021: https://www.cityofsacramento.org/-/media/Corporate/Files/CDD/Planning/Long-Range/Housing-Element/H6_Sac-HE_AdoptionDft_Energy-Conservation_Aug2021.pdf?la=en.

financial assistance programs can help vulnerable populations cool their households if they experience health hazards from urban heat.

In addition, the Sacramento County Department of Human Assistance (DHA) facilitates numerous programs to mitigate and adapt to the effects of urban heat. The severe weather sheltering program activates five cooling center locations for all community members during heatwaves. Homeless outreach partners also issue motel vouchers to highly vulnerable unsheltered individuals. Transportation will be provided to and from the hotel and individuals participating in the program are allowed to bring partners, pets, and belongings to respite facilities.

The Sacramento Municipal Utilities District (SMUD) provides utilities services within the City of Sacramento. SMUD has engaged in a number of climate readiness initiatives, including the creation of Climate Readiness Action Plan in 2016. The report lists several on-going or planned climate change-related initiatives that target increased resiliency to periods of drought and extreme weather events. Specific strategies related to urban heat include the Regional Urban Heat Island Initiative, SMUD Cool Roof Incentive, and the SMUD Shade Tree Program. SMUD's Regional Urban Heat Island Initiative focuses on reducing urban heat island effects through the identification of areas prone to urban heat island development and projected impacts on electrical load and health. This work will enable mitigation measures to be more effectively targeted and used to their greatest effect. The Cool Roof Incentive offers rebates to residential customers who use cool roofing technologies. Under this program, a single family could earn a $300 rebate (or more) for incorporating a cool roof and save an estimated $50 per year on their annual cooling bill. However, program utilization has more than doubled in 2016 yet is still quite modest. SMUD also provides low-income assistance and non-profit discount through the Community Resource Project. The Energy Assistance Program Rate (EAPR) provides discounts on monthly bills. Customers with the lowest household income, based on the federal poverty level, will receive the largest discount. Priority may be given to applicants based on the greatest need and income, vulnerable populations and households with young children. The Shade Tree Program started through a partnership between SMUD and the Sacramento Tree Foundation to provide more than 1,000,000 free shade trees to residents in the Sacramento area. This program encourages residents to strategically plant vegetation around their homes to reduce energy consumption. Homeowners must agree to plan and care for the trees.

As part of the NASA DEVELOP program in Fall 2020, the City partnered with the NASA Langley Research Center to study the effects of urban development on urban heat islands in the City of Sacramento and the potential for urban interventions to reduce risks, particularly in areas with the greatest vulnerability. The study used satellite imagery and input from City staff and Dyett & Bhatia, the 2040 General Plan Update consultant, to model current and future (2040) conditions under different scenarios—including buildout of the General Plan—down to a neighborhood scale. In turn, the results of this study informed policy development for the Environmental Justice and Environmental Resources Element of the General Plan. Specifically, urban heat priority intervention areas have been identified to target resources where they will be most effective and benefit those who are most at risk.

The Healthy Sacramento Coalition was initiated in 2011 by the Sierra Health Foundation in an effort to develop and implement a chronic disease prevention plan for Sacramento County. The goals of the Healthy Sacramento Coalition were to reduce tobacco use, obesity, death and disability due to chronic disease, reduce health disparities, build a safe and healthy physical environment, and improve the social and emotional well-being of Sacramento County residents. In 2016, the Coalition broadened its focus to include the social determinants of health and refined its vision to address health inequities in Sacramento. In 2018, the Coalition released *Advancing Health Equity and Inclusive Growth in the Sacramento Region*, highlighting inequities in income, employment, and educational opportunities in Sacramento.

Critical Facilities

The State of California's Title 24 Building Standards Code includes requirements for energy efficiency standards for residential and nonresidential buildings. Part 6 covers topics that include thermal emittance, three-year aged reflectance, and Solar Reflectance Index (SRI) of roofing materials used in new construction and re-roofing projects. These requirements apply to nonresidential, high-rise residential, and low-rise residential buildings across California. In addition, roofing products used for meeting the Title 24, Part 6 requirements must be rated and labeled by the Cool Roof Rating Council (CRRC).[345] However, it is important to note that these cool roof requirements only apply to new construction, retrofits, or additions, rather than existing buildings.

CHANGES IN PRECIPITATION AND SEA LEVEL RISE

Changes in precipitation include reduced snowpack, which can exacerbate drought conditions and impact groundwater supply, as well as increased severity and frequency of storm events that can induce flooding. Flooding impacts will also be compounded by the effect of sea level rise in areas near the Delta. Drought and flooding conditions are high-priority impacts in Sacramento, and groups who are most at risk include older adults, individuals with disabilities, low-income households, cost-burdened and poor-quality households, linguistically isolated households, agricultural workers, and communities of color. Critical facilities that are at risk include water supply, wet utilities and stormwater infrastructure, and locations within flood hazard zones (Maps 24 through 27).

General Mitigation and Adaptation Efforts

The Federal Emergency Management Agency (FEMA) manages national-level response to disasters and implements a number of programs designed to help local authorities respond to and mitigate the impacts of disasters, including the extreme weather events associated with climate change. FEMA conducts mapping of flood zones and administers the National Flood Insurance Program. The National Flood Insurance Program aims to reduce the socioeconomic impact of flooding on private and public structures through the provision of flood insurance and by encouraging communities to adopt and enforce floodplain management regulations. FEMA also provides general disaster response and hazard mitigation assistance through such entities as the Hazard Mitigation Grant Program, the Flood Mitigation Assistance Program, and the Pre-Disaster Mitigation Program.

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[345] Cool Roof Rating Council, California Building Energy Efficiency Standards (Title 24, Part 6). September 7 2021: https://coolroofs.org/resources/california-title-24.

Furthermore, the U.S. Army Corps of Engineers (USACE) may supplement state, tribal, territorial, and local governments with flood or coastal storm preparedness and response services and advanced planning measures designed to reduce the amount of damage caused by flooding. This assistance is in accordance with Public Law 84-99. When flooding occurs, it is not just a local USACE district or office that responds but may include personnel and other resources across the nation.

The California Natural Resources Agency is responsible for California EcoRestore, an initiative implemented in coordination with State and federal agencies to advance the restoration of the Sacramento-San Joaquin Delta. The Agency leads and coordinates the administration's climate adaptation policy and its natural resources climate policy and has helped guide the State's efforts towards increasing the resilience of water systems. Adaptation strategies primarily include floodplain and tidal habitat restoration and enhancement projects.

The Delta Stewardship Council is responsible for adopting and implementing a comprehensive management plan for the Sacramento-San Joaquin Delta. The Delta Plan is intended to help State and local agencies provide a more reliable water supply while protecting, restoring, and enhancing the Delta ecosystem. Policies and recommendations to meet these goals include the development of a Delta Science Plan, regional water self-reliance, water efficiency and management laws, water supply reliability guidelines, groundwater management plans, improved water conveyance infrastructure, expanded water storage, habitat and floodplain restoration projects, flood insurance requirements, and continued monitoring of existing conditions.

In addition, the City of Sacramento partnered with Sacramento County, other incorporated nearby communities, and numerous special districts to update the countywide Local Hazard Mitigation Plan (LHMP) in 2021. Flood, drought, earthquake, and severe weather are all addressed in the plan. While climate hazards such as these cannot be prevented, an LHMP forms the foundation for a community's long-term strategy to reduce disaster losses by breaking the repeated cycle of disaster damage and reconstruction. The plan aims to mitigate these hazards, such as floods, while providing the tools and information for residents to be able to better anticipate, adapt, and recover from such events.

The State Water Resources Control Board (SWRCB) engages in a number of climate change-related actions, including the expansion of recycled water to increase drought resilience, adoption of regulations to increase the capture of urban stormwater, and efforts to reduce flood risk. SWRCB has been involved in the Central Valley Region Climate Change Work Plan. Key focus areas of this plan include addressing impacts due to drought and flooding, issues related to groundwater quality, and changes in surface water supply, with a focus on disadvantaged communities.

Vulnerable Populations

A number of federal agencies provide direct relief and recovery support for drought impacts, particularly geared to those working in the agricultural industry. Short-term drought relief and recovery programs include Disaster Assistance Programs, Environmental Quality Incentives Program, Emergency Watershed Protection Program, Rural Utilities Service Water and Environmental Programs, and Economic Injury Disaster Loans. Long-term drought relief and recovery programs include the Federal Crop Insurance Corporation, Agricultural Conservation

Easement Program, Conservation Technical Assistance Program, Watersmart Drought Response Program, Watersmart Water and Energy Efficiency Grants, Building Resilient Infrastructure and Communities (BRIC) Program, and the Watersense Program.

Critical Facilities

The California Department of Water Resources engages in flood management and flood emergency response programs. It developed the Flood Emergency Response Information Exchange to improve flood emergency preparedness, response, and recovery. The Department maintains levees and access roads under their jurisdiction through the Levee Repairs Program and has supported local efforts at reducing flood risks in the Sacramento and San Joaquin Deltas. The Department has been involved in the Bay Delta Conservation Plan, the Central Valley Flood Protection Plan, and the South Sacramento Streams Groups Projects. The Department also implements the Sustainable Groundwater Management Act and administers the California Statewide Groundwater Elevation Monitoring Program.

The Central Valley Flood Protection Board is the State regulatory agency responsible for ensuring that appropriate standards are met for the construction, maintenance, and protection of the flood control system. The Board issues encroachment permits, works with other agencies to improve flood protection structures, enforces removal of problematic encroachments, and monitors the Central Valley's flood management system. In 2012, the Board adopted the Central Valley Flood Protection Plan. This Plan guides California's participation in managing flood risk along the Sacramento River and San Joaquin River systems. Primary goals of the Plan include identifying, recommending, and implementing structural and nonstructural projects and actions that benefit flood-prone lands and formulating standards, criteria, and guidelines to facilitate implementation of flood protection interventions.

The County's Department of Water Resources educates residents on flood risk and preparedness. The County has also been involved in the South Sacramento Streams Groups projects to implement more than 265 acres of habitat enhancements and the flood control projects on Magpie Creek which includes the construction of a floodwall, levee, culvert, and acquisition and protection of a 72-acre floodplain.

The Sacramento Area Flood Control Agency (SAFCA) provides regional flood control for the Sacramento Region. The overarching goal of their work includes strengthening the local levee system, improving the region's ability to manage flood events via improved reservoir level management, and addressing erosion along the Sacramento River. Key programs under this Agency include:

- **American River Common Features Project:** USACE has begun construction for up to 11 miles of erosion protection along portions of both the north and south banks of the American River. Once completed, the cumulative flood control improvements will allow the levee system to safely handle sustained flows of up to 160,000 cubic feet per second in the event of an extreme flood event in the American River watershed.
- **Folsom Dam and Reservoir Joint Federal Program:** To further increase flood control space in the reservoir, the USACE is raising the existing main dam and reservoir's surrounding dikes by 3.5 feet. Construction began in 2019 and is nearly complete.

- **Natomas Basin Levee Improvement Program:** By 2013, SAFCA and the state completed 18.3 of the 42 miles of levee improvements required to meet current flood control standards. In 2019, USACE began construction on the additional 24 miles of levee improvements necessary to provide a minimum 200-year level of flood protection to the Natomas Basin.
- **Sacramento Weir and Bypass Project:** USACE and the State of California are planning to widen the Sacramento Weir and Bypass to allow more water to enter into the Bypass system during flood events, thereby reducing the water surface elevation in the Sacramento River. This work includes widening the existing weir by 1,500 feet and constructing a new two-mile-long setback levee along the Sacramento Bypass. The first phases of construction began in 2020.

The City of Sacramento strives to build a flood resistant and resilient community through preparedness and mitigation projects. One such project is the City's Repetitive Loss Area Analysis (RLAA). This analysis identifies five regions of repetitive loss that are prone to experiencing numerous flood events. These regions include South Natomas, Downtown East, Downtown West, Southeast Sacramento, and Sutterville/Meadowview. In addition, the City has identified total of 49 repetitive loss buildings in these regions. However, 28 of these buildings have already been mitigated with measures introduced by the City. Mitigation recommendations typically include green infrastructure, grading improvements, pipe and drain improvements, construction of floodwalls, elevating buildings, combined sewer system improvements, and storm readiness outreach programs.

In 2020, City of Sacramento adopted an Urban Water Management Plan (UWMP). The purpose of the UWMP is to help water suppliers assess the availability and reliability of their water supplies and current and projected water use to help ensure reliable water service under different conditions. The Plan details water use baselines, targets, and 2020 compliance; a water supply analysis; a water service reliability and drought risk assessment, a water shortage contingency plan; and demand management measures to increase the city's resilience to droughts.

In August 2022, the federal Bureau of Reclamation published the American River Basin Study, which covers major water uses (municipal, agricultural, hydropower, recreation, flood control, and fish/wildlife), surface water uses from the American and Sacramento rivers, groundwater uses from North and South American groundwater basins, key reclamation facilities (Folsom and Nimbus dams and Folsom South Canal), and key regional facilities (Middle Fork Project 184, Sly Park Unit, and Upper American River Project). The study highlighted the growing imbalance between water demands and water supplies due to continued economic development, regulatory updates, and effects from climate change. Notably, changing climate conditions complicate operation of Folsom Reservoir. Severe drought conditions in late 2015, for example, resulted in the reservoir's lowest recorded water level (135,000 acre-feet), and only three months later in March 2016, several moderate El Nino storms necessitated releases for flood control management. Such rapid shifts underline the need for effective flood risk management strategies and potential upgrades to Folsom Dam infrastructure in response to anticipated climate changes.[346]

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[346] Bureau of Reclamation, American River Basin Study: Interior Region 10 – California-Great Basin, U.S. Department of the Interior, August 2022: https://www.usbr.gov/watersmart/bsp/docs/arbs/ARBS-Study.pdf

WILDFIRE

There is low risk of wildfire itself as a climate change effect in Sacramento, but its secondary impacts on air, water, and soil quality have more direct implications for the city's residents. In particular, smoke from wildfires in upwind high-risk areas such as the Sierras will affect the entire city and exacerbate ambient air pollution levels, especially affecting vulnerable populations such as children, older adults, individuals with disabilities, low-income households, outdoor workers, linguistically isolated households, and communities of color. Critical facilities that may be affected include clean air/evacuation centers and transportation infrastructure essential to emergency evacuation/response.

General Mitigation and Adaptation Efforts

FEMA provides general disaster response that can aid in wildfire hazard mitigation and prevention through such entities as the Hazard Mitigation Grant Program, the Pre-Disaster Mitigation Program, and the Fire Management Assistance Grant Program. These grant programs help states, tribes, and territories invest in measures that mitigate wildfire disasters and create safer and resilient communities.

The California Department of Forestry and Fire Protection (CAL FIRE) manages fire prevention and response for the State of California. CAL FIRE oversees enforcement of California's forest protection regulations, implements fuel management projects, participates in forest conservation and management, and provides training and educational programs. CAL FIRE also engages in general emergency response activities.

The California Public Utilities Commission enforces rules and regulations to ensure that energy infrastructure and utility companies run a safe and reliable electric or communication system. The Commission reviews the wildfire mitigation plans of utilities and transmission owners. The Commission also examines investor-owned utilities' public safety power shutoff processes during severe wildfire threat conditions.

Vulnerable Populations

The SMAQMD engages in a number of initiatives for protecting air quality. In cooperation with the California Air Resources Board (CARB), SMAQMD implements AB 617 by targeting air quality improvement efforts in communities disproportionately impacted by air pollution. This means sustained involvement in community-level air monitoring, the creation of community-specific emissions reduction plans, review of pollution control technologies, and provision of air quality improvement incentive programs. In 2018, SMAQMD nominated 10 communities in Sacramento for consideration under AB 617, which is a community-focused program to more effectively reduce exposure to air pollution and preserve public health. CARB selected the South Sacramento-Florin community to be one of the first 10 communities in California to develop and implement a community air monitoring plan. Since July 2019, sensors have been monitoring real-time air quality throughout the South Sacramento-Florin community as well as in the northwestern portion of the Fruitridge-Broadway area. From August 2020 to November 2021, SMAQMD deployed more advanced monitoring to collect air quality information measuring more types of toxic air pollutants, and professional-grade air monitoring is planned for the third phase of the plan in the near future.[347] Although the focus of AB 617 is to improve air quality in vulnerable communities affected by air pollution primarily resulting from industrial uses and goods movement, the air monitoring network could also be leveraged to implement protections against pollution due to smoke from wildfires.

However, air quality improvement efforts are not exclusive to the South Sacramento-Florin community selected by CARB. Local organizations such as United Latinos in South Area are also actively involved in community-based air monitoring. In 2020, SMAQMD conducted an updated suitability analysis that recommended 3 additional general community areas for the State's Community Air Protection Program: North Sacramento, Oak Park/Fruitridge, and Meadowview. These places scored in the top fifth percentile (i.e., most burdened by air quality issues), indicating that there are populations throughout Sacramento who are vulnerable to air quality impacts exacerbated by wildfire.

Fire Protection

The City of Sacramento is served by the Sacramento Fire Department (SFD). The SFD is a full-service fire department, with the responsibility for responding to and mitigating incidents involving fires, medical emergencies, hazardous materials, technical and water rescue within its service area. The department also provides a full range of support services including fire prevention, public education, fire investigation, and domestic preparedness planning and response. The SFD's operational mission and objective is to save lives, conserve property, and minimize environmental impact. To help meet this objective, SFD also participates in an automatic aid agreement with neighboring fire jurisdictions, as well as state and federal agencies.

The SFD provides fire protection services to the entire city which includes approximately 99.2 square miles within the existing city limits, as well as two contract areas that include 47.1 square miles immediately adjacent to the city boundaries within the unincorporated county. Contracted areas within SFD's jurisdiction include the Pacific/Fruitridge and Natomas Fire Protection Districts.

SFD Headquarters operates from the Public Safety Center, located at 5770 Freeport Boulevard. This facility is also the headquarters for the Sacramento Police Department. Twenty-four fire stations are strategically located throughout the city to provide assistance to area residents and businesses. Although each fire station operates within a specific response district encompassing the immediate geographical area around the station, all of the Sacramento County fire agencies (Sacramento Fire Department, Sacramento Metro Fire District, Sacramento International Airport Fire, Cosumnes Fire District, and the Folsom Fire Department) share an automatic aid agreement, known as boundary dropping, which means that the closest fire unit responds regardless of jurisdiction. Increased incidence of wildfire across the region may tax SFD in the future.

[347] Sacramento Metropolitan Air Quality Management District, "Community Air Monitoring," last updated March 9, 2022, Accessed August 29, 2022: https://www.airquality.org/air-quality-health/community-air-protection/community-air-monitoring

5 Conclusions

Overall, there are a variety of hazards and risks that are experienced in Sacramento that are likely to increase in frequency and intensity due to climate change. These risks include urban heat, flooding, drought, wildfire, infrastructure damage, and emergency evacuation and response. Certain populations face unequal exposures to climate hazards or have a reduced capacity to respond, adapt, and recover from these events. Vulnerable populations that require special consideration and support in climate action and adaptation planning include children (aged 14 and below), older adults (aged 65 and over), individuals with disabilities, low-income households, outdoor workers, cost-burdened households, linguistically isolated households, and communities of color.

5.1 Risk Assessment Summary

The Risk Assessment Matrix below approximates Sacramento's level of vulnerability to climate change hazards as well as its adaptive capacity for all residents to be able to respond and recover from these events. Risks with high levels of vulnerability and low levels of adaptive capacity should be prioritized for adaptation interventions, starting with aiming to protect and improve the livelihoods of the most vulnerable communities.

Based on analysis from this Vulnerability Assessment, urban heat interventions should be prioritized in Sacramento, with a classification as a 'Very High' level of vulnerability and 'Low' level of adaptive capacity. By midcentury, Sacramento is projected to experience between 19 and 22 extreme heat days per year and approximately 2.8 4-day heat waves per year. Moreover, vulnerable populations are particularly susceptible to urban heat, especially if they reside in urban heat islands. Interventions to mitigate urban heat island effects tend to take time and may be costly which lowers the city's adaptive capacity.

Risks to infrastructure caused by drought and flooding are classified as 'High' levels of vulnerability. Flooding impacts the majority of Sacramento and will continue to become more frequent and severe with climate change. Moreover, the majority of the City's critical infrastructure exists in many of these flood zones. However, there are numerous interventions already in place at the federal, state, regional, and local levels to protect the city from floods, including an extensive system of dams and levees that protect the city and thus increase its adaptive capacity. Drought can potentially impact the entire city, particularly the populations dependent on agricultural industries in Sacramento. Even so, there are measures that can continue to reduce water consumption, such as water reuse and incentivized water conservation programs.

Wildfire and Emergency Evacuation and Response are classified as 'Moderate' levels of vulnerability. While wildfire is not likely to directly impact the city, air pollution associated with wildfires can significantly impact the health of vulnerable populations. Emergency evacuation and response efforts always carry some level of risk depending on the type of hazard event. However, City preparedness, planning, response, recovery, and mitigation services help increase Sacramento's adaptive capacity to all the climate hazards that it endures.

Table 5-1: Risk Assessment Matrix

		Level of Vulnerability				
		Very High	*High*	*Moderate*	*Low*	*Very Low*
Adaptive Capacity	*Very Low*			Wildfire		
	Low	Urban Heat				
	Moderate		Infrastructure; Drought			
	High		Flooding	Emergency Evacuation and Response		
	Very High					

6 Appendix: Understanding Cal-Adapt and Key Scenario Assumptions

Material in this section is adapted from technical support information provided by Cal-Adapt and available on the Cal-Adapt website (www.cal-adapt.org).

Understanding Climate Projections

The data presented in Cal-Adapt tools are projections of future climate. They are not weather predictions and should not be treated as such. Weather is the behavior of the atmosphere over short periods, such as days and weeks. Climate is the long-term behavior of the atmosphere, and it is almost always expressed in averages—for example, average annual temperature, average monthly rainfall, or average water equivalent of mountain snowpack at a given time of year.

Climate projections cannot predict what will happen on a given date in the future. But they can provide information about what to expect from the future climate in general. Climate projections can also predict how much more often (or less often) extreme events such as heat waves and heavy rainfall are likely to occur in the future. However, they cannot predict when those events will actually occur.

How Climate Projections Are Produced

Climate scientists create projections of future climate using powerful tools called global climate models. Global climate models are complex pieces of computer software that crunch through thousands of mathematical equations representing the scientific theory of how the climate system works. They can be used to simulate climate over past periods or to run experiments, in which scientists impose certain conditions on the model to see how the climate system responds. A future climate projection is the product of global climate model experiments in which scientists impose upon the model some scenario of the future atmospheric concentration of greenhouse gases.

When climate scientists run a climate model, they divide the area of study into a grid, and the model performs calculations for each individual cell within the grid. The output from those calculations can then be visualized on a map.

The grid cells in most global climate models are very large—from 100 to 600 kilometers squared. This coarse resolution is OK when scientists are studying climate on the global scale, but it is not very useful when trying to understand climate change on smaller scales. Present-day climate varies greatly from region to region in California, and so future climate will vary accordingly. But that detail is lost in the global climate models, in which all of California may be represented by just a few grid cells. To be able to plan for the future, higher-resolution projections of future climate are needed. Climate scientists can create these high-resolution projections by using various techniques to "downscale" global climate model output to finer spatial scales. The data in Cal-Adapt is taken from a selection of global climate models, and downscaled to about 7-kilometer resolution.

Cal-Adapt allows users to visualize climate changes under any of ten Global Climate Models (GCMs) selected by California's Climate Action Team for performance in California. Four of these models, HadGEM2-ES (Warm/Dry), CNRM-CM5 (Cooler/Wetter), CanESM2 (Average), and MIROC5 (Compliment), are designed as priority models. These GCMs are part of the Climate Model Intercomparison Project version 5 and were developed to support the work of the United Nation Intergovernmental Panel on Climate Change (IPCC). Modeled data available on Cal-Adapt represent statistically downscaled GCMs using localized constructed analogs (LOCA) method by Scripps Institution of Oceanography as part of State of California's 4th Climate Change Assessment.

About the Greenhouse Gas Scenarios

The main driver of human-caused climate change is emissions of carbon dioxide and other greenhouse gases into the atmosphere. Greenhouse gases are so called because they trap heat in the atmosphere, causing it to warm over time. Atmospheric warming in turn leads to other changes throughout the earth system. How much the climate changes in the future depends in large part on the amount of greenhouse gases emitted now and in the future. However, since emissions of greenhouse gases depend on a variety of different social, political, and economic factors, it is difficult to predict how they will change. However, scientists can formulate educated guesses about how greenhouse gas emissions might change and use those scenarios to create future climate projections.

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

To address the uncertainty in future emissions of greenhouse gases and aerosols, Cal-Adapt allows users to visualize climate projections based on either of two possible emissions scenarios used in California's 4th Climate Assessment, originally appearing in the Fifth Intergovernmental Panel on Climate Change (IPCC). The 4th Climate Assessment uses so-called Representative Concentration Pathways (RCPs), which encapsulate different possible future greenhouse gas and aerosol emission scenarios. RCP 4.5 is a "medium" emissions scenario that models a future where societies attempt to reduce greenhouse gas emissions, while RCP 8.5 is a higher baseline emissions scenario. Key assumptions underlying the RCP 8.5 scenario include rising emissions through 2050, which plateau around 2100. RCP 8.5 is commonly understood as a business-as-usual (BAU) scenario that would result in atmospheric CO_2 concentrations exceeding 900 parts per million by 2100 and a temperature increase of 4-7 °C. RCP 4.5 is a scenario where GHG emissions rise until mid-21st century and then decline, resulting in a CO_2 concentration of about 550 ppm by 2100[348] and a temperature increase of 2-4°C[349].

[348] Bedsworth, L., Cayan D., Franco G., Fisher L., Ziaja S. (California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission). 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-013.

[349] Pierce D. W., Kalansky J.F., Cayan D.R., (Scripps Institution of Oceanography). 2018. Climate, Drought, and Sea

Sources of Uncertainty in Climate Projections

As with any statement about the future, there is no way to be certain that climate projections are accurate. One source of uncertainty in future climate projections is human greenhouse gas emissions. Projected climate data may not prove to be accurate if the actual emissions pathway differs from the scenarios used to make the projections.

Another source of uncertainty in climate projections is the fact that different climate models—the tools used to simulate the climate system and produce future climate data—may produce different outcomes. There are more than 30 global climate models developed by climate modeling centers around the world, and they have different ways of representing aspects of the climate system. In addition, some aspects of the climate system are less well understood than others. Climate scientists are constantly working to improve their theories of the climate system and its representation in climate models. In the meantime, one way to account for model differences is to look at projections from as many different models as possible to get a range of possible outcomes. Scientists can then take the average of the values across the different models, and this average value is a more likely outcome than the value from any single model. The default visualizations in Cal-Adapt are based on the average values from a variety of models.

Level Rise Scenarios for the Fourth California Climate Assessment. California Fourth Climate Change Assessment, California Energy Commission. Publication Number: CNRA-CEC-2018-006.

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