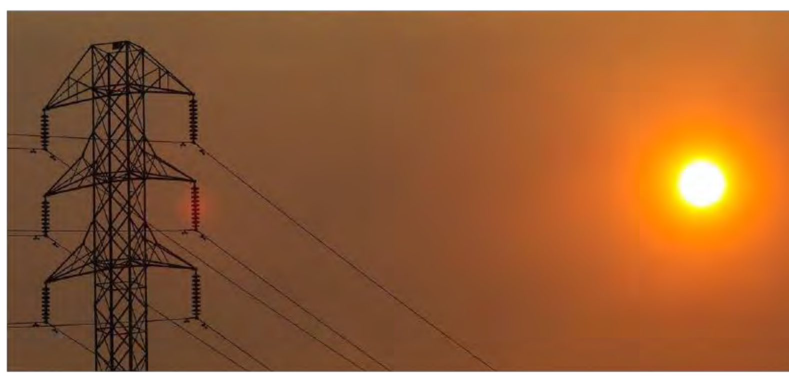
DECEMBER 2021

Climate Change Hazards and Vulnerabilities Report



City of San Luis Obispo
990 Palm Street
San Luis Obispo, CA 93401

Resilient SLO: Climate Change Hazards and Vulnerabilities Report

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LIST OF ABBREVIATIONS

°F	Fahrenheit
°C	Celsius
Q10	10-year storm event
Q100	100-year storm event
APG	Adaptation Planning Guide
AR	Atmospheric River
CALFIRE	Department of Forestry and Fire Protection
Cal Poly	California Polytechnic State University at San Luis Obispo
Caltrans	California Department of Transportation
CDC	Center for Disease Control and Prevention
CDD	Cooling Degree Day
CDHP	California Department of Public Health
CHAT	California Heat Assessment Tool
County	County of San Luis Obispo
City	City of San Luis Obispo
FEMA	Federal Emergency Management Agency
GHG	greenhouse gas
GIS	geographic information system
HDD	Heating Degree Day
HHE	Heat Health Events
HMP	San Luis Obispo County Multi-Jurisdictional Hazard Mitigation Plan
IDF	intensity, duration, frequency
IPCC	Intergovernmental Panel on Climate Change
OES	Office of Emergency Services
OPR	Governor's Office of Planning and Research
PG&E	Pacific Gas and Electric
PCTP	Pacific Coast tick fever
ppm	Parts Per Million
PSPS	Public Safety Power Shutoff
RCP	Representative Concentration Pathways
Report	Climate Change Hazards and Vulnerabilities Report
RTA	San Luis Obispo Regional Transit Authority

SB	Senate Bill
SLO	San Luis Obispo
SR	State Route
SWAT	Soil and Water Assessment Tool
UHI	Urban Heat Island
UWMP	Urban Water Management Plan
VHFHSZ	Very High Fire Hazard Severity Zones
WUI	wildland-urban interface

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1 INTRODUCTION

The climate is changing, with the pace of global warming being rapidly increased by human activities. Human-caused climate change is likely to increase the global average temperature 1.5 degrees Celsius (°C) (2.7° Fahrenheit [F]) between 2030 and 2052 (IPCC 2018). While the global community continues to reduce greenhouse gas (GHG) emissions moving forward, historic global GHG emissions have already solidified permanent changes to the environment, bringing with it substantial changes to the world, the state, the region, and the City of San Luis Obispo (City). Acknowledging the severity of these impacts and the importance of preparedness, the City of San Luis Obispo City Council has identified climate adaptation and resilience as a top priority.

The Climate Change Hazards and Vulnerabilities Report (Report) is the City's primary climate change vulnerability assessment summary document. The vulnerability assessment included in the Report identifies the City's exposure to the effects of climate change, identifies the sensitivity of population groups and community assets to specific climate-related hazards, analyzes potential climate change impacts, and assesses the City's existing capacity to address those impacts. The Report also serves to summarize and synthesize more detailed work being done that focuses on specific climate-hazards, City resources, or specific climate-related impacts. This Report is a component of the City's Resilient SLO project, a community-led initiative to improve community resilience to the worsening impacts of climate change. It is intended to help identify the specific climate vulnerabilities and impacts that are projected to occur in the City and assist in the development of a comprehensive set of climate adaptation strategies that will be incorporated into the General Plan Safety Element in compliance with Senate Bill (SB) 379, Government Code section 65302(g)(4).

SB 379, adopted in 2015, requires jurisdictions to integrate climate change adaptation into the general plan safety element development and update process. The law requires all cities and counties to update their safety elements to include the assessment of climate change vulnerabilities and adaptation strategies upon the jurisdiction's next safety element update. Under Government Code Section 65040.2, the Governor's Office of Planning and Research is charged with periodically updating and adopting the State General Plan Guidelines to guide the preparation of general plans for all cities and counties in California. The 2017 update to the General Plan Guidelines Safety Element chapter includes an additional focus on preparing communities for long-term climate change impacts (OPR 2017). The Resilient SLO project follows the four-phase adaptation planning process included in the California Adaptation Planning Guide, as shown in Figure 1. This Report serves as the culmination of Phase 2 of the project, assessing the unique vulnerabilities of the SLO community to the impacts of climate change. The findings of this Report will support development of a set of adaptation strategies (Phase 3) to be included in City's Safety Element Update.

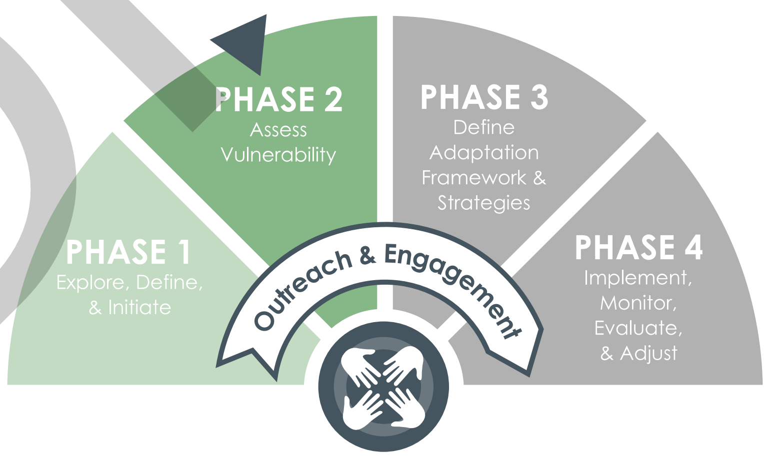

Figure 1 California Adaptation Planning Guide Adaptation Planning Phases

This Report was developed using the best available information regarding climate change projections for the City and the Central Coast region, relevant information on current efforts to adapt to climate change, and best practices and guidance provided by the State and other sources specific to climate adaptation planning. The primary resources used in developing this Report are:

- *California Adaptation Planning Guide* (Cal OES 2019);
- *Safeguarding California Plan: California's Climate Adaptation Strategy* (CNRA 2018);
- Cal-Adapt 2.0;
- *California's Fourth Climate Change Assessment* (statewide report) (OPR et al. 2018a, 2018b);
- *California's Fourth Climate Change Assessment: Central Coast Region Report* (2018b);
- *State of California General Plan Guidelines* (OPR 2017);
- State Adaptation Clearinghouse in the Integrated Climate Adaptation and Resiliency Program;
- *San Luis Obispo County Multi-Jurisdictional Hazard Mitigation Plan (San Luis Obispo County 2019a*; and
- California Department of Transportation (Caltrans) *District 5 Climate Change Vulnerability Assessment Summary Report* (Caltrans 2019a); and associated Technical Report (Caltrans 2019b).

1.1 CLIMATE CHANGE OVERVIEW

The combustion of fossil fuels, among other human activities since the Industrial Revolution in the 19th century, has introduced GHGs into the atmosphere at an increasingly accelerated rate. Significantly elevated levels of GHG emissions have intensified the greenhouse effect and led to a trend of unnatural warming of the Earth's climate, known as global climate change or global warming. The largest source of GHG emissions from human activities is the burning fossil fuels for electricity, heat, and transportation. Climate change, in recent decades, has become a priority issue on an international, national, and local scale as recent climate data reveal more extreme weather patterns, increased average global temperatures, and the rapid melting of the Earth's Artic and Antarctic poles and glaciers.

The global average temperature is expected to increase by 3.7 degrees Celsius (°C) (6.7 to 8.6 degrees °F) by the end of the century unless additional efforts to reduce GHG emissions are made (IPCC 2014). Human-caused climate change is currently increasing the global average temperature by approximately 0.2°C (0.36 °F) per decade due to past and ongoing emissions. While the global average temperature has already begun to increase, the Intergovernmental Panel on Climate Change (IPCC) has identified an increase of 1.5 degrees °C (2.7 F°) as a threshold that, if crossed, push many natural systems that sustain life past a dangerous turning point with a more limited ability to recover (IPCC 2018). Depending on future GHG emissions, average annual maximum daily temperatures in California are projected to increase between 4.4 and 5.8°F by 2050 and by 5.6 to 8.8°F by 2100 unless significant reductions in GHG emissions are made (OPR et al. 2018a). Temperature changes in the Central Coast region are expected to be even more significant, with projections of a 7 to 8°F increase by the end of the century (OPR et al 2018b) if global emissions continue on their current trend.

The state and the City have already begun to experience extreme weather effects, the frequency and intensity of which have been worsened by climate change (OPR et al. 2018a). Extreme weather effects such as volatility in precipitation, increased average temperatures, and increased frequency of extreme heat events have led to increases in the frequency and intensity of human health and natural hazard impacts such as wildfires, droughts, and changes to regional water supplies.

While the scope of the Resilient SLO project is intended to focus on local and regional climate impacts, it is important to recognize that larger scale climate impacts to natural and manmade systems may affect the SLO community and should be recognized.

In September 2021, the IPCC's Sixth Assessment Report was released. The findings highlight key new insights into the importance of global climate tipping points, a threshold that, when exceeded, can lead to large changes in the state of the climate system with one impact rapidly leading to a series of cascading events with vast repercussions. This new report is set to contain the body's strongest warnings yet on the subject.

Importantly, the draft report notes that, in terms of solutions, "We need transformational change operating on processes and behaviors at all levels: individual, communities, business, institutions and governments. We must redefine our way of life and consumption (Earth.org 2021)"

In 2020, the City adopted the Climate Action Plan for Community Recovery with the goal of achieving carbon neutrality by 2035 while focusing on using resources more effectively, improving community equity and well-being, and developing an economy that is set to recover from the impacts of COVID-19. The intent of the science-based goal is to play a proportional role in achieving global carbon neutrality and inspire similar action regionally, statewide, nationally and internationally so that global warming is kept between 1.5°C and 2°C. While it remains imperative that the City implement the Climate Action Plan and reduce GHG emissions to achieve carbon neutrality, it is equally important for communities to invest in climate change adaptation planning to improve resilience to extreme climate events that are projected over the 21st century.

1.2 WHAT IS RESILIENCE?

Resilience is the capacity of any entity—an individual, a community, an organization, or a natural system—to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience (Rodin 2014). As has been demonstrated by recent catastrophic wildfire seasons, the more frequent severe storms, the prolonged drought periods and the longer and hotter summer seasons, the effects of climate change are already occurring in California and in the Central Coast region. Planning for how to mitigate and adapt to these impacts is important to ensure the City is able to continue to prosper as a community.

Importantly, the concept of creating community resilience goes beyond preparing for the physical environment for future impacts from climate change and now considers and prioritizes the physical and psychological health of the population, social and economic equity, and well-being of the community. Developing a resilient community requires effective risk communication, integration of organizations (both governmental and community-based) in climate adaptation planning, response, and recovery, and supporting social connectedness for resource exchange, cohesion, response, and recovery efforts (CNRA 2018). In an effort to identify how the City can not only adapt to climate impacts but become more resilient and thrive in a more volatile and unpredictable climate, this Report identifies and discusses both the physical and social vulnerabilities the City has to the impacts of climate change in an effort to better support the adaptation strategy development process.

The following section (Climate Hazards Assessment) of the Report provides a detailed assessment of four key climate-related hazards (Temperature and Extreme Heat; Long-Term Drought; Wildfire; and Precipitation and Flooding) that are projected to affect the City. Section 3 (Vulnerability Scoring Summary) then provides a summary and ranking of the four climate-related hazards based on the findings of the assessment in Section 2.

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2 CLIMATE HAZARDS ASSESSMENT

This section provides a comprehensive assessment of the City's vulnerabilities to climate change. It identifies and characterizes climate-related hazards and other climate effects that are anticipated to affect the City, its residents, and visitors. The analysis in this section is organized into four distinct hazard categories. These categories are:

- Temperature and Extreme Heat
- Long-Term Drought
- Wildfire
- Precipitation and Flooding

It is important to recognize that the City is exposed to other natural and human-made hazards such as seismic events or hazardous waste. However, these hazards are addressed other planning documents in the City's Safety Element and the County Multi-Jurisdictional Hazard Mitigation Plan. This Report assesses hazards that are going be affected and exacerbated by climate change, focusing specifically on how these hazards are likely to increase in frequency and severity.

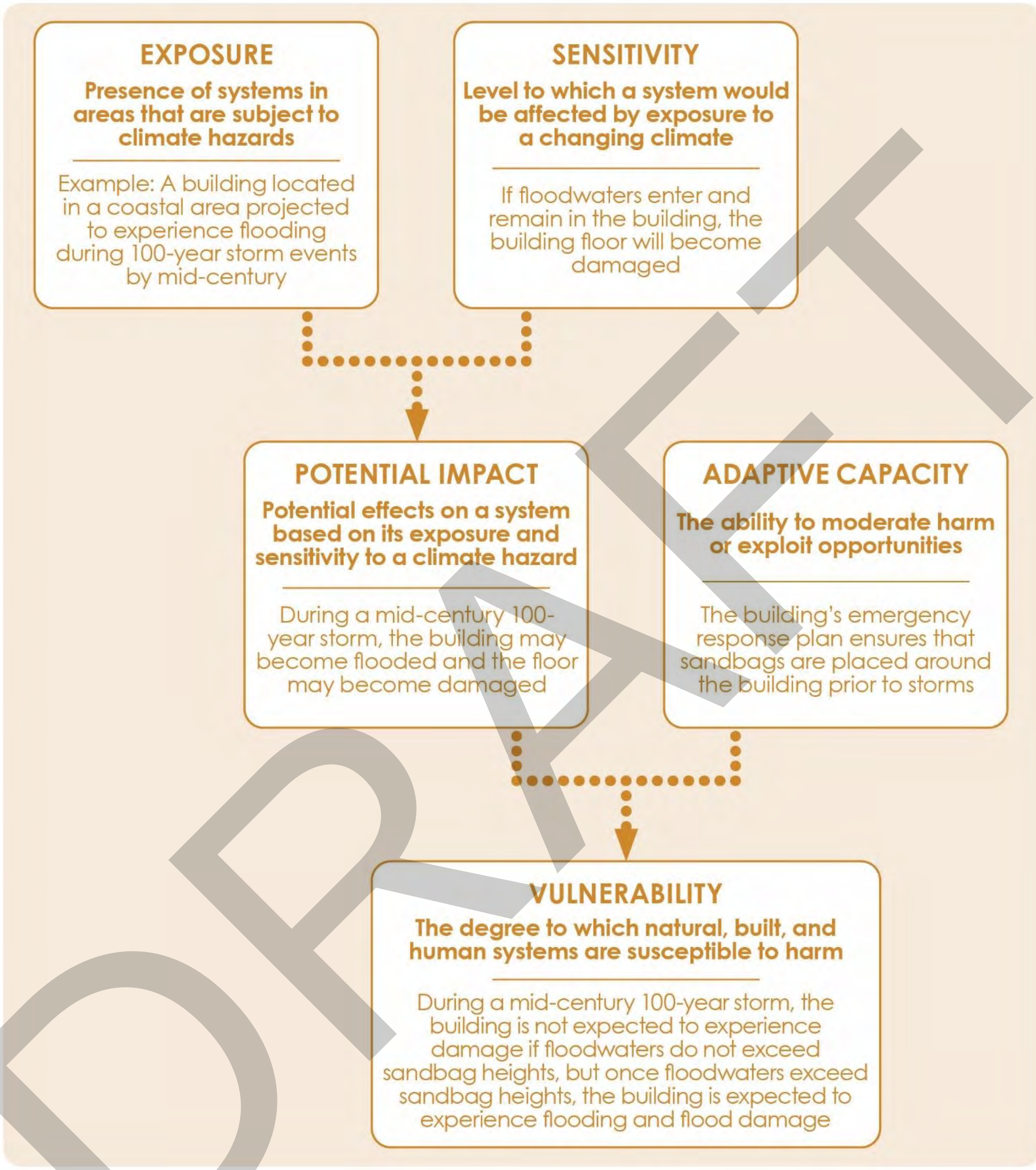
2.1 VULNERABILITY ASSESSMENT METHODOLOGY

For each of the four hazard areas listed above, the analysis follows the vulnerability assessment process outlined in the California Adaptation Planning Guide and is composed of the four steps outlined below in Figure 2. The following discussion provides an overview of the methodology used for each step of the vulnerability assessment process and provides context for the discussions of each climate-related hazard in Sections 2.2 through 2.5.

2.1.1 Exposure

The purpose of this step is to understand to what degree the City is vulnerable to impacts from each climate-related hazard under historic conditions and how changes in climate variables are projected to affect the hazard. A summary of the City's existing exposure to each hazard is provided using information from the Resilient SLO Baseline Conditions Report (City of San Luis Obispo 2021a).

According to the work of IPCC and research conducted by the State of California, partner agencies, and organizations, climate change is already affecting and will continue to affect the physical environment throughout California, including the City. To identify the local impacts of climate change in California, the California Energy Commission, and the University of California, Berkeley Geospatial Innovation Facility developed the scenario planning tool Cal-Adapt. The Cal-Adapt tool uses global climate simulation model data downscaled to a local and regional resolution to identify localized impacts from various climate metrics. Developers of the Cal-Adapt tool selected four priority global climate models to include in projections provided in the tool. This analysis uses the average of these four models to identify changes in temperature and extreme heat events.



Source: Cal OES 2019.

Figure 2 California Adaptation Planning Guide Vulnerability Assessment Process

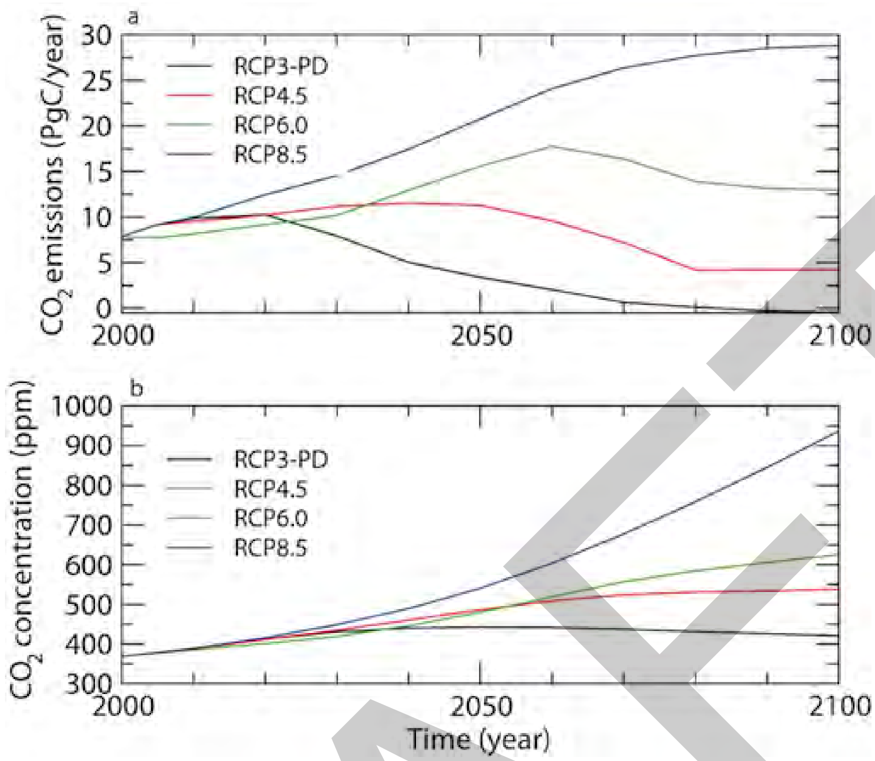
This analysis uses Cal-Adapt data to evaluate changes in several key climate variables projected to affect the City. The analysis also identifies at what point over the next approximately 80 years (2021–2099) changes in these variables will occur and at what magnitude. This exposure analysis uses three time periods to analyze changes in key climate variables. Due to annual fluctuations in climate variables, climate data is typically measured on a 30-year or longer timescale. Climate variables measured over a shorter time period is typically less accurate and not reflective of long-term averages (NOAA 2018). The time periods established for this analysis are 30-year time intervals to gather accurate data on average changes in the climate. This results in overlap among some time periods and a gap between 2064 and 2070. However, the three time periods used in this analysis have been chosen to align with time periods used in the Cal-Adapt tool and are intended to provide snapshots of how certain climate variables will change over the 21st century. The three time periods are:

- Near-term (2021–2050),
- midterm (2035–2064), and
- late-century (2070–2099).

The California Adaptation Planning Guide (APG), as well as the Governor's Office of Planning and Research's guidance for State agencies (OPR 2018), provide guidance on choosing appropriate Representative Concentration Pathways (RCP) scenarios to be included in vulnerability assessment analyses. For analysis of impacts through 2050, the APG suggests using a conservative approach and selecting the high emissions scenario, to assume a worst-case scenario but notes that impacts by 2050 under the medium and high scenarios will vary based on local context. As recommended by the APG, this analysis evaluates near-term and midterm climate change effects and their associated impacts under the high emissions scenario, as this takes a conservative approach and assumes a worst-case scenario. Additionally, as observed in the Cal-Adapt data, changes in climate variables during the near-term and midterm periods are similar under both the medium and high emissions scenarios. Because long-term global GHG emissions trends are less certain and climate impacts vary more considerably between scenarios during this period, a discussion of both the medium and high emissions scenarios is included for this timescale (OPR et al 2018a).

FORECASTING ASSUMPTIONS

The projected effects of climate change over the next century will vary depending on global GHG emissions trends. The Cal-Adapt tool includes global climate simulation model data from two emissions scenarios, known as RCPs, that were used in the IPCC's Fifth Assessment Report. The RCPs represent scenarios that estimate the level of global GHG emissions through 2099. The RCP scenarios used in the Cal-Adapt tool and discussed in the California Adaptation Planning Guide are the RCP 8.5 (high emissions) scenario, which represents a business-as-usual future emissions scenario in which global GHG emissions continue to rise through the rest of the century, peaking around 2099, and resulting in atmospheric CO_2 concentrations exceeding 900 parts per million (ppm) by 2100, and the RCP 4.5 (medium emissions) scenario, which represents a lower GHG emissions future and likely the best-case scenario for climate impacts, under which GHG emissions would peak in 2040 and then decline through the rest of the century, resulting in a CO_2 concentration of about 550 ppm by 2100. The RCP trends assumed in the analysis are illustrated in Figure 3. Figure 3 also includes other global emissions scenarios that have been analyzed by the IPCC but are not included in the Cal-Adapt tool. The RCP 4.5 and 8.5 scenarios have been included in the Cal-Adapt tool because they represent two important scenarios for future planning. The RCP 8.5 scenario is included to illustrate what climate impacts will look like if no future action is taken to reduce global emissions. The RCP 4.5 scenario is included as a potential best-case scenario for reducing global GHG emissions. The emissions scenarios depend on global GHG emissions trends in the future and the efficacy of global GHG reduction strategies proposed by the international community.



Notes: CO_2= carbon dioxide; ppm = parts per million; PgC = one billion metric tons of carbon; RCP = Representative Concentration Pathway.

Source: Goosse et al. 2010

Figure 3 Representative Concentration Pathway Used in Global Climate Modeling

Cal-Adapt also includes 10 global climate models, downscaled to local and regional resolution using the Localized Constructed Analogs statistical technique. Four of these models have been selected by California's Climate Action Team Research Working Group as priority models for research contributing to California's Fourth Climate Change Assessment. Projected future climate from these four models can be described as producing:

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

2.1.2 Sensitivity and Potential Impacts

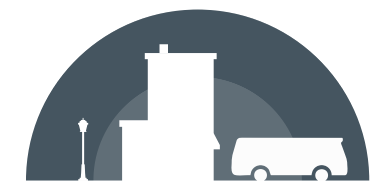
This step summarizes population groups and community assets that are sensitive to localized climate change effects. Changes in climate-related hazards are generally projected to increase in severity, with the potential for climate change to generate new impacts that communities have not experienced historically. Using historical data, research from regional and statewide reports on climate impacts, and input from stakeholders on which sensitive populations and assets should be prioritized for the analysis, this step identifies sensitive populations and assets and assesses how they are likely to be impacted by climate change.

As part of the community outreach process for the Resilient SLO project, a specific set of priority assets and functions were identified for each of the three categories described above. The priorities identified for these three categories were developed through a set of working group meetings based on the three categories and confirmed by the

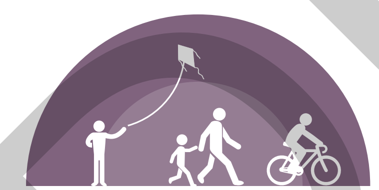
Resilience Roundtable, a community-led advisory body that is helping the City guide the approach and focus of the Resilient SLO project and the City's Safety Element update. The priorities identified through the community outreach process were then supplemented using hazard mitigation and emergency operation planning resources developed previously the by City and the County. The priorities identified by the working groups and additionally identified priority sensitive populations and assets are list below under each category.

The set of sensitive populations, assets, and community functions analyzed in this step are organized into the following three general categories.

- **Natural Systems** – This category includes systems or system components of the natural environment (e.g., forests and grasslands, flora and fauna, stream health) in the City and the surrounding region that are critical to overall ecosystem health.
    - Passive Recreation and Trails (Working Group)
    - Open Space and Ecosystem Functions (Working Group)
    - Agricultural Production and Industry (Working Group)
    - Invasive species and secondary impacts (Working Group)
    - Water (water supply, stormwater) (Working Group)
    - Urban Tree Canopy (Additional Priority)



- **Built Environment** – This category includes the physical assets that comprise the City's built environment (e.g., roadway network, buildings, utility systems, stormwater management system) that are critical to supporting normal community functions in the City.
    - Evacuation Routes and Mobility (Working Group)
    - Telecommunication Systems (Working Group)
    - Building Stock and Energy Efficiency (Working Group)
    - Community Spaces for Gathering (Working Group)
    - Energy Infrastructure and Outages (Working Group)
    - Wildland Urban Interface (Additional Priority)
    - Water Supply Reservoirs (Additional Priority)
    - Stormwater Management System (Additional Priority)



- **Community Resilience** – This category includes human-focused systems that provide essential services to residents and visitors in the City and are critical to maintaining normal community functions (e.g., economic activity, healthcare system, schools).
    - Food Systems and Supply Chains (Working Group)
    - Emergency Communications/Misinformation (Working Group)
    - Personal Resilience (Health and Finances) (Working Group)
    - Governance/Trust (Working Group)
    - Community Organizations and Social Networks (Working Group)
    - Climate Vulnerable Populations (Additional Priority)

These three categories, marked by their signature color shown above, are discussed throughout this report in relation to each hazard.

While these three categories are intended to encompass important components of the City and its functions, impacts in these categories are likely to affect one another and result in secondary or compounding impacts. Alongside the discussion of potential impacts, the sections below that discuss each hazard also includes a discussion of how some of the various impacts in these categories may overlap or compound one another.

Based on guidance from the California Adaptation Planning Guide, potential impacts from each of the four climate-related hazards listed above are rated on a qualitative scale comprised of Low, Medium, and High ratings. A description of each qualitative rating for potential impacts is provided in Table 1.

Table 1 Potential Impact Scoring

Score	Potential Impact Scoring Description
Low (1)	Impact is unlikely based on projected exposure; would result in minor consequences to public health, safety, and/or other metrics of concern.
Medium (2)	Impact is somewhat likely based on projected exposure; would result in some consequences to public health, safety, and/or other metrics of concern.
High (3)	Impact is highly likely based on projected exposure; would result in substantial consequences to public health, safety, and/or other metrics of concern.

Source: CalOES 2020

2.1.3 Adaptive Capacity

Adaptive capacity is defined as the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC 2014). The City, partner agencies, and community organizations in the City have already taken substantial steps to build resilience and protect the City from existing climate-related hazards. The purpose of this step is to analyze and summarize the City's current adaptive capacity to address and reduce risk from future climate impacts. This step includes a review of the City's existing policies, plans, programs, and resources, as well as those from relevant regional and State agencies and organizations that provide an assessment of the City's current ability to reduce vulnerability to hazards and adapt to climate change over the 21st century. Although the City has already taken comprehensive steps to reduce risk from these hazards, climate change is projected to increase the frequency and severity of climate-related hazards in the future and may exceed the City's current capacity to address these hazards or may pose novel threats the City has not encountered historically.

Based on the analysis of current resources and efforts undertaken by the City or partner agencies, the City's adaptive capacity for each climate-related hazard is rated Low, Medium, or High. High adaptive capacity indicates that measures are already in place to address the points of sensitivity and impacts associated the specific climate-relate hazard, while a low rating indicates a community is unprepared and requires major changes to address specific sensitivities. Adaptive capacity ratings are described in Table 2.

Table 2 Adaptive Capacity Scoring

Score	Adaptive Capacity Scoring Description
Low (3)	The community lacks capability to manage climate impact; major changes would be required.
Medium (2)	The community has some capacity to manage climate impact; some changes would be required.
High (1)	The community has high capacity to manage climate impact; minimal to no changes are required.

Source: CalOES 2020

2.1.4 Vulnerability Scoring

This step determines the City's priority climate vulnerabilities through a vulnerability scoring process. The City's vulnerability to each identified impact is assessed based on the magnitude of risk to and potential impacts on City while considering the current adaptive capacity to mitigate for these impacts. Based on the ratings of potential impacts and adaptive capacity, an overall vulnerability score has been assigned to each climate-related hazard category. This scoring helps the City better understand which climate hazards pose the greatest threat and should be prioritized for future planning efforts. Table 3 presents the rubric used to determine overall vulnerability scores based on the ratings for potential impacts and adaptive capacity.

Table 3 Potential Impact Summary

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

Source: CalOES 2020; adapted by Ascent Environmental in 2021

Vulnerability scoring for each climate change effect identified and evaluated in Sections 2.2 through 2.5 is included in Section 3 which also provides a summary of all climate-related hazards analyzed.

2.2 SOCIAL VULNERABILITY AND ENVIRONMENTAL JUSTICE

This section provides an overview of the sociodemographic characteristics of the City and highlights specific social vulnerabilities and environmental justice issues that may place certain populations or areas in the City at a disproportionately higher risk of climate change related impacts. The information in this section is then used, as appropriate, in each hazard discussion, highlighting where and how certain populations may be at increased risk from climate impacts.

Certain populations in urban areas are particularly vulnerable to a variety of hazards that are likely to be exacerbated by climate change. Vulnerabilities can include being disproportionately exposed to hazards and environmental pollution; being more sensitive to impacts because of preexisting health conditions; or having less resources or opportunities to prepare for and recover from hazard impacts. Vulnerable populations often include persons over the age of 65, infants and children, communities of color, individuals with chronic health conditions (e.g., cardiovascular disease, asthma), low-income populations, athletes, and outdoor workers (CDC 2019). More broadly, any trait that would limit or prevent people from avoiding a hazard, seeking medical attention, or obtaining essential food, supplies, and/or care in an emergency would make them vulnerable to hazards.

2.2.1 Population Overview

The U.S. Census bureau estimates the City's population to be 47,459 persons as of July 2019 (U.S. Census Bureau 2019). Table 4 illustrates the City's demographics by sex, race, and age according to the U.S. Census. As shown, the majority of residents identify as white with those identifying as Hispanic being the second largest demographic group. In terms of youth and elderly populations, 29 percent of City residents are either under 18 years or over 65 years old. The City is highly educated: 93 percent of the population over 25 years old has at least a high school degree, and 50 percent of the population over 25 years old has a bachelor's degree or higher (U.S. Census Bureau 2018).

Table 4 City Demographics by Sex, Race, and Age

Demographic Characteristics	City of San Luis Obispo	San Luis Obispo County	California
Population	47,459	283,111	39,512,223
Male	51%	51%	50%
Female	49%	49%	50%
White alone	84%	89%	72%
Hispanic or Latino	18%	23%	39%
Asian alone	6%	4%	16%
Two or more races	4%	4%	4%
Black or African American alone	2%	2%	7%
American Indian and Alaska Native alone	0.4%	1.4%	1.6%

Demographic Characteristics	City of San Luis Obispo	San Luis Obispo County	California
Persons under 5 years	3%	5%	6%
Persons under 18 years	13%	18%	23%
Persons 65 years and older	13%	21%	15%

Source: U.S. Census Bureau 2019

HOUSING COSTS

Overall, the cost of living in the City is high relative to household income. Table 5 provides key information about housing costs in the City. As shown in Table 6, around 57 percent of renters spend 35 percent or more of their income on rent (U.S. Census Bureau 2018). Around 6 percent of all families and 14 percent of families with a female single parent had an income that fell below the poverty level in the span of a year (U.S. Census Bureau 2018).

Table 5 Housing Cost Characteristics

Housing Characteristic	Housing Cost
Median monthly cost for owners with a mortgage	$2,340
Median monthly cost for renters	$1,461 per unit
Median household income	$52,740

Source: U.S. Census Bureau 2018

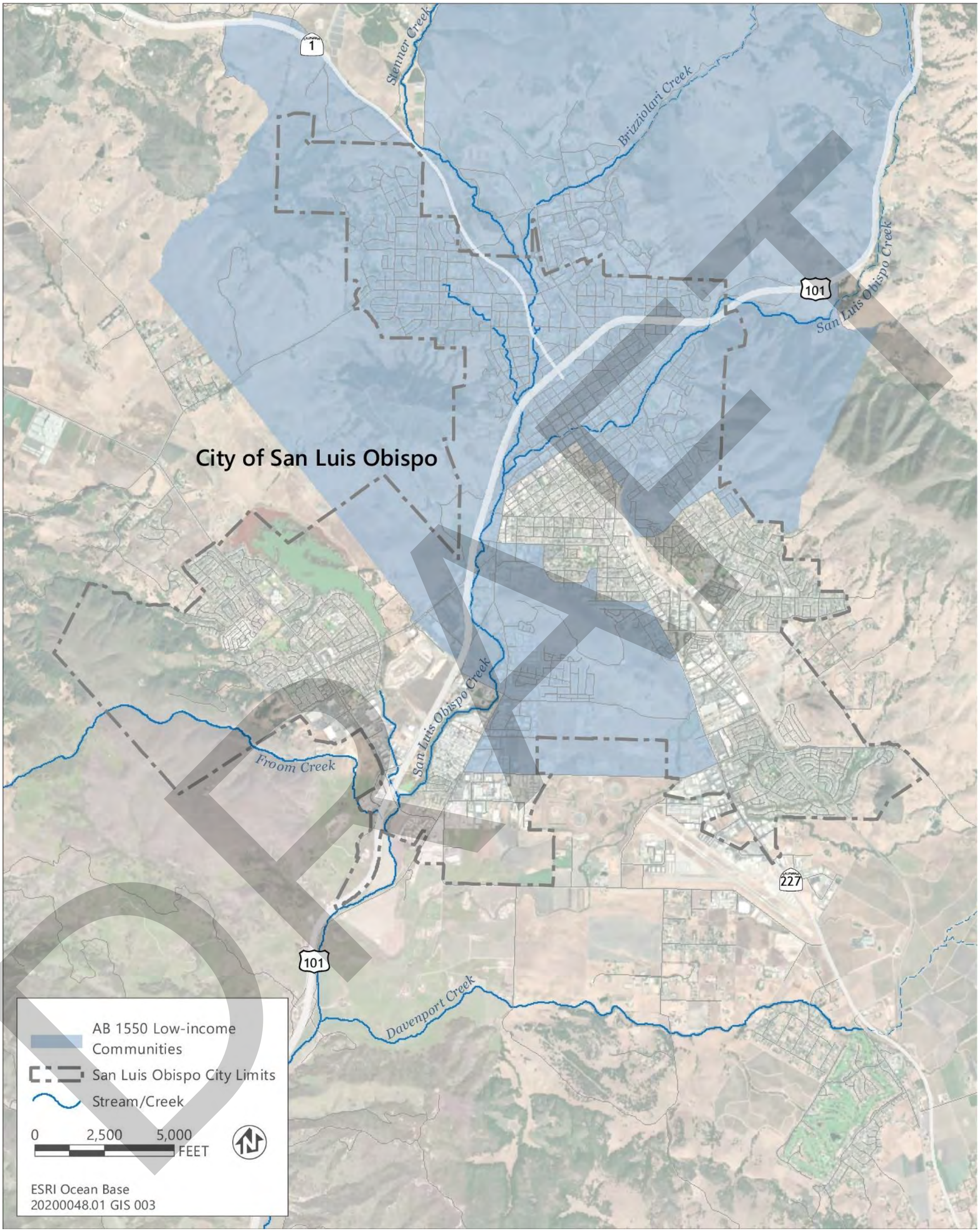
Table 6 Gross Rent as a Percentage of Monthly Household Income

Housing Characteristic	Percent of Occupied Units
Less than 15 percent	7%
15 to 20 percent	8%
20 to 25 percent	9%
25 to 30 percent	13%
30 to 35 percent	6%
35 percent or more	57%

Source: U.S. Census Bureau 2018

As illustrated in Figure 4, the City has a substantial low-income population, as mapped consistently with definitions provided in Assembly Bill 1550, which defines low-income communities as census tracts with median household incomes at or below 80 percent of the statewide median income or with median household incomes at or below the threshold designated as low income by the California Department of Housing and Community Development's list of state income limits adopted pursuant to California Code Section 50093. As demonstrated in Figure 4, this population is located primarily in the northern and central parts of the City. It is estimated that Cal Poly State University and Cuesta College students comprise more than one third of the City's population. As a result, students strongly influence the City's housing supply and demand. As noted in the City's Housing Element, although often grouped into low-income categories statistically, many students can spend more on housing than income data suggests because of parental support or larger household sizes. By pooling their housing funds, groups of students can often afford more expensive housing. This contributes to higher rents in San Luis Obispo compared to other parts of the County (City of San Luis Obispo 2020a).

Research has found that housing affordability is one of the strongest predictors of rates of homelessness in a community, with higher median rents leading to higher rates of homelessness and higher rates of sheltered homeless populations. To better understand the issue of homelessness, the U.S. Interagency Council on Homelessness categorizes homeless individuals in three basic groups: chronically homeless (i.e., people who have experienced long-term homelessness), episodic homeless (i.e., people who alternate between permanent housing and supportive housing or shelters), and transitional homeless (i.e., people who become temporarily homeless because of an event, such as loss of employment) (U.S. Interagency Council on Homelessness 2009). There are approximately 482 homeless individuals in the City (City of San Luis Obispo 2020a).



Source: CalEPA 2020

Figure 4 Low-Income Communities as Defined under Assembly Bill 1550

DISABILITY STATUS

Individuals with disabilities, especially those who are also unemployed or underemployed, are especially vulnerable to climate hazards largely because they, along with youth and senior populations, often rely heavily on family or caretakers for transportation and other basic needs (e.g., taking medications, cooking food). Around 9 percent of the City's total civilian noninstitutionalized population has a disability, with the majority of these people 65 years and over. Around 35 percent of people 65 years and over in the city have reported having a disability (U.S. Census Bureau 2018).

LANGUAGE

Cultural and linguistic isolation can make it difficult for people to access or understand important information regarding preparing for and responding to emergency situations. Approximately 6 percent of the City's population primarily speaks a language other than English and reports that they can speak English less than "very well" (U.S. Census Bureau 2018). Table 7 includes information about languages spoken in the City as well as what percentage of residents that speak another language do not speak English "very well" and may experience linguistic isolation.

Table 7 Languages Spoken by City Residents

Language Spoken	Percentage of Population	Percentage of population that speak English less than "very well"
Speak only English	83%	n/a
Speak Spanish	11%	33%
Other Indo-European Language	2.5%	26%
Asian-Pacific Island Language	3%	45%
Other Languages	0.5%	21%

Notes: n/a = not applicable

Source: U.S. Census Bureau 2018

2.2.2 Social Vulnerability Mapping and Environmental Justice

While the City includes sociodemographic characteristics that may place residents at increased risk to climate impacts, it is important to recognize that these social vulnerabilities are not spread evenly across the City. Populations with specific vulnerabilities may be concentrated in key areas of the City and have the potential to overlap with key climate related hazards that place these populations at a disproportionate level of risk from climate impacts. In general, low-income residents, communities of color, tribal nations, and immigrant communities have disproportionately experienced some of the greatest environmental burdens and related health problems throughout the history of the U.S. and in California. These historic inequities are, in the majority of cases, not a coincidence but a result of inappropriate zoning and negligent land use planning, intersecting structural inequalities, failure to enforce proper zoning or conduct regular inspections, deed restrictions and other discriminatory housing and lending practices, limited political and economic power among certain demographics, the prioritization of business interests over public health, development patterns that tend to concentrate pollution and environmental hazards in certain communities, and the placement of economic and environmental benefits in areas outside of disadvantaged communities (California Environmental Justice Alliance 2017).

Based on the State's definition of disadvantaged communities, no census tracts within the San Luis Obispo region are designated as disadvantaged communities. However, the San Luis Obispo Council of Governments (SLOCOG) has created a regional definition of disadvantaged communities to better compete for grant funding, distribute funds more equitably, and meet the state and federal environmental justice requirements. The Disadvantaged Communities Assessment was approved by the SLOCOG Board for use in the 2023 RTP and the 2022 Programming Cycle on June 2nd, 2021.

In the San Luis Obispo Region, disadvantaged communities are defined as disproportionately burdened areas that are economically distressed and/or historically underrepresented as a part of the local government process. The Disadvantaged Communities Assessment identifies 13 variables that address a wide range of socioeconomic and population-based factors to geographically define these disproportionately-burdened areas. The 13 variables are:

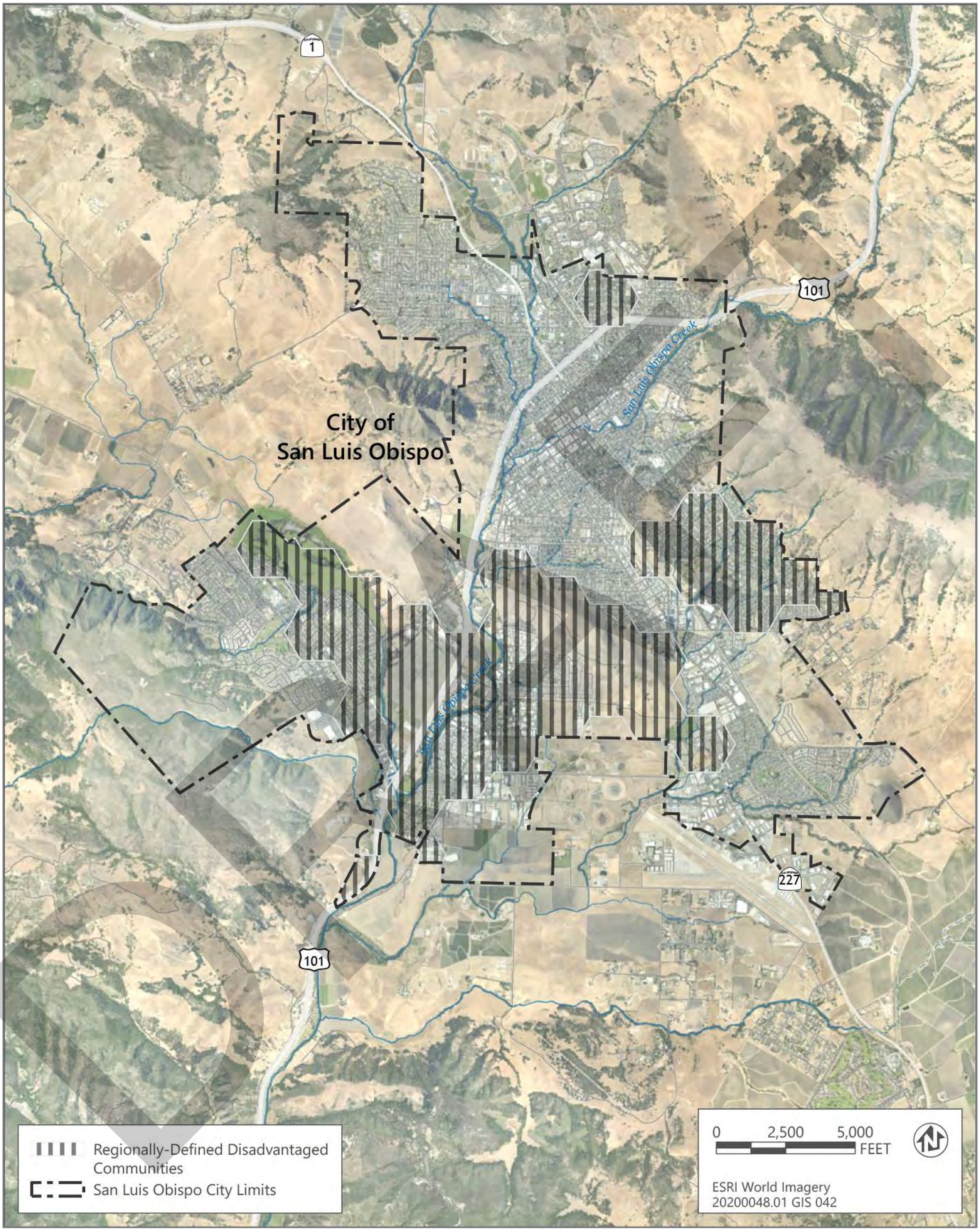
- Racial Minority
- Ethnic Minority
- Disability Status
- Household Income
- Free or Reduced-Price Meals
- Educational Attainment
- Language Proficiency
- Renter Affordability
- Housing Ownership Affordability
- Older Adults: Age 75 Years and Older
- Youth: Age 15 Years and Under
- Households with No Vehicle Available
- Households with No Computing Device Available

Similar to the SLOCOG assessment of disadvantaged communities, the Public Health Alliance of Southern California has developed the California Healthy Places Index (HPI). The California HPI provides an interactive map, graphs, data tables, and a policy guide to examine local health factors and compare local conditions to those across the state. Climate health vulnerability indicators are built into the HPI by incorporating climate-related hazards data layers into the mapping (e.g., air conditioning access, public transit access); incorporating select climate-resiliency metrics into the HPI score, which combines 25 community characteristics into a single indexed score to describe a community's overall health; and addressing climate challenges in the policy guide.

The HPI score for the City combines 25 community characteristics across eight areas (i.e., economic, social, education, transportation, neighborhood, housing, clean environment, and health care) into a single indexed score correlated to life expectancy at birth. The HPI score ranking for the combined census tracts in the City places it in the 61st percentile, meaning it has healthier community conditions than 61 percent of other California census tracts. Certain geographic areas and populations may be more vulnerable than others, by identifying these specific populations or geographic areas, the City can work to address these vulnerabilities and, in turn, make the whole community more resilient.

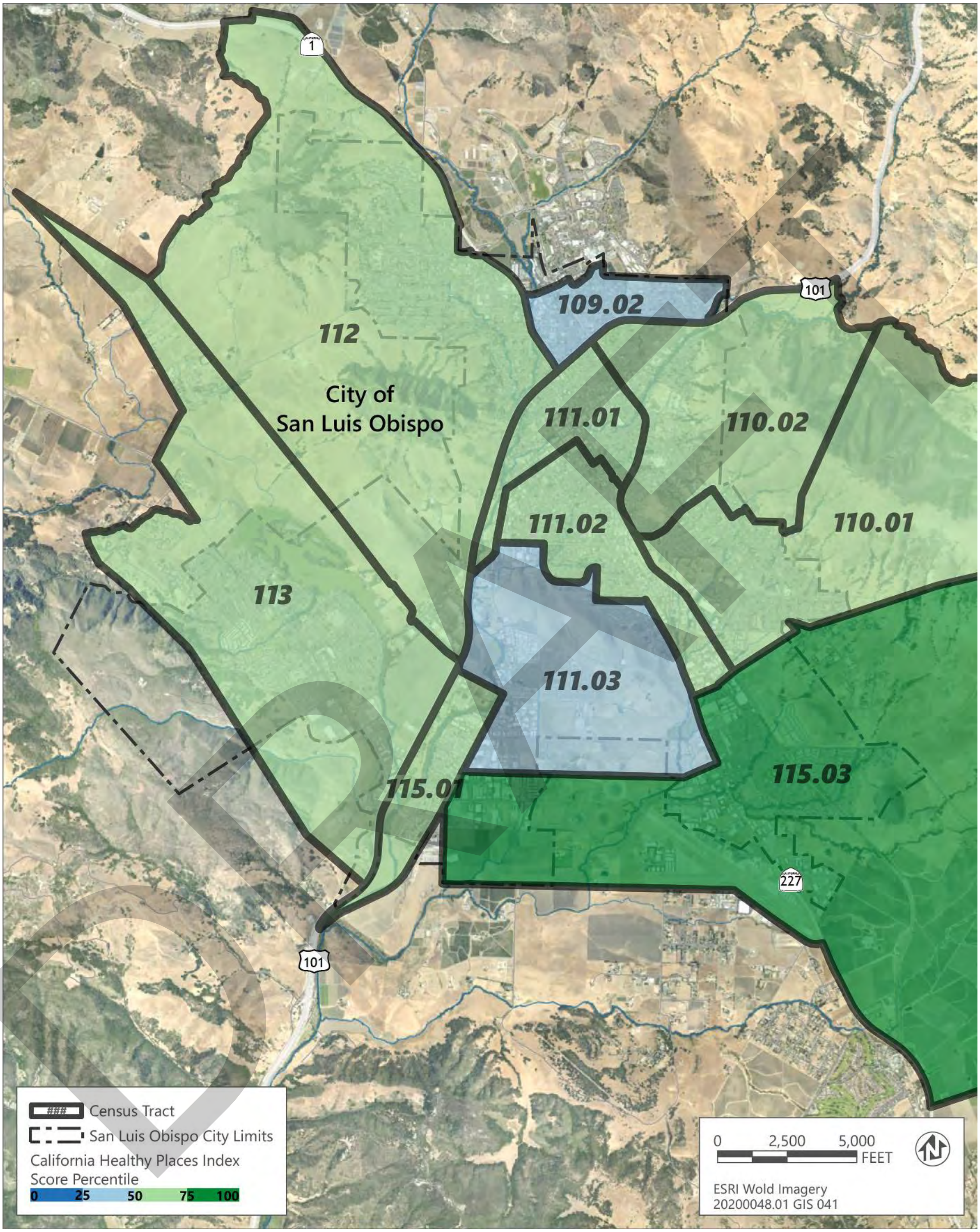
Compared to the City's overall HPI score, the City is doing particularly well in terms of education, performing better than 78 percent of other California census tracts in preschool enrollment and residents with a bachelor's degree or higher. However, the City ranks lower in terms of the economic factors score (39th percentile overall), which includes factors such as median household income, unemployment rate, and population with an income exceeding 200 percent of federal poverty level. The City also ranks low in terms of the housing factors score (17th percentile overall), which includes indicators such as low-income homeowners and renters with a severe housing burden (HPI 2020). This summary provides highlights of the City overall HPI score. To see all information on individual indicators, visit the California HPI website (https://map.healthyplacesindex.org/).

Figure 6 below includes the main census tracts that comprise the City. Table 8, which corresponds with Figure 6, includes a set of sociodemographic characteristics for each of the City's census tracts. Figure 5 also includes the HPI scoring scale for each census tract in the City, highlighting the portions of the City with lower scores that may be more vulnerable to climate impacts. The HPI scores for each census tract can be compared across the state to paint an overall picture of health and well-being in each census tract relative to the rest of California. For example, a census tract HPI score of 21 means that that tract has healthier community conditions than just 21.5 percent of other California census tracts. This means the lower the HPI score equates to, in general, less healthy living conditions and health outcomes for residents and potentially more climate vulnerability.



Sources: Data received from SLOCOG in 2021 and from CBEC Engineering in 2020, and downloaded from City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020

Figure 5 Regionally Defined Disadvantaged Communities in the City of San Luis Obispo



Sources: Data downloaded from US Census in 2019, City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020

Figure 6 Census Tracts in the City of San Luis Obispo

Table 8 Social Vulnerability and Environmental Justice Indicators by Census Tract

Name	Cal Poly Neighborhood	North Monterey Street and Johnson Avenue	Sinsheimer Neighborhood	Downtown SLO and Mill Street Historic District	South Downtown SLO and Railroad District	Margarita Avenue Neighborhood	Foothill Boulevard Neighborhood	Laguna Lake and Los Osos Valley Road	West of South Higuera	South Broad Street Neighborhood
Census Tract	**109.02**	**110.02**	**110.01**	**111.01**	**111.02**	**111.03**	**112**	**113**	**115.01**	**115.03**
Healthy Places Index Score	**27.6**	**70.5**	**72.7**	**55.5**	**69.6**	**37.4**	**50.9**	**68.4**	**60.4**	**84.6**
Latino	12%	9%	16%	15%	16%	25%	10%	18%	17%	9%
Black	<1%	<1%	<1%	2%	<1%	2%	<1%	0.01	2%	<1%
Asian	6%	4%	5%	3%	3%	3%	5%	7%	4%	4%
Poverty Level	80%	51%	30%	49%	42%	50%	59%	38%	32%	22%
Linguistic Isolation	2%	2%	4%	1%	3%	8%	1%	8%	4%	0%
Outdoor Workers	<1	2%	2%	4%	4%	3%	2%	3%	5%	2%
Elderly Populations	3%	8%	20%	9%	10%	17%	13%	14%	17%	12%
Youth Populations	2%	2%	7%	2%	3%	5%	3%	3%	5%	6%
Disabled Population	3%	4%	12%	7%	11%	11%	8%	10%	15%	7%
Tree Canopy	5%	1%	7%	6%	3%	4%	9%	9%	5%	3%
Park Access	76%	78%	93%	100%	100%	94%	60%	99%	100%	93%
Supermarket Access	33%	67%	30%	83%	99%	40%	58%	53%	92%	32%
Renter Housing Cost Burden	70%	42%	22%	29%	25%	35%	70%	34%	11%	41%
Active Commuting	31%	20%	11%	35%	23%	21%	22%	13%	9%	6%
CalEnviroScreen Score	9.89	14.99	6.69	11.85	10.95	26.9	15.86	16.58	12.86	10.9

Notes: n/a = not applicable

Source: California Healthy Places Index 2021; U.S. Census Bureau 2017

<u>Sociodemographic Characteristic Definitions</u>

- Latino – Percent of population in the census tract that identify as Latino.
- Black – Percent of population in the census tract that identify as Black or African American.
- Asian – Percent of population in the census tract that identify as Asian.
- Poverty Level - Percent of people in the census tract earning less than 200% of the federal poverty level (Federal poverty level = $12,880 per individual in 2021). 200% is often used to measure poverty in California due to high costs of living.
- Linguistic Isolation – Percent of households in the census tract that do not have one or more persons 14 years or older who speaks English well.
- Outdoor Workers - Percent of adults (over 16) in the census tract who work outdoors.
- Elderly Populations - Percent of population in the census tract under 5 years old.
- Youth Populations - Percent of population in the census tract under 5 years old.
- Disabled Population - Percent of people in the census tract with access and functional needs (a physical or mental disability).
- Tree Canopy - Percent of land in the census tract has tree canopy (weighted by number of people per acre).
- Park Access - Percent of people in the census tract who live within walkable distance (half-mile) of a park or open space greater than 1 acre.
- Supermarket Access - Percent of land in the census tract that reside less than 1/2 mile from a supermarket/large grocery store.
- Renter Housing Cost Burden - Percent of low-income renters in the census tract who pay more than 50 percent of their income on housing costs.
- Active Commuting - Percent of workers (16 years old and older) in the census tract commute to work by transit, walking, or cycling.
- CalEnviroScreen Score – CalEnviroScreen score which identifies communities disproportionately burdened by multiple sources of pollution and with population characteristics that them more sensitive to pollution. An area with a high score is one that experiences a much higher pollution burden than areas with low scores, with scores (0 -100) being compared across all census tracts in the state.

As shown in Figure 6 and Table 8, the city includes several census tracts which include both sociodemographic characteristics and characteristics of the built environment that make the populations in these census tracts more vulnerable to climate-related hazards and may be at a larger disadvantage in their ability to become more resilient to the impacts of climate change. However, as shown in Table 8, other census tracts in the City display specific characteristics that may make those residents particularly vulnerable to certain climate related hazards and should not be overlooked.

Margarita Avenue Neighborhood (Census Tract 111.03) stands out as a particularly vulnerable area of the City and includes the second lowest HPI score and highest CalEnviroScreen score. Notable characteristics of this area that make it particularly vulnerable, compared to the rest of the city, include a high percentage of minority residents, a high percentage of elderly and disabled residents, a high percentage of residents experiencing linguistic isolation, low access to supermarkets and grocery stores, and 50 percent of residents earning less than 200 percent of the federal poverty level. The West of South Higuera neighborhood (Census Tract 115.01) also stands out as a particularly vulnerable area of the City to climate impacts. Notable characteristics of this area that make its residents particularly vulnerable, compared to the rest of the city, include a high percentage of elderly and disabled residents, the highest percentage of outdoor workers in the City, and a high percentage of Latino residents who are generally more vulnerable to climate impacts (Natural Resource Defense Fund 2016) and may not have the same level of access to emergency resources of information.

The analysis of each hazard also takes into account the information on social vulnerabilities presented above to assesses how populations in different areas of the City are vulnerable to specific hazards.

Figure 7 includes the location and relative density of homeless encampments in the city. The city's homeless population are particularly vulnerable to climate-related hazards with less access to shelter and resources to protect themselves during emergency events (e.g., flooding, heat waves). Similar to the sociodemographic trends prevalent in some areas of the City, which make them particularly vulnerable to climate-related hazards, the locations of the homeless encampments identified in Figure 7 are also identified as areas in the City with particularly vulnerable populations.

2.2.3 Community-Based Adaptative Capacity

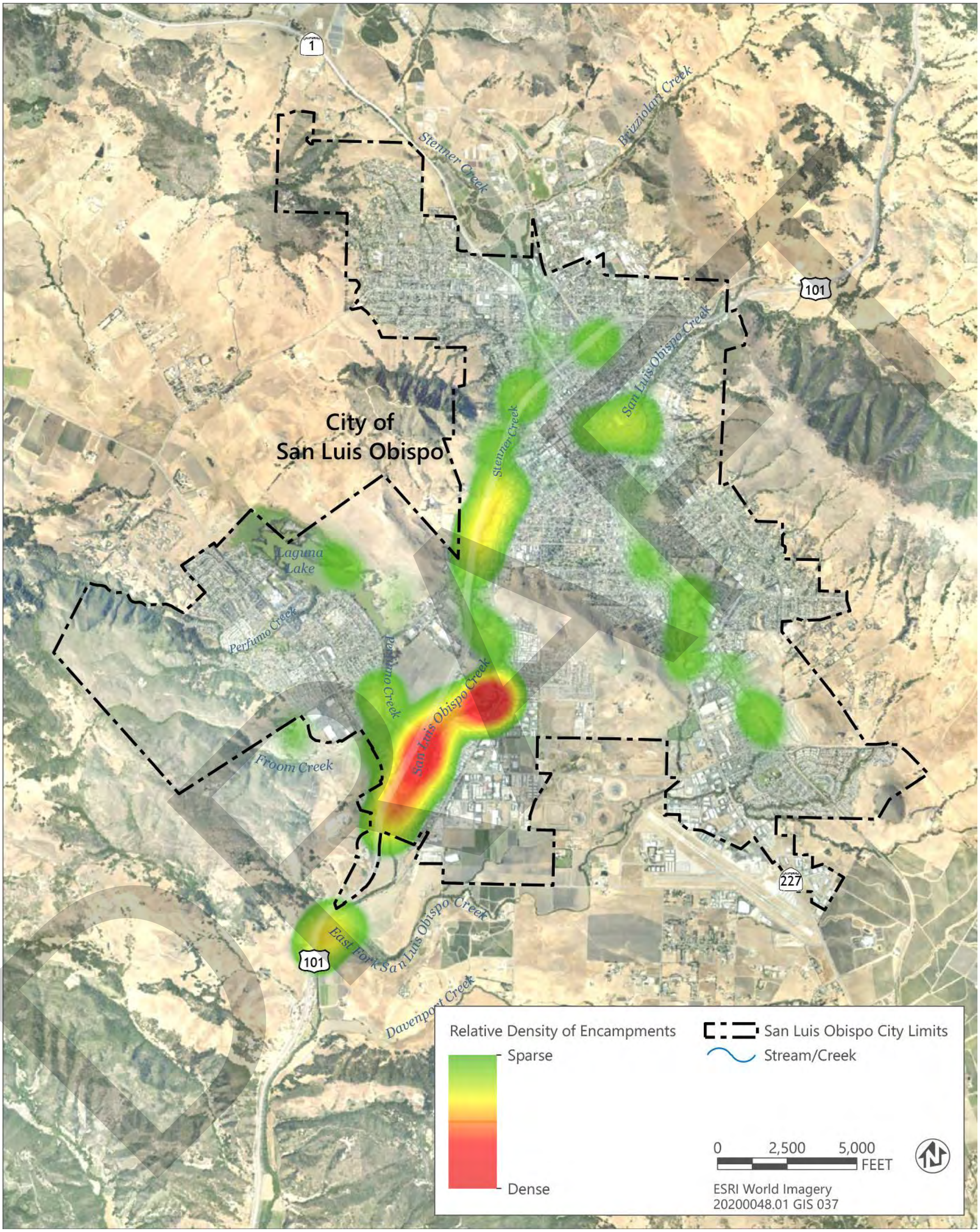
As discussed in 2.1.3, adaptive capacity is defined as the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC 2014). Alongside the steps the City and partner agencies have already taken protect the City from existing climate-related hazards, it is important to recognize the role community organizations and informal social networks can play in building adaptive capacity to the impacts of climate change.

SOCIAL NETWORKS AND SOCIAL COHESION

Aside from resources provided by the City or other agencies to help mitigate the impacts on residents and businesses during these events, social cohesion can play an important role in helping protect residents, particularly vulnerable populations, during climate-related disasters. Social cohesion, generally understood as the extent of connectedness and solidarity among groups in society or community, is one of the strongest indicators of resilience during disaster events as well as in post-disaster recovery efforts (Townshend et al. 2015). Important indicators of social cohesion, from the this research include:

- Belonging versus isolation, which means shared values, identity, feelings of commitment;
- Inclusion versus exclusion, which concerns equal opportunities of access;
- Participation versus non-involvement;
- Recognition versus rejection, which addresses the issue of respecting and tolerating differences in a pluralist society; and,
- Legitimacy versus illegitimacy (Jenson 1998).

An important component in remaining resilient to the impacts of climate change and climate-related disasters is the post-disaster recovery period. As noted in research on the topic, a focus not only of the physical rehabilitation of the built environment but on the addressing the emotional and mental health impacts of disasters is needed to ensure a successful community recovery during the post-disaster period. The emotional and mental health impacts of disasters can be addressed though various types of social cohesion including social and support networks (including access to social support in times of need), social participation (as the obverse of social isolation and being cut off from relationships providing friendship and company), and community engagement (including volunteering which draws people together to work for the benefit of others) (Townshend et al. 2015). While measuring the degree of social cohesion present in the City is not possible at this point, this subject is discussed here to emphasize the importance of social cohesion in increasing community resilience to the impacts of the climate change. Social cohesion here is highlighted as important component of community-based adaptative capacity and is discussed, as appropriate, in the discussions on specific climate-related hazards.



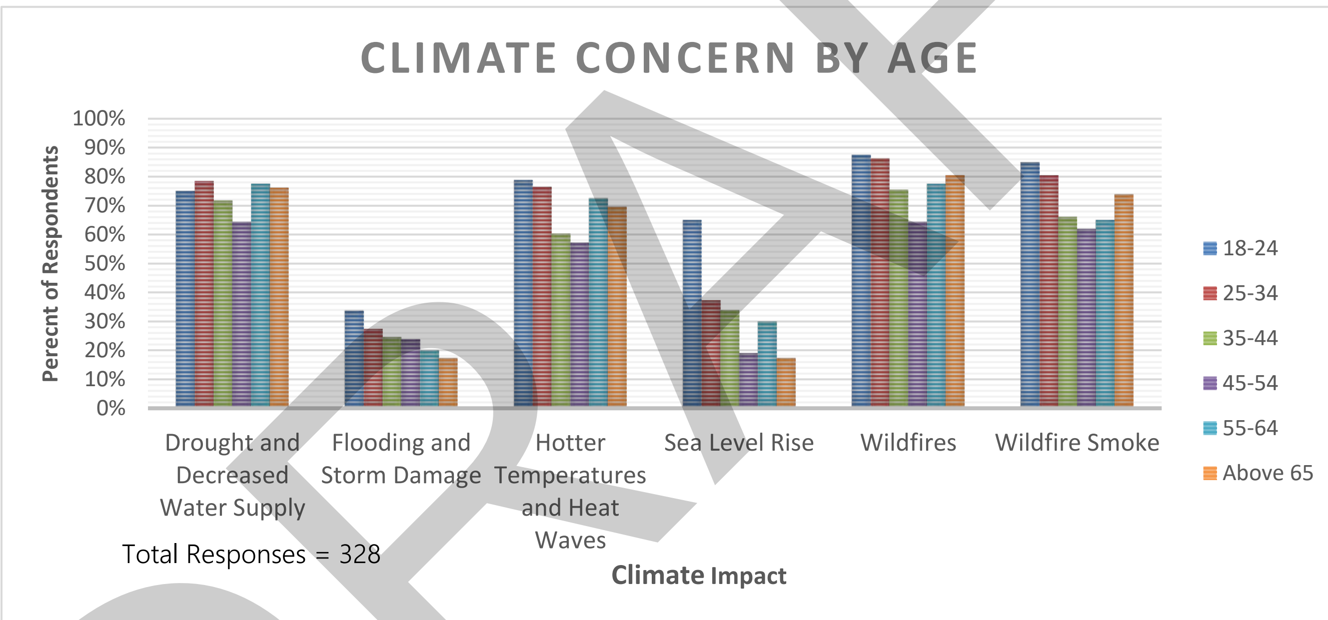
Sources: City of San Luis Obispo in 2021

Figure 7 Location and Relative Density of Homeless Encampments in the City of San Luis Obispo

RESILIENT SLO COMMUNITY PRIORITIES SURVEY

The effects of climate change are already being felt by community members. In an effort to gather input on overall community priorities regarding climate-related hazards, concerns related to climate change impacts, experience with past hazard events and response efforts, and priorities for local action, a community priorities survey was developed and provided to community residents. The survey, consisting of 19 questions, was open from August 31, 2020 – October 11, 2020 and had 328 responses. Highlights from the survey results have been included in this Report to help better understand the community's priorities regarding climate-related hazards and how the residents may already be affected climate-related hazards. The survey results are also included in the discussion on specific climate-related hazards.

As part of the survey, participants were asked what climate-related impact they were most concerned about. Figure 8 illustrates the responses to this question by age group. As shown in Figure 8, respondents were most concerned about wildfires and associated poor air quality events. Leading up to and during the survey response period, the City experienced poor air quality from several wildfires in the surrounding region, which may have influenced survey results. The large majority of respondents were also concerned about drought, increasing temperatures, and heat wave events and much less concerned about flooding and sea level rise. Survey results for this question also highlight that respondents in the 18-24 year old age cohort were the most concerned about almost all climate issues. To explore the full results of the community priorities survey, please refer to Baseline Conditions Report



Sources: Resilient SLO Community Priorities Survey

Figure 8 City Resident's Climate Concern by Age

COMMUNITY-BASED ORGANIZATIONS

Community-based organizations are generally understood as public or private nonprofit organizations that represent one or more segments of a community and/or provide educational or other community services to individuals or specific segments of the population. Climate-related hazards can also affect the ability of community-based organizations to operate and provide services to the communities they serve. Community-based organizations also play an important role in providing a wide variety of services to any community both during disaster and post-disaster recovery periods as well as during non-disaster periods (Tyler and Moench 2012). In many cases, community-based organizations provide services to a communities most vulnerable population and as a result are the institutions most in touch with the day-to-day needs and concerns of these populations during both disaster and non-disaster periods (Murray and Poland 2020). There is a comprehensive network of organizations in the city and the County that provide a wide variety of services to SLO community residents and visitors. In June 2020, a brief survey was sent out to community-based organizations in the City to better understand how these organization's operations were being affected by climate-related hazards and what responses were being taken to better prepare for the impacts of climate change. A total of eight community organizations responded to the survey. Figure 9 includes the results from two key questions in the survey, highlighting which climate-hazards community-based organizations have been affected by and which hazards they are concerned will affect their operations. The survey also asked what actions are being taken by the organizations to better prepare for climate changes. These results will be incorporated in the resilience strategy development process of the Resilient SLO project.

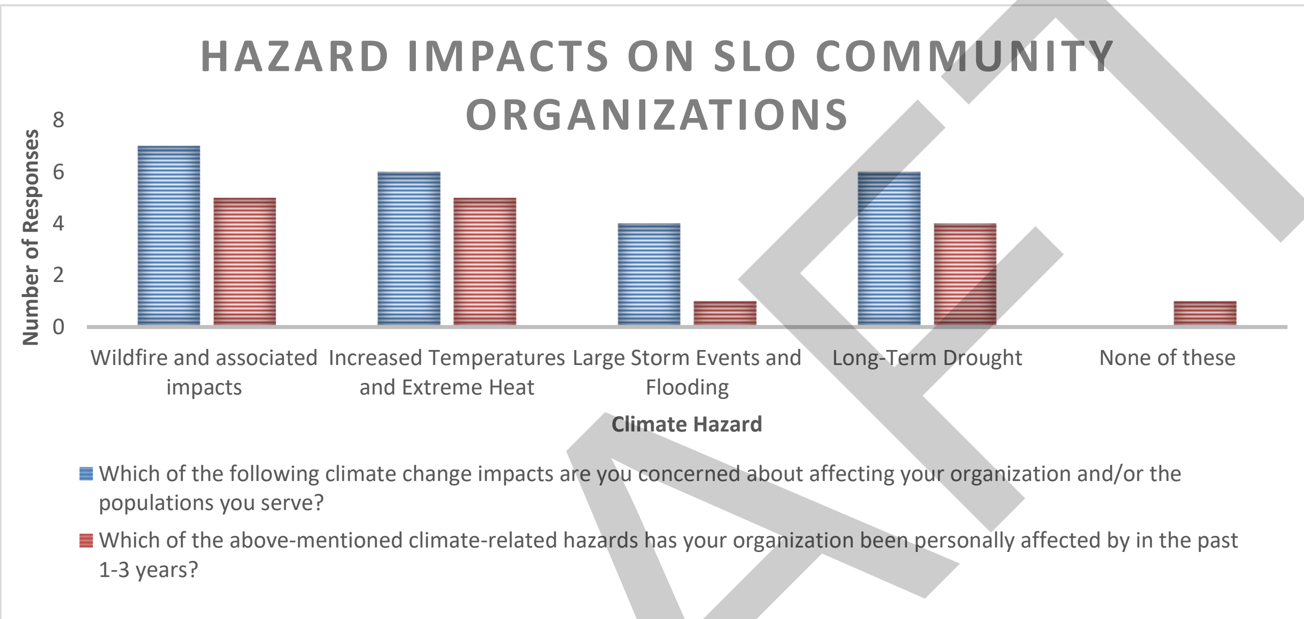


Figure 9 Climate -Related Hazard Impacts on Community Organizations in the City of San Luis Obispo

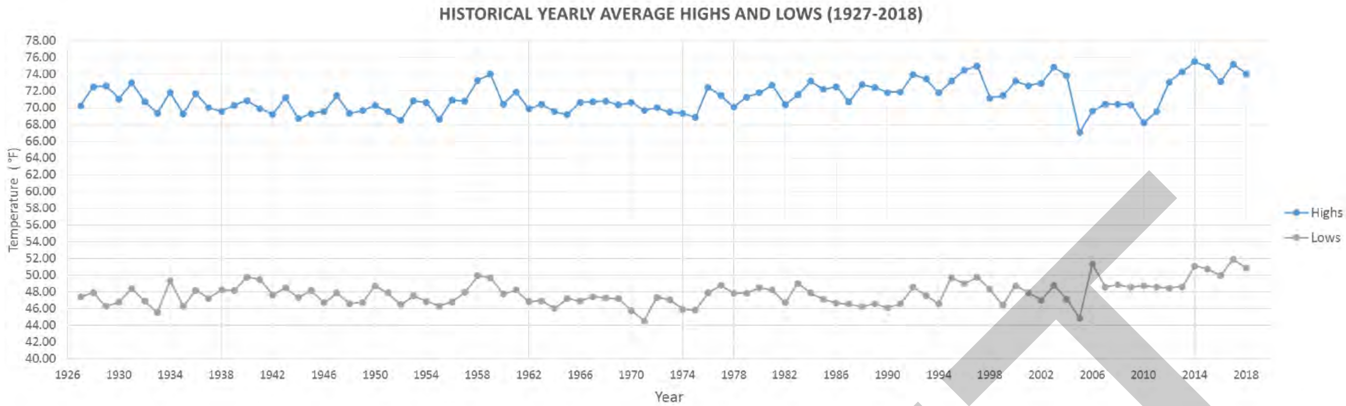
2.3 TEMPERATURE AND EXTREME HEAT ANALYSIS

This section discusses future increases in temperature and extreme heat in the City and analyzes how these changes are likely to impact the City and its population as well as highlighting what capacity the City and partner agencies already have in place to address future heat-related impacts.

2.3.1 Future Exposure to Temperature Increases and Extreme Heat

The City is characterized by a Mediterranean climate. While the City is generally considered to have a mild climate, historically unseasonably warm periods and cold spells have been observed. According to Cal-Adapt, during the historic period (1961–1990), the annual average maximum temperature in the City was 71.1°F and the annual average minimum temperature was 43.7°F (CEC 2019a). The annual maximum and minimum daily temperatures are calculated by averaging daily values of maximum and minimum temperatures for the full year, which is then averaged over a thirty-year time-period to account for year-to-year variability.

Although the City has not historically experienced many extreme heat conditions, the City is likely to experience increased sensitivity to extreme temperatures because residents are not acclimatized to or prepared for extreme heat conditions, even if increases are relatively mild compared to other parts of the state. Extreme heat events are described in this section in terms of their intensity (i.e., average maximum temperature), frequency (i.e., how often they occur), time of year in which they occur, and duration (total number of consecutive extreme heat days). Figure 10 includes the average annual maximum and minimum temperatures for the City from 1926 through 2018.



Sources: Cal Poly 2020

Figure 10 Average Annual Maximum and Minimum Temperatures in the City (1926-2018)

AVERAGE TEMPERATURE

As shown in Table 9, both annual maximum and minimum are projected to increase throughout the 21st century. The average annual maximum temperature in the City is projected to increase to 71.6°F in the near-term and 73.1°F in the midterm under the high emissions scenario. The average annual maximum temperature is projected to increase to 73.1°F and 75.6°F in the late-century period under the medium and high emissions scenarios, respectively. The average annual minimum temperature in the City is projected to increase to 48.7°F in the near-term and 49.7°F in the midterm under the high emissions scenario, and the late-century average annual minimum temperature is projected to increase to 50.1°F and 52.7°F under the medium and high emissions scenarios, respectively (CEC 2019a). Increased temperatures in the City will influence secondary climate effects, including extreme heat events, wildfire, and drought.

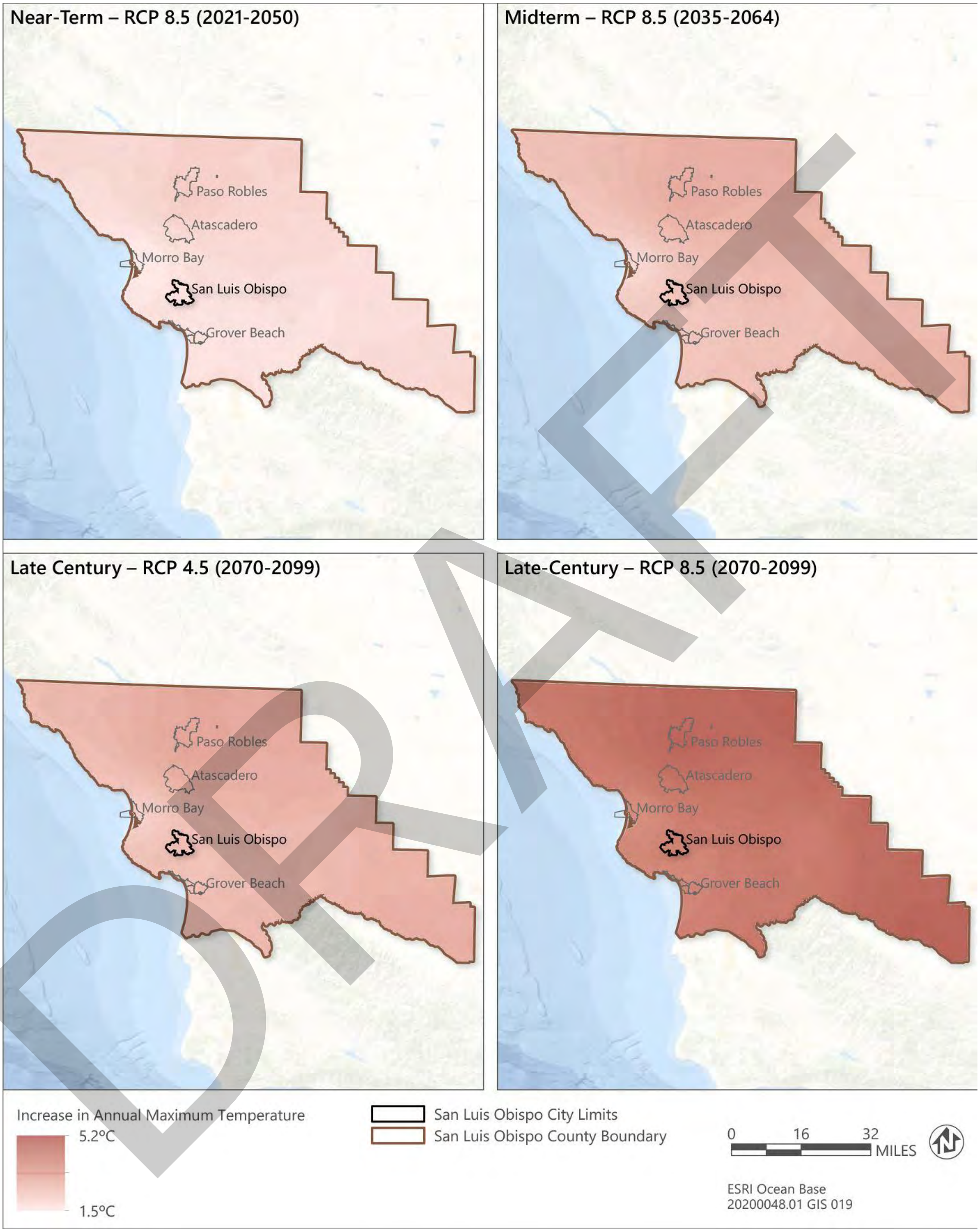
Table 9 Changes in Average Annual Temperature in City of San Luis Obispo

Geography	Average Annual Temperature	Historic Average Annual Temperature (1961-1990)	Near-Term (2021-2050)	Midterm (2035-2064)	Late-Century (2070-2099)	
					Medium Emissions	High Emissions
City of San Luis Obispo	Maximum Temperature (°F)	68.4	71.6	73.1	73.1	75.6
	Minimum Temperature (°F)	45.7	48.7	49.7	50.1	52.7
San Luis Obispo County	Maximum Temperature (°F)	69.8	72.9	74.3	74.7	77.3
	Minimum Temperature (°F)	42.2	45.4	46.6	46.9	49.8

Notes: °F = degrees Fahrenheit; RCP = Representative Concentration Pathway.

Source: CEC 2019a

Figure 11 illustrates the projected change in average annual maximum temperature in the city and in San Luis Obispo County (County) in the near-term and midterm periods under the high emissions scenario and average annual maximum temperature in the late-century period under both emissions scenarios. As shown in the Figure 11, the average annual maximum temperature is expected to rise through the late-century period under both emissions scenarios. As shown in Table 9, the County compared to the city, has had slightly higher maximum and minimum temperatures historically with this trend continuing under both emissions scenarios as temperatures continue to rise in both the city and the County. This difference is also reflected in Figure 11, which shows the City experiencing smaller increases in annual average maximum temperatures compared to northern and eastern portions of the County.



Sources: Data downloaded from City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020 and downloaded from Cal-Adapt in 2021

Figure 11 Changes in Annual Average Temperature in San Luis Obispo County through 2099

EXTREME HEAT EVENTS

The Cal-Adapt tool provides estimates of future instances of extreme heat events. Extreme heat events include extreme heat days and heat waves. Cal-Adapt defines an extreme heat day as a day when the daily maximum temperature exceeds the 98th historical percentile of daily maximum temperatures based on observed data from 1961–1990 between April and October. Heat wave events are characterized as periods of sustained extreme heat and are defined by Cal-Adapt as four or more consecutive extreme heat days.

The extreme heat threshold for the city is 89.6°F, meaning 98 percent of all recorded temperatures in this period were below 88.6°F. Historically (1961-1990), the city experienced an average of four extreme heat days per year. As a result of rising temperatures from climate change, the city is projected to experience up to 7 extreme heats days annually in the near-term and 10 extreme heat days annually in the midterm under the high emissions scenario. In the late-century period, the city is projected to experience up to 10 extreme heat days annually under the medium emissions scenario and 18 extreme heat days annually under the high emissions scenario (CEC 2019b). As shown in Table 10, the number of extreme heat days is already increasing from historic averages and will continue to increase through the late-century under both emissions scenarios. The city is already beginning to experience increases in extreme heat with a new September record high temperature of 117°F being set on September 6th, 2020 (NOAA 2021).

Table 10 Changes in Extreme Heat Events in City of San Luis Obispo

Annual Averages	Historic Annual Averages (1961-1990)	Near-Term (2021-2050)	Midterm (2035-2064)	Late-Century (2070-2099)	
				Medium Emissions	High Emissions
Number of Extreme Heat Days	4	7	10	10	18
Number of Heat Waves	0.2	0.3	0.4	0.4	1.3
Number of Days in Longest Stretch of Consecutive Extreme Heat Days	2.6	2.8	3	3.4	4.6

Notes: RCP = Representative Concentration Pathway; Extreme Heat Day = day with maximum temperature above 89.6°F; Heat Wave = four or more consecutive extreme heat days

Source: CEC 2019b

While heat waves have historically been infrequent in the City, with a historical average of less than one heat wave annually, climate change is expected to increase the frequency of heat waves. Under the high emissions scenario, the City is projected to still experience less than one heat waves per year in the near-term and in the midterm. In the long term, the City is projected to experience less than one heatwave per year under the medium emissions scenario and 1.3 heat waves per year under the high emissions scenarios.

Extreme Heat Definitions

Extreme Heat Day = Day with maximum temperature above 89.6°F

Heat Wave = Four or more consecutive Extreme Heat Days

The average number of days in the longest stretch of consecutive extreme heat days per year is also projected to increase. Historically, the longest stretch of consecutive extreme heat days lasted for an average duration of approximately two-and-a-half days. The longest stretch of consecutive extreme heat days is projected to increase only slightly in the near-term and 3 days in the midterm under the high emissions scenario. In the late century, the duration is projected to increase to an average of 3.4 days under the medium emissions scenario and 4.6 days under the high emissions scenario (CEC 2019b). The timing of extreme heat days is also projected to change over the 21st century with more extreme heat days and heat wave events occurring earlier in the year (April through May) and more severe events occurring in the historically hot months of September and October (CEC 2019b). The projected number of heat waves and number of days in the longest stretch of consecutive extreme heat days is shown in Table 10.

2.3.2 Extreme Heat Sensitivities and Impact

This section discusses the City's existing sensitivities to extreme heat and analyzes potential impacts to City with impacts discussed in the three general impact categories (e.g., Natural Systems, Built Environment, Community Resilience).

EXTREME HEAT AND NATURAL SYSTEMS

Open Space and Ecosystem Functions

Increases in annual average maximum and minimum temperatures are likely to alter suitable habitat for specific flora and fauna in the City, particularly in the City's recreation and open space areas. In general, plant species in the Central Coast mountain ranges in or near the city will shift upslope to track warming temperatures while, in the lowlands, species will move northward over the 21st century. The City's designated open space areas are comprised of a of a mixture of vegetation types including oak woodland, grassland, coastal sage scrub, and chaparral. Changes in annual average temperatures as well as long-term drought periods are projected to place increased pressure on these vegetation types. Invasive species have become more common in coastal sage scrub communities and compete with native coastal sage scrub species including commercial cultivars of the Monterey Pine (Pinus radiata) from New Zealand. However, it is unclear what effect climate change will have on invasive species in these open space areas (OPR et al. 2018b).

Many of the open spaces in and around the city also include inland grasslands. Historically, the duration and intensity of annual droughts in California varies substantially with elevation, latitude, distance to coast, and local soil characteristics. However, it is projected that most grassland species should be adaptive to tolerate climate extremes and variability (OPR et al. 2018b). As noted in the Central Coast Region Report, future changes in precipitation and drought will impact grasslands and wildflowers on the Central Coast and will be dependent on 1) the proximity to coast, 2) the relative proportion of native to exotic, and perennial to annual species.

Currently, the city has an extensive urban tree canopy with approximately 20,000 public trees on designated public property within the city limits. The City's tree canopy provides key benefits to residents and business owners including shading, traffic calming, beautification, and carbon sequestration. However, due to shifts in annual average minimum and maximum temperatures in the future, the urban tree canopy may be threatened, with some tree species no longer suitable given future minimum and maximum temperature thresholds. Research indicates that increases in temperature result in decreased photosynthesis and tree growth, and subsequently less carbon sequestration potential, as well as elevated incidence of pests (Meineke et al. 2016). Research on the impact of climate change on street trees in 16 California cities indicates that certain tree species that may be less suitable under future climate conditions may be more resilient when they are part of urban tree network. This is because urban tree networks are managed by staff which typically includes irrigation and pest management (McBride and Laćan 2018), two important factors that affect the suitability of various tree species under future climate conditions. The combined urban heat island effect as well as increase in temperatures due to climate change will also place increased heat stress on the City's urban tree canopy (McBride and Laćan 2018).

Invasive Species

As temperatures have increased over the past decade or more, observations have shown that invasive species have become more common in coastal sage scrub communities and compete with native coastal sage scrub species with the potential for coastal sage scrub habitats to convert to grasslands after fires, grazing, or nitrogen deposition. However, as noted in a recent study, while climate change is projected to affect coastal sage scrub communities, anthropogenic land use changes are likely to be a stronger indicator of effects on this habitat (Riordan and Rundel 2014).

In terms of forests and tree species in and surrounding the City, climate change's impacts on physical conditions in Central Coast forests will interact with biotic factors such as insect and disease outbreaks alongside changes in temperature and precipitation. The increasing presence of non-native species in the City's riparian areas also creates competing demand for water resources alongside native populations of plant species. For the last several decades, Sudden Oak Death has affected coast live oak, canyon live oak, California black oak, Shreve oak, and the closely related tan oak. During wet weather, spores of the disease of (Phytophthora ramorum) are produced on infected leaves, which can be dispersed by wind or via transported soil transported by humans (e.g., hikers, bikes) to infect new hosts. Climate models suggest broad scale movement Sudden Oak Death into California's North Coast by 2030, but less toward the southern portions (e.g., San Barbara County and San Luis Obispo County) of the Central Coast because of drier conditions there (Meentenmeyer et al. 2011).

Agriculture

Agricultural production is a prominent industry in the County of San Luis Obispo, including a thriving wine industry. The City also includes some agricultural land uses most notably the San Luis Ranch and the City Farm, a community-based urban farm hub, both located in the southern portions of the city west of US 101. The agricultural industry is highly sensitive to climate impacts including specific climate variables such as amounts, forms, and distribution of precipitation and changes in temperatures. Decrease in water availability due to long-term drought can affect crop yields and areas suitable for growing (Tanaka et al. 2015).

Increases in temperature, along with the frequency of extreme heat events and heat waves, has the potential to affect livestock operations in the County. Higher temperatures will lead to increased rates of evaporation of surface waters and evapotranspiration in plants, resulting in decreased moisture content of soils. These effects will lead to increased demand for irrigation to water crops. Warmer nighttime temperatures will reduce or eliminate the required number of "chill hours" that certain crops (e.g., fruit trees) need to bud (Union of Concerned Scientists n.d.). Strawberry production accounts for approximately 26 percent of total crop value in the County (County of San Luis Obispo 2018). It is projected that increases in temperatures caused by climate change could decrease yields of California strawberries by about 10 percent by 2050 and up to 43 percent between 2070 and 2099 (USDA 2016). Crop loss of this magnitude would result in significant loss of tax revenue to the County and result in impacts to employment opportunities for agricultural workers. Additionally, changes in temperatures will alter the range of crop-damaging pests and microbial diseases, which could increase the susceptibility of certain crops to predation, increased spoilage, reduced nutritional content, and other damage. Livestock operations, which accounts for approximately 3 percent of total crop value in the County, could also be subject to heat stress, which can result in reduced livestock pregnancy rates, increased length of time needed to meet market weight, and reduced milk production (CNRA 2014:24).

Total yields for wine grapes may be reduced due to warmer winters in the future. Changes in temperature can also affect plant diseases, insects, and invasive weeds (Pathak et al. 2018). Because the City relies heavily on tourism including wine and vineyard-based tourism, impacts on agriculture and the wine industry due to climate change in the County could have negative economic impacts for the City and businesses. There are over 250 wineries throughout Paso Robles, Edna Valley, and other areas of the County that are national and international tourist destinations. The grape and wine industry has a large influence on agricultural production in the County. Grapes alone accounted for approximately 27 percent of all crop value in 2018, while the County produced one billion dollars in total crop value, demonstrating the significance of agriculture in supporting the County's economy (County of San Luis Obispo 2018).

Key Findings and Policy Considerations

- Changes in temperature and extreme heat are likely to have negative impacts on the City's tree canopy with some tree species no longer suitable for future minimum and maximum temperatures. Any future policies focused on improving the City's tree canopy or green spaces to mitigate the urban heat island effect should carefully consider what plant and tree species will be suitable for future climate conditions.
- Climate change is projected in invasive species in the City's open spaces, affecting coastal sage scrub habitats as well as the City's oak species from Sudden Oak Death.

- Regional impacts on the agriculture and viticulture industries from shifting temperatures have the potential impact the City via decreases in wine and vineyard-based tourism, with the City relying heavily on revenue and employment opportunities in these industries. Resilience strategies focused on economic impacts should consider potential impacts on viticulture vineyard-based tourism and potential diversification of the City's tax revenue sources and employment industries.

EXTREME HEAT AND THE BUILT ENVIRONMENT

Urban Heat Island

Although the city's Mediterranean climate includes high temperatures during summer and fall months, the city's urban land use patterns can intensify periods of extreme heat through the "urban heat island" effect. The urban heat island effect is generally understood as the phenomenon of urban areas being significantly warmer than surrounding rural areas because of human activity and land use patterns in the built environment. Several factors contribute to the urban heat island effect, including land use patterns; the presence of large-paved areas (e.g., roads and parking lots); traffic from high-volume roadways (Zhu et al. 2017), impervious surfaces (e.g., roofs). Conversely, the presence of vegetation and trees in urban environments increases evapotranspiration in which water is released form plants in its gas vapor form and has a cooling effect on the surrounding air.

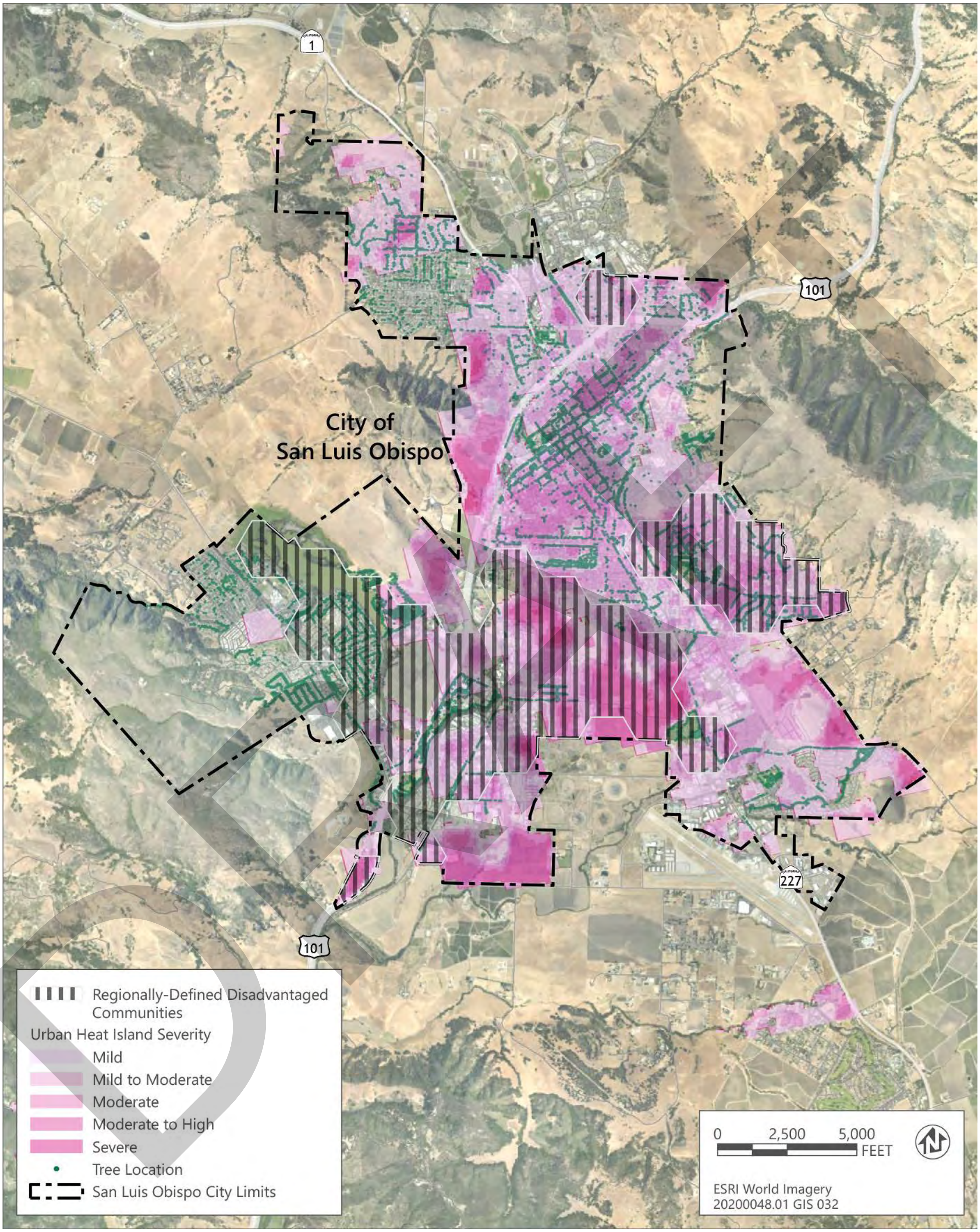
SLOCOG developed a regional definition for disadvantaged communities. Disadvantaged communities are disproportionately burdened areas that are economically distressed and/ or historically underrepresented as a part of the local government process. SLOCOG examined 13 variables, such as racial and ethnic minority, disability status, language proficiency, renter affordability, and household income. Many of these indicators also result in increased susceptibility to extreme heat impacts. To show how the urban heat island effect may further exacerbate projected heat impacts on the city, including vulnerable populations, Figure 12 identifies SLOCOG identified disadvantaged community areas, as well as the locations of critical facilities for vulnerable populations.

As shown in Figure 12, areas in the city with an increased concentration of commercial and industrial land uses have above-average surface temperatures. Notable urban heat island hotspots in the city include:

- the Service and Manufacturing, Office, and Business Park land uses near Tank Farm Road and South Higuera Street
- the Neighborhood Commercial land uses near Broad Street and Tank Farm Road
- some Commercial land uses along the northern portions of Monterey Street in downtown San Luis Obispo (SLO)

Notably, the urban heat island hotspot along South Higuera Street is directly adjacent to residential land use to the east of South Higuera Street and north of Prado Road likely resulting in disproportionate impacts on these residential areas including increased energy demand for cooling.

Additionally, as shown in Figure 12, southern portions of the city include far less tree cover than areas near the downtown and the Laguna Lake area to the west of US 101, which is likely contributing to urban heat island hotspots in these areas. This include the Margarita Avenue Neighborhood (Census Tract 111.03) and the West of South Higuera Neighborhood (Census Tract 115.01) which have four and five percent tree cover, respectively, which is lower than many other parts of the City. Southern portions of the city including areas adjacent to southern portions of Broad Street and Tank Farm Road include newer residential and commercial developments which include younger trees and vegetation. This may reduce potential urban heat island effects as vegetation and the tree canopy increase in these areas in the future.



Source: Data received and downloaded from City of San Luis Obispo and the Trust for Public Land.

Figure 12 Urban Heat Island Effect and Tree Cover in the City

Buildings and Energy Use

Changes in annual average temperature and extreme heat events are likely to effect buildings primarily through changes in energy use as well as disproportionate impacts on individuals residing in units that do not have air conditioning. Cal-Adapt provides data on the shifts in Cooling Degree Days and Heating Degree Days, which are measurements used to assess the energy demand needed for cooling and heating buildings in different climate zones throughout California. A degree day does not equate to a single day of the year but rather compares the mean (the average of the high and low) outdoor temperatures recorded for a location to a standard temperature (i.e., 65°F). For example, if the average temperature for a day is 80°F, the day has 15 Cooling Degree Days (80 – 65 = 15). Degree days are used in the State's Title 24 Building Energy Efficiency Standards to help design the energy demand needed for heating and cooling in the various climate zones throughout the state. To illustrate how climate change is likely to affect energy demand for heating and cooling in the future, Table 11 includes the relative shift in Cooling Degree Days and Heating Degree Days in the city through 2099.

Table 11 Changes in building energy use through 2099

Impact	Impact Type	Percent Change in Energy Demand for Heating and Cooling				Threshold Source
		Near-Term (2021-2050)	Midterm (2035-2064)	Late-Century (2070-2099)		
				Low Emissions	High Emissions	
Building Energy Use	Cooling Degree Days	66%	77%	80%	89%	CEC 2019c
	Heating Degree Days	-43%	-68%	-82%	-161%	CEC 2019c

Note: NA = not available.

Source: CEC 2019c

As shown in Table 11, in the near-term period, Cooling Degree Days in the City will increase by 66 percent while Heating Degree Days will decrease by 43 percent compared to historic averages. By the midterm period, Cooling Degree Days in the City will increase by 77 percent while Heating Degree Days will decrease by 68 percent compared to historic averages. In the late-century period under the medium emissions scenario, Cooling Degree Days will increase by 80 percent while Heating Degree Days will decrease by 82 percent. Under a high emissions scenario in the late-century period, Cooling Degree Days will increase by 89 percent while Heating Degree Days will decrease by 161 percent.

Changes in Cooling Degree Days will have implications for energy demand in residential and nonresidential buildings in the City with a higher energy demand for cooling and a decrease in energy demand for heating, in general. In general, for buildings in the City, increases in Cooling Degree Days will result in increased electricity demand for cooling and place increased demand on the electricity grid, particularly during extreme heat days and heat wave events which is projected to increase peak electricity demand for utilities. Currently, during extreme heat days and heat wave events, electricity utilities and the State's grid operator, California Independent System Operator, initiate "Flex Alerts", requesting customers to conserve energy during certain times of the day to reduce stress on the electricity grid (KSBY Santa Barbara-San Luis Obispo 2021). Some initial research that models future changes in peak load for utilities in California during extreme heat events has demonstrated that peak loads are substantially more sensitive to temperature anomalies, indicating warm-anomalous temperatures (e.g., extreme heat days and heat waves) will have a disproportionate impact on higher-intensity electricity consumption (Kumar et al. 2020). The research also indicates that disregarding the asymmetry in temperature response of electricity demand will lead to underestimating the climate-sensitive portion of the upper extremes of demand for electricity utilities in California, for short-term (2021-2040) and long-term (2081-2099) time periods included in the study.

As noted above, the urban heat island effect and hotspots in the City are likely to experience disproportionate increases in ambient air temperature during extreme heat days and heat wave events, further increasing electricity demand for cooling for homes with air conditioning while potentially resulting in heat-related public health impacts for homes without air conditioning. As noted in the City's recent Housing Element update, approximately 79 percent of the City's housing stock was built before 1989 (City of San Luis Obispo 2020a). These older and, in general, less energy efficient homes are more susceptible to increases in energy demand for heating and cooling.

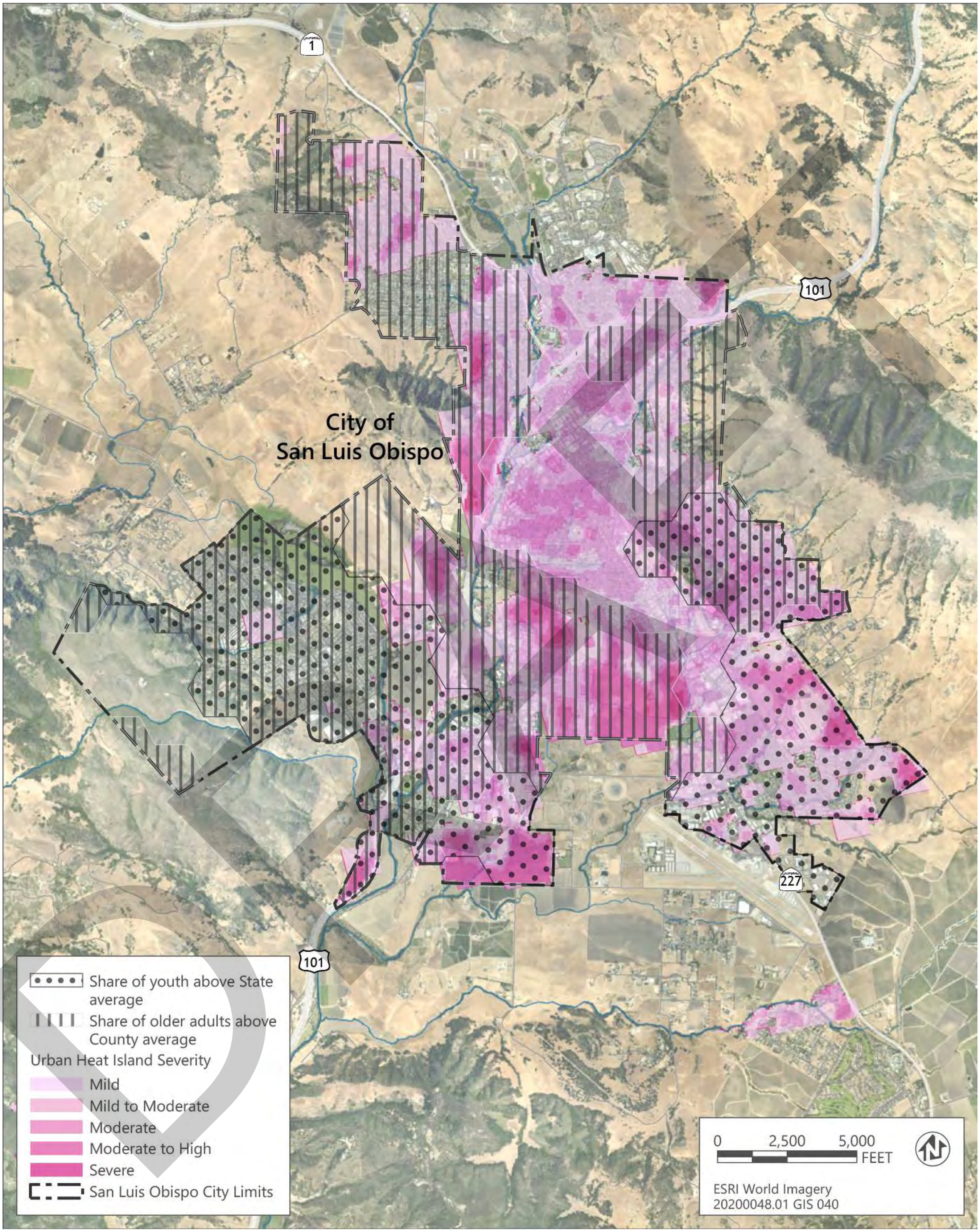
Key Findings and Policy Considerations

- The Margarita Avenue Neighborhood (Census Tract 111.03) includes population characteristics that make this area particularly vulnerable to extreme heat and is located in an area of the City with increased urban heat island severity. Resilience strategies that mitigate impacts of the urban heat island effect should focus on supporting this area of the City.
- Shifts in temperature and extreme heat will result in changes in energy demand for cooling in the City, with increased demand in areas experiencing more severe urban heat island hotspots. As the City implements it's recently adopted Climate Action Plan and as well as the Resilient SLO strategies, solutions that both reduce GHG emissions and help the City adapt to impacts of climate change should be prioritized.
- Older and, in general, less energy efficient homes are more susceptible to increases in energy demand for heating and cooling. Only 34 percent of homes in San Luis Obispo County have air conditioning with likely similar percentages in the City, making the City and it's building stock particularly ill-equipped to projected increases in heat wave events.
- Extreme heat days and heat waves will have a disproportionate impact on electricity demand, with higher electricity demand projected for these events in the future. These projections place an increased urgency on electricity utilities to plan for higher electricity demand during these events in future.

EXTREME HEAT AND COMMUNITY RESILIENCE

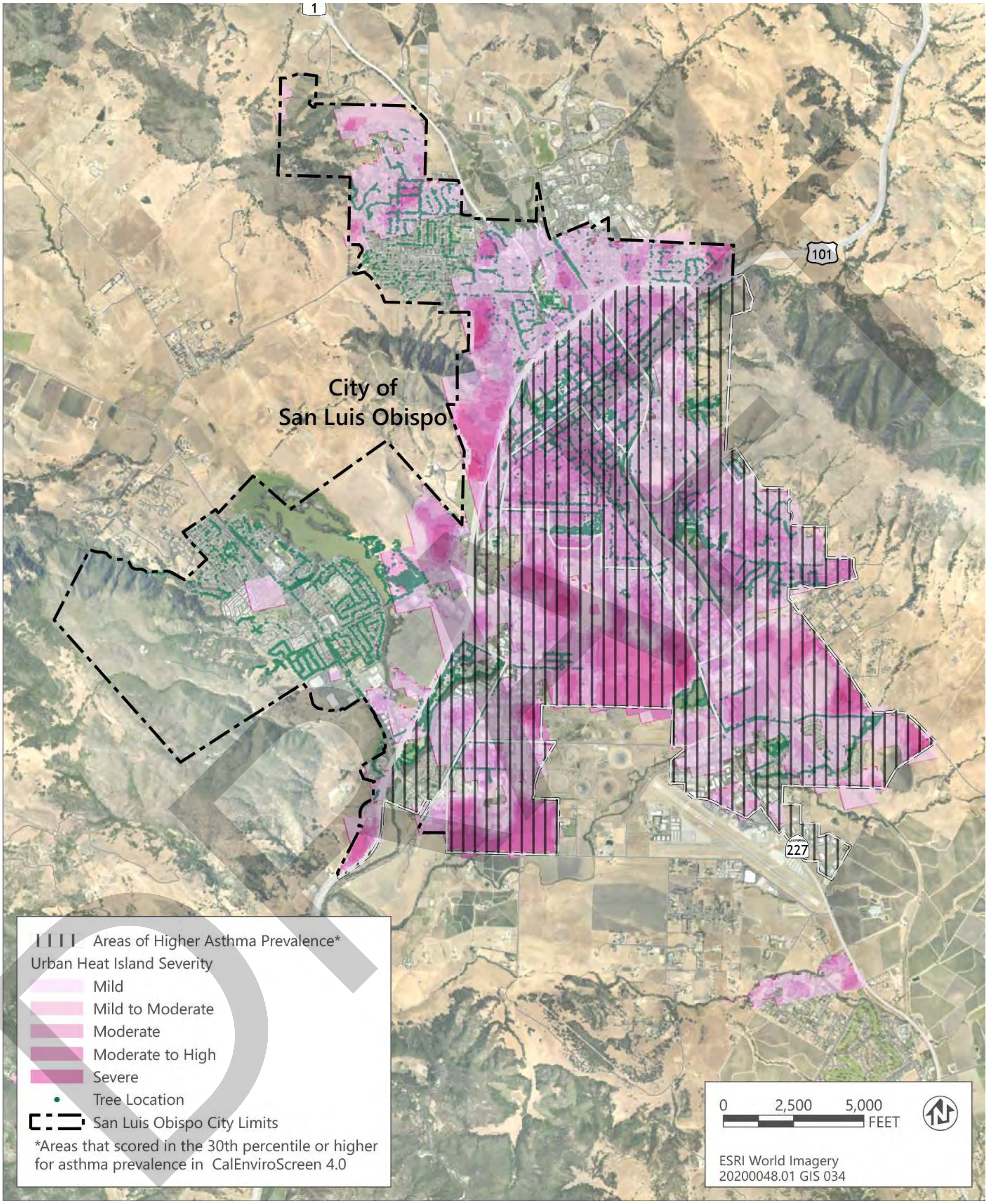
Heat-Sensitive Populations

As discussed in Section 2.2., over the age of 65, infants and children, individuals with chronic health conditions (e.g., cardiovascular disease, asthma), low-income populations, athletes training outdoors, and outdoor workers are particularly vulnerable to climate-related hazards including extreme heat (CDC 2019). Increased temperatures have been reported to cause heat stroke, heat exhaustion, heat syncope, and heat cramps, with certain vulnerable populations at increased probability of experiencing these effects (Kovats and Hajat 2008). Homeless populations often have higher rates of chronic disease because of extreme poverty, delays in seeking care, nonadherence to therapy, substance abuse, cognitive impairment, and other factors, placing them at increased risk during extreme heat events. Additionally, preexisting psychiatric illness can triple the risk of death for homeless populations during extreme heat events (Ramin and Svoboda 2009). Extreme heat can also worsen air quality, quickening the production of ozone in areas with increased concentrations of ozone precursors (i.e., oxides of nitrogen and reactive organic gases) (Knowlton et al. 2004). As shown in Figure 13 there is significant overlap between areas of moderate to severe urban heat island effect and areas with a higher share of older adults and youth under 5 years of age. The California Communities Environmental Health Screening Tool (CalEnviroScreen 4.0) includes an asthma prevalence indicator that measures the rate of emergency department visits for asthma. Although asthma rates in the City are low compared to statewide levels, there are areas of the City with relatively high asthma prevalence compared to local levels. Exposure to extreme heat has been shown to increase the risk of hospitalization for those with asthma (Dahl et al. 2019). As shown in Figure 14, the southern part of the City includes areas of more severe urban heat island effect and higher asthma prevalence. As noted in Section 2.2.2., the Margarita Avenue Neighborhood (Census Tract 111.03) and the West of South Higuera neighborhood (Census Tract 115.01) both include population characteristics that make these areas particularly vulnerable to extreme heat including higher percentages of elderly and disabled residents in these areas as well 50 percent of residents earning less than 200 percent of the federal poverty level in the Margarita Avenue Neighborhood.



Sources: Data received from SLOCOG in 2021, downloaded from The Trust for Public Lands in 2020, City of San Luis Obispo in 2020, County of San Luis Obispo in 2020

Figure 13 Youth and Elderly Populations and Urban Heat Island Severity in the City



Sources: Data downloaded from OEHHA in 2021, downloaded from The Trust for Public Lands in 2020, City of San Luis Obispo in 2020, County of San Luis Obispo in 2020 and received from CBEC Engineering in 2020

Figure 14 Asthma Rate Prevalence and Urban Heat Island Severity in the City

Public Health and Extreme Heat

For this analysis, the California Heat Assessment Tool (CHAT) was used to identify how Heat Health Events would increase in the future. A Heat Health Event, for the purposes of the tool, is defined as any event that results in negative public health impacts, regardless of the absolute temperature. The tool includes unique Heat Health Events threshold for locations throughout the state, specific to the climate and the historical sensitivity of people in that area to past extreme heat events. Heat Health Events are defined by a set of meteorological conditions over several days that have been associated with significant negative public health impacts (i.e., rate of visits to local emergency rooms) in a specific location. The defined temperature threshold for the City in the CHAT tool is days when maximum temperatures reach 92.6°F and maximum humidity reaches 50.5 percent. Specifically, the tool focuses on emergency room visits for individuals under four and above 65 as well as all non-white individuals, to define a vulnerable population cohort. For this analysis, the CHAT tool and the projected increase in Heat Health Events in the City for the general populations and vulnerable populations, as defined by the tool, are used. For more information on the tool and methodology used to identify Heat Health Events, please visit the CHAT Tool website (cal-heat.org). Table 12 includes increases in Heat Health Events for the general population and vulnerable populations in the City through 2099.

Table 12 Heat Health Events through 2099

Impact	Impact Type	Population	Historic (1961-1990)	Near-Term (2021-2050)	Midterm (2035-2064)	Late-Century (2070-2099)		Threshold Source
						Low Emissions	High Emissions	
Building Energy Use	Heat Health Events (HHE)	General Population	NA	1.3	1.4	1.75	5.4	CEC 2018
	Heat Health Events (HHE)	Vulnerable Populations	NA	8.23	10	11.2	12	CEC 2018

Note: NA = not available; CHAT = California Heat Assessment Tool.

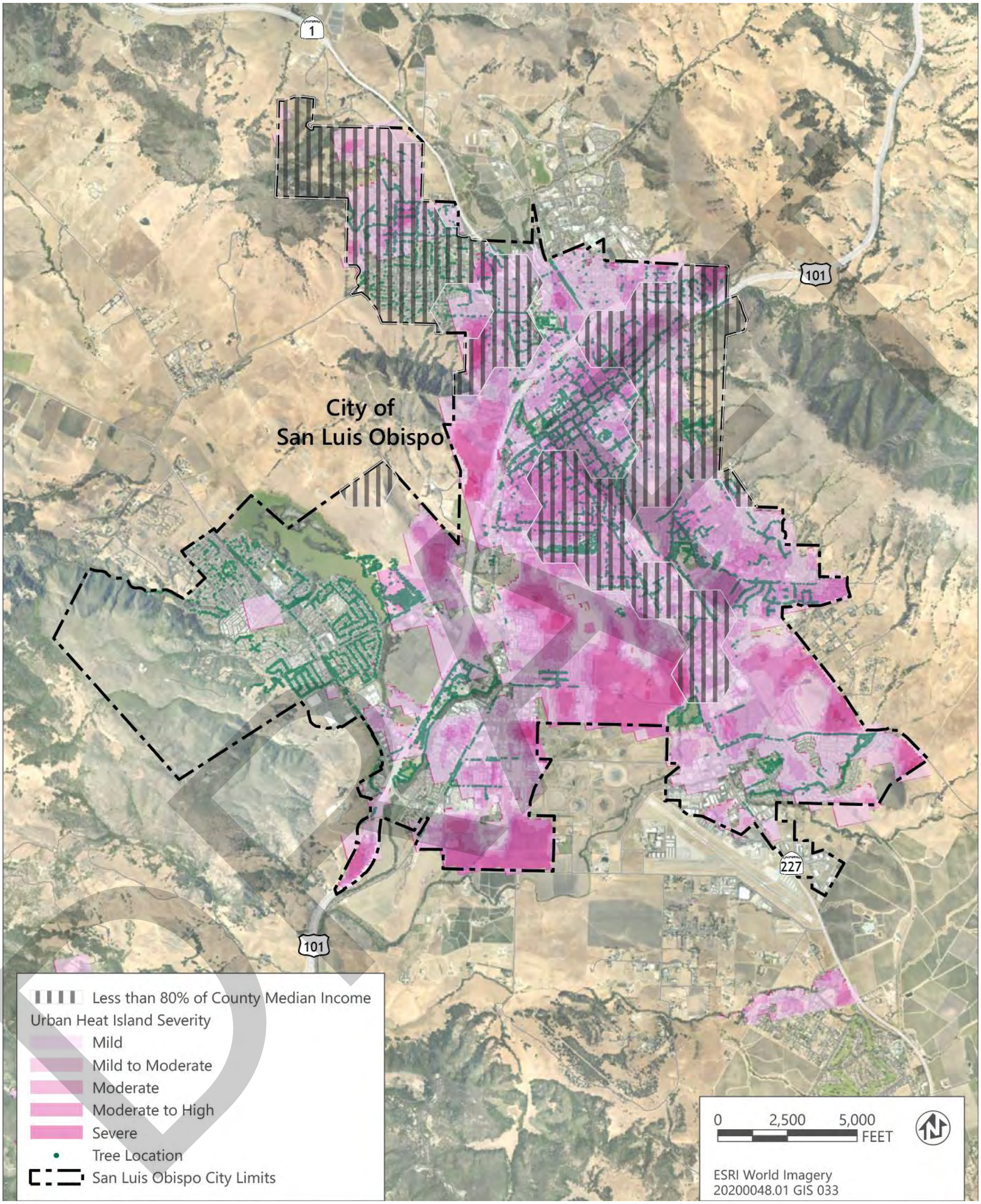
Source: CEC 2018

As shown in Table 12, during the near-term period, the City's general population will experience approximately 1.3 Heat Health Events while vulnerable populations to extreme heat will experience 8.23 Heat Health Events per year resulting in projected increases in demand for emergency services and hospital room visits. By the midterm period, the City's general population will experience approximately 1.4 Heat Health Events per year while vulnerable populations will experience 10 Heat Health Events per year. In the midterm period under the medium emissions scenario, the general population will experience approximately 1.75 Heat Health Events per year while vulnerable populations will experience 11.2 Heat Health Events per year. Under the high emissions scenario for the late-century period, the City's general population will experience a large increase to approximately 5.4 Heat Health Events per year while vulnerable populations to extreme heat will experience 12 Heat Health Events per year. As shown in Table 12, Heat Health Events for both the general population and vulnerable populations will continue to increase through the late-century period. For the general population, by the late-century period, Heat Health events will increase between 33 percent (low emissions scenario) and 315 percent (high emissions scenario). For vulnerable populations at increased risk from heat-related impacts, by the late-century period, Heat Health events will increase between 36 percent (low emissions scenario) and 46 percent (high emissions scenario). This analysis demonstrates a general increase in Heat Health Events throughout the century with a more pronounced impact on vulnerable populations who are at increased risk during Heat Health Events.

Environmental Justice and Extreme Heat

Alongside populations with health sensitivities, residents with specific sociodemographic characteristics are at increased sensitivity to extreme heat events (CDC 2019). Research has found that low-income residents spend a larger proportion of their income on utilities, including electricity use for cooling, with these residents being disproportionately affected during extreme heat events (Voelkel et al. 2018). Additionally, research has found that low-income neighborhoods can often have less tree coverage and park space, further contributing to the disproportionate impact on low-income residents (Zhu and Zhang 2008). Additionally, decreased access to transportation services can further increase exposure and health risks from extreme heat events for the unhoused community (Ramin and Svoboda 2009). Unhoused individuals are also at increased risk from extreme heat events with, generally, less access to places to cool off and healthcare resources during these events. Figure 15 shows the location of low-income areas in the City, based on the San Luis Obispo Council of Government's (SLOCOG) regional definition of low-income. The map shows urban heat island hotspots and areas where average income level is less than 80 percent of the region's average median income. Unhoused individuals are also at increased risk from extreme heat events with, generally, less access to places to cool off and healthcare resources during these events. Additionally, decreased access to transportation services can further increase exposure and health risks from extreme heat events for the unhoused community (Ramin and Svoboda 2009).

The Margarita Avenue Neighborhood (Census Tract 111.03) is an area of the city with a particularly vulnerable population in regard to extreme heat. This area includes a high percentage of elderly and disabled residents, a high percentage of residents experiencing linguistic isolation, and 50 percent of residents earning less than 200 percent of the federal poverty level. This census tract also is located in a portion of the City that experiences a more intense severity of the urban heat island effect, resulting in potentially disproportionate impacts on this population during extreme heat events. The West of South Higuera neighborhood (Census Tract 115.01) also stands out as a particularly vulnerable to extreme heat, with the area also near urban heat island hotspots and includes a high percentage of elderly and disabled residents.

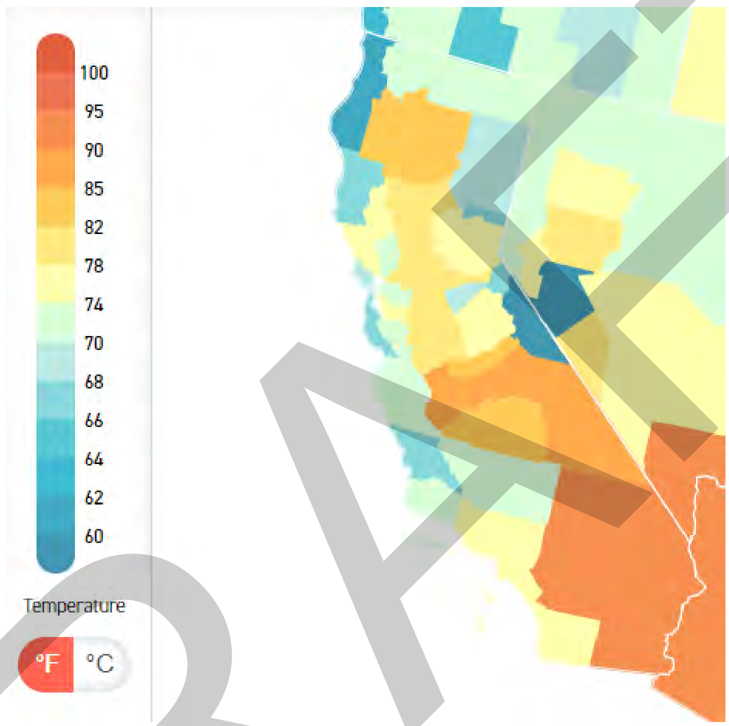


Sources: Data received from SLOCOG in 2021, The Trust for Public Lands in 2020, City of San Luis Obispo in 2020, County of San Luis Obispo in 2020 and received from CBEC Engineering in 2020

Figure 15 Low-Income Areas and Urban Heat Island Severity in the City

Economic Systems and Extreme Heat

As discussed previously and shown in Table 9 and 10, the City will experience increases in average annual temperature and extreme heat days throughout the 21st century. However, these increases are, in general, less intense than increases many other parts of California, particularly in southern California and the San Joaquin Valley. Coastal communities in the County as well as the City already experience an influx of visitors during the summer months, many of them escaping the more extreme summer heat in the San Joaquin Valley. This phenomenon was even more pronounced during the recent heat waves in the summer of 2020, with the County and the City experiencing record maximum temperatures coupled with an influx of visitors escaping heat in other parts of the state (San Luis Obispo Tribune 2020). As shown in Figure 16, by approximately 2050, increases in average temperatures will be less severe relative to other parts of the state.



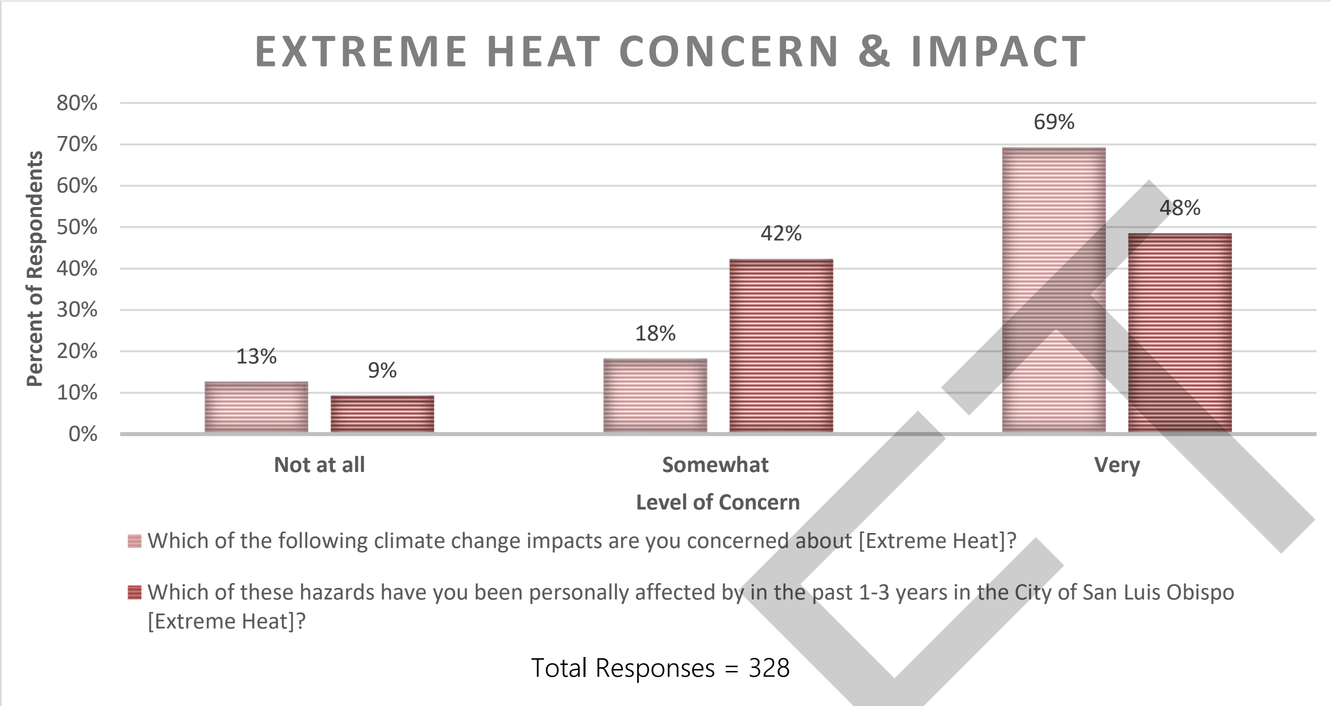
Increases in average temperature in June through July by 2050 under a high emissions scenario.
Source: Climate Impact Labs 2021

Figure 16 Relative Changes in Extreme Heat by 2050

Due to this milder change in temperature, the City and the County are likely to increasingly become a refuge for visitors and future permanent residents looking to escape more extreme climate impacts. This influx could have secondary impacts on the City including increase demand for services, increases in traffic congestion, and increases demand for housing, placing additional pressure on the City's housing market and affordability issues. Given that the City is an attractive destination for tourism, coupled with the characteristics that could serve as a refuge for the impacts from climate change, these factors pose a unique issues with potential benefits and drawbacks that should be considered carefully.

Community Extreme Heat Concerns

As part of the community priority survey, when participants were asked to report on their level of concern for extreme heat, as shown in Figure 17, 87 percent of respondents indicated that they were "Somewhat" or "Very" concerned about the issue. Ninety percent of individuals indicated they had been "Somewhat" or "Very" impacted by extreme heat in the past 1-3 years. Additionally, individuals with a household income of less than $50,000 and individuals between the ages of 18 and 24 had the highest level of concern for extreme heat. Individuals who note their housing situation as "Renter" or "Other" indicate the highest level of concern for extreme heat (i.e., 79 percent versus 58 percent for homeowners).



Sources: Resilient SLO Community Priorities Survey

Figure 17 City Resident's Extreme Heat Concern and Impact

Key Findings and Policy Considerations

- The Margarita Avenue Neighborhood (Census Tract 111.03) West of South Higuera neighborhood (Census Tract 115.01) is an area of the city with a particularly vulnerable population in regard to extreme heat, with a high percentage of elderly, disabled, or low-income residents. The West of South Higuera neighborhood (Census Tract 115.01) also includes a high percentage of elderly and disabled residents, making this area particularly vulnerable to extreme heat impact.
- Low-income residents are particularly vulnerable to extreme heat impacts due to a number of factors including a higher reliance on public transit (leaving these residents more exposed to extreme heat during transit use), a higher percentage of income being devoted toward utility bills, and a trend of lower income neighborhoods having less tree cover. Unhoused individuals are also at increased risk from extreme heat events with, generally, less access to places to cool off and healthcare resources during these events.
- The City and the County, in general, have historically served as a destination for summer tourists to escape more extreme summer heat in the San Joaquin Valley and southern California. As extreme heat events continue to increase disproportionately in those areas of the state compared to less severe increases locally, the City may experience increases in this phenomenon placing increased demand on services, impacts on City infrastructure and resources, as well increased pressure on the housing shortage issue in the City from new permanent residents.

2.3.3 Adaptive Capacity for Temperature and Extreme Heat Events

ADAPTIVE CAPACITY RATING: LOW

While the City has experienced periods of extreme heat historically, this climate-related hazard has not been a prominent issue for the City in the past. Because prolonged heat events have been rare in the City, both the City's 2006 Local Hazard Mitigation Plan and the more recent Annex G of the County's Multi-Jurisdictional Hazard Mitigation Plan do not discuss or evaluate extreme heat events in any detail. Specifically, the City's portion of Annex G of the County's Multi-Jurisdictional Hazard Mitigation Plan does not include any mitigation actions specific to extreme heat or protecting vulnerable populations from extreme heat. The City's Emergency Operation Plan also does not include a specific discussion or protocols for addressing extreme heat events when they occur. The exclusion of extreme heat from these documents is likely because these events have not been an issue historically.

The City is currently working to implement its recently adopted Climate Action Plan which includes strategies for the electrification of new and existing buildings (Green Buildings 1.1 and 1.2 in City's Climate Action Plan). As the City continues this work to electrify new and existing buildings, changes in electricity demand for cooling will remain an important consideration for the energy design of new buildings and existing building retrofits. Decreases in HDDs due increase in annual maximum and minimum temperatures as shown in Table 11, will result in decreased demand for heating fuels, which for buildings in the City is primarily natural gas. Decreases in energy demand for heating also has the potential to decrease the City's overall GHG emissions and help achieve the City's GHG emissions reduction targets.

As noted previously, 79 percent of the City's housing stock was built before 1989, reducing the ability of these older and less energy efficient homes to adapt to changes in extreme heat. In the County as a whole which can serve as proxy for the City, only 34 percent of households include air conditioning, placing these households at increased risk when extreme heat events do occur (CEC 2009). Retrofitting homes with central air conditioning or air conditioning units can be a major expense, especially for low-income households, and may not be possible for City residents who are renting. Overall, because the City has not historically experienced many extreme heat conditions,, residents are not acclimatized to or prepared for extreme heat conditions, which makes the City particularly sensitive to extreme temperatures.

Climate Action Plan and Resilient SLO

In 2020, the City adopt the Climate Action Plan for Community Recovery which establishes a community-wide goal of carbon neutrality by 2035, adopts sector specific goals, and provides foundational actions to establish a trajectory towards achieving those goals. The Resilient SLO project focuses on developing strategies to make the City more resilient to the impacts of climate change. However, as the City implements the Climate Action Plan and the Resilient SLO strategies, it will be important to prioritize solutions that both reduce GHG emissions and help the City adapt to impacts of climate change. Both reducing emissions and adapting to climate change serve to create a more resilient community.

For these reasons, the adaptive capacity ranking for increased temperatures and extreme heat is ranked as low.

2.3.4 Vulnerability Summary

Overall, the City is projected to experience noticeable increases in annual average temperatures and extreme heat events. These changes will result in varying impacts on the City and its residents as discussed above. Based on the analysis of various impacts discussed in Section 3.2.2, the City's potential impact scoring is Medium (2). Impacts that are unique to the City and should be given increased consideration during the adaptation strategy development process are discussed below.

Natural System Findings

- Changes in temperature and extreme heat are likely to have negative impacts on the City's tree canopy with some tree species no longer suitable for future minimum and maximum temperatures. Any future policies focused on improving the City's tree canopy or green spaces to mitigate the urban heat island effect should carefully consider what plant and tree species will be suitable for future climate conditions.
- Climate change is projected in invasive species in the City's open spaces, affecting coastal sage scrub habitats as well as the City's oak species from Sudden Oak Death.
- Regional impacts on the agriculture and viticulture industries from shifting temperatures have the potential to impact the City via decreases in wine and vineyard-based tourism, with the City relying heavily on revenue and employment opportunities in these industries. Resilience strategies focused on economic impacts should consider potential impacts on viticulture vineyard-based tourism and potential diversification of the City's tax revenue sources and employment industries.

Built Environment Findings

- The Margarita Avenue Neighborhood (Census Tract 111.03) includes population characteristics that make this area particularly vulnerable to extreme heat and is located in an area of the City with increased urban heat island severity. Resilience strategies that mitigate impacts of the urban heat island effect should focus on supporting this area of the City.
- Shifts in temperature and extreme heat will result in changes in energy demand for cooling in the City, with increased demand in areas experiencing more severe urban heat island hotspots. As the City implements it's recently adopted Climate Action Plan and as well as the Resilient SLO strategies, solutions that both reduce GHG emissions and help the City adapt to impacts of climate change should be prioritized.
- The City's historically moderate climate has, in general, not required the City's existing building stock to be designed or equipped with air conditioning. However, as average temperatures and extreme heat events increase in the future, residents are ill-equipped to prepare for these events. Additionally, increases in temperature and extreme heat will result in increased energy demand for cooling, which underscores the need to support distributed energy resources, customer sited energy storage, demand response, and grid/building connected appliances and vehicles.
- Extreme heat days and heat waves will have a disproportionate impact on electricity demand, with higher electricity demand projected for these events in the future. These projections place an increased urgency on electricity utilities to plan for higher electricity demand during these events in future.

Community Resilience Findings

- The Margarita Avenue Neighborhood (Census Tract 111.03) West of South Higuera neighborhood (Census Tract 115.01) is an area of the city with a particularly vulnerable population in regard to extreme heat, with a high percentage of elderly, disabled, or low-income residents. The West of South Higuera neighborhood (Census Tract 115.01) also includes a high percentage of elderly and disabled residents, making this area particularly vulnerable to extreme heat impact.
- Low-income residents are particularly vulnerable to extreme heat impacts due to a number of factors including a higher reliance on public transit (leaving these residents more exposed to extreme heat during transit use), a higher percentage of income being devoted toward utility bills, and a trend of lower income neighborhoods

having less tree cover. Unhoused individuals are also at increased risk from extreme heat events with, generally, less access to places to cool off and healthcare resources during these events.

- The City and the County, in general, have historically served as a destination for summer tourists to escape more extreme summer heat in the San Joaquin Valley and southern California. As extreme heat events continue to increase disproportionately in those areas of the state compared to less severe increases locally, the City may experience increases in this phenomenon placing increased demand on services, impacts on City infrastructure and resources, as well increased pressure on the housing shortage issue in the City from new permanent residents.

Temperatures and Extreme Heat Vulnerability Score

Adaptive Capacity: Low (3)

Potential Impact: Medium (2)

Vulnerability Score: 4

2.4 LONG-TERM DROUGHT ANALYSIS

This section discusses future long-term drought scenarios for the City and analyzes how long-term drought could impact City and its population as well as highlighting what capacity the City and partner agencies already have in place to address future drought impacts.

2.4.1 Future Exposure to Long-Term Drought Scenarios

Long-term drought can have environmental, agricultural, health, economic, and social consequences. The County, along with larger areas of California, experiences periods of long-term drought that stress ecosystems and water supplies; and subsequently, impact agriculture, public health, and the economy. The City relies on regional water supplies with the four primary sources being Whale Rock Reservoir, Salinas Reservoir, Nacimiento Reservoir, and recycled water (City of San Luis Obispo 2019). Because the City relies on reservoirs in the County, outside the City limits, this analysis focuses on long-term drought scenario projections for the County as a whole.

While average annual precipitation in the County is projected to trend upward in future years, the key finding for this climate effect is that precipitation patterns are expected to become more volatile, with potentially less frequent but intense storms that produce above average amounts of precipitation. As discussed in more detail in Section 2.5, precipitation patterns in California oscillate between extremely dry and wet periods. Climate change is anticipated to exacerbate these seasonal extremes with dry periods becoming dryer and wet periods becoming wetter (OPR et al. 2018b:19). As a result, the frequency and severity of large storm events are anticipated to increase as well. These oscillations between extremely dry and extremely wet periods, which have occurred historically in the state, are anticipated to become more severe with rapid shifts from dry to wet periods known as "whiplash events" (Swain et al. 2016). With the increased severity of oscillation between wet and dry periods and precipitation occurring over more intense but shorter periods in the year, this will reduce opportunities for groundwater recharge which ideally occurs during prolonged wet periods allowing for soil infiltration, deeper percolation, and the resulting groundwater recharge. As discussed further in Section 2.4.2, while a unique long-term drought scenario would likely affect the City's overall water supply management practices, there is the potential for there still to be above average wet years within a long-term drought, as shown in Figure 18. These above average wet years have the potential to replenish water supplies in the City's reservoirs and help mitigate the impacts of long-term drought. Table 13 includes projections for average annual precipitation in the County through 2099 as well as rainfall projections for changes in the 5-year storm event, demonstrating the increased intensity of large storm events and wet years in the future.

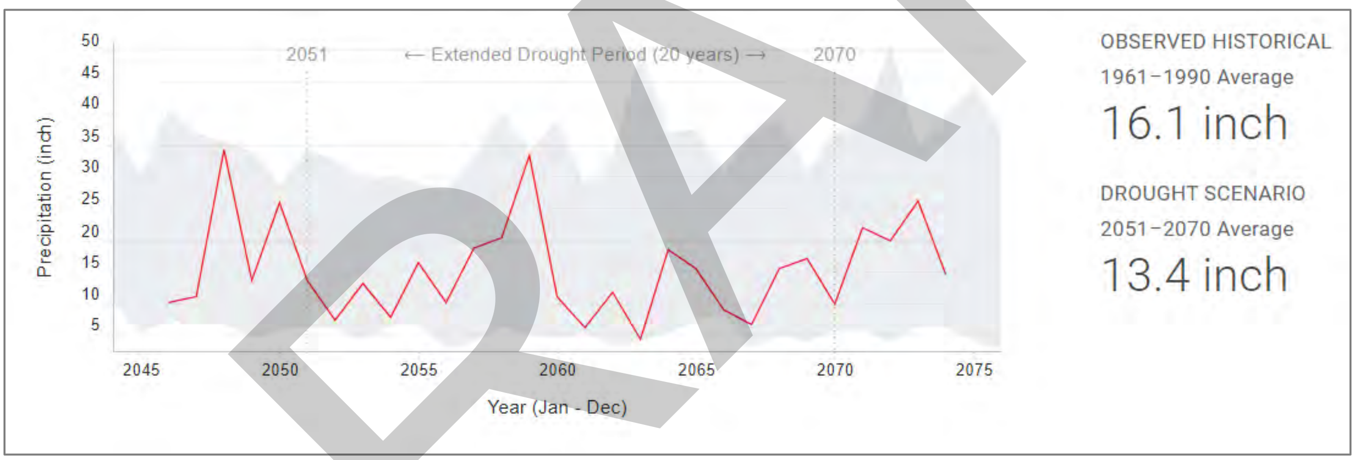
Table 13 Changes in Average Annual Precipitation and 5-Year Storm Event in San Luis Obispo County

Average Annual Precipitation	Historic Average Annual Precipitation (1961-1990)	Near-Term (2021-2050)	Midterm (2035-2064)	Late-Century (2070-2099)	
				Medium Emissions	High Emissions
Average Annual Precipitation (inches)	16.1	18.1	17.8	17.2	19.8
5-Year Storm Event (2-day rainfall)	7.9	7.9	8	8.2	9.8

Source: CEC 2019a

As shown in Table 13 above, under both the low and high emissions scenarios, the County is expected to experience slight overall increases in average annual precipitation in the late century. However, projections show the County will experience increased variability and volatility in precipitation events such as droughts. The County and state have a highly variable climate that is susceptible to prolonged periods of drought, and recent research suggests that extended drought occurrence (a "mega-drought") could become more pervasive in future decades (OPR et al. 2018b).

Cal-Adapt uses data to model an extended drought scenario for all of California from 2051 to 2070 specifically using the HadGEM2-ES GCM model under a high emissions scenario. The extended drought scenario is based on the average annual precipitation over 20 years. As shown in Table 13, the County's observed historical (1961-1990) average annual rainfall accumulation is 16.1 inches. Under the anticipated drought scenario between 2051 and 2070, the County's average annual rainfall accumulation would decrease to 13.3 inches (CEC 2019a), resulting in an approximately 18 percent decrease in annual average rainfall over a 20-year period.



Source: Cal-Adapt 2021

Figure 18 Projected Drought Conditions between 2051 and 2070 for San Luis Obispo County

2.4.2 Drought Sensitivities and Impacts

This section discusses the City's existing sensitivities to long-term drought and analyzes potential effects on the City, discussed in the three general impact categories (e.g., Natural Systems, Built Environment, Community Resilience).

DROUGHT AND NATURAL SYSTEMS

Open Space and Ecosystem Functions

The City's designated open space areas include a mixture of vegetation types including oak woodland, grassland, coastal sage scrub, and chaparral that are anticipated to be impacted by changes in annual average temperatures, extreme heat, and long-term droughts (OPR et al. 2018b). Historically, the duration and intensity of droughts in California varies substantially with elevation, latitude, distance to coast, and local soil characteristics. Native perennial grasses tend to concentrate growth periods during wet winter months, adapting to the annual summer drought (Vaughn et al. 2011). Some native perennial grasses can survive prolonged droughts in a non-green state and then regenerate after it rains (Potter 2015). As a result, it is projected that most grassland species should be adaptive to tolerate climate extremes and variability (OPR et al. 2018b). The diversity of ecological communities along the California coast are linked to the summer marine layer of fog and low clouds, allow for adaptations. Chaparral shrubs, in general are more drought tolerant. Future changes in precipitation and drought will impact grasslands and wildflowers on the Central Coast and will be dependent on the proximity to the coast as well as the relative proportion of native to non-native, and perennial to annual species (OPR et al. 2018b).

In dryer years and drought periods, demographic rates for annual plants (e.g., survival, reproduction) are lower than in wetter years (Fox et al. 2006). As dry years and long-term droughts become more common in the future, population growth rates of annual plant species will become marginal, and populations are likely to become locally extinct. Foraging on these annuals, particularly by deer, rabbits, and woodrats reduces population growth even more than drought in some species, but not others (OPR et al. 2018b).

Deer browse (e.g., leaves, twigs, and buds of woody plants eaten by deer) reduces growth, reproduction, and survival in ceanothus (e.g., California Lilac). As the abundances of deer and other wildlife declined during the recent drought of 2011-2017, previously browsed shrubs grew and reproduced well and then responded rapidly to the two wet years since. These observations suggest that unless deer populations increase again between droughts, or in areas without much deer browse, ceanothus shrub are likely to grow rapidly, but will become vulnerable with further droughts projected under climate change (OPR et al. 2018b).

Key Findings and Policy Considerations

- The City's designated open space areas include a mixture of vegetation types including oak woodland, grassland, coastal sage scrub, and chaparral that are anticipated to be impacted by changes in annual average temperatures, extreme heat, and long-term droughts (OPR et al. 2018b).
- As dry years and long-term droughts become more common in the future, population growth rates of annual plant species will become marginal, and populations are likely to become locally extinct (OPR et al. 2018b).

DROUGHT AND THE BUILT ENVIRONMENT

Water Supply

While increasingly frequent and prolonged droughts affect the City's drinking water supply, the City's built environment (e.g., buildings, roadways) will not experience direct physical impacts associated with this climate-related hazard. However, drought conditions and other climate-related effects will likely effect reservoirs, located outside the City boundaries, which provide water to the City. For the Central Coast, a 50-year projection for land uses from 2012 to 2062 suggest potential changes that could affect groundwater supplies including a large amount of grassland habitat loss over 50 years that will exacerbate challenges in preserving and recharging groundwater aquifers, as well as increased water demand due to urbanization and expansion of berries and vineyards (Wilson et al. 2016).

As shown in Figure 18, even during a future long-term drought scenario, there would be years with above average rainfall for one or even multi-year periods. However, these one or multi-year periods with above average rainfall may not be sufficient to restore reservoirs to normal water levels compared to non-drought periods. For example, during the statewide drought between approximately 2011 and 2016, water supplies on the Central Coast were severely affected with increases in reservoirs and groundwater levels varying significantly across the Central Coast region following the above average 2016-2017 winter rain season (OPR et al. 2018b). As noted in the City's 2017 Water Resources Status Report, between January 2017 and June 2017 the water supply in the Salinas Reservoir went from 10 percent to 100 percent, the Whale Rock Reservoir went from 32 percent to 79, and the Nacimiento Reservoir shifted from 25 percent to 78 percent (City of San Luis Obispo 2021b). This dramatic shift from a multi-year drought between 2011 and 2015 drought followed by an above average wet year in the 2016-2017 winter rain season was characteristic of a whiplash event (Swain et al. 2018) and allowed the City to replenish its water supplies. However, these whiplash events may affect water supply management practices over the long-term, particularly as the swings from multi-year dry to wet periods become more prolonged and more severe (Persad et al. 2020).

As part of the City's 2020 Urban Water Management Plans (UWMP), climate change modeling was conducted to determine future projections on the City's safe annual yield. Safe annual yield is generally defined as a measurement used to determine the average replenishment rate of a water body or aquifer from natural and artificial recharge, which factors in evaporation, transpiration, and basin outflow into the replenishment rates. Safe annual yields are calculated as the quantity of water which can be withdrawn regularly and permanently without dangerous depletion of the storage reserve. Based on the climate modeling included in the 2020 UWMP, it was determined that, when accounting for future precipitation patterns due to climate change, the safe annual yield for Whale Rock and Salinas Reservoirs (two reservoirs included in the City's water supply portfolio) could shift from a decrease of as much as 850-acre-feet per year (AFY) to an increase of as much as 160 AFY. However, these potential shifts are relatively small compared to the City's overall safe annual yield of 10,130 acre-feet from the full water supply portfolio, with shifts from climate change accounting for an approximately 8 percent decrease to 2 percent increase in the City's overall supply (City of San Luis Obispo 2021b).

Sediment Deposition

The buildup of sedimentation in reservoirs can reduce a reservoir's available storage volume. As noted in the City's 2020 Urban Water Management Plan (UWMP), the Whale Rock and Salinas Reservoirs, which provide water to City, are projected to experience an total loss of 500 acre-feet of water between 2010 to 2060 period (a rate of 10 acre-feet per year over 50 years). Intense, long-duration winter storm rainfall can result in the movement of large sediment quantities into reservoirs (OPR et al. 2018b). In the Central Coast region, annual sediment movement from individual watersheds varies by a factor of 500 or more between extreme dry and extreme wet years (Conaway et al., 2013; East et al., 2018). Landscape disturbances including wildfire, post-wildfire runoff, or landslides after wet winters, is projected to increase sediment yield from watersheds along the Central Coast (OPR et al. 2018b) and will reduce the amount of water-storage capacity in dammed Central Coast reservoirs (Smith et al. 2018). Changes in vegetation and fire regimes could also potentially add to the likelihood of increased sediment flux (Sankey et al., 2017). Sediment, including the nutrients and chemicals adsorbed in sediment, can result in decreased water quality and make water treatment more technically complex and more costly.

Key Findings and Policy Considerations

- Dramatic shifts from multi-year dry periods to wet periods, similar to the 2011-2015 drought followed by an above average wet year in the 2016-2017, are known as whiplash events (Swain et al. 2018) and they are expected to become more severe in the future. These whiplash events may affect water supply management practices over the long-term, particularly as the swings from multi-year dry to wet periods become more prolonged and more severe, with an emphasis on increasing rainfall storage when it does occur during the wet periods (Persad et al. 2020).
- Buildup of sedimentation that reduces a reservoir's available volume already occurs in the City's water storage system, with the City implementing programs and policies to address this storage loss over the long term. However, landscape disturbances including wildfire, post-wildfire runoff, or landslides after wet winters, is projected to increase sediment yield from watersheds along the Central Coast (OPR et al. 2018b), with the potential to further reduce the amount of water-storage capacity in dammed Central Coast reservoirs (Smith et al. 2018).
- The City's Safe Annual Yield analysis included in the 2020 UWMP modeled potential impacts on the City's water supplying, finding that changes in precipitation could result in a decrease of as much as 850 AFY to an increase of as much as 160 AFY, accounting for an approximately 8 percent decrease to 2 percent increase in the City's overall water supply (City of San Luis Obispo 2021b).

DROUGHT AND COMMUNITY RESILIENCE

Vector-borne and Infectious Disease

Increases in temperature and extreme heat events are associated with increases in vector-borne and infectious disease transmission (OPR et a. 2018b). Based on recent research, summarized in the Central Coast Report, future long-term drought scenarios have the potential to increase the prevalence of certain vector-borne diseases present on in the central coast region. For example, long-term drought can affect the life cycles and extend the habitat range of native tick species that can harbor Lyme disease and other illnesses (OPR et a. 2018b). Cases of vector-borne disease, including Lyme disease, are projected to increase in the future due to climate change (Estrada-Pena, A., N. Ayllon, and J. de la Fuente 2012). However, in the Central Coast region, the spread of Lyme disease has likely been contained due to the area's drier climate and differing vegetation (MacDonald, A.J. et al. 2017). A newly identified vector-borne disease, Pacific Coast tick fever (PCTP), has been identified (Padgett, K.A., et al. 2016). Although an emerging illness, a few of the human cases originated specifically in the Central Coast. PCTP has exhibited a summer trend so far. Therefore, increasing temperatures have the potential to extend PCTP's transmittal season in the Central Coast.

A lack of soil moisture during long-term droughts can increase dust particle concentration, which can include harmful fungal spores and viruses, including coccidioidomycosis (valley fever) (OPR et a. 2018b). The California Department of Public Health (CDHP) has highlighted the Central Coast as a high-risk area for valley fever (OPR et a. 2018b). Valley fever is found in disturbed, dry soil particles that must be inhaled. Symptoms of Valley fever include chest pain, exhaustion, fever, coughing, joint and muscle pain, and difficulty breathing. Certain populations including pregnant women, the elderly, African, and Filipino Americans are particularly vulnerable to the severe cases of the disease (Brown et al. 2013). Santa Barbara and San Luis Obispo Counties, where the Valley fever fungus, *C. immitis*, is endemic, reported larger numbers of cases in 2017, with the CDPH reporting over 500 cases for these two counties (San Luis Obispo Tribune 2016).

Key Findings and Policy Considerations

- Increases in temperature and extreme heat events are associated with increases in vector-borne and infectious disease transmission, with future long-term drought scenarios potentially increasing the prevalence of certain vector-borne diseases present on in the central coast region including Lyme disease and Valley fever.

2.4.3 Adaptive Capacity for Drought Impacts

ADAPTIVE CAPACITY RATING: HIGH

Utilities Department and Water Management

Short- and long-term droughts have historically been an issue for the City and the Central Coast region. As a result, the City already has a comprehensive set of initiatives and resources in place to address drought periods when they do occur. In 2021, the City adopted the 2020 UWMP which evaluates the current and projected water supplies through the year 2040. The UWMP was prepared in accordance with the Urban Water Management Planning Act, and accordingly, will be updated every 5 years and submitted to the California Department of Water Resources. Goals in the UWMP related to this this Report include the following:

- assess current and future water use trends in the community;
- summarize the water supply and the water system;
- assess water supply reliability;
- document the water demand; and
- manage measures in place to balance supply and demand.

The 2020 UWMP includes a section specially on Water Resiliency Planning which highlights a set of strategies the City has taken to ensure long-term water resiliency and to mitigate the impacts from a long-term drought scenario. These include:

- a multi-source water supply;
- conservative water supply projections;
- water use efficiency;
- water recycling; and
- future groundwater recharge.

As noted in the 2020 UWMP, the City has a Reliability Reserve and a Secondary Water Supply which have been incorporated in water management planning and calculations to provide a buffer for future unforeseen or unpredictable long-term impacts to the City's available water resources such as loss of yield from an existing water supply source and impacts due to climate change. The Reliability Reserve provides a twenty percent buffer beyond the City's projected water demand at build out. As discussed in Section 2.4.2, the 2020 UWMP includes forecasted projections on the City's safe annual yield which accounts for potential shifts in precipitation caused by climate change. The 2020 UWMP also includes key considerations on how climate change may affect water demand in years with less rainfall (City of San Luis Obispo 2021b).

In 2006, the City completed the Water Reuse Project, creating the first new source of water for the City since 1961. The project included improvements to the City's Water Resource Recovery Facility and an initial eight miles of distribution pipeline for use by City residents and businesses for landscape irrigation and other approved uses. In 2017, the City completed the Recycled Water Master Plan. The plan describes future opportunities for the City to consider potable reuse, presents a plan to serve recycled water to developing areas of the community for use as landscape irrigation, prioritizes opportunities to retrofit existing sites to offset potable water use, and explores use of recycled water outside the City limits during periods where much of the City's recycled water supply goes underutilized. Chapter 7 of the plan includes a capital improvement plan for future expansion of the City's recycled water distribution system, which is consistent with the City's larger water supply management strategy to maintain multi-source water supply. The City's current recycled water program can generate over 1,000 acre-feet of recycled water for approved uses, reducing water demand from the City's other water supply sources. In 2020, 245 acre-feet of recycled water were delivered to the community (City of San Luis Obispo 2021b).

As part of the 2020 UWMP, the City has also developed the 2020 Water Shortage Contingency Plan, which establishes the foundation for a staged response to worsening water shortage conditions that could occur due to drought, earthquake, infrastructure failure, or other emergencies. The 2020 Water Shortage Contingency Plan establishes the City's water supplies for a normal year, single dry year (2013) and a multiple dry year scenario, identified as the years 2011 to 2015, with combined rainfall total for those five years being the lowest on record. Alongside developing a water shortage assessment, the plan also includes a comprehensive water shortage response to temporarily augment supply and/or reduce water demand. This response would include voluntary reduction measures, mandatory reduction measures, water use prohibitions, and supplemental water supply options.

General Plan Water and Wastewater Management Element

The City's General Plan Water and Wastewater Management Element, most recently updated in 2020, includes a comprehensive set of goals, policies, and programs manage the City's water supply and includes measures to address the potential impacts of climate change on the City's water supply. The updated Water and Wastewater Management Element coincides with the City's efforts to incorporate climate change projections into the City's safe annual yield assessment and water management practices. Goals in the element focus on the various components of successful water management including managing the City's multi-source water supply, water supply accounting and water demand projections, water conservation practices, and the implementing the City's recycled water program. The Water and Wastewater Element also includes a goal specifically for siltation management in the City's reservoirs, noting the potential for the increasing intensity of rainfall events as well as post-wildfire runoff to increase siltation rates and reduce the overall storage capacity of the City's reservoirs. Noting this potential threat, the Siltation portion of the element includes a set of policies and programs to proactively implement best management practices to reduce erosion and subsequent siltation consistent with other City watershed management goals.

Sustainable Groundwater Management Act and Groundwater Recharge

The City, in coordination with the County and partner agencies, are increasing efforts to achieve sustainable groundwater management through requirements in the Sustainable Groundwater Management Act. The City and County, in coordination with local water purveyors including the Edna Valley Growers Mutual Company, Edna Ranch Mutual Water Company, Varian Ranch Mutual Water Company and Golden State Water Company, developed a Groundwater Sustainability Plan to sustainably manage groundwater resources in the San Luis Obispo Valley Groundwater Basin and prevent an unreasonable reduction of groundwater storage in the basin. The City's portion of the San Luis Valley Groundwater Basin is currently estimated to have a 700 acre-foot per year surplus of groundwater. This is largely because the City is not currently pumping groundwater. The City plans to resume groundwater pumping within the next five years to better balance surface water and groundwater use in order to mitigate climate change impacts.

Alongside development and implementation of the Groundwater Sustainability Plan, through implementation of the State mandated NPDES Stormwater Program and the Post Construction Requirements, new and re-developments are required to retain and infiltrate water that would have previously been piped off the property. This requirement helps to mitigate stormwater runoff and supports groundwater recharge in the San Luis Valley Groundwater Basin.

For these reasons, the adaptive capacity ranking for increased long-term drought is high.

2.4.4 Vulnerability Summary

Due to increases in annual average temperatures and extreme heat discussed in Section 3.2, as well as the increased likelihood of a long-term drought scenario, the City is vulnerable to impacts from drought caused by climate change. These changes will result in varying impacts on the City and its residents as discussed above. Based on the analysis of various impacts discussed in Section 3.3.2, the City's potential impact scoring is High (3). Impacts that are unique to the City and should be given increased consideration during the adaptation strategy development process are discussed below.

Natural System Findings

- The City's designated open space areas include a mixture of vegetation types including oak woodland, grassland, coastal sage scrub, and chaparral that are anticipated to be impacted by changes in annual average temperatures, extreme heat, and long-term droughts (OPR et al. 2018b).
- As dry years and long-term droughts become more common in the future, population growth rates of annual plant species will become marginal, and populations are likely to become locally extinct.

Built Environment Findings

- Dramatic shifts from multi-year dry periods to wet periods, similar to the 2011-2015 drought followed by an above average wet year in the 2016-2017, are known as whiplash events (Swain et al. 2018) and they are expected to become more severe in the future. These whiplash events may affect water supply management practices over the long-term, particularly as the swings from multi-year dry to wet periods become more prolonged and more severe, with an emphasis on increasing rainfall storage when it does occur during the wet periods (Persad et al. 2020).
- Buildup of sedimentation that reduces a reservoir's available volume already occurs in the City's water storage system, with the City implementing programs and policies to address this storage loss over the long term. However, landscape disturbances including wildfire, post-wildfire runoff, or landslides after wet winters, are projected to increase sediment yield from watersheds along the Central Coast (OPR et al. 2018b), with the potential to further reduce the amount of water-storage capacity in dammed Central Coast reservoirs (Smith et al. 2018).
- The City's 2020 UWMP modeled potential impacts on the City's water supplying, finding that changes in precipitation could result in a decrease of as much as 850 AFY to an increase of as much as 160 AFY, accounting for an approximately 8 percent decrease to 2 percent increase in the City's overall water supply (City of San Luis Obispo 2021b).
- With more rapid shifts from dry to wet periods known as "whiplash events," precipitation will occur over shorter more intense periods. This shift has the potential to reduce groundwater recharge which ideally occurs during prolonged wet periods to allow for soil infiltration, deeper percolation, and more effective groundwater recharge. However, increases in the intensity of rainfall events, when they do occur in the wet periods, provides an opportunity to offset potential losses in storage during periods of drought.
- The 2020 UWMP includes a section specially on Water Resiliency Planning which highlights a set of strategies the City has taken to ensure long-term water resiliency and mitigate the impacts from a long-term drought scenario. These strategies include a multi-source water supply; conservative water demand projections; water use efficiency; water recycling; and future ground water recharge.

Community Resilience Findings

- Increases in temperature and extreme heat events are associated with increases in vector-borne and infectious disease transmission, with future long-term drought scenarios potentially increasing the prevalence of certain vector-borne diseases present on in the central coast region including Lyme disease and valley fever.

Long-Term Drought Vulnerability Score

Adaptive Capacity: High (1.5)

Potential Impact: High (3)

Vulnerability Score: 3.5

2.5 WILDFIRE ANALYSIS

This section discusses future changes in wildfire in the County and areas surrounding the City and analyzes how these changes are likely to impact City and its population as well as highlighting what capacity the City and partner agencies already have in place to address these future impacts.

2.5.1 Future Exposure to Wildfire Risk

Wildfire risk is determined by several factors, such as wind speeds, drought conditions, available wildfire fuel (i.e., vegetation), past wildfire suppression activity, and expanding wildland-urban interface (WUI) in and around forests, grasslands, shrub lands, and other natural areas (Westerling 2018). Climate change effects, including increased temperatures and changes to precipitation patterns, will exacerbate many of the factors that contribute to wildfire risk. Recent research has found that increases in global temperatures may be affecting wind patterns and increasing global wind speeds, however these changes would not be experienced uniformly across geographies in the future (Chen 2020). While the impact of climate change on wind speeds is still uncertain, it is important to recognize this potential effect and how it may also contribute to wildfire risk in the future.

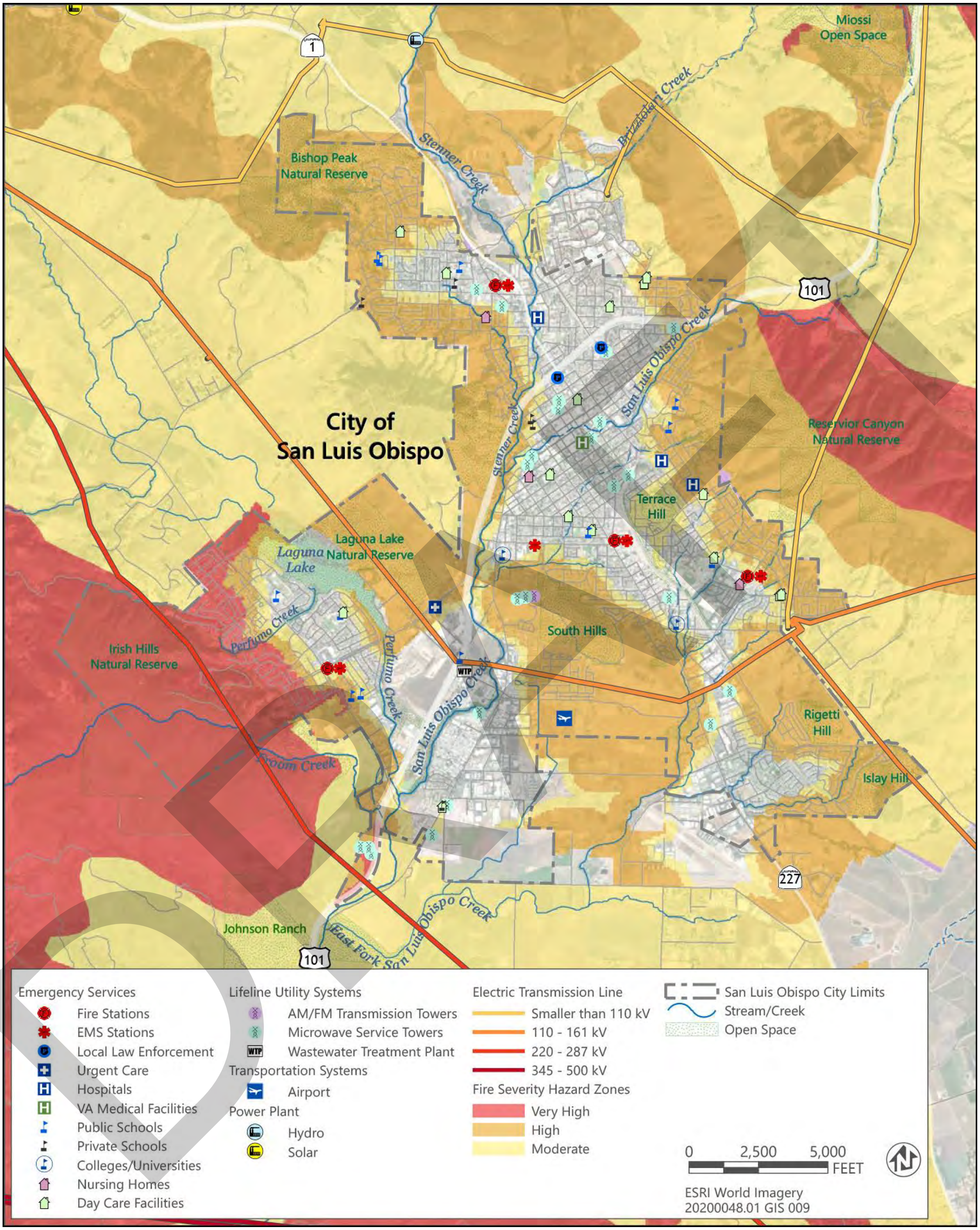
Increased variability in precipitation may lead to wetter winters and increased vegetative growth in the spring, and longer and hotter summer periods will lead to the drying of vegetative growth and ultimately result in a greater amount of readily burned fuel for fires. This has already been seen across the state in recent years, with the area burned by wildfires increasing in parallel with rising air temperatures (OEHHA 2018). These factors, combined with the increasing frequency and severity of intense wind conditions, will cause fires to spread rapidly and irregularly, making it difficult to predict fires' paths and effectively deploy fire suppression forces. Pacific Gas and Electric (PG&E) also has several electrical transmission lines running through the City, which carry significant potential fire risk.

Relative humidity is also an important fire-related weather factor; as humidity levels drop, the dry air causes vegetation moisture levels to decrease, which consequently increases the likelihood that plant material will ignite and burn. With an increase in hotter and drier landscapes, humidity levels may continue to drop and result in higher fuel levels, increasing the risk of wildfire (Schwartz et al., 2015).

Environmental and climatic conditions in and around the City influence the frequency and magnitude of wildfires. The City often experiences high-wind events, such as the Santa Lucia winds, which originate inland and flow westward during the late summer and early fall, counter to the prevailing westerly winds that occur throughout much of the year. Santa Lucia winds contain little humidity, and summers in the City are hot and dry, with precipitation primarily occurring in the winter months. Thus, the combination of the relatively hot, dry Santa Lucia winds occurring at a time when vegetation in the County and the City is particularly dry following the summer months can contribute to the ignition and spread of wildfires. Periods of low relative humidity, when dead trees and vegetation cannot absorb moisture from the air, can also increase the risk of wildfires (City of San Luis Obispo 2011).

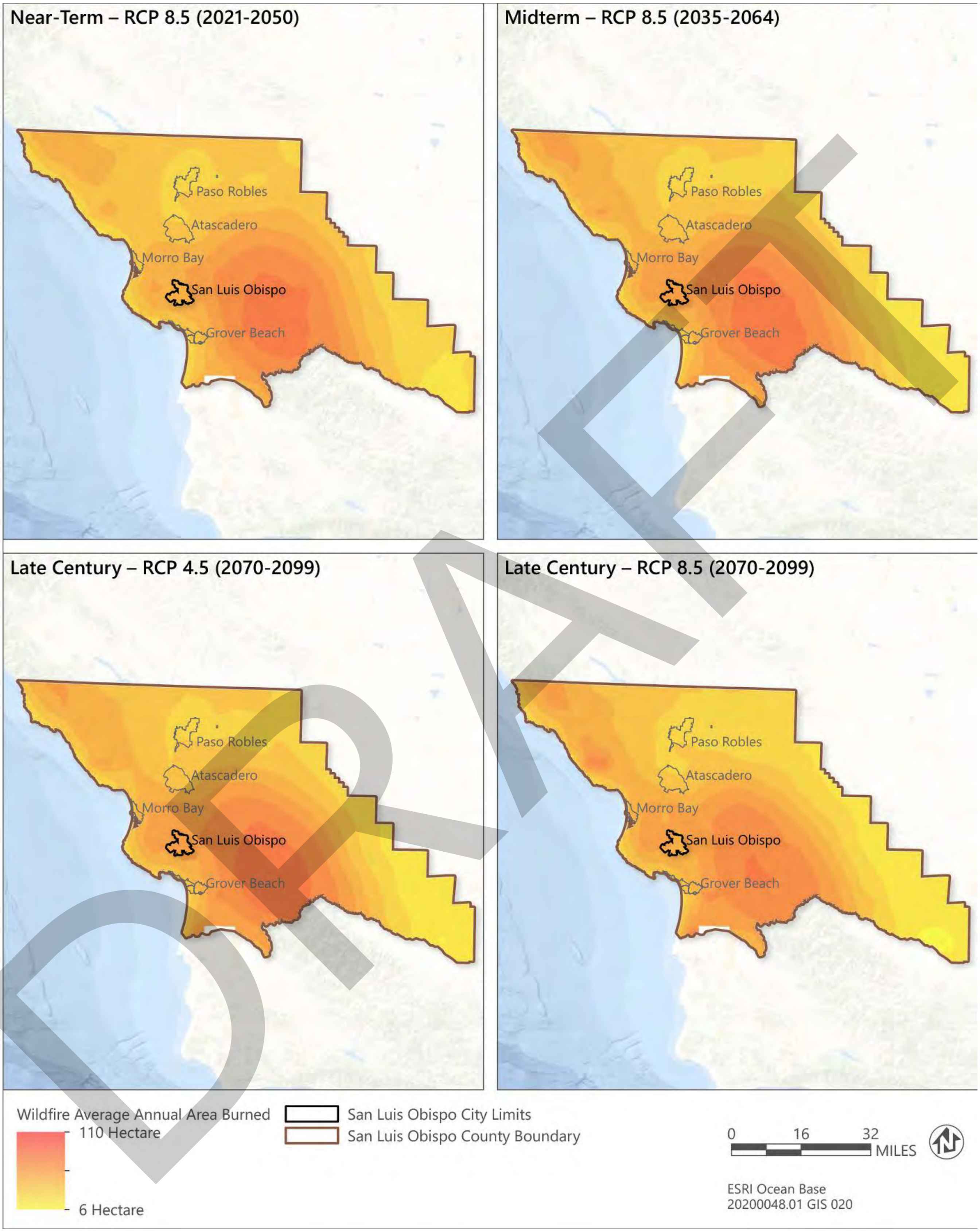
The risk of wildfires and subsequent impacts to property and life is greatest at the WUI, which is where urban development borders wildland fuels. Wildfire risk is compounded in areas of the WUI that are also located in or near High or Very High Fire Hazard Severity Zones (VHFHSZ). Figure 19 includes CAL FIRE designated Fire Hazard Severity Zones in and surrounding the City. Portions of southwestern (near the Irish Hills Natural Reserve) and northeastern (near Reservoir Canyon Natural Reserve) parts of the City are located in or near a VHFHSZ, and many of these portions of the City overlap with the WUI. Beyond these areas of the City, the risk of urban fires decreases, with most of the areas surrounding and some locations within the City designated as Moderate Fire Hazard Severity Zone.

Given the City's urban setting, with minor portions of the City in the VHFHSZ, the analysis for future wildfire risk incorporates County-level changes in wildfire risk to assess how larger regional risks and potential impacts may affect the City. Using a statistical model based on historical climate vegetation, population density, and large fire history, Cal-Adapt provides projections for future annual mean hectares burned within the County when wildfires do occur. Cal-Adapt does not account for current or planned wildfire management projects. Table 14 and Figure 20 shows the projected change in average annual area burned within the County under low and high emissions



Source: San Luis Obispo County 2019a

Figure 19 Wildfire Hazard Severity Zones In and Near the City of San Luis Obispo with Critical Facilities



Sources: Data downloaded from City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020 and downloaded from Cal-Adapt in 2021

Figure 20 Change in Average Annual Maximum Temperature in San Luis Obispo County through 2099 scenarios for the central population growth scenario at midterm and late-century timescales. The total area burned annually by wildfire within the County is expected to rise 15 percent from the historic (1961-1990) annual average of 9,248 hectares to 10,723 hectares in the near-term and increase in the midterm to 10,728 hectares burned annually. In the late-century, average annual area burned in the County is projected to increase to 10,728 hectares and decrease slightly to 9,867 hectares under the low and high emissions scenarios, respectively (CEC 2019d). This reduction in annual average hectares burned in the late-century period is noted in the research conducted to develop the Cal-Adapt wildfire tool. As vegetation type and fuel amount, structure, and continuity change in the future due to altered disturbance regimes (e.g., changes in the frequency, seasonality, duration, extent and severity of wildfire and infestations by beetles and other pathogens) and climate, future wildfire activity and its response to climatic variability may reduce wildfire activity in some ecosystems (Westerling 2018).

Importantly, Figure 20 illustrates that anticipated changes in wildfire impacts are not homogenous across the County; for instance, the Santa Lucia Wilderness and the La Panza Mountain range located in the southern central portions of the County are projected to experience the largest increases in average area burned over the 21st century under both emissions scenarios. While these areas are outside of the City boundaries and jurisdiction, due to the regional characteristics of wildfire impacts, wildfire events in these areas could affect the City through secondary impacts such as short-term and long-term wildfire evacuees, wildfire smoke, and impacts on the County's regional transportation network.

Table 14 Changes in Annual Average Area Burned in San Luis Obispo County

Average Annual Area Burned	Historic Modeled[1] Average Annual Area Burned (1961-1990)	Near-Term (2021-2050)	Midterm (2035-2064)	Late-Century (2070-2099)	
				Medium Emissions	High Emissions
Average Annual Area Burned (hectares)	9,248	10,723	10,728	10,728	9,867

Notes: RCP = Representative Concentration Pathway.

[1] Observed historical average annual area burned data were not available from Cal-Adapt; the modeled historical average annual area burned data under the medium emissions scenario was available and used as proxy data.

Source: CEC 2019d.

2.5.2 Wildfire Sensitivities and Impact

This section discusses the City's existing sensitivities to wildfire impacts and analyzes future wildfire risk in the City, discussed in the three general impact categories (e.g., Natural Systems, Built Environment, Community Resilience).

WILDFIRE AND NATURAL SYSTEMS

Open Space and Ecosystem Functions

Changes in climate variables including increased average annual temperatures, annual climatic water deficit, and relative humidity are all strong predictors of fire occurrence and burned area in semi-arid regions. These changes in climate variables are projected to increase wildfire risk in open spaces and wooded areas in and surrounding the City. As noted in the Central Coast Region Report, the size of wildfires in the Central Coast region increases with both air temperature in the month of ignition and with lower rates of precipitation in the 12 months preceding the fire, which create conditions in the natural landscape that increase wildfire risk (Potter 2017).

Chaparral habitat, which is present in the City's designated open spaces and surrounding areas, is a fire-dependent evergreen shrubland vegetation community. Human ignitions, fire suppression, and short-term meteorological events have dominated variability in fire activity in chaparral zones in recent decades (Abatzoglou et al. 2016, Mann et al. 2016). Some research has shown that the increasing frequency of fire on these landscapes have caused coastal sage shrubs and chaparral to shift to grasses, including exotic grasses (OPR et al. 2018b). Some research has suggested that annual and some perennial grasses have the strongest effects on fire regimes and act as ecosystem transformers. Noting that in many ecosystems, the dense growth habit and flammable tissue of invasive grasses create continuous drier fuels that are not present in areas not invaded by non-native grasses (Linder et al. 2018). However, the impact of these shifting vegetation communities on wildfire risk specific to the City is not known at this time.

Plant communities in riparian habitats typically have higher foliar moisture than upland plants. This higher moisture content can help to reduce damage from fire, and further, riparian corridors are often considered to be functional barriers to the spread of wildfire (Pettit and Naiman 2007). However, some invasive plants such as the Giant reed (*Arundo donax*) and tamarisk (*Tamarix spp.*) are highly flammable in California riparian systems, and are changing these dynamics. However, both species recover rapidly from fire by regrowth from below-ground plant parts. By contrast, cottonwoods, willows, and other native woody plants are less tolerant of direct exposure to fire. The invasive plants mentioned above as well as Giant reed, a large, bamboolike grass, are making riparian systems fire-prone, particularly in drier periods when this vegetation can increase fuel loads and subsequent wildfire risk (Linder et al. 2018).

Wildfire impacts in riparian zones can reduce canopy cover, resulting in increased water temperatures in creeks and other shaded waterways, as well as increased sediment flux in stream beds and adjacent areas. These changes can directly affect the food web of burned stream areas, increasing the density of algae as well as the potential to decrease terrestrial vegetation inputs, resulting in more invertebrate algae consumers (Cooper et al. 2015).

Post-wildfire conditions can also alter runoff production and streamflow. Studies have shown that post-wildfire streamflow can increase between 82 and 200 percent in the first year after a wildfire event (OPR et al. 2018b). High intensity rainfall events increase the export of sediment flow in affected landscapes while lower intensity events stimulate post-fire regrowth and increase the pace of hydrologic recovery. Research has also shown the floatation of nutrients in post-wildfire streamflows in central portions of the state can affect nearshore marine and estuarine waters. Specifically, post-fire runoff typically has elevated nitrogen concentrations due to the amount of biomass burned in these landscapes during wildfire events (OPR et al. 2018b).

Post-Wildfire Runoff and Debris Flow

Wildfire events can result in post-wildfire scarring on effected landscapes and can alter the hydrologic response of a watershed with the potential for even modest rainstorms to produce dangerous flash floods and debris flows events, in which a mix of water, soils, vegetation, and fragmented rock can rush down mountainsides and funnel into waterways. These events are due to vegetation loss and soil exposure on scarred landscapes, which would otherwise support the stability of soils in steeper terrains. Post-wildfire runoff and debris flows can be affected by several factors but are generally triggered by one of two processes: surface erosion caused by rainfall runoff, and landslides caused by rainfall seeping into the ground. While it is difficult to determine the potential risks of post-wildfire runoff prior to wildfire events, the United States Geological Survey conducts post-fire debris-flow hazard assessments for select fires in the Western U.S that are deemed susceptible to potential post-fire debris-flow events. These assessments analyze burn severity, soil properties, and rainfall characteristics to estimate the probability and volume of debris flows that may occur in response to a design storm and can help communities better prepare for these events. Design storms are defined as hypothetical discrete rainstorms characterized by a specific duration, temporal distribution, rainfall intensity, return frequency, and total depth of rainfall. While the effect of climate change on post-wildfire runoff and debris flow is uncertain, climate change is projected to result in higher intensity rainfall events as well as "whiplash events" with oscillations between extremely dry and extremely wet periods, potentially affecting post-wildfire hazards. Additionally, drought inhibition of vegetation recovery in areas affected by wildfire can decrease soil stability and increase the risk of post wildfire events (OPR et al. 2018b). Impacts from post-wildfire runoff and debris flow can result in blockage of drainage systems causing further flooding, damage to infrastructure and property, as well as short-term and long-term roadway closures. Impacts from these hazards are more likely to affect areas surrounding waterways and areas with steeper terrain (USGS n.d.).

Key Findings and Policy Considerations

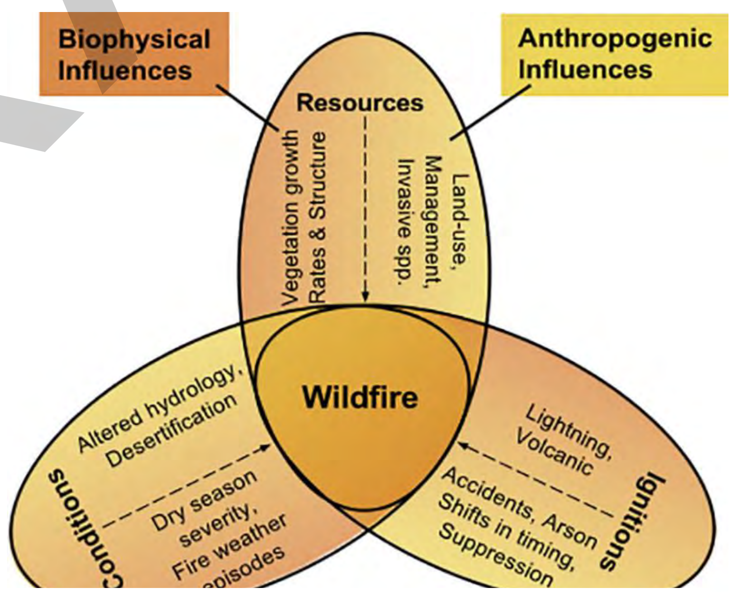
- The increasing frequency of fire on chaparral landscapes have caused coastal sage shrubs and chaparral to shift to grasses, including exotic grasses. Some research has suggested that annual and some perennial grasses have the strongest effects on fire regimes and act as ecosystem transformers.
- Wildfire impacts in riparian zones can reduce canopy cover, resulting in increased water temperatures in creeks and other shaded waterways as well as produce increased sediment flux in stream beds and adjacent areas, affecting the food web of burned stream areas and increasing the density of algae in waterways.
- Post-wildfire runoff and debris flows can be affected by several factors but are generally triggered by one of two processes: surface erosion caused by rainfall runoff, and landslides caused by rainfall seeping into the ground. While it is uncertain the effect climate change will have on post-wildfire runoff and debris flows event, climate change is projected to result in higher intensity rainfall events as well as "whiplash events" with oscillations between extremely dry and extremely wet periods, potentially affecting post-wildfire hazards.

WILDFIRE AND THE BUILT ENVIRONMENT

Anthropogenic Factors and Wildfire Risk

As noted extensively in research, while the effects of climate change are projected to increase the frequency and severity of wildfires when they do occur, approximately 95 percent of wildfires in the state are caused by human ignition (Mann et al. 2016). This fact helps to place into perspective the large influence human development has on the fire regime in the state even with the increasing influence of climate change throughout the 21st century. In assessing the influence of climate change on wildfire risk for the City, it is important to recognize and consider the other anthropogenic factors influencing risk. As show in Figure 21, the risk of wildfire is dependent on a variety of factors not excluding biophysical factors that are affected by climate change. These determinants, both anthropogenic and biophysical, can be organized into three categories: Resources (e.g., land use patterns, vegetation growth), Ignitions (e.g., lightning, accidental ignitions, arson), and Conditions (e.g., precipitation, wind, seasonal variation).

Modeling conducted on the anthropogenic influences of future wildfire risk in California note that there are three dominant anthropogenic mechanisms aside from climate change that will heavily influence wildfire risk. These are increasing ignitions, fire management practices, and the modification of land cover. The research also suggests that fire activity will increase in public lands, especially those surrounding urban areas, influenced by the promotions of fire suppression through firefighting and the physical properties of a dense urban environment (OPR et al. 2018b)



Source: Mann et al. 2016

Interactions of wildfire requirements as regulated by biophysical and anthropogenic influences.

Figure 21 Biophysical and anthropogenic determinants of wildfire

A part of this increased risk from anthropogenic factors is the presence electric transmission lines that travel from power plant substations to electric distribution substations via utility easements called rights-of-way which are present throughout the state including areas around the City as show in Figure 28. To reduce the risk of power outages, damage, or wildfire, the rights-of-way are cleared of trees or vegetation that can contact the transmission line. However, the combination of dry climate conditions and the seasonal high autumn winds in California can increase the risk of trees or branches falling on transmission lines and causing power outages or wildfires. High winds can also cause power lines to contact with one another and cause electrical arcs with sparks or hot molten materials that can cause fires in dry grasses underneath transmission lines. While there are variety of factors which affect the risk of wildfires being caused by damaged transmission lines, several recent wildfires have been blamed on electrical utility infrastructure including a wildfire in San Diego County in 2007, the Thomas Fire in 2017, and the Camp Fire in 2019. As climate change contributes to drier conditions and tree mortality rates, the risk of wildfires caused by transmissions lines will increase if actions are not taken to mitigate this risk (Congressional Research Service 2019).

Wildland Urban Interface (WUI)

As shown in Figure 22, portions of the City as well as areas immediately surrounding the City limits are increasingly at risk of wildfire impacts. As noted above, climate change will increase the frequency of wildfire events and increase the severity and average acreage burned when wildfire events do occur. Buildings and structures in and near VHFHSZ are at increased risk of damage or destruction in the event of wildfire. Increased wildfire risk may also result in a loss of housing stock and reduced regional housing affordability.

To better understand how anthropogenic influences, specifically development patterns, may affect wildfire risk, the degree of urbanization within WUI zones in the City over several decades was analyzed. Processed satellite imagery from the National Land Cover Database (Dewitz 2019) was used to determine changes in several land use categories over three periods: 2001-2006, 2006-2011, and 2011-2016. Specifically, changes in high, medium, and low-intensity development and developed open space over these three time periods for each of 18 WUI zones within the City were assessed using a geographic information system (GIS) analysis. The results of the analysis are illustrated in Figure 22 and in Table 15.

Table 15 Percent Change in Developed Area for WUI Areas within the City 2001-2016

WUI Area	Percent change in developed area in the WUI		
	2011-2016	2006-2011	2001-2006
Highland Area	-	-	-
Foothill Area	-	-	-
Buena Vista Area	-	-	-
San Luis Drive Area	-	-	-
Lizzie/Sunset Area	-	-	3.2%
Flora Area	-	-	-
Tanglewood Area	-	-	-
Woodbridge Area	-	-	-
Fontana Area	-	-	-
Margarita Area	86.3%	-	-
Tank Farm Road Area	-	-	0.2%
Prefumo Canyon Area	-	-	-
Madonna Area	-	0.2%	54.3%
North Broad	-	-	-
Stoneridge	-	-	1.0%
Terrace Hill	-	-	-
Righetti South	-	-	-
Righetti North	-	1.2%	-

Source: National Land Cover Database processed by Cbec eco-engineering 2021

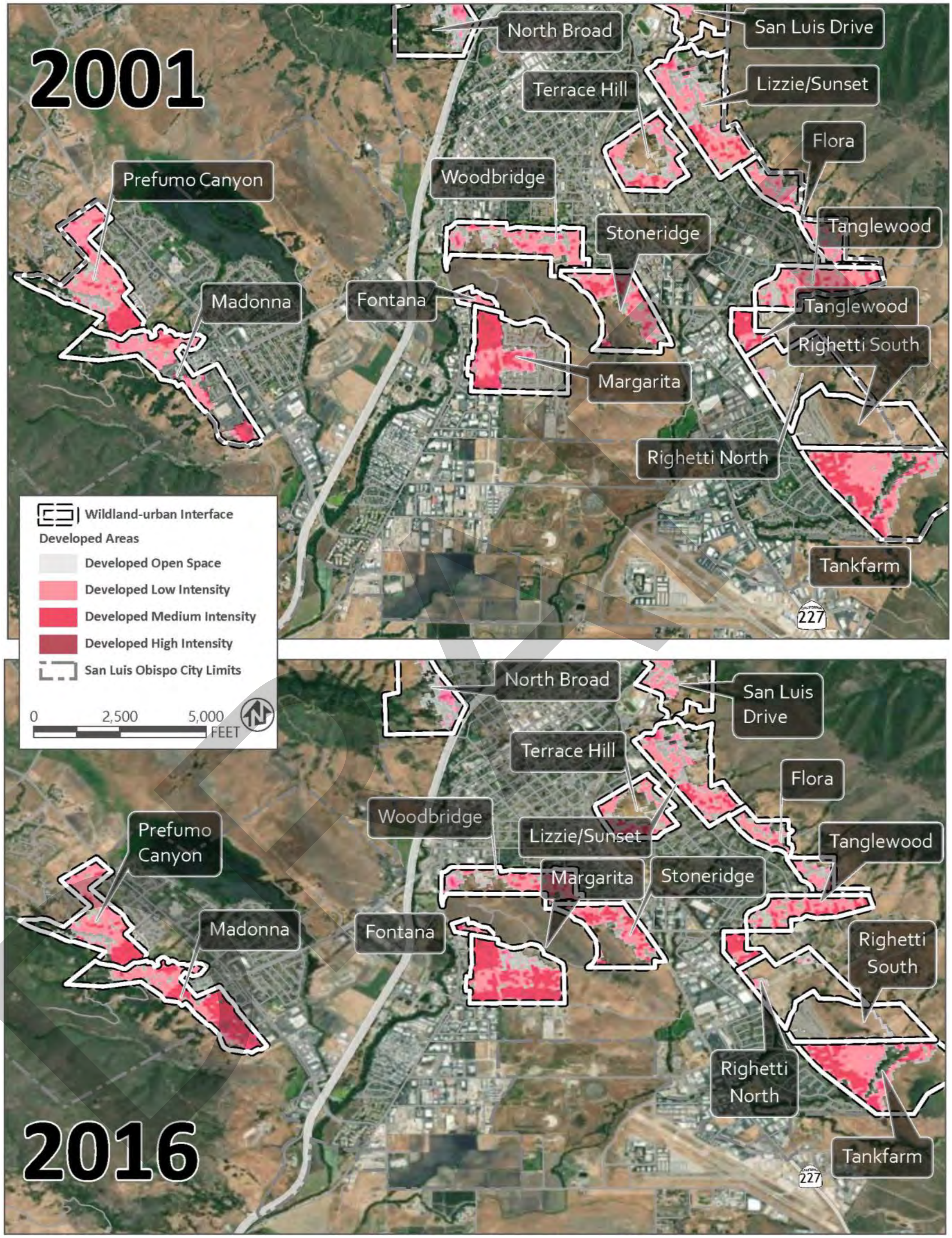


Figure 22 Changes in the WUI areas within the City 2001-2016

Overall, there was limited development within the WUI for the period of 2001 – 2016, with a few prominent exceptions. The Madonna Area experienced over a 50 percent increase in developed area in the early 2000's due to commercial and residential development on former agricultural land along Los Osos Valley Road. Secondly, the Margarita Area experienced an increase in developed area of over 85 percent in the 2011 – 2016 period as a result of residential development. These statistics represent a conservative estimate of development within the WUI areas, because areas that are classified as 'developed open space' may include grass and other open vegetated areas and in-fill into these zones by more intensive development is not considered. Instead, land cover needed to change from non-developed to developed for inclusion in the assessment. Increases in these WUI areas, although limited, do represent an increase in overall wildfire risk for the City, increasing the probability of ignitions that could have impacts on other portions of the City as well.

While buildings within the WUI are at risk from direct flame contact and radiant heat during wildfire events, buildings outside of the WUI are also at risk from ignition due to the spread of firebrands (or embers) that can initiate new spot fires up to one mile ahead from the main fire front. The risk of spot fires initiated by embers depends on several characteristics including fuel material type, condition of the fuel (e.g., live or dead fuels and moisture content levels), the thermal degradation characteristics of the fuel, the combustion properties of the fuel, and environmental conditions the fuel is subjected to (such as wind, relative humidity, temperature, and external heating condition) (U.S. Department of the Interior 2019). Once embers have been transported to new locations and have the potential to cause new spot fires, there are several pathways into structures such as eaves, vents, windows, roofs, fences, and decking as well as potential fuels (e.g., mulch, landscaping, woody vegetation) surrounding structures, all of which affect the risk of new spot fires igniting. Eaves and vents are seen to be significant sources of ignition for homes during wildfire events, which have historically been included in homes for thermal efficiency and to minimize the chance of moisture buildup in attics. The location and arrangement of homes and land uses can also contribute to the overall fire risk within a community. Research has determined that fire risk within communities is primarily governed by structure-to-structure spread and can vary significantly by the density and flammability of homes and associated landscaping within the WUI (Fire Protection Research Foundation 2015).

Key Findings and Policy Considerations

- The risk of wildfire is dependent on a variety of factors not excluding biophysical factors that are affected by climate change including Resources (e.g., land use patterns, vegetation growth), Ignitions (e.g., lightning, accidental ignitions, arson), and Conditions (e.g., precipitation, wind, seasonal variation). Approximately 95 percent of wildfires in the state are caused by human ignition. However, climate change is projected to increase the frequency and severity of wildfires, when they do occur (Mann et al. 2016).
- The combination of dry climate conditions and the seasonal high autumn winds in California can increase the risk of trees or branches falling on transmission lines and causing power outages or wildfires. While these events have occurred historically, the effect of climate change on biophysical features that increase the risk of wildfires (e.g., precipitation, wind, seasonal variation) will increase the frequency and severity of wildfires from transmission line ignitions.
- There was limited development within the WUI in the city for the period of 2001 – 2016, with a few prominent exceptions including the Madonna Area and the Margarita Area to the east of South Higuera Street. However, buildings outside of the WUI are also at risk from ignition due to the spread of firebrands (or embers) that can initiate new spot fires.

WILDFIRE AND COMMUNITY RESILIENCE

Wildfire Evacuation Route Analysis

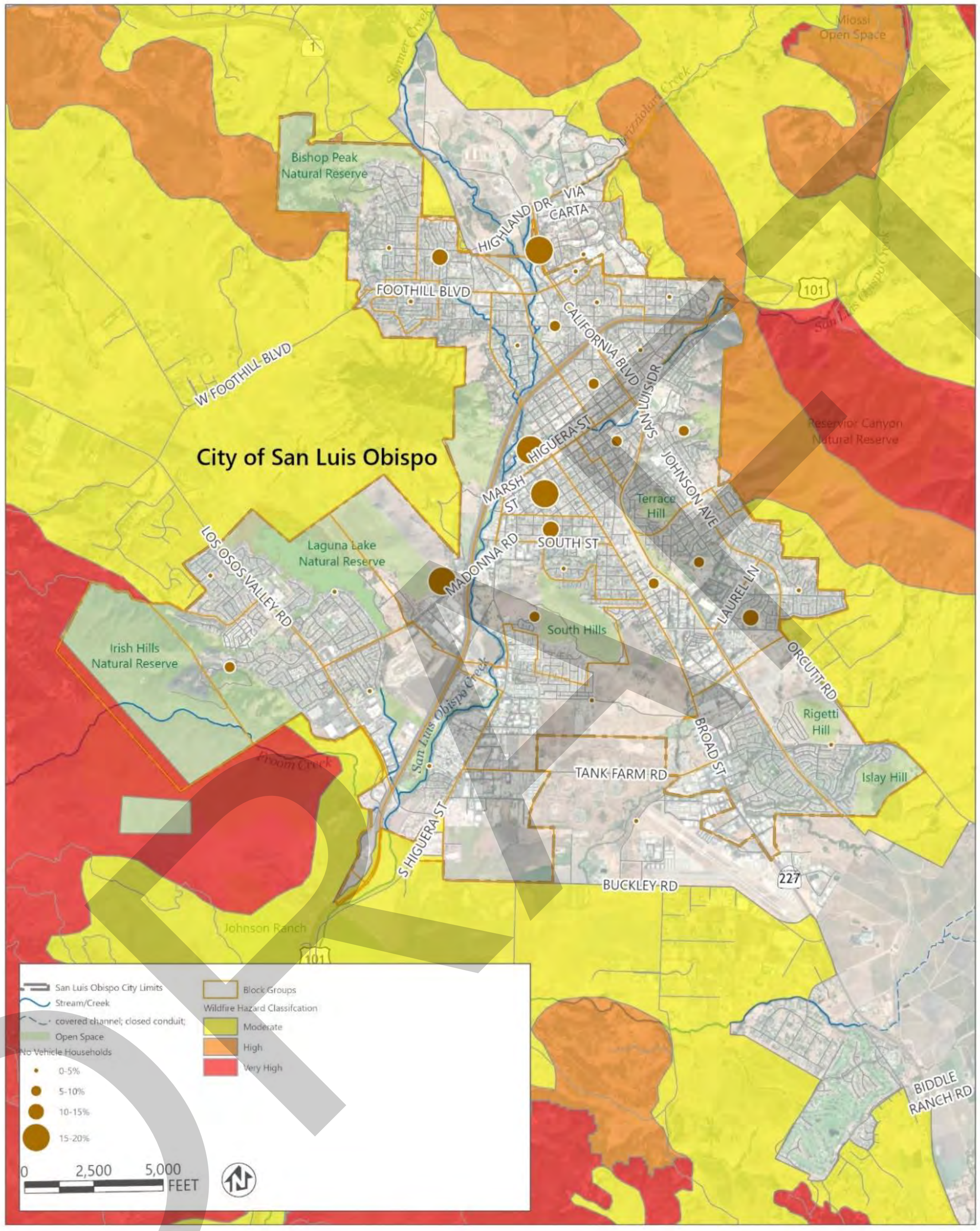
Wildfire events in or near the City, when they do occur, could result in emergency evacuations for certain areas. As show in Figure 22, the areas at highest risk from wildfire impacts are located in the WUI in the peripheral areas of the City Limits. As a result, impacts to the City's evacuation gateways (e.g., major ingress and egress points in and out of the City) are not projected to be affected by wildfires. Wildfire events in the VHFHSZ near the Irish Hills Natural Reserve could potentially have immediate impacts to some residential areas on Royal Way, Sterling Lane and Isabella Way. Additionally, areas in the northeast of the City south of US 101 along San Luis Road are at risk from wildfire impacts and could potentially compromise evacuation management when wildfires do occur in this area. Figure 23 identifies census block groups in the City based on the percentage of vehicle access. Table 16 summarizes the number of census blocks in the City relative to households with vehicle access. Although not located adjacent to any VHFHSZ, the neighborhoods north of Foothill Boulevard include areas with higher percentage of households without access to a vehicle, likely due to the high percentage of California Polytechnic State University at San Luis Obispo (Cal Poly) students who live in these neighborhoods located adjacent to the campus. As part of Cal Poly's emergency management planning, the University has contracted with multiple bus and shuttle companies in County to provide emergency transportation services, if needed, and worked with the County's Office of Emergency Services to ensure transportation resources would be available during large scale emergency events (Cal Poly 2018).

Table 16 Wildfire Hazard Severity Zones and Percent of No Vehicle Households per Block Group

Percent of No Vehicle Households	Number of Block Groups
0-5%	17
5-10%	8
10-15%	3
15-20%	4

Source: Fehr and Peers 2021

The other portion of the City with a noticeably high percentage of households without access to vehicles is the downtown area near Marsh Street and High Street, likely to due to the high-density housing and closer proximity to goods and services in these areas. It is important to note here that areas of the City with lower vehicle access do not necessarily mean increased vulnerability to emergency evacuation events but that more coordination is needed in these areas including Car Less Collection Points during evacuation scenarios for residents without vehicles. The City has identified Car Less Collection Points in this area including one in Meadow Park and one in the San Luis Obispo Mission Plaza. As the City continues to implement its CAP, which includes efforts to reduce single-occupancy vehicle trips and the needs for personal vehicle ownership, coordination and planning for evacuation scenarios for these areas of the City will need careful consideration.



Note: No vehicle Households: Low = 0-5%, High = 5-21%; Source: Fehr and Peers 2021

Figure 23 Wildfire Hazard Severity Zones and Percent of No Vehicle Household per Block Group

As shown in Figure 24, areas with a higher share of older adults and youth include areas of moderate to very high FHSZs. The Sinsheimer Neighborhood (Census Tract 110.01) is particularly vulnerable to wildfire impacts as the neighborhood is adjacent to moderate to very high FHSZs, and has the highest percentage of elderly (20 percent) and youth (7 percent) populations in the city, as well as the second highest percentage of disabled populations (12 percent). The Laguna Lake and Los Osos Valley Road (Census Tract 113) is also particularly vulnerable to wildfire risk, with a high percentage of elderly residents (14 percent), disabled (10 percent) populations, and households experiencing linguistic isolation (8 percent), which may present issues during emergency evacuation events.

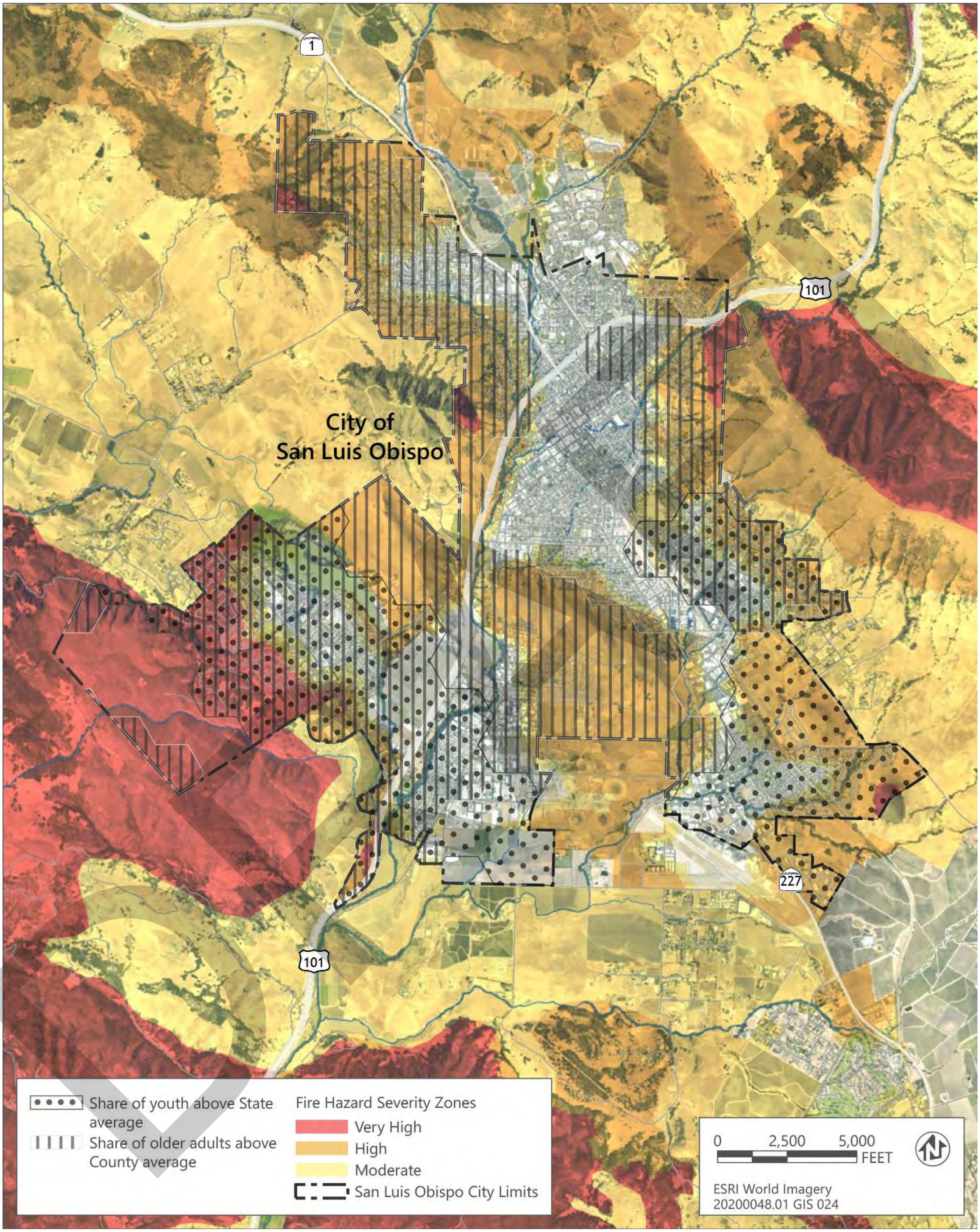
Wildfire Smoke

While the City is at risk from the impacts of wildfires, the City and its residents are also susceptible to impacts of smoke from wildfires in the coastal mountain ranges of central California and the Los Padres National Forest to the east of the City. Wildfire smoke in the surrounding region and, due to wind patterns, wildfires along the central coast in general, can greatly reduce air quality in the City and cause public health impacts as well as impacts to tourism and normal community functions. Community public health factors that can increase the impacts of wildfire smoke include the prevalence of asthma in children and adults; chronic obstructive pulmonary disease; hypertension; diabetes; obesity; percent of population 65 years of age and older; and indicators of socioeconomic status, including poverty, income, and unemployment. In addition to health risks from smoke inhalation, older adults may also be less mobile and experience challenges with evacuation. Disadvantaged communities are vulnerable to wildfire impacts because they score high on many of the public health factors and socioeconomic indicators described above. As shown in Figure 25 and in Figure 26, disadvantaged communities and low-income areas in the City are also located in high and very high fire hazard severity zones. This overlap may present challenges for low-income residents, who may not have resources to recover from wildfire events when they do occur or resources for increasing their preparedness for wildfire events (e.g., defensible space improvements, emergency resources). Figure 27 includes the high and very high fire hazard severity zones as well as the location and density of homeless encampments in the City. The co-location of homeless populations and areas with higher wildfire risk places these populations at higher risk to wildfire impacts when they do occur as well as higher risk of wildfire occurrence due to ignitions at these encampments.

Exposure to wildfire smoke, particularly exposure to vulnerable populations, can result in worsening of respiratory symptoms, increased rates of cardiorespiratory emergency visits, hospitalizations, and even death (Rappold et al. 2017). In the summer of 2020, wildfire smoke alerts were issued for the County due to poor air quality caused by the Dolan Fire near Big Sur (The Tribune 2020a). Wildfire smoke can also have impacts on the labor market and the economy in general, with air quality affecting the ability of outdoor workers to perform their work, industries that operate partially or entirely outdoor (e.g., wineries, recreation activities, sporting events), and the tourism industry (Borgschulte et al. 2019).

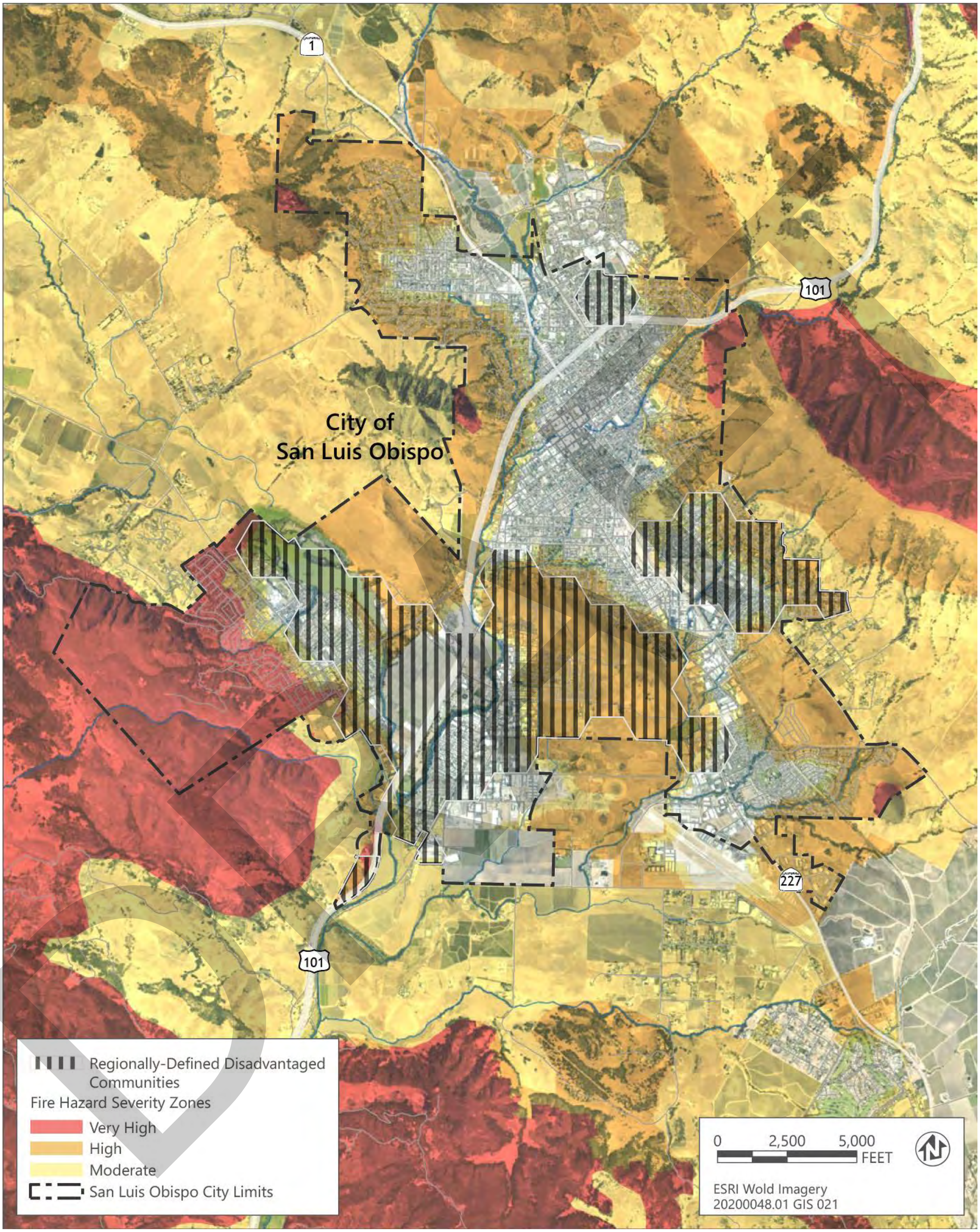
Tourism and Economic Impacts

Wildfires can damage not only buildings and infrastructure, but also the natural environment, including portions of the City and the areas in the County that serve as regional recreation and tourism opportunities. Hiking, camping, biking, wine tasting, fairs, music festivals, and other popular tourism and recreation activities can be disrupted by wildfires both during and in post-wildfire periods. In addition to reducing the abilities of individuals to partake in these activities, the financial impacts caused by wildfires on these industries and the economy at large can be devastating. Major wildfires often result in damage to transportation infrastructure and/or closure of roadways. Combined with potential impacts of wildfire smoke from surrounding areas, wildfires may significantly reduce the overall desirability of the City and County for visitors coming from other areas in the state as well as locations outside the state.



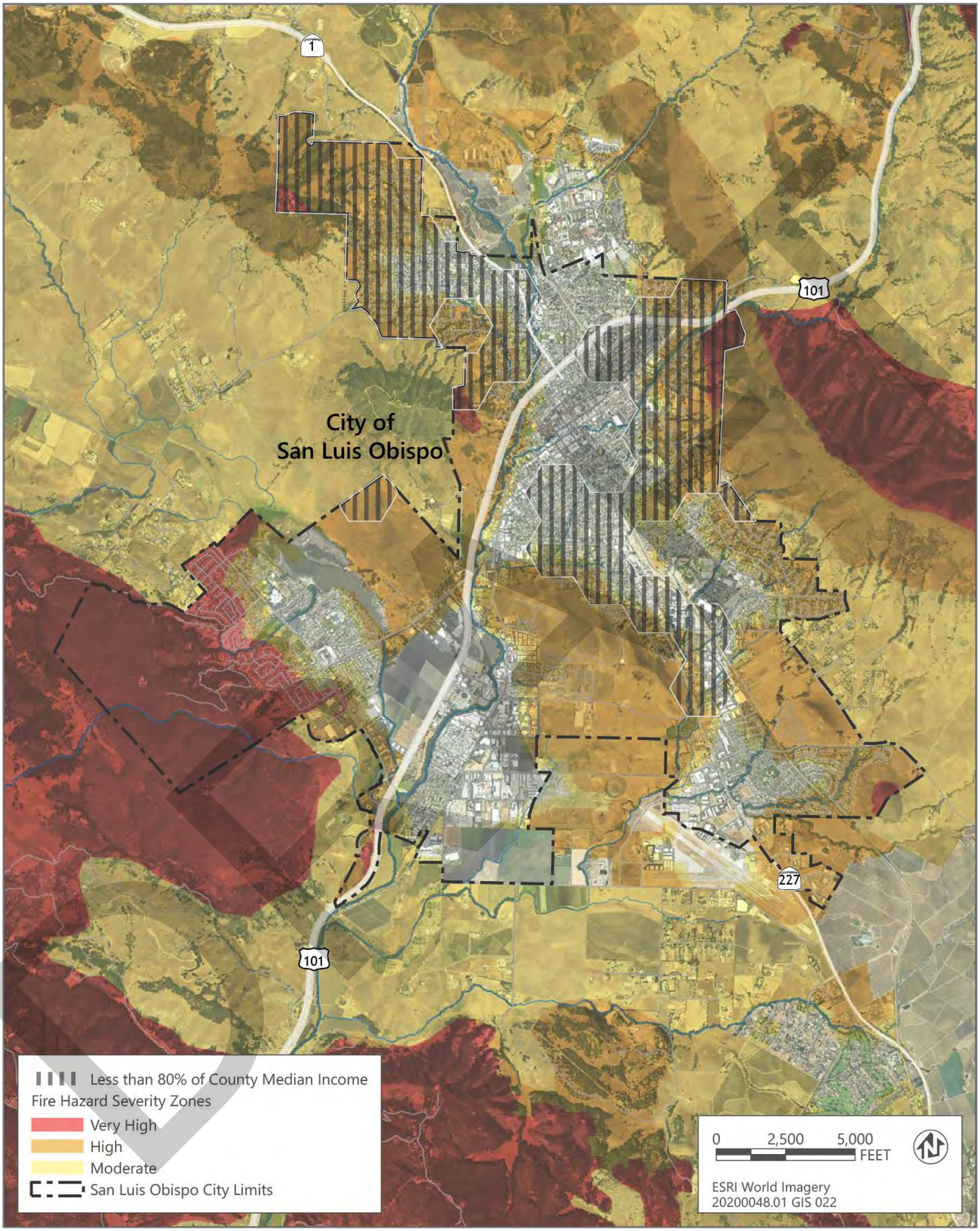
Sources: Data received from SLOCOG in 2021 and data downloaded from CAL FIRE in 2008 & 2020, City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020

Figure 24 Share of Older Adults and Youth and Fire Hazard Severity Zone in the City



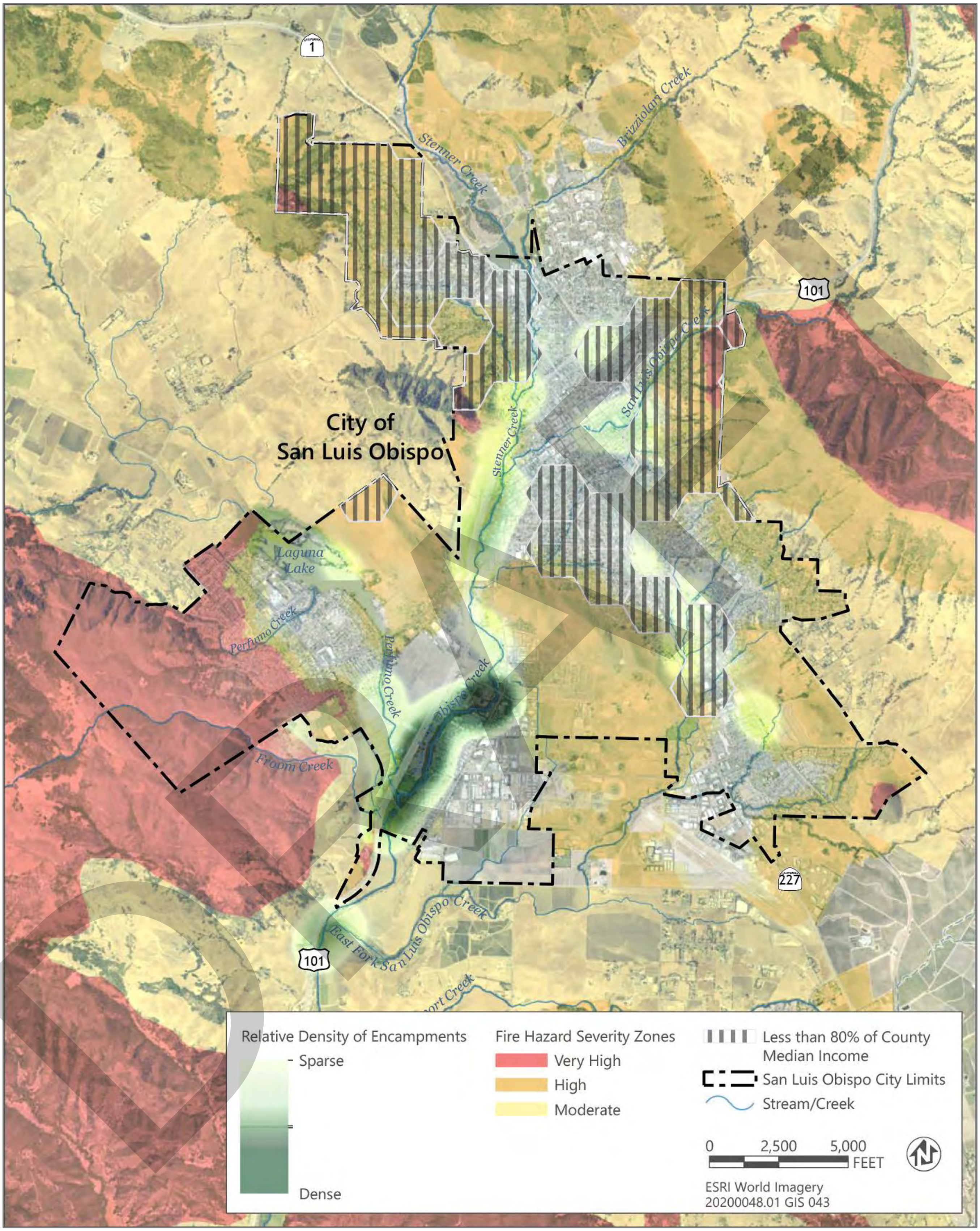
Sources: Data received from SLOCOG in 2021 and data downloaded from CAL FIRE in 2008 & 2020, City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020

Figure 25 SLOCOG Identified Disadvantaged Communities and Fire Hazard Severity Zone in the City



Sources: Data received from SLOCOG in 2021 and data downloaded from CAL FIRE in 2008 & 2020, City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020

Figure 26 Low-Income Populations and Fire Hazard Severity Zone in the City



Sources: Data received from SLOCOG in 2021 and data downloaded from CAL FIRE in 2008 & 2020, City of San Luis Obispo in 2020, 2021 and County of San Luis Obispo in 2020

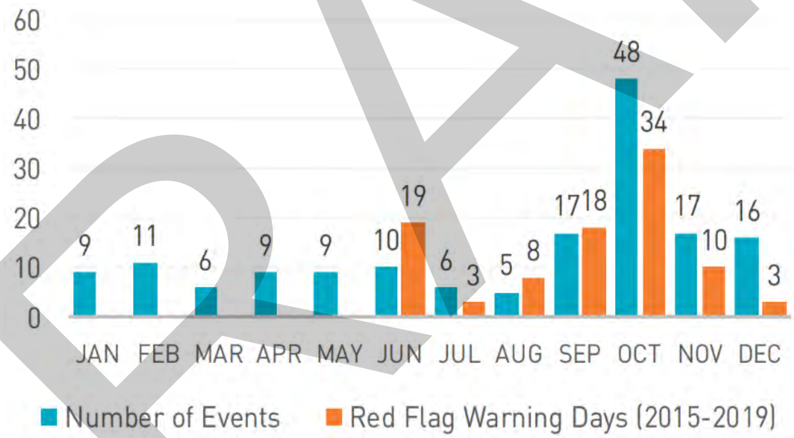
Figure 27 Homeless Encampments and Fire Hazard Severity Zone in the City

Public Safety Power Shutoffs

Beginning in 2019, electrical utilities in the state began to administer pre-emptive power shutoffs known as Public Safety Power Shutoffs (PSPSs) to portions of the electricity grid that were experiencing increased risk of wildfire due to specific weather conditions. PG&E, which operates the transmission lines in and around the City and has administered several PSPS events throughout their service territory, use specific criteria when determining a PSPS events (PG&E 2020). These include:

- Low humidity levels (generally 20 percent or below)
- High wind forecasts (sustained winds above 25 miles per hour and wind gusts above 45 miles per hour)
- Low moisture content of live vegetation
- Red Flag Warnings declared by the National Weather Service
- Real-time ground observations from the PG&E Wildfire Safety Operations Center

PG&E has projected that future occurrence of these events will occur across their service territory more frequently with most events occurring in the late summer and fall months during the historic fire season as shown in Figure 28. Additionally, to help identify areas in the state with increased risk from wildfires caused by utility infrastructure, the California Public Utilities Commission has developed a Fire Threat Map. As shown below in Figure 29, while future frequency of PSPS events in the City is unknown, the City is in a location adjacent to "Elevated" and "Extreme" Fire Threat Hazard Zones and transmission lines that help provide power to the City transverse both Elevated and Extreme Fire Threat Hazard Zones, making the City more likely to experience PSPS events in the future as the climate conditions that lead to these events become more common due to climate change.

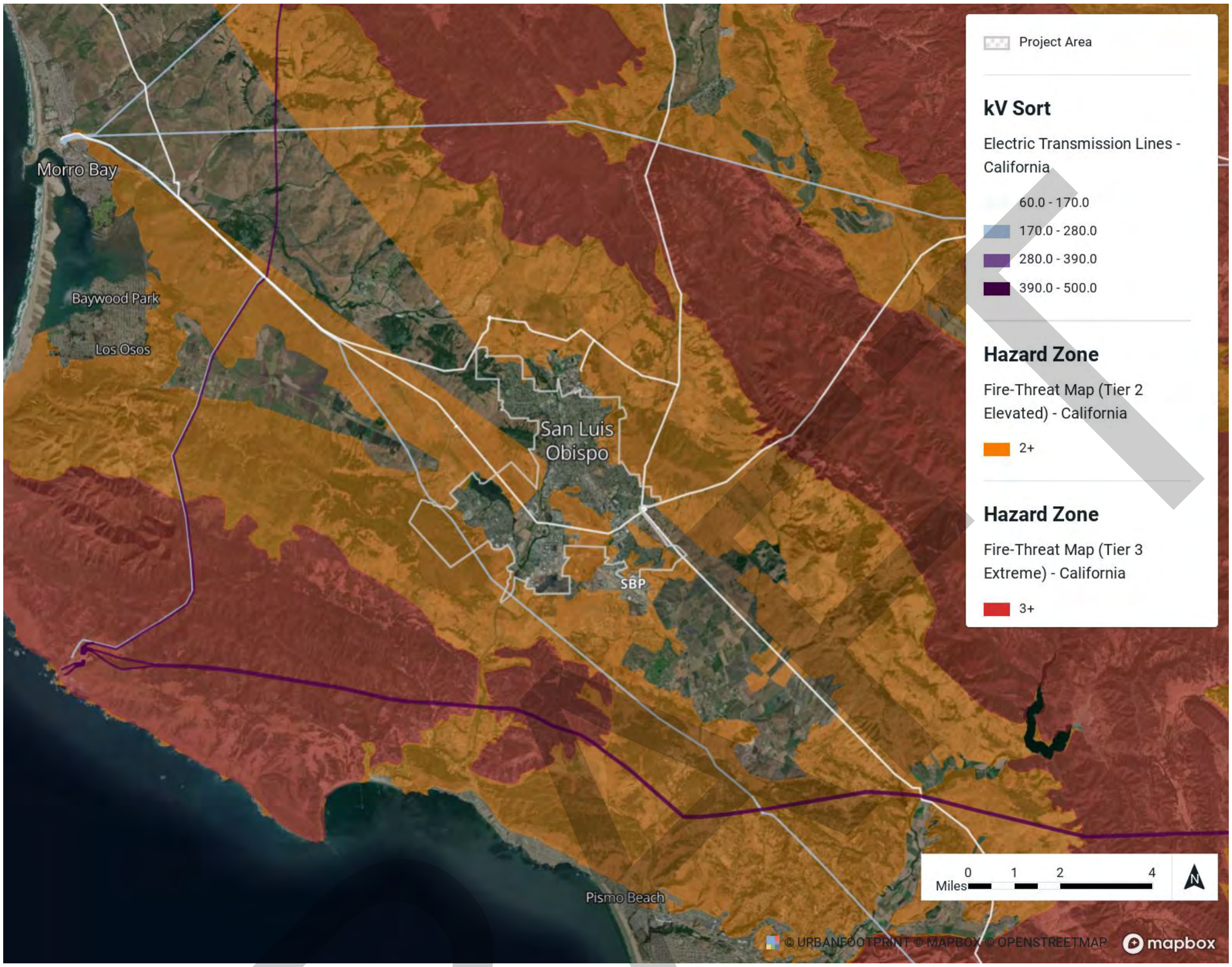


Projected PSPS events per month based on weather data collected over the last 30 years.

Source: PG&E 2020

Figure 28 Potential PG&E PSPS Events per Year by Month

Electricity to the City is provided by PG via a 115 kilovolt (kV) transmission line and three 21kV distribution lines from the Morro Bay area. Currently, there are no redundant or backup facilities or resources for continuous electrical service if a utility disruption were to occur to these facilities. Through coordination with PG&E, the City will be notified during planned shut offs to any of the distribution lines servicing the City.



The CPUC Fire-Threat Map depicts areas with increased risk from wildfires caused by transmission lines and where enhanced fire safety regulations have been enacted for utilities by the CPUC.

Source: CPUC 2021

Figure 29 California Public Utility Commission Fire Threat Map

Although residents in the City may not live or work in a high fire-threat area, their power may also be shut off if their neighborhood or home relies upon a line that passes through an area experiencing extreme fire danger conditions. During PSPS events, businesses and homes in the City lose power temporarily which can result in a variety of short-term impacts on the community including access to pharmacies, grocery stores, and other essential businesses for residents; secondary economic impacts on these businesses; loss of productivity for employees and employers; and loss of products for businesses requiring refrigeration such as grocery stores and restaurants. PSPS events may also affect telecommunication services such as cell towers and inhibit the ability to communicate information to residents during emergency events. However, in January 2020, SB 431 was adopted, which requires telecommunications service providers to develop backup power supplies to maintain minimum service for at least 72 hours during power outages. The bill also requires that during a utility deisruption, telecommunications servicee providers must provide communication services to emergency communication dispatch centers, emergency operations centers, federally-qualified health centers, fire stations, general acute care hospitals, police stations, and rural health clinics.

Considering that PSPS events are projected to occur in the late summer and fall months which are typically the warmest months in the City, the compounded effect of power loss during heat wave events could have considerable public health impacts leaving residents and businesses without power and air conditioning during heat wave periods.

These impacts would be even more severe for populations who are at increased risk from heat-related illnesses including persons over the age of 65, infants and children, individuals with chronic health conditions (e.g., cardiovascular disease, asthma), low-income populations, athletes, and outdoor workers (CDC 2019). Residents who require at home supplemental oxygen, refrigerated medications, and other medical equipment that requires electricity are also at increased risk during PSPS events. Additionally, a loss of power can disrupt heating, ventilation, and air conditioning (HVAC) systems in homes and business, which are critical for maintaining indoor air quality. The combination of PSPS events occurring during periods of poor air quality caused by wildfire smoke can lead to poor indoor air quality and result in increased public health impacts.

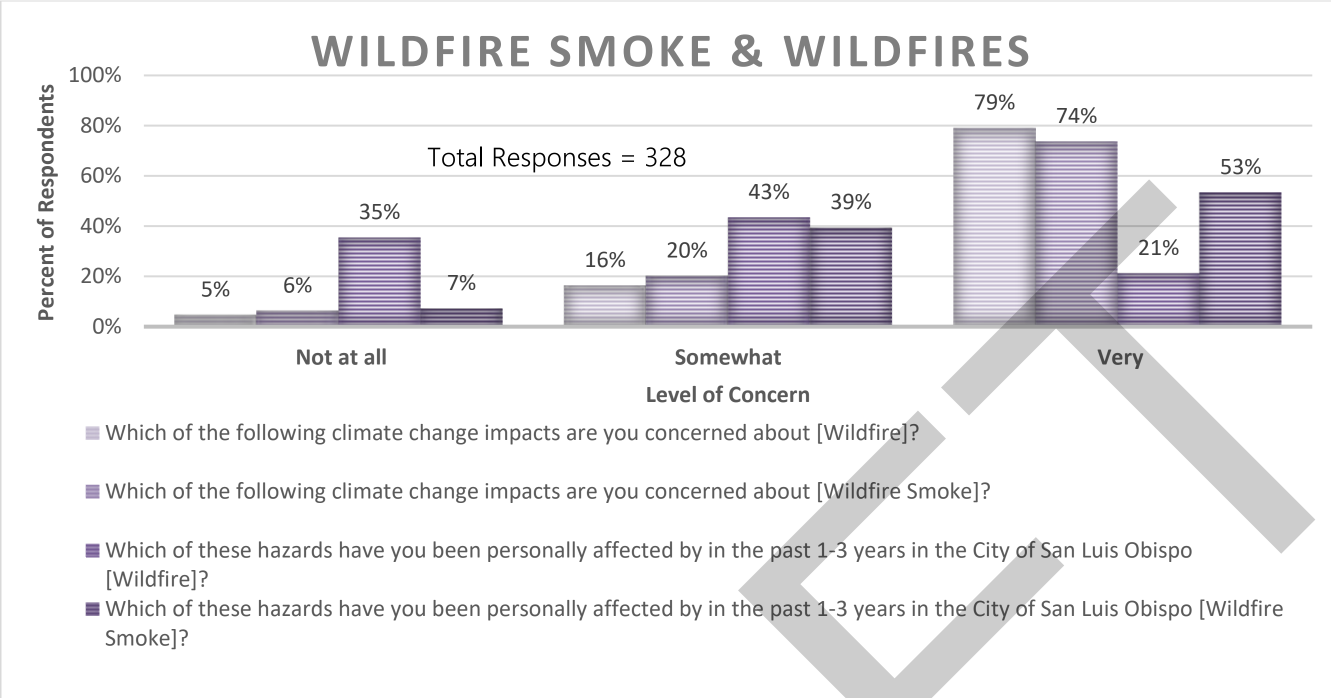
Aside from the power supply related impacts of PSPS events, recent research has shown that PSPS events likely result in a 'looming threat' that can be linked to unintended poor mental health outcomes compounded by self-reported trauma lingering from previous wildfire experiences. Specific concerns expressed by individuals affected by PSPS events in 2019 included, rotting food in refrigerators, people with medical needs being unable to access needed electricity, in addition to personal concerns about individuals' ability to conduct their normal daily activities. Other concerns included worries about how the PSPS events affected their ability to go to work or school, having to personally care or find childcare for children who were out of school due to the PSPS, and being unable to use air conditioning or a fan when needed. Regardless of actual impacts, the persistent "looming threat" of PSPS events for residents was a clear concern that led to worse mental health outcomes for some (Wong-Parodi 2020).

Local Impacts from Regional Wildfires

As shown in Figure 120, climate change is projected to increase the frequency and severity of wildfires not only in and near the City but at the County and regional level as well. Wildfires that occur at other locations in the County can have secondary impacts on the City as well including short-term impacts from route closures or delays, regional wildfire smoke impacts as discussed above, and economic impacts for employees who work in affected areas. Wildfires that occur in the County or in the larger central coast region can also result in temporary or permanent wildfire refugees who need to relocate due to property loss or damage and may relocate in the city. This influx of new residents can place increased pressure on local resources and infrastructure as well as exacerbate housing supply and affordability issues that already exist (National Academies of Sciences, Engineering, and Medicine 2020).

Community Wildfire and Wildfire Smoke Concerns

As part of the community priorities survey, when asked about their concern for wildfires and wildfire smoke, as shown in Figure 30, 94 percent of participants indicated "Somewhat" or "Very" concerned. When asked about whether they have been personally affected by either event, 64 percent of respondents indicated "Somewhat" or "Very" for wildfires and 92 percent of respondents indicated "Somewhat" or "Very" for wildfire smoke. Additionally, wildfire smoke was of paramount concern for individuals within the lowest income group (i.e., 84 percent). Renters and individuals between the ages of 18 and 24 expressed the highest level of concern for wildfire and wildfire smoke. Individuals who identify as White or Caucasian express a slightly higher level of concern both wildfire and wildfire smoke than individuals who identify as all other Races/Ethnicities.



Sources: Resilient SLO Community Priorities Survey

Figure 30 City Resident's Wildfire and Wildfire Smoke Concern and Impact

Key Findings and Policy Considerations

- Wildfire events in the VHFHSZ near the Irish Hills Natural Reserve could potentially have immediate impacts to some residential areas on Royal Way, Sterling Lane and Isabella Way. Additionally, areas in the northeast of the City south of US 101 along San Luis Road are at risk from wildfire impacts and could potentially compromise evacuation management when wildfires do occur in this area.
- The City serves as regional employment center, regional destination for tourism, and home to a university (Cal Poly) with approximately 20,000 students. These factors create an environment in which the City experiences a large influx of daily visitors to the City with a daytime population is estimated to be 90,000 (City of San Luis Obispo 2021c). If a wildfire event was to occur in or near the City during daytime hours, evacuation management would be particularly difficult and pose additional challenges due to this large influx of daily visitors. Additionally, because US 101 serves the main commuter corridor for locations north and south, wildfire events that occur along this route causing route closures (e.g., Cuesta Grade) can disproportionately impact employers and employees in the City.
- While the majority of the City is not at high risk from direct wildfire impacts, regional PSPS events have the potential to result in secondary impacts. Specifically, PSPS events occurring during heat wave events could have considerable public health impacts, leaving residents and businesses without power and air conditioning and further threaten residents who are medically-reliant on electricity for supplemental oxygen and refrigeration.
- The confluence of PSPS, bad air quality, wildfire threat, and high heat days underscores the importance of homes and businesses as places of potential refuge.
- The Sinsheimer Neighborhood (Census Tract 110.01) and the Laguna Lake and Los Osos Valley Road (Census Tract 113) areas are particularly vulnerable to wildfire impacts as these areas of the City are located near moderate to very high FHSZs and include higher percentages of elderly (20 percent) and youth (7 percent) populations. Additionally, these areas have a high percentage of households experiencing linguistic isolation (8 percent) which may present issues during emergency evacuation events.

- Exposure to wildfire smoke, particularly exposure to vulnerable populations, can result in worsening of respiratory symptoms, increased rates of cardiorespiratory emergency visits, hospitalizations, and even death (Rappold et al. 2017). Wildfires can damage not only buildings and infrastructure, but also the natural environment, including portions of the City and the areas in the County that serve as regional recreation and tourism destinations. Accordingly, wildfire smoke has the potential to harm the local economy by reducing tourism and its related industries.

2.5.3 Adaptive Capacity for Wildfire Impacts

As discussed in the previous section, portions of the City are at considerable risk from wildfire impacts as well secondary impacts to residents and businesses from wildfire smoke and PSPS events. However, wildfire risk is not a new hazard for the City and partner agencies have taken considerable steps to mitigate wildfire impacts when they do occur.

WILDFIRE RISK REDUCTION AND PREPAREDNESS

Wildfire risk is addressed in the City's Annex G of the County's Multi-Jurisdictional Hazard Mitigation Plan and includes a set of mitigation goals, objectives, and actions specifically focused on addressing wildfire risk. Additionally, the City of San Luis Obispo adopted the Community Wildfire Protection Plan in 2019 which focuses on fire protection planning in the City, working on minimizing wildfire risk to areas in and around the City limits. Section IV of the plan includes a comprehensive set of goals and policies with implementation timelines to reduce wildfire risk in the community. The strategy categories include:

- Education policies to prepare response organizations, communities, the public, and policy makers regarding appropriate community actions and interactions to reduce the unwanted impacts of fires in the wildland urban interface.
- Fuels Management policies to mitigate the unwanted impacts of wildfires on communities through proper vegetation management techniques that reduce hazardous fuels and the resulting wildfire intensity.
- Planning policies to help mitigate wildfire impacts in the City through community planning (including new resilient community design, retrofitting existing communities, and community recovery from the impact of fire), response planning, evacuation planning, and preparedness planning for responders, communities, individuals, animals, and livestock.
- Emergency Response policies to mitigate wildfire impacts on life, property, and resources by having an efficient and effective response that includes properly trained personnel, appropriate equipment, and a community prepared to take appropriate action or evacuate.
- Ignition Resistance policies mitigate structural ignitions from radiant heat, flame contact, or embers from wildland urban interface fires.

In regard to helping prepare the general public for wildfire hazards, the City's Fire Department has provided a comprehensive set of videos and resources through the Prepare SLO information campaign to inform residents and businesses on how to reduce risk from wildfires, prepare for wildfire events when they do occur, as well as how to recover from wildfire impacts. In addition to the City's wildfire preparedness efforts, the County's Office of Emergency Services (OES) works to help coordinate emergency response efforts between the County, the City, and relevant partner agencies including CAL FIRE during emergency events. The County OES also manages the Ready SLO website which provides a comprehensive set of resources to help County residents prepare for hazard events including information needed in preparing for hazards, key hazard resources such as evacuation routes, and the County's emergency alert system which residents can sign up for to receive notifications and alerts during emergency events.

ENERGY RESILIENCE

In recent years, PG&E has also taken considerable steps to reduce the severity of impacts of PSPS events when they do occur (PG&E 2020). These steps include:

- electricity grid upgrades to break the grid into smaller parts to limit the size of outages when they do occur;
- preparing microgrids in areas most likely to experience PSPS events to safely provide electricity to areas that are safe to keep energized during PSPS events;
- supporting communities and customers to develop their own multi-customer or community-level microgrids;
- implementing system hardening improvements including installing stronger, fire resistant poles, covered lines and conducting targeted undergrounding in areas of high wildfire risk; and
- using better weather monitoring technology and installing new weather stations to more precisely forecast the weather that could lead to PSPS events.

The City also benefits from the efforts undertaken by the San Luis Obispo County Fire Safe Council (Fire Safe Council). The Fire Safe Council is a diverse group of local and regional stakeholder that work to create fire safe communities in the County. The group provides educational resources to residents and businesses to reduce wildfire risk at the neighborhood and property level as well as help manage and fund wildfire fuel reduction projects throughout the County.

Central Coast Community Energy (3CE) is a Community Choice Energy agency established by local communities to source clean and renewable electricity for Monterey, San Benito and Santa Cruz counties, and parts of Santa Barbara and San Luis Obispo counties (including the City of San Luis Obispo). 3CE has begun to implement Resiliency Programs to help increase energy resilience for their customers. Most notably, 3CE has allocated $25 million to create the Uninterruptible Power Supply (UPS) Fund to accelerate and help finance the adoption of reliable backup power for public and private entities operating critical facilities, helping to ensure continuity of service and operations during PSPS events. 3CE is also working to develop a Residential Resiliency Incentive Program 2021 to help residential customers increase energy resilience through reliable backup power systems.

UTILITY DISRUPTION EMERGENCY OPERATIONS

Annex I of the City's Comprehensive Disaster Leadership Plan focuses specifically on procedures to ensure a continuity of operations during a Utility Disruption event affecting portions or all of the City. This document is in in part a response to the potential increase in PSPS events effecting the City as well as other climate related hazards that may affect utility services. The City of San Luis Obispo has adopted the Incident Command System, the Standard Emergency System, and the National Incident Management System as the emergency organization and the emergency management system for response to a Utility Disruption event impacting the City. The document includes a set of actions to be taken prior to a Utility Disruption when any notification of anticipated severe fire weather concerns are issued by PG&E as well as assigned roles for appropriate City departments during a Utility Disruption event. As stated in Annex I, the PG&E event notification will include:

- Estimated start time of a potential event
- Forecasted weather duration
- Estimated time range to full restoration
- Number of medical baseline customers in the potentially impacted area
- Weather and Utility Disruption information can be found at www.pge.com/weather
- Maps that include boundaries of the area subject to de-energization and affected circuits will be posted at www.pge.com/pspsportal

Annex I also includes an initial assessment of what impacts may occur to various operations in the City during a Utility Disruption including disruptions to leadership operation, emergency reporting, evacuation, resource center information, animal sheltering, school disruptions, emergency services, City utilities (discussed below), transportation systems, communication systems, emergency public information communications, and security. The document also includes recovery actions to be taken once a Utility Disruption event has ended.

As a result of potential future PSPS, the City's Utility Department has begun to develop precautionary measures to ensure the City is able to provide uninterrupted water service during short-duration power outages. The City's 2020 UWMP includes discussion of efforts to prepare for power outages of up to seven days and to ensure water is provided to critical facilities including the City's Emergency Operations Center, area hospitals, the SLO County Emergency Operations Center, the Cal Poly campus, and the SLO County airport. The City has a set of portable generators that are deployed as needed to various locations in the City's water conveyance system during power outages. The City also has a set of permanent back-up generators at key facilities including the City's Water Treatment Plant, Whale Rock Reservoir, and other pump stations and lift stations to ensure uninterrupted water service is provided in power outage scenarios.

For these reasons, the adaptive capacity ranking for wildfire risk is medium.

2.5.4 Vulnerability Summary

As discussed above, climate change is projected to cause an increase in the size and frequency of wildfire events due to changes in average temperatures, extreme heat events, and long-term drought scenarios over the 21st century. While the City includes some areas that are a high risk from wildfire impacts, the majority of the City is at moderate risk from direct wildfire impacts. However, due to the regional characteristics of wildfire impacts the City is still vulnerable to secondary wildfire impacts including untended consequences of PSPS events as well as public health impacts from regional wildfires that generate wildfire smoke and poor air quality in the City. These changes will result in varying impacts on the City and its residents as discussed above. Based on the analysis of various impacts discussed in Section 3.3.2, the City's potential impact scoring is High (3). Wildfire impacts that are unique to the City and should be given increased consideration during the adaptation strategy development process are discussed below.

Natural System Findings

- The increasing frequency of fire on chaparral landscapes have caused coastal sage shrubs and chaparral to shift to grasses, including exotic grasses. Some research has suggested that annual and some perennial grasses have the strongest effects on fire regimes and act as ecosystem transformers.
- Wildfire impacts in riparian zones can reduce canopy cover, resulting in increased water temperatures in creeks and other shaded waterways, as well as increased sediment flux in stream beds and adjacent areas, affecting the food web of burned stream areas and increasing the density of algae in waterways.
- Post-wildfire runoff and debris flows can be affected by several factors but are generally triggered by one of two processes: surface erosion caused by rainfall runoff, and landslides caused by rainfall seeping into the ground. While it is uncertain the effect climate change will have on post-wildfire runoff and debris flow events, climate change is projected to result in higher intensity rainfall events as well as "whiplash events" with oscillations between extremely dry and extremely wet periods, potentially affecting post-wildfire hazards.

Built Environment Findings

- The risk of wildfire is dependent on a variety of factors not excluding biophysical factors that are affected by climate change including Resources (e.g., land use patterns, vegetation growth), Ignitions (e.g., lightning, accidental ignitions, arson), and Conditions (e.g., precipitation, wind, seasonal variation). Approximately 95 percent of wildfires in the state are caused by human ignition. However, climate change is projected to increase the frequency and severity of wildfires, when they do occur (Mann et al. 2016).
- The combination of dry climate conditions and the seasonal high autumn winds in California can increase the risk of trees or branches falling on transmission lines and causing power outages or wildfires. While these events have occurred historically, the effect of climate change on biophysical features that increase the risk of

wildfires (e.g., precipitation, wind, seasonal variation) will increase the frequency and severity of wildfires from transmission line ignitions.

- There was limited development within the WUI in the city for the period of 2001 – 2016, with a few prominent exceptions including the Madonna Area and the Margarita Area to the east of South Higuera Street. However, buildings outside of the WUI are also at risk from ignition due to the spread of firebrands (or embers) that can initiate new spot fires.
- Wildfire events in the VHFHSZ near the Irish Hills Natural Reserve could potentially have immediate impacts to some residential areas on Royal Way, Sterling Lane and Isabella Way. Additionally, areas in the northeast of the City south of US 101 along San Luis Road are at risk from wildfire impacts and could potentially compromise evacuation management when wildfires do occur in this area.

Community Resilience Findings

- The City serves as regional employment center, regional destination for tourism, and home to a university (Cal Poly) with approximately 20,000 students. These factors create an environment in which the City experiences a large influx of daily visitors to the City. If and when a wildfire event was to occur in or near the City during daytime hours, evacuation management would be particularly difficult and pose additional challenges due to this large influx of daily visitors. Additionally, because US 101 serves the main commuter corridor for locations north and south, wildfire events that occur along this route causing route closures (e.g., Cuesta Grade) can have a disproportionate impact on employers and employees in the City.
- While the majority of the City is not at high risk from direct wildfire impacts, regional PSPS events that affect the City will result in a set of potential secondary impacts. Specifically, PSPS events occurring during heat wave events could have considerable public health impacts, leaving residents and businesses without power and air conditioning and further threaten residents who are medically-reliant on electricity for supplemental oxygen and refrigeration.
- The confluence of PSPS, bad air quality, wildfire threat, and high heat days underscores the importance of homes and businesses as places of potential refuge.
- The Sinsheimer Neighborhood (Census Tract 110.01) and the Laguna Lake and Los Osos Valley Road (Census Tract 113) are particularly vulnerable to wildfire impacts as these areas of the City are located near moderate to very high FHSZs and include the higher percentages of elderly (20 percent) and youth (7 percent) populations. Additionally, these areas have a high percentage of households experiencing linguistic isolation (8 percent) which may present issues during emergency evacuation events.
- Exposure to wildfire smoke, particularly exposure to vulnerable populations, can result in worsening of respiratory symptoms, increased rates of cardiorespiratory emergency visits, hospitalizations, and even death (Rappold et al. 2017). Wildfires can damage not only buildings and infrastructure, but also the natural environment, including portions of the City and the areas in the County that serve as regional recreation and tourism destinations. Accordingly, wildfire smoke has the potential to harm the local economy by reducing tourism and its related industries.

Wildfire Vulnerability Score

Adaptive Capacity: Medium (2)

Potential Impact: High (3)

Vulnerability Score: 4

2.6 PRECIPITATION AND FLOODING ANALYSIS

This section discusses future increases in annual precipitation and increases in the frequency and severity of large storm events in watersheds affecting the City. The section analyzes how these changes are likely to impact the City and its population as well as highlights what capacity the City and partner agencies already have in place to address these future impacts.

2.6.1 Future Exposure to Changes in Precipitation and Flooding

According to Cal-Adapt, the historic average annual precipitation in the City is 21.2 inches. As shown in Table 17, the average annual precipitation in the County is projected increase to 22.6 inches in the near-term and 22.6 inches in the midterm under the high emissions scenario. Average annual precipitation is projected to be 21.6 inches under the medium emissions scenario and 25.2 inches under the high emissions scenario in the late century (CEC 2021a). Although the City is anticipated to experience only moderate increases in annual precipitation, research indicates that the majority of the increase in annual rainfallis anticipated to occur during large storm events, which are projected to increase in size and frequency in the future.

Table 17 Changes in Average Annual Precipitation in City of San Luis Obispo

Average Annual Precipitation	Historic Average Annual Precipitation (1961-1990)	Near-Term (2021-2050)	Midterm (2035-2064)	Late-Century (2070-2099)	
				Low Emissions	High Emissions
Average Annual Precipitation (inches)	21.2	22.6	22.6	21.6	25.2

Notes: RCP = Representative Concentration Pathway.
Source: CEC 2019a

CLIMATE-INFORMED FLOOD RISK MODELING

As part of the development of the vulnerability assessment, a climate-informed flood risk modeling exercise was conducted to understand how changes in precipitation caused by climate change could affect the frequency and severity of large storm events (e.g., 100-year storm event) and how these changes would affect the flow of water through the City's existing flood plains. The following section discusses the process used to develop this modeling and a summary of the modeling results.

Flooding Characteristics

Two interchangeable, technical terms that characterize flood frequency are used throughout the section and are defined as follows:

- Recurrence Intervals: A common way to describe floods is by stating their recurrence intervals, which refer to how often, on average, a given flood may occur. A 100-year event, for example, is described as an event that may occur about once in every 100 years, on average. However, this terminology can be misleading because flood events are statistical occurrences, and events may occur more frequently than their recurrence interval suggests.
- Exceedance Probability: The exceedance probability of a given flood event is the percent chance that a larger flood will occur in any given year, and it is calculated by dividing the number 1 by the recurrence interval. Thus, the "100-year event" becomes the "1-percent exceedance event," or a flow rate that has a 1-percent chance in any given year of being equaled or surpassed by a larger flow rate. This representation, although interchangeable with the recurrence interval, provides a more helpful way to think about flood risk.

There are several overall mechanisms by which flooding can occur:

- dam inundation flooding, in which impounded water is released because of dam breaching;
- localized flooding, which occurs when intense rainfall overwhelms the capacity of local drainage infrastructure; causing the ponding of water; and
- riverine flooding, which occurs when channels (i.e., the relatively deep, narrow sections of creeks and rivers) cannot contain the flow volume moving through them, causing water to spill out into the overbank areas (i.e., the relatively wide, flat regions on one or both sides of the channel, also called "floodplains").

According to the Annex G of the County's HMP, the City is not at risk of dam inundation flooding, as there are no major reservoirs within the watershed, and localized flooding is considered a minimal risk. The highest flooding concern for the City is riverine flooding, which may include "flash" flood risks (San Luis Obispo County 2019b).

Floods occur when the amount of water within the creek channels exceeds the channel capacity, causing water to spill over the banks and into the surrounding land. In these flat, flood-prone areas beyond the channel, called floodplains, slow moving or stagnant water that escapes the channel may remain until water levels within the channels recede or the areas are drained by infrastructure, percolation, or evapotranspiration. Naturally, these floodplain areas would have been flooded every few years, but as the City developed onto portions of the floodplains of the creeks within the San Luis Obispo Creek watershed, channel incision and flood protection measures constrained flows to the creeks. During periods of intense rainfall, however, the watershed outflow, including urban runoff, can exceed the capacity of the channels. Under existing conditions, different creeks within the watershed may experience flooding every 10-25 years (Questa Engineering Corporation 2003). The goal of the flood impacts assessment was to determine how the current level of flood risk is projected to vary as a result of climate change.

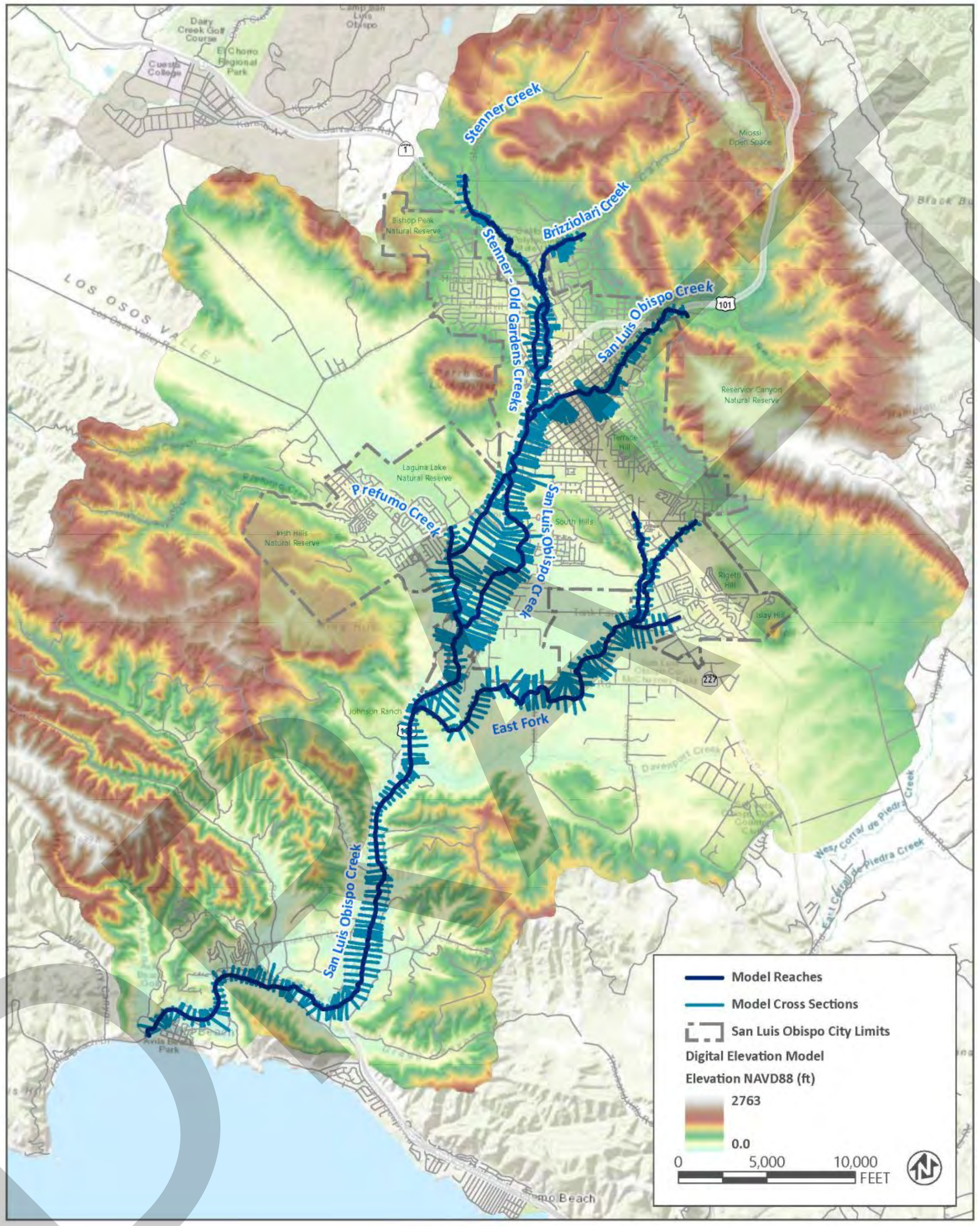
Flood Risk Modeling Methodology

To understand how flood risk for the City is likely to change in the future due to climate change, modeling software was used to assess projected changes in rainfall and analyze how these changes would affect flood inundation. The first step in determining the change in flood risk involves conducting long-term hydrologic modeling of the San Luis Obispo Creek watershed with historic and future daily precipitation data to understand changes in stream flow. This type of model simulates the ability of the watershed to store and release water over time through various processes, and by determining how quickly water is passed through the system, the model can be used to understand how flow within creek channels will respond to rainfall. It is based on physical watershed attributes such as slope, drainage area, land cover, geology, channel geometry, and initial soil moisture conditions, which control how much of the precipitation will be converted to streamflow versus being held within the watershed or lost to the atmosphere. For this analysis, a hydrologic model was developed using the Soil and Water Assessment Tool platform (SWAT), which was calibrated using historical gridded precipitation data (Livneh et al. 2015) and United State Geological Survey daily flow records from 1978 – 1985 for the Lower SLO Creek gage.

The SWAT hydrologic model was then used to simulate both historic (1970 – 1999) and future (2070-2099) daily precipitation records from 10 General Circulation Models recommended by the California Department of Water Resources for this type of modeling. These atmospheric models simulate global patterns for temperature, precipitation, and other atmospheric data over long periods of time. For the purpose of this assessment, the high emissions scenario over the long-term period (2070-2099) was used for this exercise. The 30-year future daily precipitation records were then simulated in the SWAT model, in addition to historic precipitation records (1970 – 1999). Using the average of the 10 future simulations, flow frequency statistics (England et al. 2019) were computed to determine how different flood events (e.g., the 100-year event) are projected to vary as a result of climate change.

To assess flood impacts on the City's existing floodplains from changes in precipitation, further hydraulic modeling was needed. Hydraulic modeling is a process that uses the physical representation of a river network, including channel geometries, land slopes, surface characteristics, and structural information, to understand how quickly water moves through different channel reaches, how deep it is, and where overbank flooding may occur. For example, water flowing across a smooth concrete surface will move much faster than water passing through vegetation or through gravelly waterways. From a hydraulics perspective, the vegetation is said to have higher 'roughness' than the concrete, and empirical values are available to indicate this concept of roughness within hydraulic models. Likewise, channels that have steeper slopes or greater cross-sectional areas will be able to move water more quickly than those with gentler slopes or smaller areas. Bridges, culverts, and other structures can also greatly affect flow. As illustrated in Figure 31, a suite of hydraulic models using the HEC-RAS platform was developed for the Waterway Management Plan (Questa Engineering Corporation 2003), spanning San Luis Obispo Creek from Reservoir Canyon to Avila Beach, Prefumo Creek from Madonna Road to the San Luis Obispo Creek confluence, East Fork San Luis Obispo Creek and portions of its tributaries, and portions of Stenner, Brizziolari, and Old Garden Creeks. These models were adapted to the current study by scaling the peak flows used in the WMP by the factors from Table 18. The 500-year event was not studied for the Waterway Management Plan, but 500-year flow rates were determined for Federal Emergency

Management Agency (FEMA) flood insurance studies (FEMA 1978) for all examined creeks except for East Fork San Luis Obispo Creek.



Source: cbec eco-engineering 2021

Figure 31 HEC-RAS Hydraulic Model Extent

Table 18 Climate-induced Changes in Peak Stream Flow for the San Luis Obispo Creek Watershed

Flood Event (Return Interval)	Percent chance of flood occurring in any given year	Percent increase in peak stream flow		
		90th Percentile	50th Percentile (median)	10th Percentile
500-Year	0.2%	122%	38%	4%
200-Year	0.5%	116%	38%	4%
100-Year	1%	110%	38%	4%
50-Year	2%	103%	37%	4%
20-Year	5%	93%	35%	3%
10-Year	10%	84%	33%	3%
5-Year	20%	73%	29%	3%
2-Year	50%	51%	28%	8%
1-Year	99%	64%	17%	-31%

Source: cbec eco engineering 2021. The late century (2070-2099), RCP 8.5 scenario was used to determine flood impacts.

For each flood event, historic flow rates (using WMP hydrology for 10-year, 50-year, and 100-year and FEMA [1978] hydrology for the 500-year excluding East Fork of San Luis Obispo Creek) and scaled future peak flow rates based on projections from Table 18 were simulated in the HEC-RAS models representing channel conditions in the early 2000's. Flood inundation maps were then generated by extending modeled water surface elevations over a digital elevation model of the watershed (Woolpert 2019) to determine inundated acreage and depth of water on floodplain areas (not including channels or Laguna Lake) that were physically connected to flood sources. The assessment was divided into 9 regions to understand how flood impacts varied throughout the City and outlying areas.

Modeling Results

The following section discusses the results of the climate-informed flood risk modeling exercise. Table 18 includes the modeling results for various size storm events in the San Luis Obispo Creek watershed for the long-term period (2070-2099) under a high emissions scenario.

As shown in Table 18, the 10th percentile results indicate an extremely dry scenario, which experiences decreases in flow for events with less than a 2-year recurrence interval, while the 90th percentile results represent an extremely wet future scenario and results in peak flows more than doubling for events that occur every 50 or more years. For flood events occurring more rarely than every 2-years, flows are expected to increase across all scenarios including the 10th percentile projection. Overall, the median projection represents the best available estimate at this time for the San Luis Obispo Creek watershed for how peak flows are likely to change if global GHG emissions maintain the high emissions scenario trajectory for the long-term period.

The climate-induced increases in flood magnitude are due to increases in precipitation intensity. As the atmosphere warms, its ability to hold water vapor increases. While total annual precipitation in different parts of the state is projected to increase, decrease, or stay the same depending on the location, the trend of increasing rainfall within shorter periods of time (increasing intensity) is projected to occur broadly (OPR et al. 2018). In this way, even areas that may become drier and experience water scarcity as a result of climate change may also experience increased flood risk. Based on California's location next to the Pacific Ocean, the state is exposed to the atmospheric river (AR) phenomenon, a narrow corridor of concentrated moisture in the atmosphere. California is subject to precipitation from an AR that transports water vapor from as far south as Hawaii to the state. The presence of the AR contributes to the frequency of "wet years" in the state, when there is an above-average number of AR storms and above-average annual precipitation. Projected peak stream flow increases are also greater for larger (less frequent) flood events than for smaller ones, as a result of the watershed's diminishing ability to absorb increasingly high levels of rainfall. For example, following a long, dry summer, the land surface, soils, and vegetation will have a relatively high capacity to hold incoming rain and very little stream flow may be generated from a notable amount of rainfall. In the mid-winter months, after a series of precipitation events has passed through, the soils are relatively saturated and generate runoff more quickly. For very large precipitation events, the capacity of the watershed to absorb incoming rainfall can be quickly exceeded, causing large increases in stream flow within the system. For the median scenario, peak flow rates are projected to increase from 17 percent to 38 percent for events that occur every year to every 500 years, on average, as show in Table 18.

While research indicates that the frequency of large storms events does increase in these wet years, the most severe flooding from ARs may not be in wet years (Swain et al. 2018). The largest flooding impacts are caused by persistent storm sequences on sub-seasonal timescales (i.e., short time periods, typically 2 weeks to 3 months), which bring a significant fraction of annual average precipitation over a brief period. These storms events are similar to the Great Flood events of 1861–1862, which caused widespread damage throughout northern California (Swain et al. 2016). Based on current climate modeling, the frequency of these large storm sequences over short timeframes is projected to increase noticeably under the high emissions scenario. It is estimated that a storm similar in magnitude to the Great Flood event is more likely than not to occur at least once between 2018 and 2060 (Swain et al. 2018).

Although annual precipitation is anticipated to increase in the City and the larger central coast region, California's climate oscillates between extremely dry and extremely wet periods with annual precipitation varying widely from year to year. Climate change is anticipated to exacerbate these seasonal extremes with dry periods becoming dryer and wet periods becoming wetter (OPR et al. 2018b:19). As a result, the frequency and severity of large storm events are anticipated to increase as well. These oscillations between extremely dry and extremely wet periods, which have occurred historically in the state, are anticipated to become more severe with rapid shifts from dry to wet periods known as "whiplash events" (Swain et al. 2016). As Swain et al. note in their research, the recent 2012–2016 drought followed by the 2016–2017 flood events throughout the state serve as a good example of the type of whiplash events that will occur more frequently over the next century. These types of events are estimated to increase by approximately 100 percent in southern California, with increases in frequency occurring largely after 2050 (Swain et al. 2016).

2.6.2 Precipitation and Flooding Sensitivities and Impact

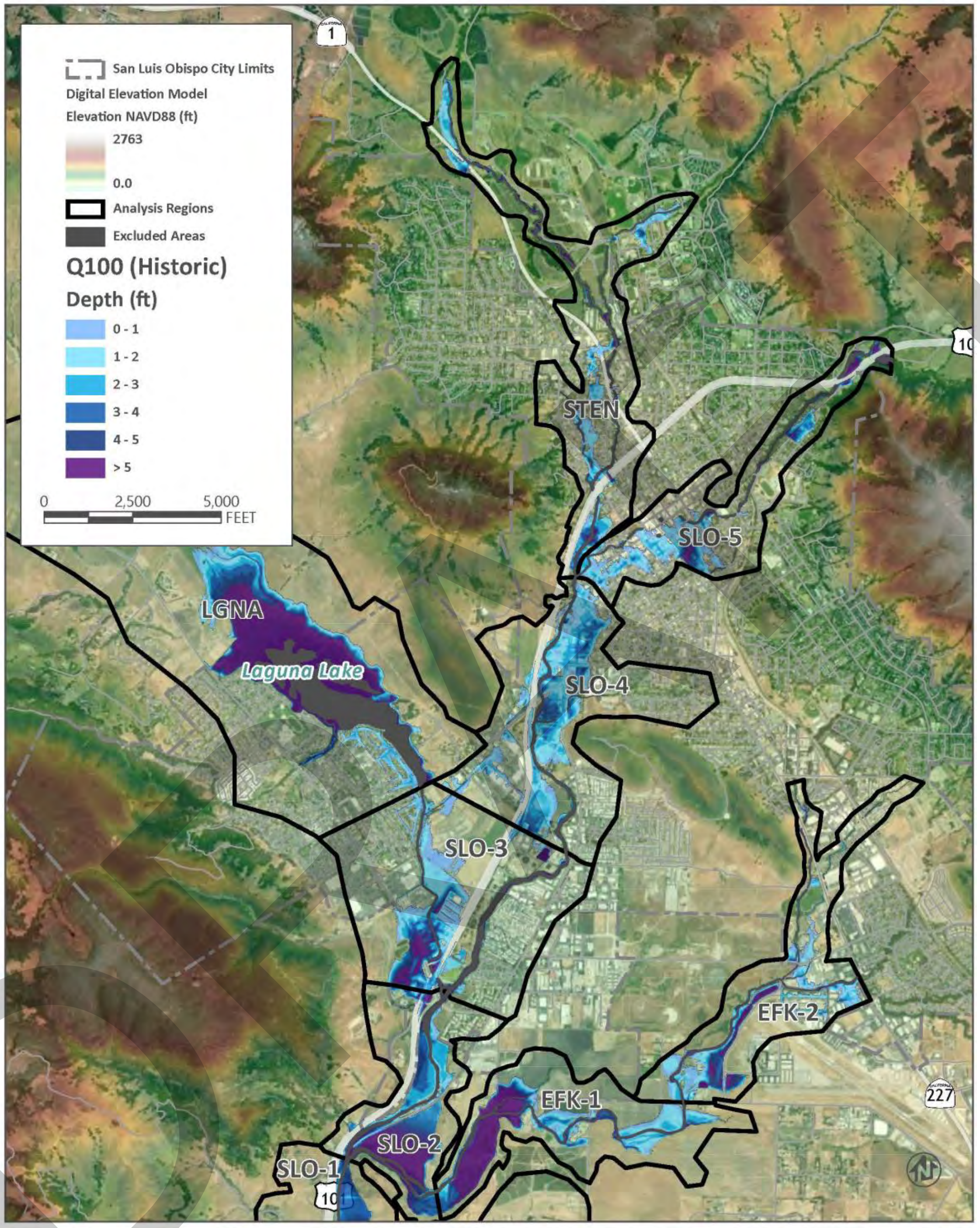
This section discusses the City's existing sensitivities to increases in annual precipitation and flooding events, analyzing potential effects on the City including a discussion of general impacts as well as secondary impacts. This impact analysis focuses specifically on impacts to the City's built environment and transportation network.

FLOODING AND NATURAL SYSTEMS

Future Flood Mapping Results

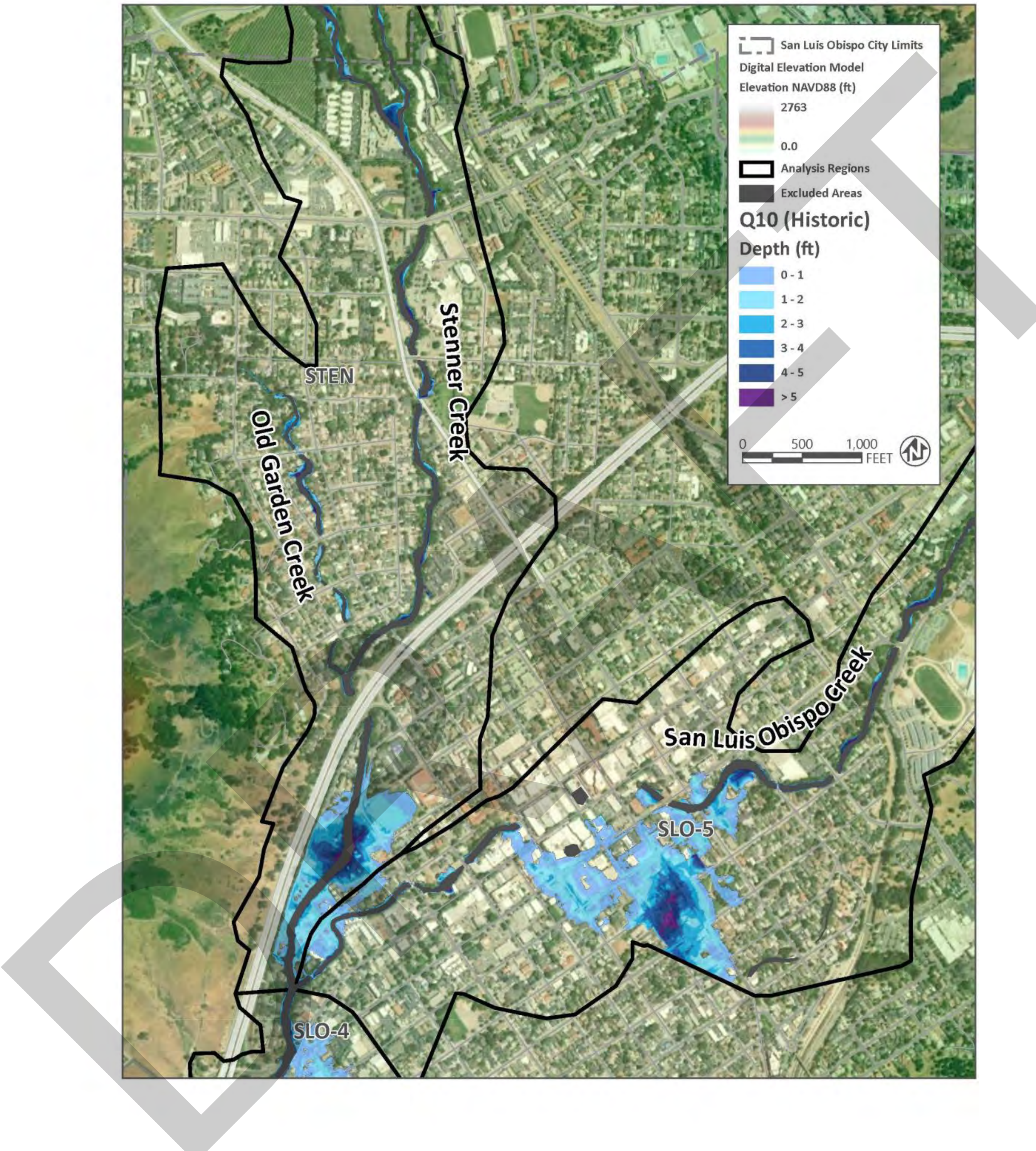
Based on hydraulic modeling discussed above, future floodplain maps were generated to understand how changes in precipitation for the 10-year, 50-year, and 100-year storms events would impact the City as shown in Figures 32 through 40. Additional modeling for the 10-year, 50-year, 100-year, and 500-year storms events is included in Appendix A. Figures 32 through 40 show the generated depth maps for historic and future (long-term high emissions [RCP 8.5] scenario) conditions for the 10-year (Q10) and 100-year (Q100 events within the San Luis Obispo Creek – Stenner Creek and San Luis Obispo Creek – Prefumo Creek confluence areas. These figures provide an illustration of the future extent of flood plains in the San Luis Obispo Creek watershed. However, there are limitations preventing these maps from being used for more detailed or more absolute flood extent delineations for historic and future conditions. One main limitation is the reliance upon hydraulic models that are almost two decades old and do not cover all areas of the City as well as an uncertain range of possibilities for future precipitation and future global emissions trends during the late-century period. However, the mapping exercise is useful for indicating the locations and extents of relative flood impacts that may reasonably be expected to occur due to climate change under the late-century high emissions scenario.

To further understand relative flood impacts, the hydraulic model domain was divided into nine analysis regions where changes in inundated area in acres and average depth on the floodplain (ft) were compared between historic and future conditions for each flood event, as shown in Tables 19 and 20. To determine these statistics for floodplain areas, the regions within the creek channels and Laguna Lake were removed from the analysis.



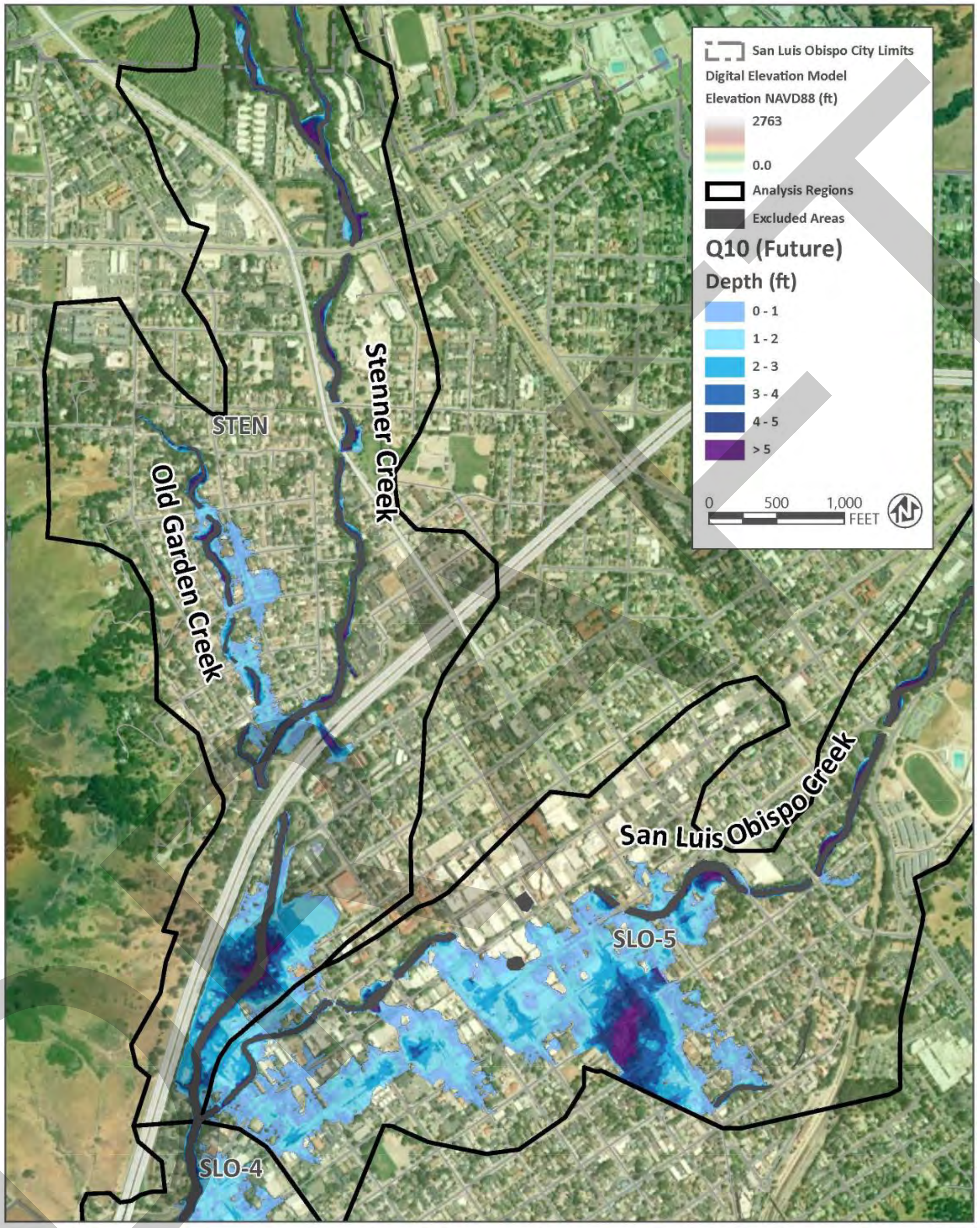
Source: cbec eco engineering 2021

Figure 32 Flood Depth: Full Extent - Q100 (Historic)



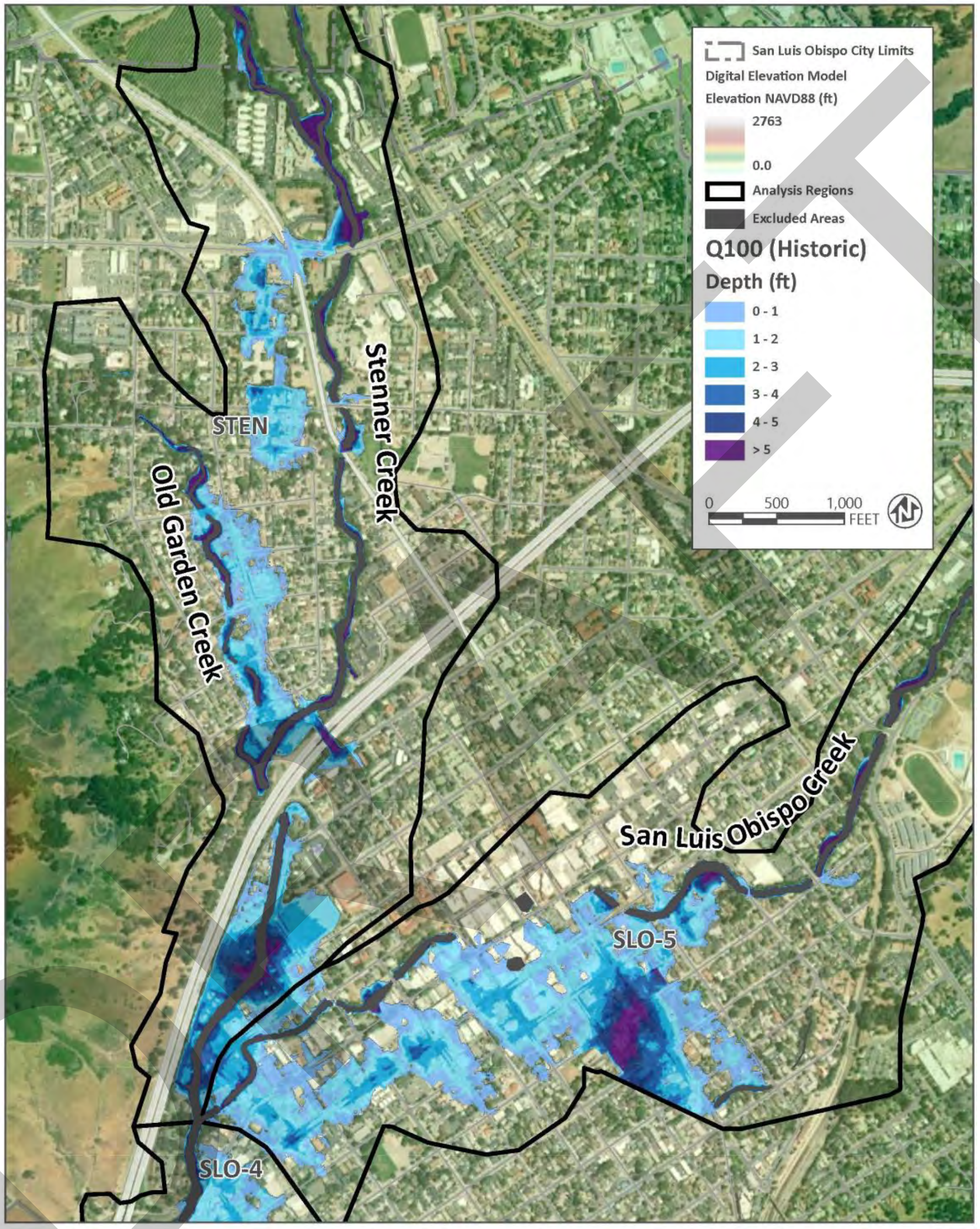
Source: cbec eco engineering 2021

Figure 33 Flood Depth: SLO-Stenner - Q10 (Historic) Flood Depth - Q100 (Historic)



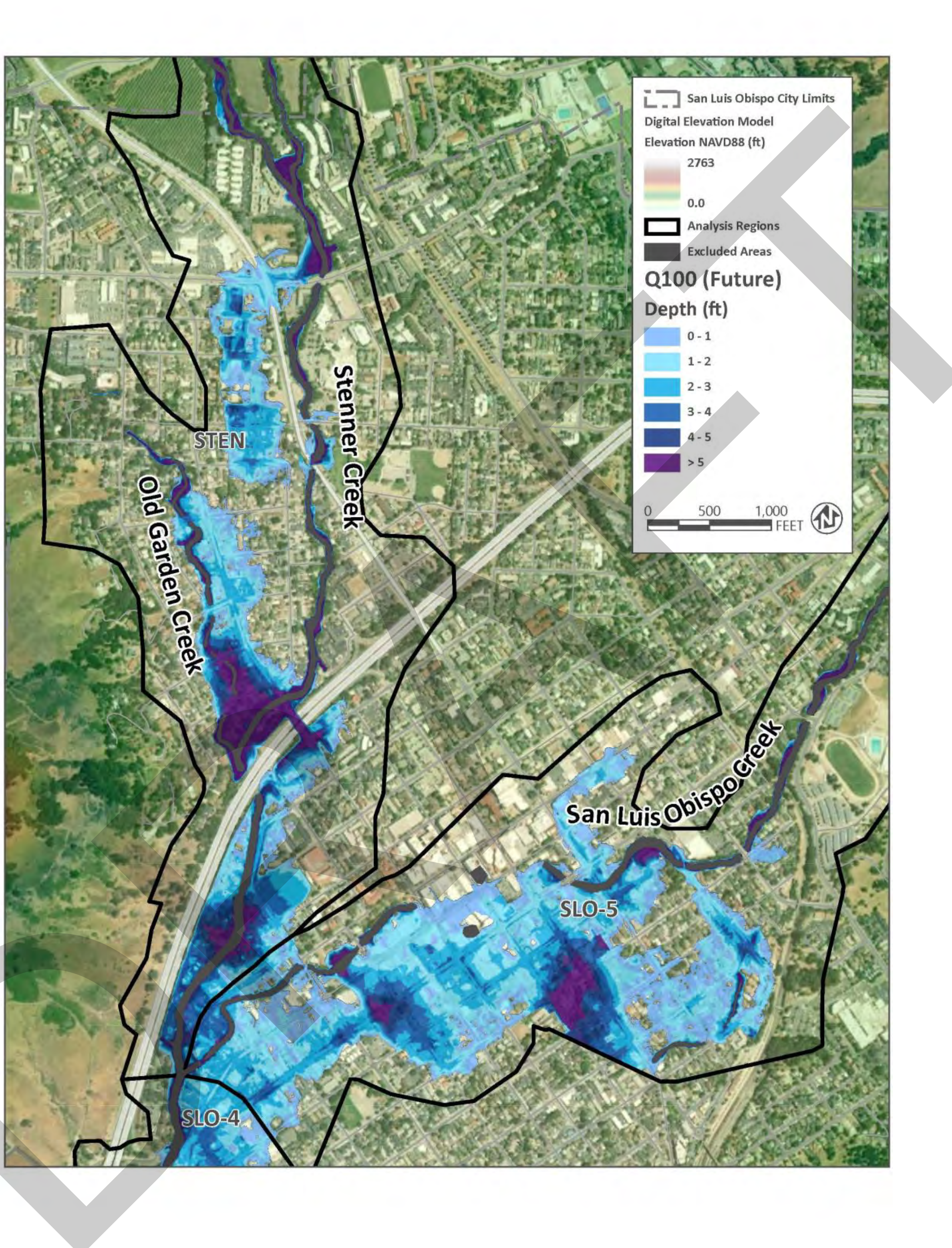
Source: cbec eco engineering 2021

Figure 34 Flood Depth: SLO-Stenner - Q10 (Future 2070-2099 – RCP 8.5)



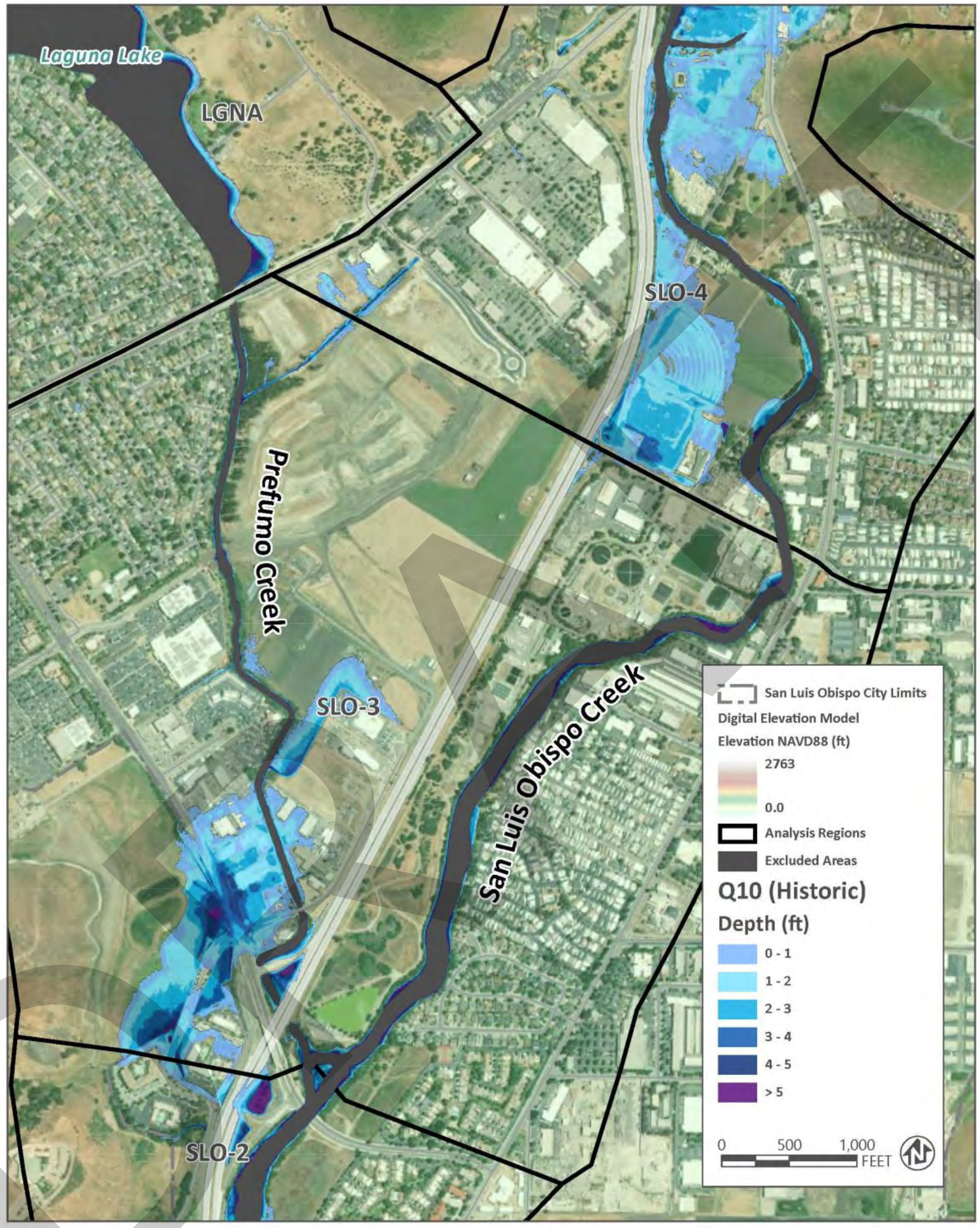
Source: cbec eco-engineering 2021

Figure 35 Flood Depth: SLO-Stenner - Q100 (Historic)



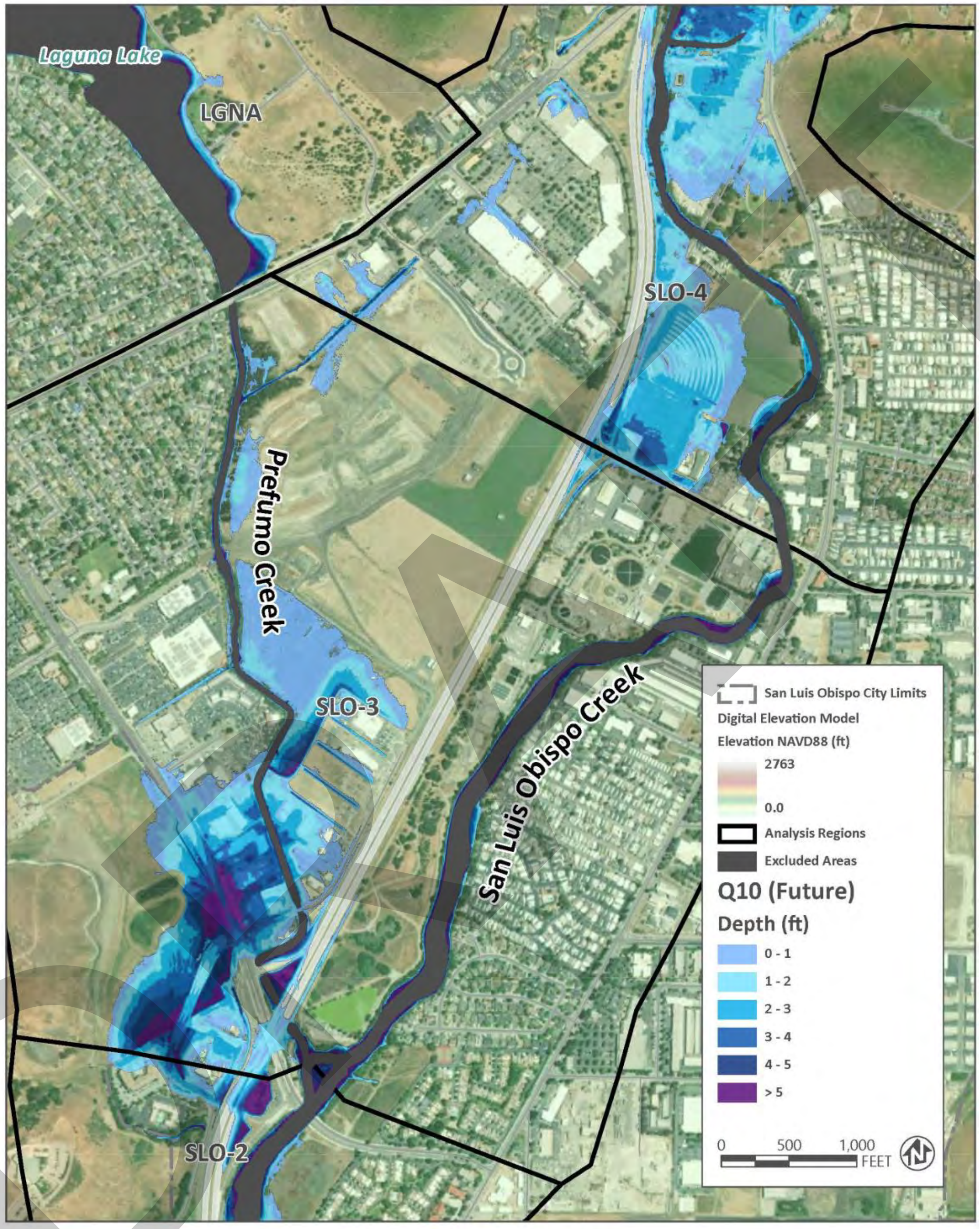
Source: cbec eco-engineering 2021

Figure 36 Flood Depth: SLO-Stenner - Q100 (Future 2070-2099 – RCP 8.5)



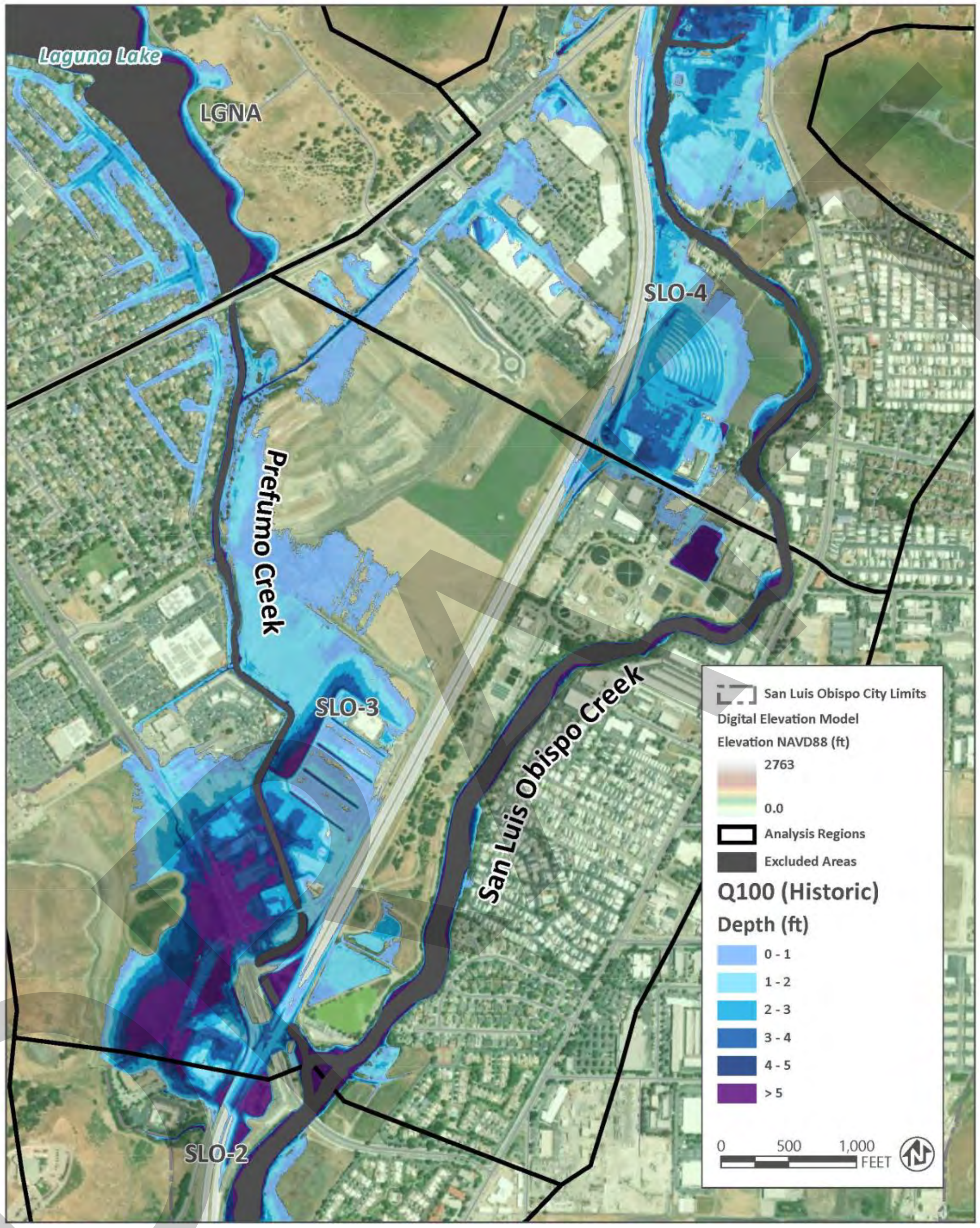
Source: cbec eco-engineering 2021

Figure 37 Flood Depth: SLO-Prefumo - Q10 (Historic)



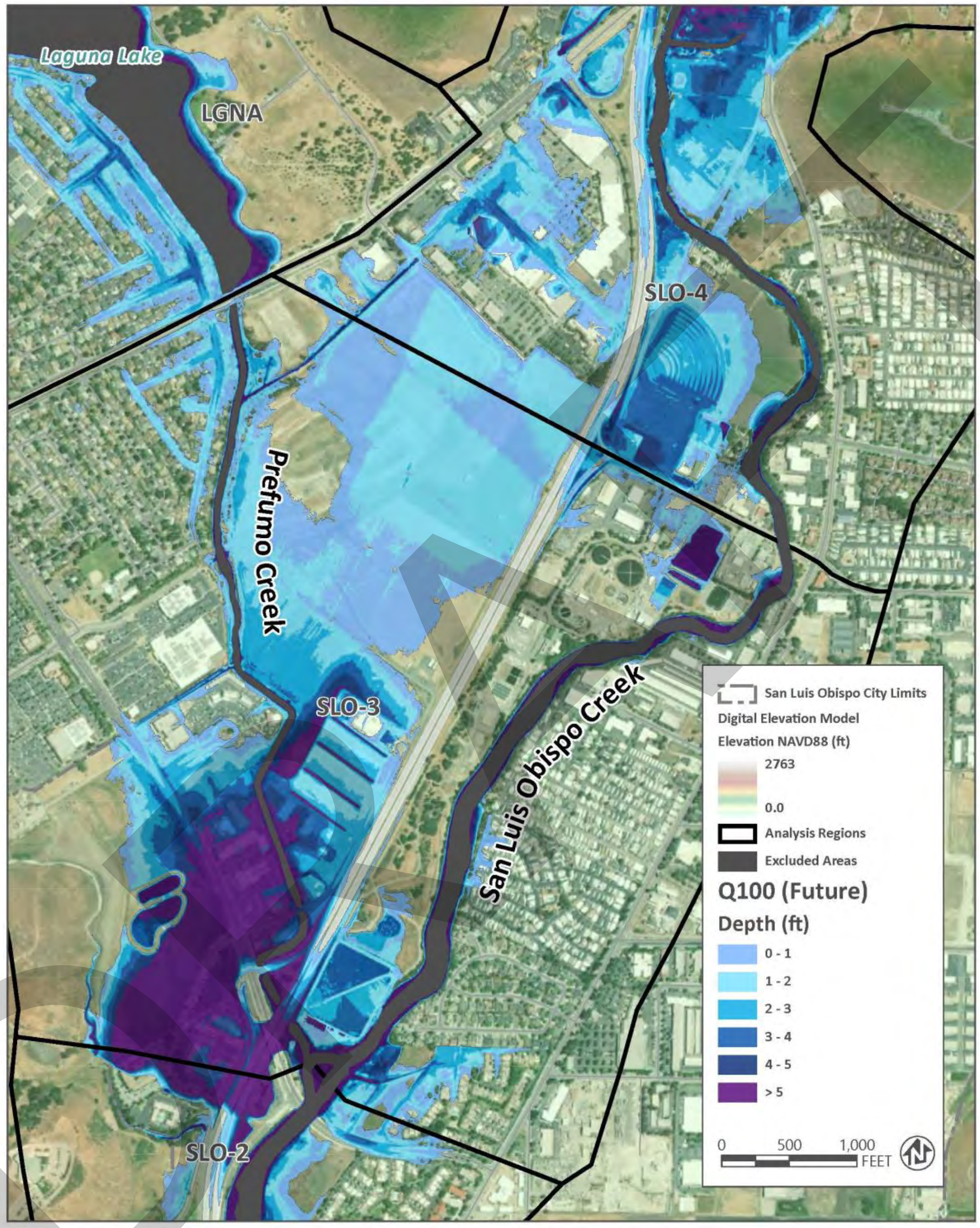
Source: cbec eco-engineering 2021

Figure 38 Flood Depth: SLO-Prefumo - Q10 (Future 2070-2099 – RCP 8.5)



Source: cbec eco-engineering 2021

Figure 39 Flood Depth: SLO-Prefumo - Q100 (Historic)



Source: cbec eco-engineering 2021

Figure 40 Flood Depth: SLO-Prefumo - Q100 (Future 2070-2099 – RCP 8.5)

Table 19 Change in Connected Floodplain Areas for 9 Analysis Regions from Historic to Future (median) Conditions.

Region	Description	Connected floodplain area (acres)											
		Q10			Q50			Q100			Q500		
		Historic	Future	Change	Historic	Future	Change	Historic	Future	Change	Historic	Future	Change
SLO-1	SLO Cr. below East Fork	456.49	483.01	5.8%	501.64	546.1	8.9%	518.52	570	9.9%	639.41	696.2	8.9%
SLO-2	SLO Cr. from Prefumo to East Fork	120.52	130.44	8.2%	135.11	151.6	12.2%	138.97	155.7	12.0%	165.46	179.8	8.7%
SLO-3	SLO Cr. / Prefumo Cr. confluence area	49.91	94.57	89.5%	119.76	240.7	101.0%	151.44	256.4	69.3%	306.49	365.3	19.2%
SLO-4	SLO Cr. from Stenner confluence to Prado Rd.	123.78	153.36	23.9%	163.81	227	38.6%	182.15	238.7	31.0%	271.45	296.3	9.1%
SLO-5	SLO Cr. upstream of Stenner confluence	43.39	91.53	110.9%	93.98	145.1	54.4%	99.79	149.7	50.0%	195.61	218.1	11.5%
STEN	Stenner, Brizziolari, and Old Garden Cr.	43.72	63.4	45.0%	78.73	109.9	39.6%	98.77	129.7	31.3%	152.21	183.8	20.7%
LGNA	Laguna Lake area	203.84	226.38	11.1%	260.8	287.1	10.1%	275.39	304	10.4%	367.98	409.5	11.3%
EFK-1	East Fork from SLO Cr. confluence to Buckley Rd.	105.86	124	17.1%	133.24	145.4	9.1%	143.3	154	7.5%	-	-	-
EFK-2	East Fork and tributaries upstream of Buckley Rd.	50.72	79.22	56.2%	93.19	120.3	29.1%	108.72	129.5	19.1%	-	-	-

Source: cbec eco-engineering 2021

Table 20 Change in Connected Floodplain Depths for 9 Analysis Regions from Historic to Future (median) Conditions.

Region	Description	Average connected floodplain depth (ft)											
		Q10			Q50			Q100			Q500		
		Historic	Future	Change	Historic	Future	Change	Historic	Future	Change	Historic	Future	Change
SLO-1	SLO Cr. below East Fork	4.1	4.8	17.1%	5.3	6.4	20.8%	5.8	6.8	17.2%	8.3	9.8	18.1%
SLO-2	SLO Cr. from Prefumo to East Fork	2.6	3.3	26.9%	3.8	4.8	26.3%	4.1	5.1	24.4%	6.1	7.6	24.6%
SLO-3	SLO Cr. / Prefumo Cr. confluence area	2	2.2	10.0%	2.3	2.5	8.7%	2.4	2.7	12.5%	3.6	4.9	36.1%
SLO-4	SLO Cr. from Stenner confluence to Prado Rd.	1.4	1.7	21.4%	1.8	2.1	16.7%	1.9	2.2	15.8%	2.8	3.4	21.4%
SLO-5	SLO Cr. upstream of Stenner confluence	1.7	2.1	23.5%	2.1	2.5	19.0%	2.2	2.6	18.2%	3.4	4.2	23.5%
STEN	Stenner, Brizziolari, and Old Garden Cr.	2	2.2	10.0%	2.3	2.7	17.4%	2.4	3	25.0%	3.5	4.3	22.9%
LGNA	Laguna Lake area	4.6	5	8.7%	5.1	5.4	5.9%	5.3	5.5	3.8%	6.1	6.4	4.9%
EFK-1	East Fork from SLO Cr. confluence to Buckley Rd.	4	4.1	2.5%	4.3	4.7	9.3%	4.6	4.8	4.3%	-	-	-
EFK-2	East Fork and tributaries upstream of Buckley Rd.	2.4	2.3	-4.2%	2.3	2.3	0.0%	2.3	2.4	4.3%	-	-	-

Source: cbec eco-engineering 2021

Key Findings and Policy Considerations

- Although annual precipitation is anticipated to increase in the City and the larger central coast region, California's climate oscillates between extremely dry and extremely wet periods with annual precipitation varying widely from year to year. These oscillations between extremely dry and extremely wet periods are anticipated to become more severe with rapid shifts from dry to wet periods known as "whiplash events" (Swain et al. 2016). These types of events are estimated to increase by approximately 100 percent in southern California, with increases in frequency occurring largely after 2050 (Swain et al. 2016).
- Based on California's location next to the Pacific Ocean, the state is exposed to the atmospheric river (AR) phenomenon, a narrow corridor of concentrated moisture in the atmosphere. The presence of the AR contributes to the frequency of "wet years" in the state, when there is an above-average number of AR storms and above-average annual precipitation. While research indicates that the frequency of large storms events does increase in these wet years, the most severe flooding from ARs may not be in wet years (Swain et al. 2018). The largest flooding impacts are caused by persistent storm sequences on sub-seasonal timescales (i.e., short time periods, typically 2 weeks to 3 months), which bring a significant fraction of annual average precipitation over a brief period. Based on current climate modeling, the frequency of these large storm sequences over short timeframes is projected to increase noticeably under a future high emissions scenario. It is estimated that a storm similar in magnitude to the Great Flood events is more likely than not to occur at least once between 2018 and 2060 (Swain et al. 2018).
- For very large precipitation events, the capacity of the watershed to absorb incoming rainfall can be quickly exceeded, causing large increases in stream flow within the system. By as early as 2070 under a high future emissions scenario, peak flow rates in the San Luis Obispo Creek watershed are projected to increase, on average, from 17 percent to 38 percent depending on the size of the storm event. By this period, for the storm event with a 50 percent chance of occurring in any given year (2-year storm event), the median peak stream flow is projected to increase by 28 percent with a small likelihood (90^{th} percentile) of stream flow increasing by 51 percent.
- By as early as 2070 under a high future emissions scenario, for the 100-year event, dramatic increases are observed on Stenner and Old Garden Creeks upstream of the San Luis Obispo Creek confluence and within the downtown area. In both cases, flooding is exacerbated by the capacity of the existing infrastructure to manage historic flooding events. Similar, during the 100-year event, increases in flow within San Luis Obispo Creek increasingly cause flood waters to break out of the channel upstream of the culvert and flow along the Higuera and Marsh Street corridor towards the Stenner Creek confluence

FLOODING AND THE BUILT ENVIRONMENT

Key Flood Impact Areas

Areas with the greatest increases in connected floodplain inundation for the 10-year through 100-year events included SLO Creek upstream of the Stenner confluence (SLO-5, including parts of downtown SLO), the SLO Creek – Prefumo Creek confluence area (SLO-3, including SLO Creek from Prado Road to the Prefumo Creek confluence and Prefumo Creek below Madonna Road), East Fork and its tributaries upstream of Buckley Road (EFK-2), and Stenner, Brizziolari, and Old Garden Creeks (STEN). In the modeling, these areas tended to have greater expanses of floodplain areas, such as the SLO Creek – Prefumo Creek confluence area, or limiting infrastructure, as is the case with the undercity culvert through downtown. Areas that were more confined by topography, such as SLO Creek below East Fork (SLO-1), experienced smaller increases in area, as shown in Table 19. Average connected floodplain depth, on the other hand, can be slightly more difficult to assess because it was calculated as the average of wet areas with greater than 0.1 ft of depth. Therefore, the average depth can decrease even if the inundated area increases with large areas of shallow depth flooding in a future scenario that are currently inundated under existing flood conditions. Percent increases in depth for the region containing parts of downtown were on the order of 18 to 23.5 percent across the range of flood events, with an increase in average floodplain depth for the 100-yr event of 0.4 ft increasing to 2.2 to 2.6 ft, as shown in Table 20.

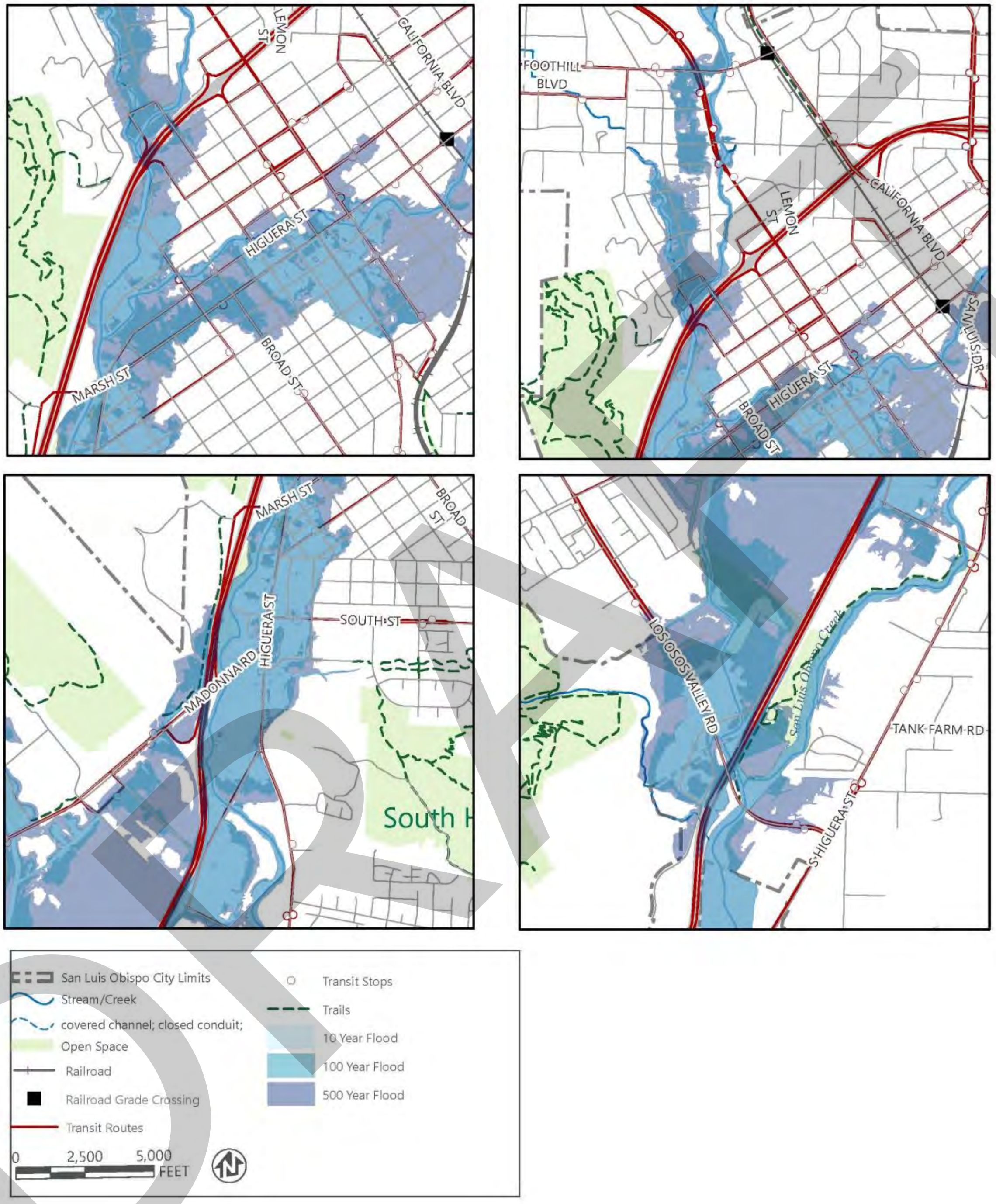
Figures 32 through Figure 36 show inundation depth for the 10-year and 100-year events for the San Luis Obispo Creek – Stenner Creek confluence area, including a portion of downtown. For the 10-year event, increases in flooding along Old Garden Creek are apparent, along with portions of downtown and at the confluence of the two creeks (Figures 32 and 33). Some of the flooding within the downtown area from the 10-year event may be due to the model generally over-predicting flood levels (Questa Engineering Corporation 2003). For the 100-year event, dramatic increases are observed on Stenner and Old Garden Creeks upstream of the San Luis Obispo Creek confluence and within the downtown area. In both cases, flooding is exacerbated by the capacity of the existing infrastructure to manage historic flooding events. For Stenner Creek, the water level passing underneath Highway 101 reaches up to the bottom of the bridge and begins to exceed the flow capacity of the structure. Similarly, the undercity culvert within downtown has a capacity of about a 15-year event under historic conditions (Questa Engineering Corporation 2003). For larger events, such as the 100-year, increases in flow within San Luis Obispo Creek increasingly cause flood waters to break out of the channel upstream of the culvert and flow along the Higuera and Marsh Street corridor towards the Stenner Creek confluence, as shown in Figures 35 and 36.

Figures 37 through 39 show similar results for the San Luis Obispo – Prefumo Creek confluence area. Within these regions of the City, large expanses of relatively flat, low-lying land persist between and along the two creeks. Flood waters can spill into these areas by crossing Highway 101 near Madonna Road from San Luis Obispo Creek or by escaping the creek channels in the confluence area and causing backwater conditions for upstream reaches. The City undertakes regular maintenance activities within Prefumo Creek from Laguna Lake to Los Osos Valley Road to manage flood risk in this area. The southern end of the Los Osos Valley Road area north of Highway 101 is particularly vulnerable. For the 100-year event, large areas of agricultural land between Prefumo and San Luis Obispo Creeks may become inundated under future conditions, as shown in Figures 39 and 40.

Ultimately, changes in flood risk need to be understood using multiple metrics. The flood maps and summary tables of changes in inundated area and average depth are important for understanding how different levels of risk are present within different areas of the City. These varying levels of risk may be due to the topography of the landscape and channels, but they may also be affected by infrastructure. In either case, changes in flood risk do not necessarily vary in the same way as changes in stream flow, which in turn may not directly mirror changes in precipitation, reinforcing the importance of conducting hydrologic and hydraulic modeling. For the 100-year event, there was a 38 percent increase in stream flow for the median future scenario compared to historical conditions, as show in Table 19. However, this does not necessarily translate to flooding being 38 percent worse. The reach of San Luis Obispo Creek upstream of the Stenner Creek confluence and the San Luis Obispo – Prefumo Creek confluence areas experienced increases in inundated floodplain acreage of 50 and 69.3 percent, respectively, as shown in Table 19, while average floodplain depths increased from 2.2-2.4 ft to 2.6-2.7 ft, as shown in Table 20. Further, it is helpful to think about flood risk statistically. As shown in Table 19, the future 50-year event has similar levels of inundation to the historic 100-year event. This means that with a 37 percent increase in flow (from the historic 50-year event, Table 19), the level of inundation from an event that used to occur about once every 100-years would be experienced twice as frequently.

IMPACT ANALYSIS OF THE TRANSPORTATION SYSTEM

Using the climate-informed flood analysis discusses above, a high-level impact analysis on the City's transportation system was conducted, focusing on the facilities identified through community feedback including impacts to the transit network, the City's open space trails network, and the viability of the City's roadway network and evacuation routes during emergency evacuation scenarios related to flooding. The analysis was conducted using the 10-year, 100-year, and 500-year flood mapping layers, assessing how these flood events would affect the City's transportation system. Figure 41 overlays the flood zones on the transportation network and is discussed below.



Source: Fehr and Peers 2021

Figure 41 City Transportation Assets Impacted by Flooding

Roadways

The City's roadway network is identified as local streets, arterials, freeway, and bicycle and pedestrian facilities, providing circulation within the City as well as roadway network connections to the other areas in the County. The extent of roadway network impacts on the City is dependent on the varying size of the storm events analyzed. Figure 41 illustrates those potential impacts adjacent to San Luis Obispo Creek along US 101, specifically at the Madonna Road interchange and the Los Osos Valley Road interchange during the 10-year,100-year, 500-year storm events. The greatest area of impact to local roads during these events would be areas just south of San Luis Obispo Creek through the downtown area with the farthest extent along Santa Barbara Street as far South as Leff Street occurring during the 100-year storm event. Moving away from the downtown area, flooding occurs to the east of the SLO Creek between US 101 and Higuera Street between the US 101 and Broad Street interchange and the US 101 and Madonna Road interchange. During the 100-year and 500-year storm events, flooding would likely occur along US 101 in the northbound lanes at the Prado Road on and off ramp. Flooding would also occur along Prado Road near San Luis Obispo Creek. The flood modeling analysis also identifies the Chorro Street undercrossing at US 101 would be impacted by the 10-year, 100-year, and 500-year floods. These same flood zones would also result in potential impacts between Foothill Boulevard and US 101 between Broad Street and State Route 1.

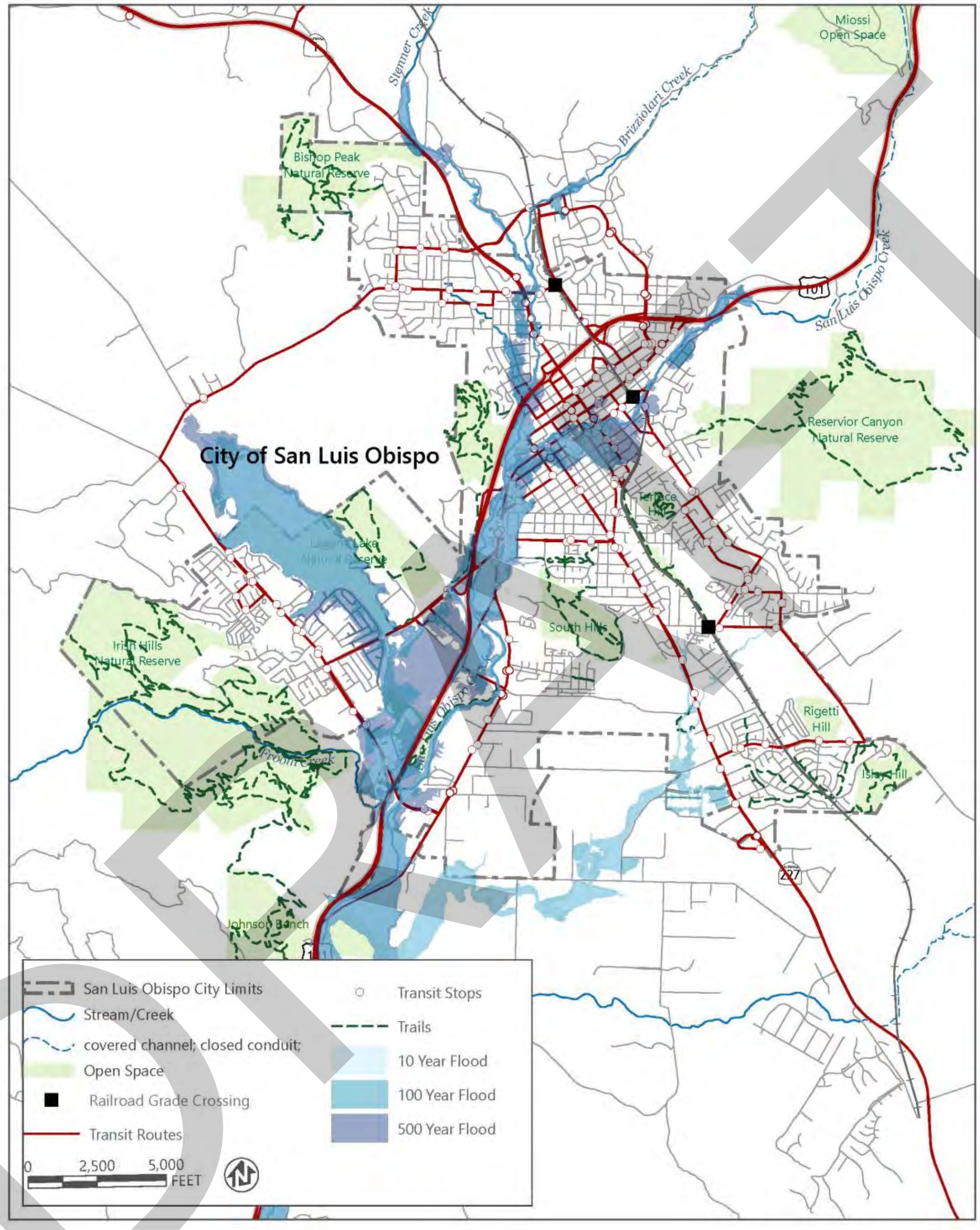
Transit

Alongside the roadway network, future flood impacts would also affect transit operations and assets. Extensive flooding has the potential to limit transit service, thus eliminating transport options for populations in the City dependent on transit. Table 21 illustrates the number of impacted transit stops and percent of stops in the total network that would be affected, categorized by each size storm event and transit provider. The rail network in the City would not be affected during the potential flood events. The exact location of the transit stops impacted by the 10-year, 100-year, and 500-year storm events are visualized in Figure 42.

Table 21 Transit Stops Impacted by Storm Event

Transit Agency	Total Number of Stops	10-year	100-year	500-year
SLO Transit	161	7 - 11 %	16 - 26 %	35 - 57%
San Luis Obispo Regional Transit Authority (RTA)	26	2- 8%	3 - 12%	6 – 23%

Source: Fehr and Peers 2021



Source: Fehr and Peers 2021

Figure 42 Transit Assets Impacted by Flooding

Recreation Trails and Existing Bicycle Transportation

Flood related impacts on the City's bicycle and recreational trails network were similar to impacts on the roadway network. Bicycle infrastructure through the downtown area south of the San Luis Obispo creek are likely to be affected by future flood impacts. As shown in Figure 42, the following recreational trail are also likely to be impacted by flooding.

- Bob Jones Trail
- Johnson Ranch
- Madonna Inn Bike Trail
- Laguna Lake Upper Loop Trail

The areas of highest concern are located in the downtown area South of the San Luis Obispo Creek, the Chorro Street undercrossing, and around the Los Osos Valley Road interchange at US 101. It is important to define transit options for the limited number of stops impacted by flooding during flood events. If applicable, mitigation and engineering can remedy the flooding sources, transit would likely be unimpacted. Alternatively, the use of bicycle transit to transport populations without adequate mobility resources should be considered for evacuation plans.

Key Findings and Policy Considerations

- From the results of the climate-informed flood modeling, areas with the greatest increases in connected floodplain inundation for the 10-year through 100-year events included SLO Creek upstream of the Stenner confluence (including parts of downtown SLO), the SLO Creek – Prefumo Creek confluence area, East Fork and its tributaries upstream of Buckley Road, and Stenner, Brizziolari, and Old Garden Creeks. In the modeling, these areas tended to have greater expanses of floodplain areas, such as the SLO Creek – Prefumo Creek confluence area, or limiting infrastructure, as is the case with the undercity culvert through downtown.
- By as early as 2070 under a high future emissions scenario, for the 100-year event, dramatic increases are observed on Stenner and Old Garden Creeks upstream of the San Luis Obispo Creek confluence and within the downtown area. In both cases, flooding is exacerbated by the capacity of the existing infrastructure to manage historic flooding events. Similar, during the 100-year event, increases in flow within San Luis Obispo Creek increasingly cause flood waters to break out of the channel upstream of the culvert and flow along the Higuera and Marsh Street corridor towards the Stenner Creek confluence.
- Near the San Luis Obispo – Prefumo Creek confluence area near Higuera Street and Madonna Road, large expanses of relatively flat, low-lying land persist between and along the two creeks. During larger storm events (50-year and 100-year storms), flood waters can spill into these areas by crossing Highway 101 near Madonna Road from San Luis Obispo Creek or by escaping the creek channels in the confluence area and causing backwater conditions for upstream reaches.
- The greatest area of impact to local roads during large storm events (100-year storm) would be areas just south of San Luis Obispo Creek through the downtown area with the farthest extent along Santa Barbara Street as far South as Leff Street. The Chorro Street undercrossing at US 101 would be impacted by the 10-year, 100-year, and 500-year floods.
- Extensive flooding from larger storm events also has the potential to limit transit service, thus eliminating transport options for populations in the City dependent on transit, with between 16 to 26 percent of SLO Transit stops being affected depending on the storm size.

FLOODING AND COMMUNITY RESILIENCE

Evacuation Routes and Emergency Communications

As part of this analysis, an assessment of the underlying hazards and appropriate access to gateways (e.g., major ingress and egress points in and out of the City) and evacuation centers has been completed to facilitate the development of reliable accurate communication for emergency needs and evacuations. With the projected increases in the frequency and severity wildfire events, and large storm events expected to occur due to climate change, new methods of administering evacuation information have been evolving. Iterative development and updating of the emergency preparedness plan are critical and should identify a communication plan for residents and visitors on how to evacuate in case of an emergency. To support the communication components of evacuation planning, a detailed analysis of access to City gateways and evacuation centers is provided below to assist in identifying areas where infrastructure improvements would benefit future evacuation planning.

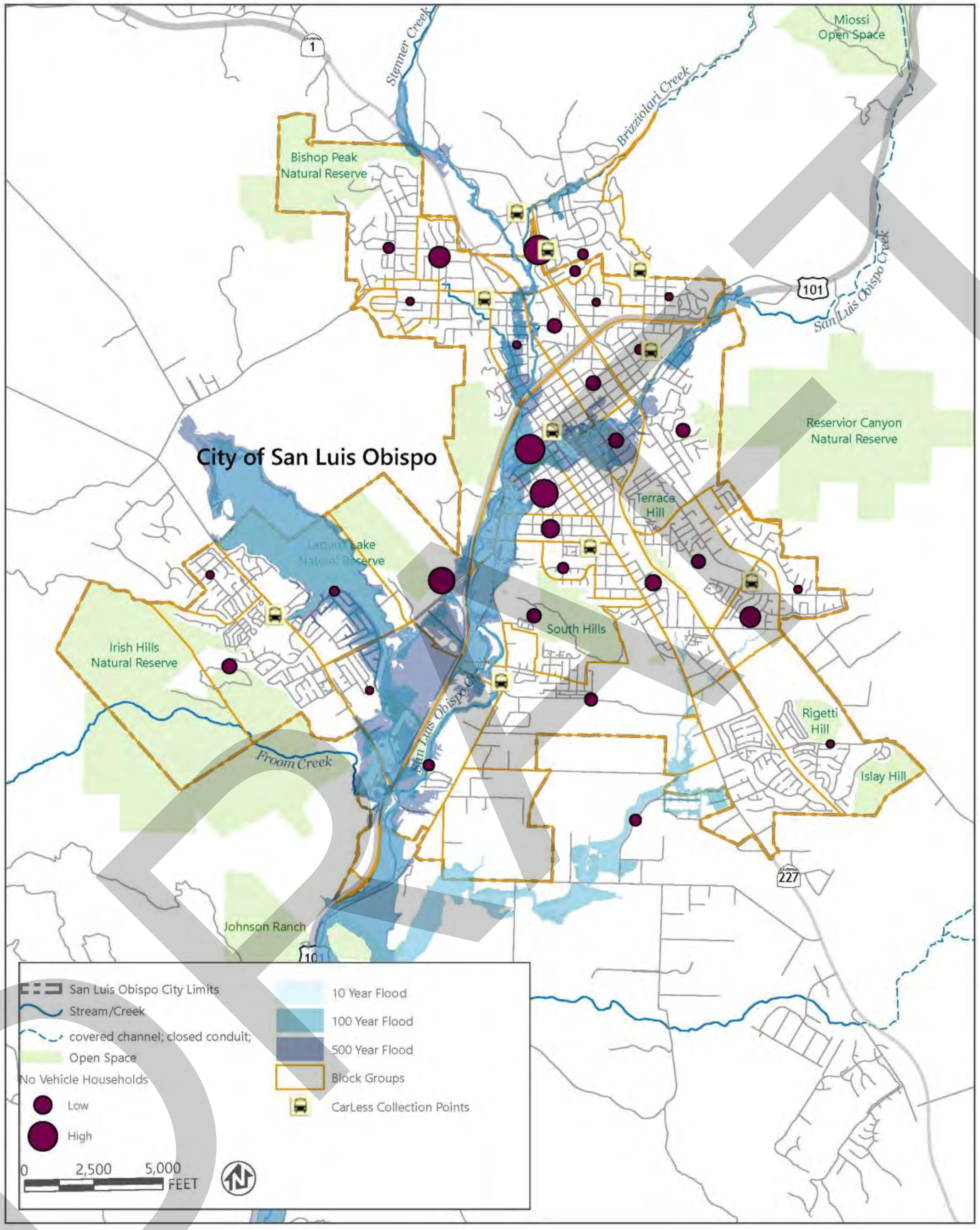
Flood Impacts and Low-Vehicle Access

Using the US Census block group data, Figure 43 illustrates census blocks in the City with the percentage of occupied housing units without access to a vehicle. According to the Census data, in the City, approximately 8 percent of occupied housing units do not have access to at least one vehicle. However, the range for all the block groups within the City is 0 to 21.4 percent. Certain block groups have higher numbers of households without vehicles available, therefore specific consideration for services to access evacuation centers or assistance of these populations to leave the City during an emergency should be prepared. The City’s Car Less Collection Points layer is included and shows some correspondence to the census block groups with a higher portion of households without vehicles. These populations tend to primarily be located adjacent to US 101 and the San Luis Obispo Creek.

Gateway and Evacuation Center Access Assessment

This section includes a scenario level review of residential access to City gateways and evacuation centers from the centroids of census block groups for the City. This assessment is based on an evolving methodology created for evacuation studies consistent with Assembly Bill (AB) 747 and SB 99, which requires an assessment of residential evacuation routes during the City’s next Safety Element update. The analysis included here is not a comprehensive assessment of the City’s evacuation routes but provides supporting resources for an evacuation study consistent with AB 747 and SB 99.

This document is intended to provide an assessment of roadway access under the described flood scenarios but should not be considered a full evacuation plan. Additionally, flooding patterns are, to a certain degree, unpredictable as is individual behavior related to evacuation events. As such, this assessment is intended to provide the City with a broad “planning level” assessment of the access of the transportation system during flood events; it does not provide guarantees as to the adequacy of the transportation system nor can it guarantee that the findings are applicable to any or all situations.



Source: Fehr and Peers 2021

Figure 43 Census Block Groups with No Vehicles per occupied housing unit

Evacuation Route Analysis Methodology

This analysis was developed in ArcGIS using network analyst as a variation on an evacuation scenario tool including the centroid of census block groups, and the flood zone layers provided by the City. The analysis calculates the closest route by distance from the centroid of a block group to the gateway outside of the City or the evacuation center nearest the centroids. As it relates to this study, gateways are defined as major arterials and highways located at the City limit. The gateways used in this analysis include the following roads, US 101 Northbound and Southbound at the respective City limits, State Route (SR) 227 or Broad Street, Orcutt Road, South Higuera Street, SR 1, and Los Osos Valley Road. The gateways matched the evacuation routes the City designated and communicates through the fire evacuation plan (City of San Luis Obispo n.d.).

Census block groups are statistical divisions of census tracts, are generally defined to contain between 600 and 3,000 people. In this analysis, the centroids of these block groups were calculated and joined with specific demographic data, citing whether vehicles were available for occupied housing units. This was done to visualize an even distribution of population and access throughout the City. When required the centroid locations were adjusted to reflect street network connectivity. The block group centroids were used to begin the travel analysis to both City gateways and evacuation centers. Flood zone for the analysis is defined by FEMA as the area that will be inundated by the 100-year flood event and 500-year flood event as discussed previously on section 2.5.1. CBEC generated the 10-, 100-, and 500-year flood waters data used in our transportation models.

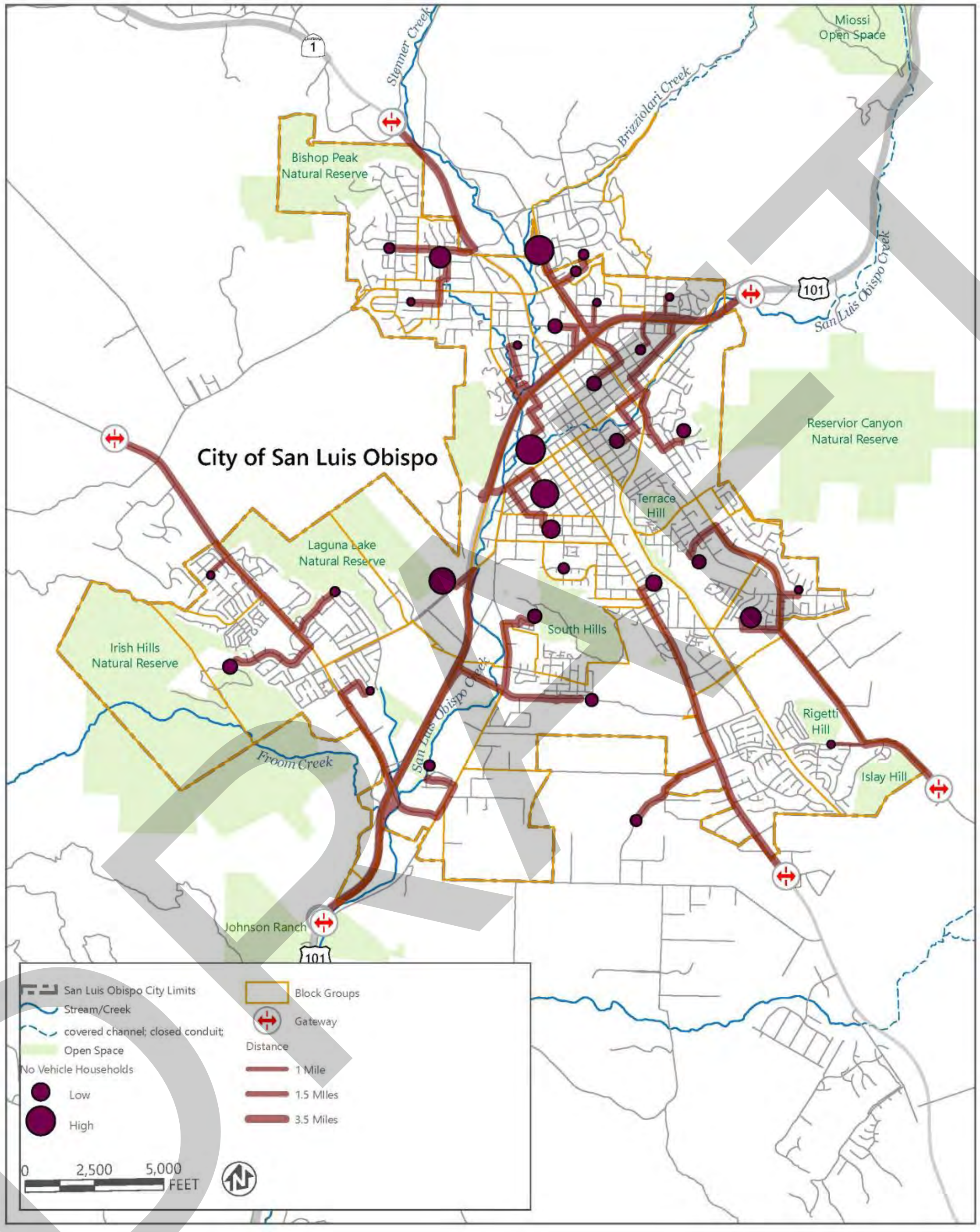
Evacuation Route Analysis Results

For this analysis, access to the City's gateways and evacuations centers were assessed without any flooding as a baseline condition. Access to these locations was then analyzed for the 10-year, 100-year, 500-year flood events to identify transportation route and asset vulnerabilities under each of these events. The following figures represent a visual representation of the analysis for the defined year flood events discussed above.

As shown in Figures 44 through 49, access from census block group centroids to City gateways for the 10-year, 100-year, and 500-year flood events are relatively similar as the locations of flooding occur in generally the same location under various storm events. As shown, under each flood event some routes within the City's street network are compromised, in which case, an alternative route is created to analyze route diversions as a result of flood impacts. In many cases, this may result in a longer distance to be travelled to access the gateway or evacuation center under different flood scenarios.

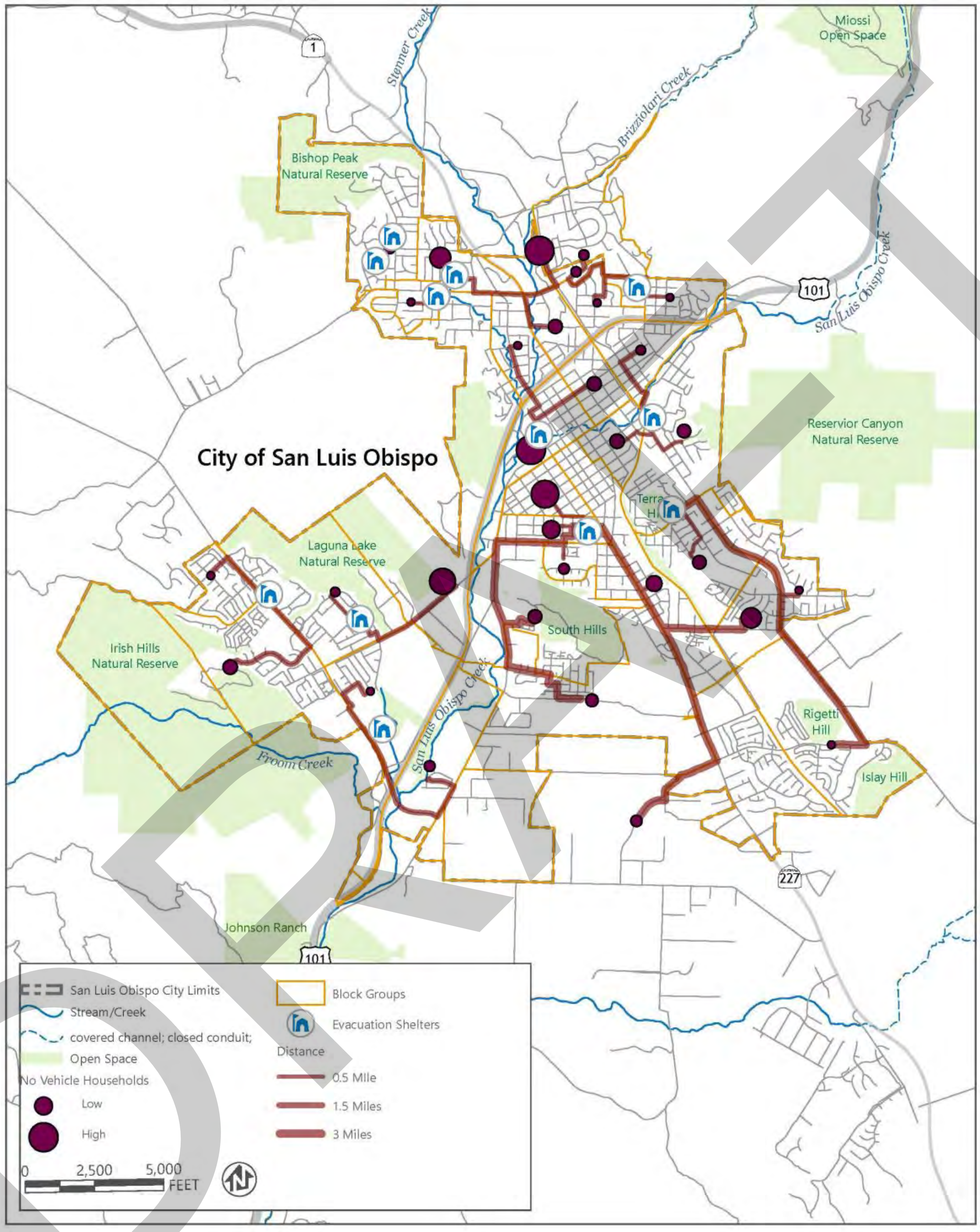
For all flooding events (i.e., 100-year and 500-year flood events), access to the Southern Gateway of US 101 is compromised due to potential flooding of US 101 and Los Osos Valley Road. However, all centroids under these scenarios are able to access at least one alternative City gateway, which means no portions of the City would be closed off due to roadway network flooding. The 100-year flood scenario shows impacted access to many neighborhoods throughout the City, resulting in one Block Group centroid being cut off to both a gateway and evacuation center. This is in the area North of US 101 and West of SR 1.

The 500-year flood scenario shows an inability of four census block group centroids to access either the City gateways or evacuation centers as they experience extensive flooding, isolating their ability to connect to a route. These centroids are located within the 500-year flood layer, thus preventing a routed network to be completed. The depth of the flooding is available however further analysis identifying the height of the infrastructure would be required to understand the extent of actual access from neighborhoods to gateways and evacuation centers.



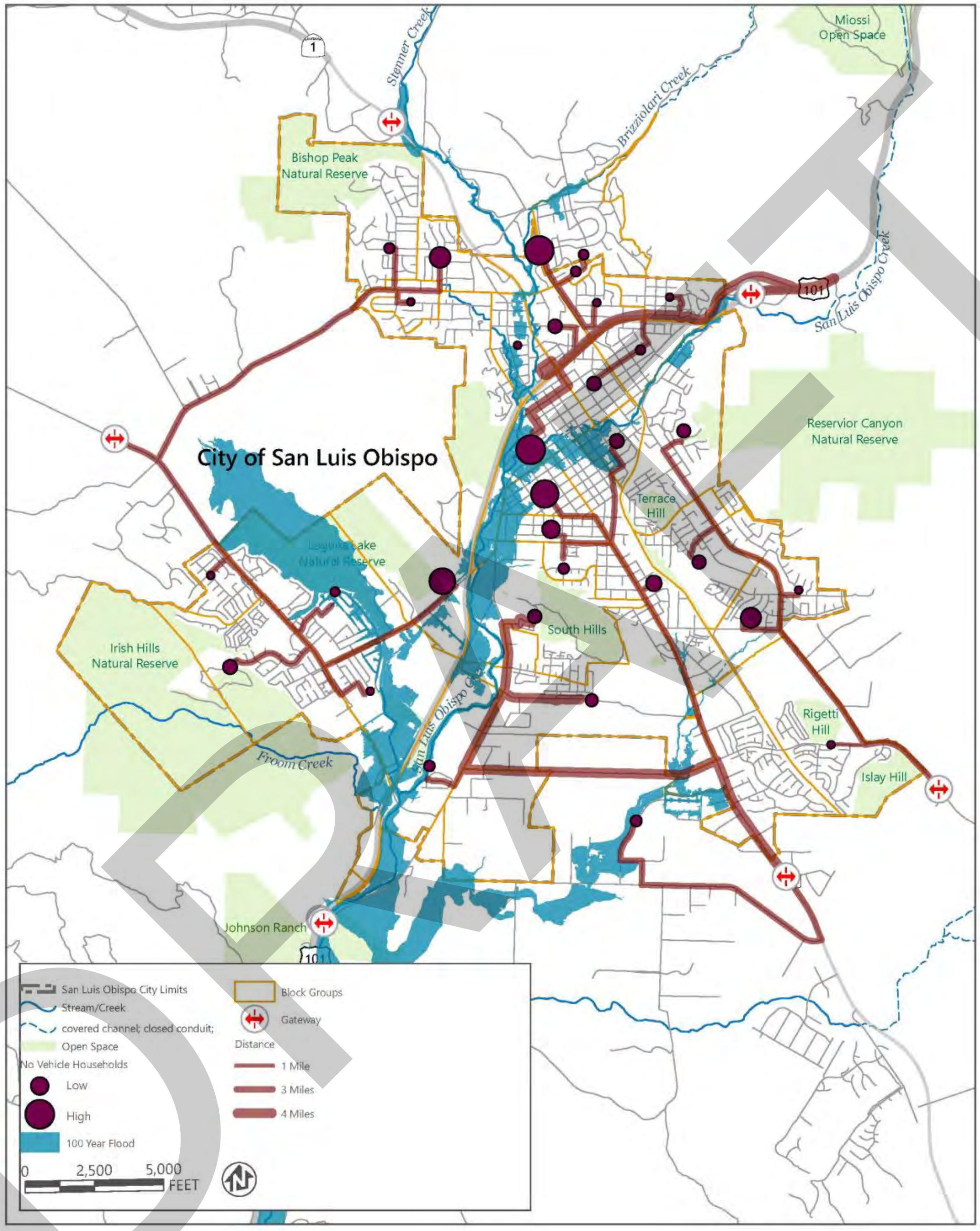
Source: Fehr and Peers 2021

Figure 44 Access from Census Block Group Centroid to City Gateways



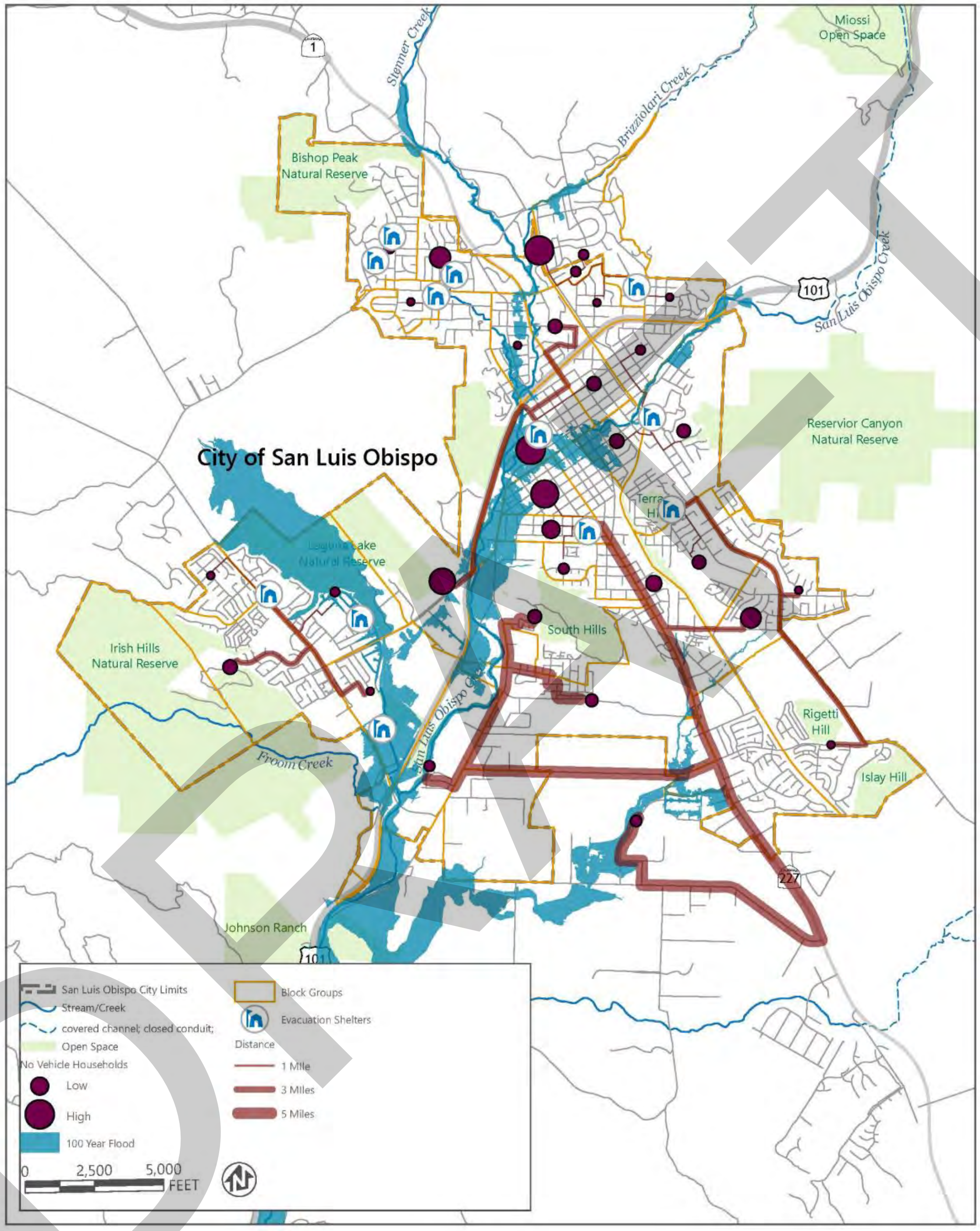
Source: Fehr and Peers 2021

Figure 45 Access from Census Block Group Centroid to City Evacuation Centers



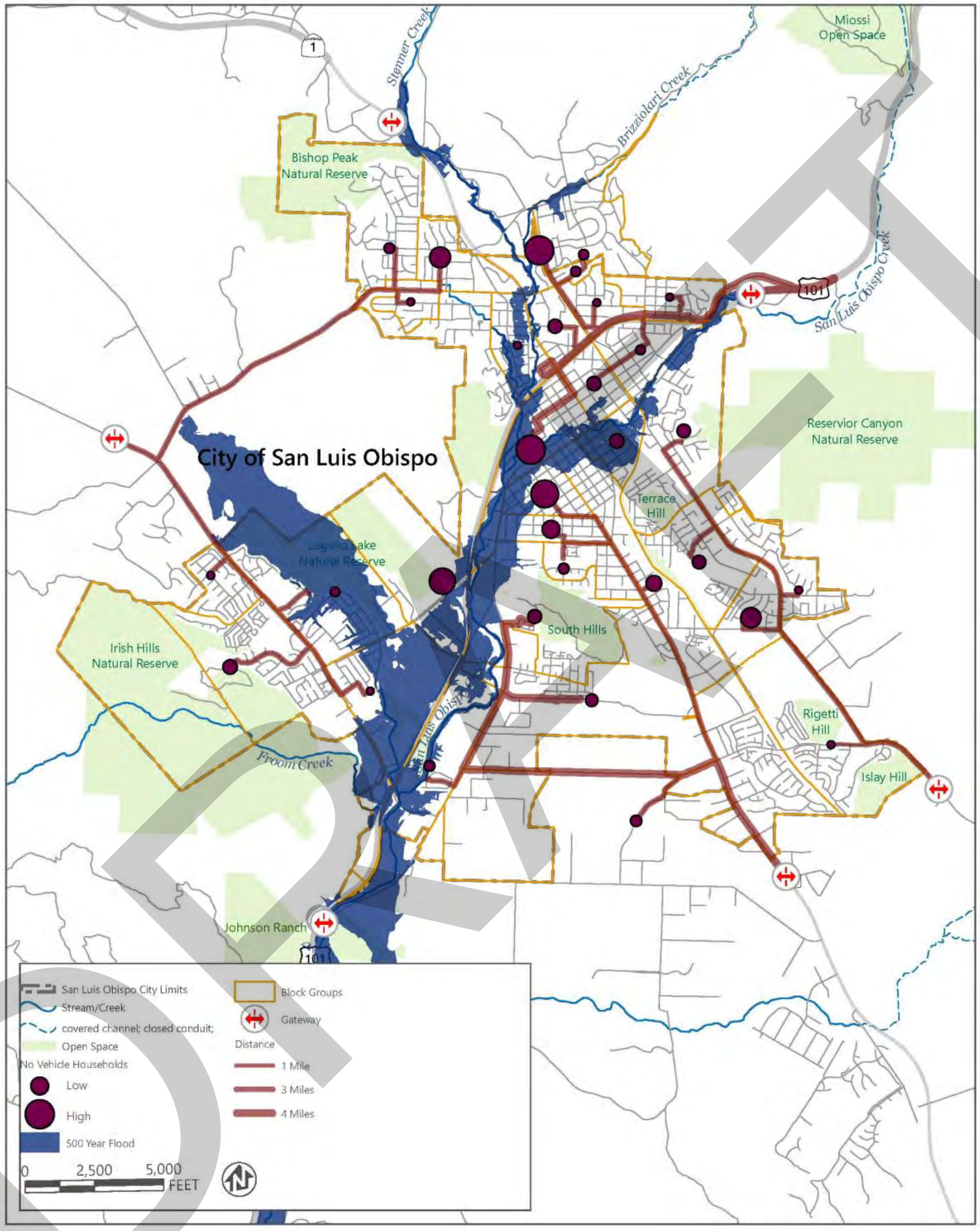
Source: Fehr and Peers 2021

Figure 46 Access from Census Block Group Centroid to City Gateways with 100 Year Flood



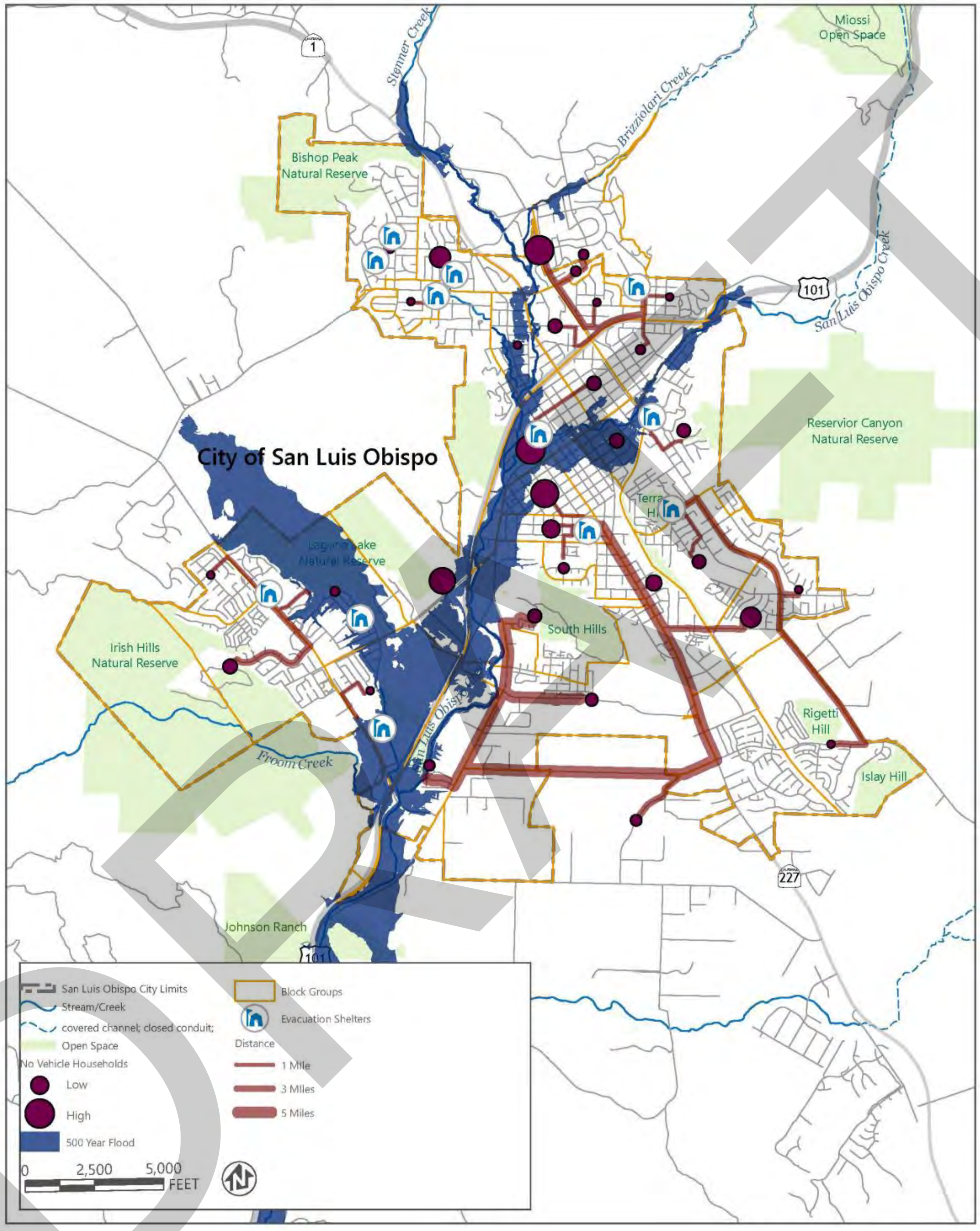
Source: Fehr and Peers 2021

Figure 47 Access from Census Block Group Centroid to City Evacuation Centers with 100 Year Flood



Source: Fehr and Peers 2021

Figure 48 Access from Census Block Group Centroid to City Gateways with 500 Year Flood



Source: Fehr and Peers 2021

Figure 49 Access from Census Block Group Centroid to City Evacuation Centers with 500 Year Flood

Table 22 shows the difference between the baseline conditions access and each flood scenario.

Table 22 Flood Year and Longest Distances to City Gateways and Evacuation Centers

Destination	Baseline – No flood	100 year*	500 year**
Gateways	3.5 miles	4 miles	4 miles
Evacuation Centers	3 miles	5 miles	5 miles

Note: * = Signifies 1 Block Group centroid was cut off from both gateways and evacuation centers. ** - Signifies 4 Block Group centroids were cut off from both gateways and evacuation centers.

Source: Fehr and Peers 2021

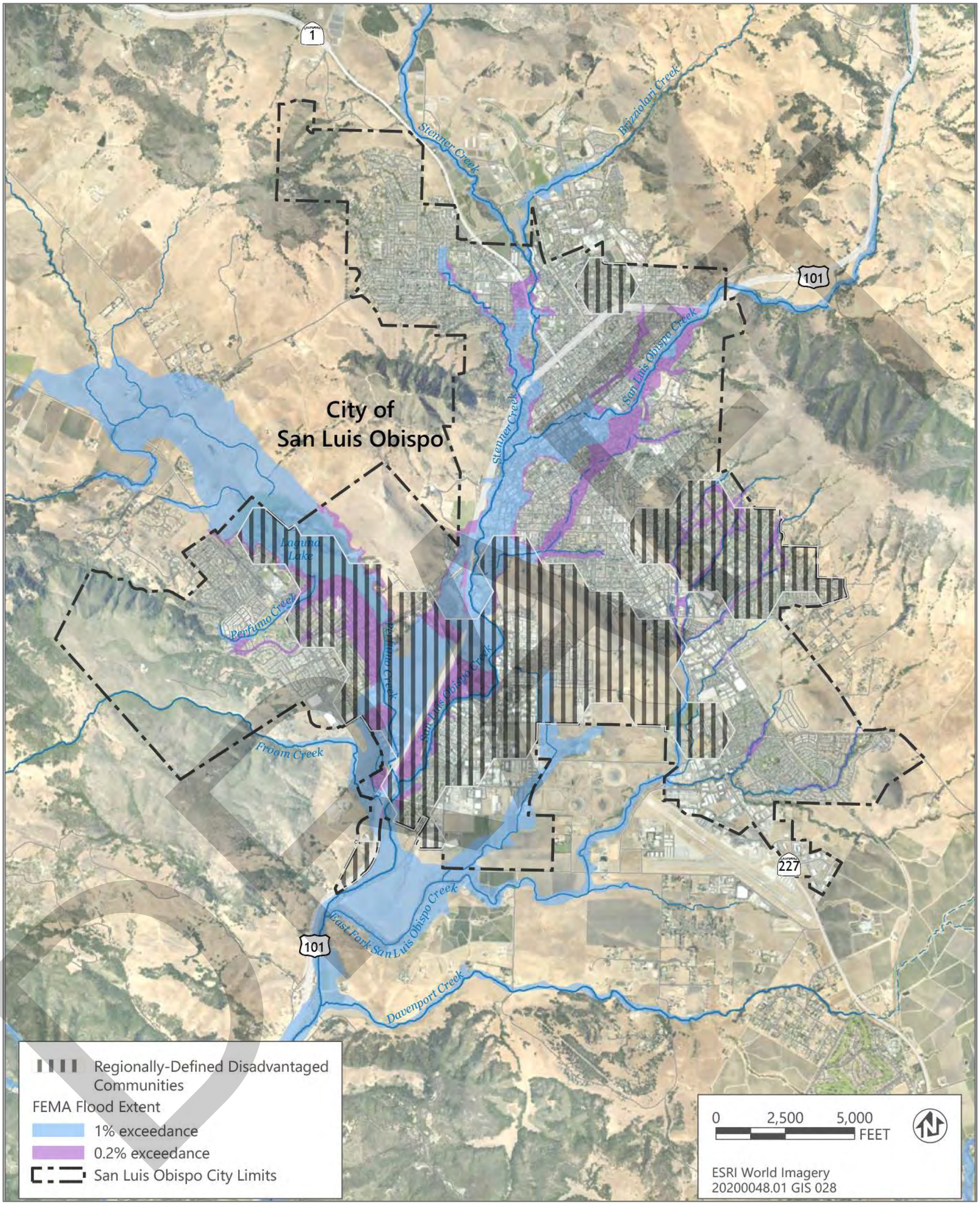
Flooding and Vulnerable Populations

Several populations within the City may experience disproportionate impacts from flooding due to social characteristics and environmental burdens. Disadvantaged communities are more likely to be located in flood prone areas, may be linguistically isolated and unable to interpret and respond to warning messages and evacuation notices, and have limited mobility. As shown in Figure 50, the disadvantaged communities in the central portion of the City are located within the 100- and 500-year flood zones.

Lack of vehicle access is another social factor that may lead to increased vulnerability to flood events. Using the US Census block group data, Figure 43 illustrates census blocks in the City with the percentage of occupied housing units without access to a vehicle. According to the Census data, in the City, approximately 8 percent of occupied housing units do not have access to at least one vehicle. However, the range for all the block groups within the City is 0 to 21.4 percent. Certain block groups have higher numbers of households without vehicles available, therefore specific consideration for services to access evacuation centers or assistance of these populations to leave the City during an emergency should be prepared. The City's Car Less Collection Points layer is included and shows some correspondence to the census block groups with a higher portion of households without vehicles. These populations tend to primarily be located adjacent to US 101 and the San Luis Obispo Creek.

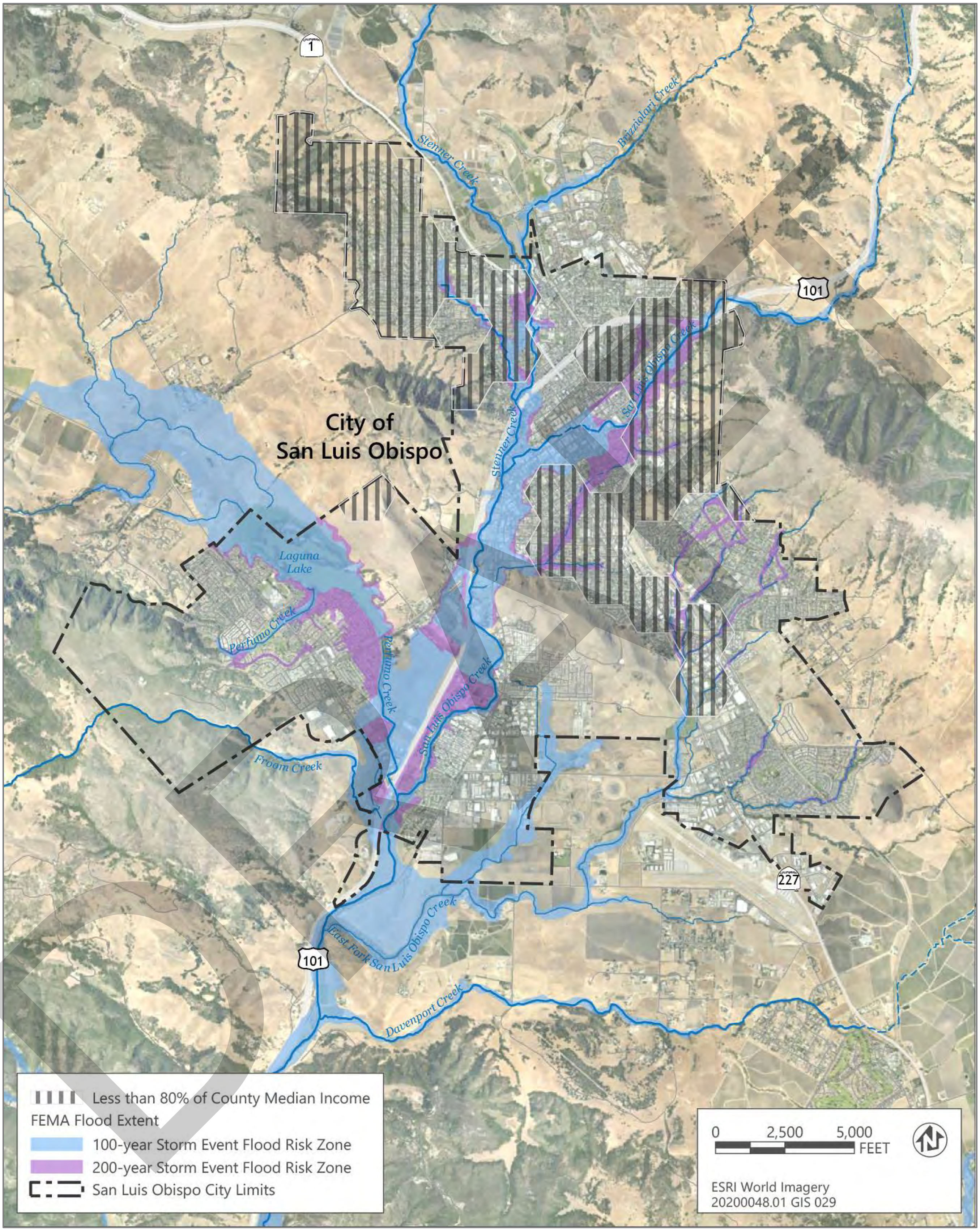
A key environmental burden is the presence of cleanup sites, which are sites monitored by the Department of Toxic Substances Control that are contaminated with harmful chemicals. Flooding could release hazardous and/or toxic materials if cleanup sites are inundated, exposing nearby communities to public health impacts. CalEnviroScreen 4.0 includes a cleanup sites indicator that considers the number and types of cleanup sites in or near each census tracts, as well as how close the sites are to where people may live. As shown in Figure 52, there are several cleanup sites located within the 100-year flood zone. There are also census tracts in the City within the City's 100- and 500-year flood zones that score in the 70th percentile and higher for clean up site exposure, based on the weighted score of potential pollution exposure used in CalEnviroScreen. This means these census tracts have higher potential exposure than 70 percent of all census tracts in the State, indicating that there is a potential for residents in these areas to be exposed to contaminants in the event of a flood.

As show in Figure 50, the area West of South Higuera Street (Census Tract 115.01) is located almost entirely within the 100- and 500-year flood plain which is anticipated to expand in the future due to climate change. This area is particularly vulnerable with high percentage of elderly residents (17 percent) as well as a high percent of disabled residents (15 precent), presenting potential challenges during emergency evacuation events. Figure 51 includes areas in the City with low-income households (i.e., households earning 80 percent less of the County median income) as well as the 100- and 500-year flood plain. During larger flood events, these households are at a potential disadvantage during the post-disaster recovery period with less financial or other resources available for recovery efforts. Additionally, as show in Figure 53 there is significant overlap between the location of homeless encampments throughout the City and the location of the existing and future 100- and 500-year flood plains. Shelters and encampments built by unhoused individuals are often developed in or near flood plains, placing these populations at increased risk during flood events, particularly in areas with lower levels of access to transportation in emergency events. Increased heavy precipitation and flooding will disproportionately impact homeless populations because they occupy marginal areas, they are less able to transport themselves out of flood areas and they are more likely to suffer sequelae (i.e., exacerbation of existing health conditions) from such disasters. (Ramin and Svoboda 2009).



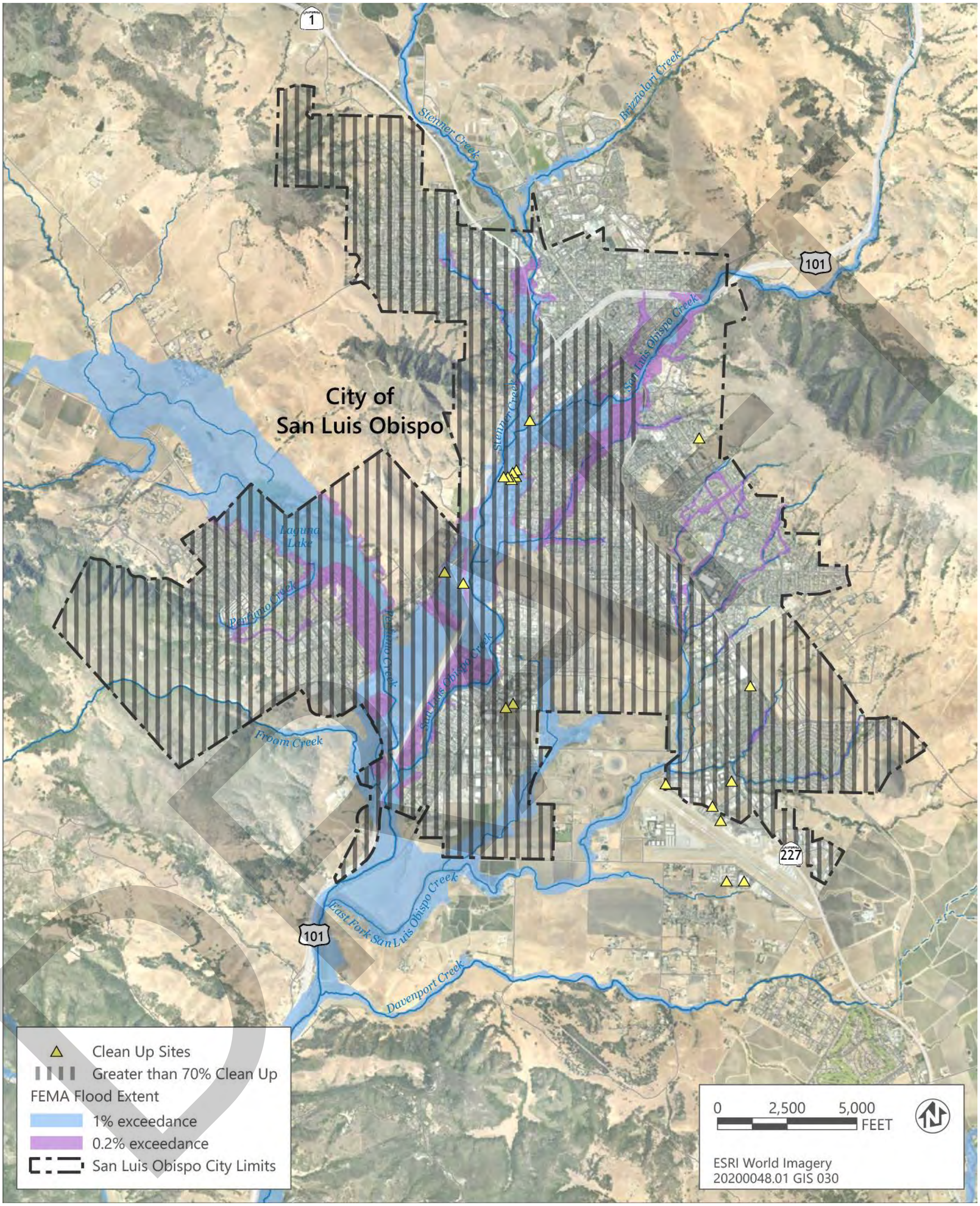
Sources: Data received from SLOCOG in 2021 and from CBEC Engineering in 2020, and downloaded from City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020

Figure 50 Disadvantaged Communities and 100-year and 500-year Flood Plains



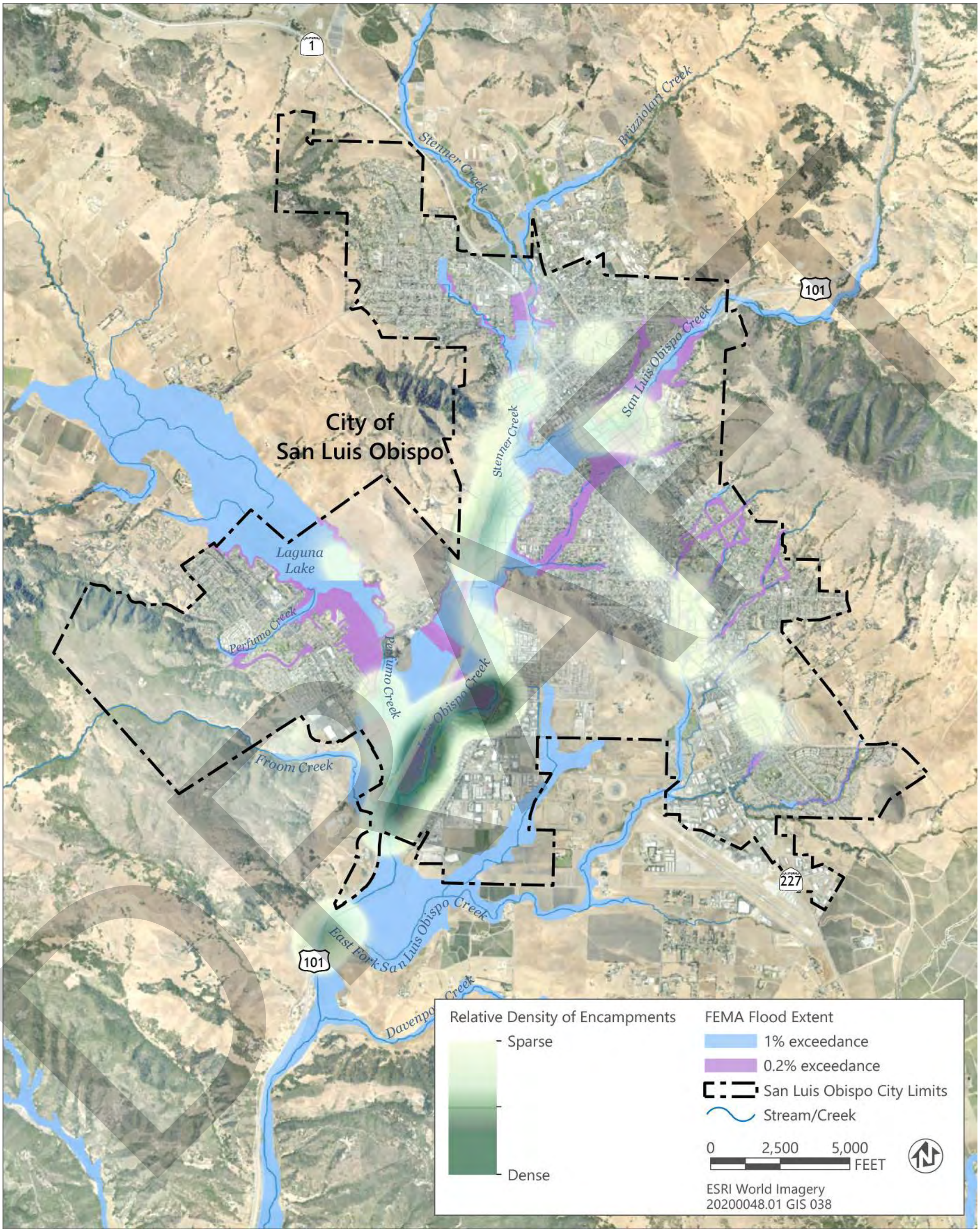
Sources: Data received from SLOCOG in 2021 and from CBEC Engineering in 2020, and downloaded from City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020

Figure 51 Low-Income Areas and Flood Plains in the City



Sources: Data downloaded from OEHHA in 2021 and received from CBEC Engineering in 2020, and downloaded from City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020

Figure 52 Hazardous Material Clean Up Sites and Flood Plains in the City

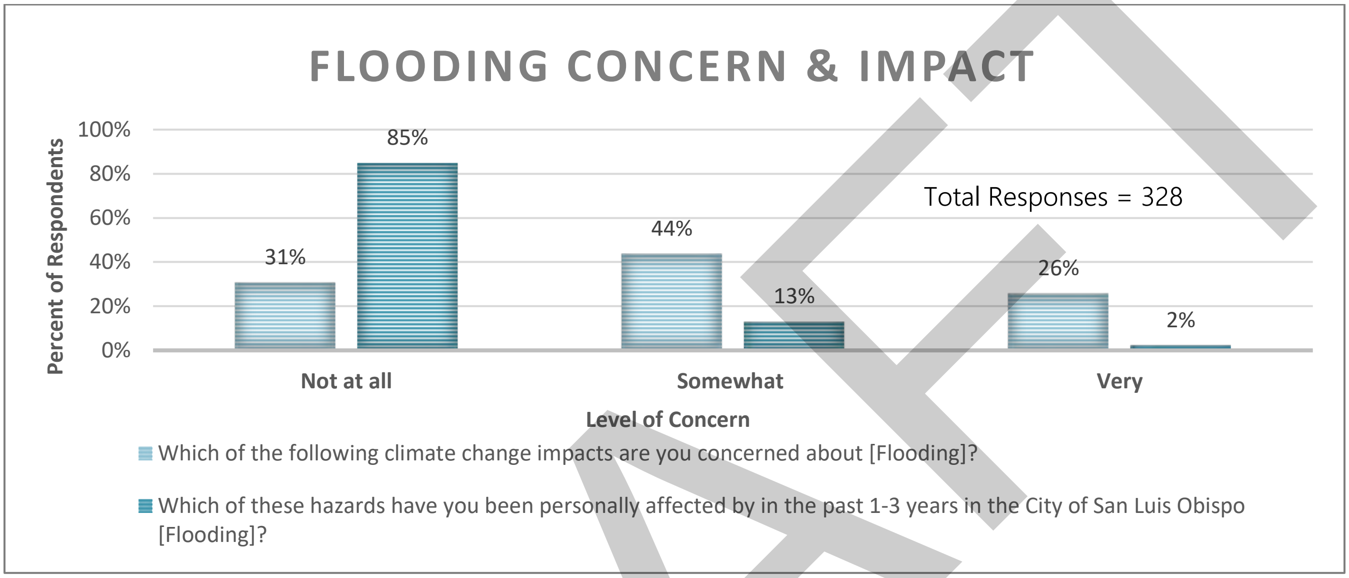


Sources: Data downloaded from US Census in 2019, City of San Luis Obispo in 2020 and County of San Luis Obispo in 2020

Figure 53 Location and Relative Density of Homeless Encampments in the City of San Luis Obispo

Community Flooding Concerns

As part of the community priorities survey, when participants were asked to report on their level of concern for flooding, as shown in Figure 54, 70 percent of respondents indicated that they were "Somewhat" or "Very Concerned" about the issue. When asked about whether they had been impacted by flooding in the last 1-3 years, only 15 percent of respondents indicated "Somewhat" or "Very". Additionally, individuals with a household income of less than $50,000 and individuals aged 18 to 24 reported the highest level of concern for flooding. Individuals who identify as all other races and ethnicities, compared to individuals who identify as white or caucasian, also expressed a higher level of concern for flooding (i.e., 36 percent v. 24 percent, respectively).



Sources: Resilient SLO Community Priorities Survey

Figure 54 City Resident's Flooding Concern and Impact

Key Findings and Policy Considerations

- For all flooding events (i.e., 100-year and 500-year flood events), access to the Southern Gateway of US 101 is compromised due to potential flooding of US 101 and Los Osos Valley Road. However, all centroids under these scenarios are able to access at least one alternative City gateway, which means no portions of the City would be closed off due to roadway network flooding.
- The 500-year flood scenario, illustrated in Figure 42, shows an inability of four census block groups to access either the City gateways or evacuation centers as they experience extensive flooding, isolating their ability to connect to a route.
- There is significant overlap between areas in the City where disadvantaged communities have been identified and the 100- and 500-year floodplain, resulting in potentially disproportionate impacts on these populations in the City during large storm events.
- The area West of South Higuera Street (Census Tract 115.01) is located almost entirely within the 100- and 500-year flood plain which is anticipated to expand in the future due to climate change. This area is particularly vulnerable with high percentage of elderly residents (17 percent) as well as a high percent of disabled residents (15 precent), presenting potential challenges during emergency evacuation events.
- Increased heavy precipitation and flooding will disproportionately impact homeless populations because they occupy marginal areas, they are less able to transport themselves out of flood areas during these events.

2.6.3 Adaptive Capacity for Precipitation and Flooding Impacts

Adaptive Capacity Rating: Medium/Low

Given its geographical location and the presence of several waterways within its boundaries, the City has been subject to a number of significant flooding events in the past. As a result, the City has taken considerable steps to analyze potential impacts from larger flooding events and mitigate the effects of these events when they do occur. Annex G of the Multi-Jurisdictional Hazard Mitigation Plan (San Luis Obispo County 2019b) includes a thorough analysis of flooding impacts from the 100-year and 500-year storm events, assessing the critical facilities that would be affected by these storms. Annex G also includes a capability assessment that provides an inventory of existing regulatory tools (e.g., ordinances, plans), personnel resources, financial resources (e.g., grants, fees), and partnerships that are currently used or could be used in the future to implement hazard mitigation activities.

Although the City has some authority under the City's Municipal Code for emergency removal of vegetation and other debris, general maintenance of the creeks falls upon the owners of property adjacent to the creek. Additionally, the creek corridor is highly confined in areas, particularly through downtown, making projects such as channel widening infeasible. Following the 1973 flood, the George S. Nolte & Associates study, completed in 1977, identified proposed flood control projects, but few were adopted because of the environmental effects associated with channel widening and other alternatives (Questa Engineering Corporation 2003). Several areas of the City, including downtown areas along San Luis Obispo Creek, the intersection of U.S. 101 and Los Osos Valley Road, the Johnson Avenue railroad underpass, and areas surrounding Laguna Lake, have been at a high risk for frequent flooding (City of San Luis Obispo 2011). To address these issues, large projects have been proposed to manage flood risk in the increasingly urbanized City. One such project is a high-flow bypass channel for the confluence of Laguna Lake and (the upstream portion) Prefumo Creek. An additional proposed project is the Mid-Higuera Bypass Project, which would increase conveyance capacity of San Luis Obispo Creek between Marsh Street and Madonna Road. This area, downstream of the confluence of Stenner and San Luis Obispo Creeks, has flooded and received extensive damage in some of the historical floods previously mentioned. The planned removal of sediment and Arundo stands from San Luis Obispo Creek south of Los Osos Valley Road will also serve to reduce local flood risk.

In 2003, the City developed and adopted its current Waterway Management Plan in coordination with the San Luis Obispo County Flood Control and Water Conservation District Zone 9 Advisory Committee (Questa Engineering Corporation 2003). The purpose of this plan is to adopt an approach and schematic plans to address flooding, erosion, water quality, and ecological issues in the San Luis Obispo Creek Watershed that can be implemented with approval from various regulatory agencies.

The plan includes five key components to achieve the plan's objective. These include the following:

- Stream Maintenance and Management Program and guidance document for routine stream maintenance;
- New Drainage Design Manual for storm water, flood control, and bank repair design;
- Flood Management Plan that outlines the conceptual flood control alternatives;
- Bank Stabilization Program that provides a management framework and conceptual plans for addressing current and future bank instability problem areas; and
- Habitat Enhancement and Restoration Program that provides a conceptual plan and framework for stream resource enhancement, restoration, and protection.

The City is currently enrolled in the State's mandated National Pollution Discharge Elimination System Program which includes requirements to help manage urban stormwater. One of the Best Management Practices (BMP) included in these requirements are practices to address sediment and debris in the storm drain system so the material/pollutants can be removed, and the capacity can be restored to system and allow it to function as designed. The City has undertaken this BMP and achieved significant improvements in the performance of the stormwater management system. In the first 5 years of this BMP, over 80 percent of the storm drain system was restored and was able to convey water from the streets to the creeks and drainages under full capacity (City of San Luis Obispo, Otte pers. comm., 2021).

In current practice, the stormwater management system for the City is designed to manage small and large storm events based on characteristics of rainfall specific to the region from observed historical data. These characteristics are described using the intensity, duration, frequency (IDF) curves of historic storm events. These IDF curves are used to design various components of urban drainage systems including pipes, culverts, and waterway channels. Given that the City's existing water management system has been designed and built to manage historic precipitation levels, this infrastructure can be difficult to retrofit and adjust to manage larger storm events, limiting the City's options for managing more intense storm events due to climate change (CEC 2018).

For the reasons discussed above, the adaptive capacity ranking for increased precipitation and flooding is medium/low.

2.6.4 Vulnerability Summary

Under existing conditions, without the influence of climate change, the City has experienced larger scale flood events in the past. As discussed in Sections 2.5.1 and 2.5.2, the City is particularly vulnerable to increased future flooding risk due to climate change with the intensity and frequency of large storm events increasing significantly by the end of the century. Because the City's existing stormwater management and flood management infrastructure have been designed and built to manage historic flood events, as the size of large storm events increases, the City's existing infrastructure will be compromised in its ability to successfully manage these events. Flooding impacts on the City's physical infrastructure could result in secondary impacts including interruptions to the City's evacuation routes as discussed in Section 2.5.2, impacts to life and property for homes and businesses located in existing floodplains and new more extensive floodplains, faster degradation of infrastructure, and economic impacts during post-disaster recovery. Based on the analysis of various impacts discussed above, the City's potential impact scoring is High (3). Precipitation and flooding impacts that are unique to the City and should be given increased consideration during the adaptation strategy development process are discussed below.

Natural Systems Findings

- Although annual precipitation is anticipated to increase in the City and the larger central coast region, California's climate oscillates between extremely dry and extremely wet periods with annual precipitation varying widely from year to year. These oscillations between extremely dry and extremely wet periods are anticipated to become more severe with rapid shifts from dry to wet periods known as "whiplash events" (Swain et al. 2016). These types of events are estimated to increase by approximately 100 percent in southern California, with increases in frequency occurring largely after 2050 (Swain et al. 2016).
- Based on California's location next to the Pacific Ocean, the state is exposed to the atmospheric river (AR) phenomenon, a narrow corridor of concentrated moisture in the atmosphere. The presence of the AR contributes to the frequency of "wet years" in the state, when there is an above-average number of AR storms and above-average annual precipitation. While research indicates that the frequency of large storms events does increase in these wet years, the most severe flooding from ARs may not be in wet years (Swain et al. 2018). The largest flooding impacts are caused by persistent storm sequences on sub-seasonal timescales (i.e., short time periods, typically 2 weeks to 3 months), which bring a significant fraction of annual average precipitation over a brief period. Based on current climate modeling, the frequency of these large storm sequences over short timeframes is projected to increase noticeably under a future high emissions scenario. It is estimated that a storm similar in magnitude to the Great Flood events is more likely than not to occur at least once between 2018 and 2060 (Swain et al. 2018).
- For very large precipitation events, the capacity of the watershed to absorb incoming rainfall can be quickly exceeded, causing large increases in stream flow within the system. By as early as 2070 under a high future emissions scenario, peak flow rates in the San Luis Obispo Creek watershed are projected to increase, on average, from 17 percent to 38 percent depending on the size of the storm event. By this period, for the storm event with a

50 percent chance of occurring in any given year (2-year storm event), the median peak stream flow is projected to increase by 28 percent with a small likelihood (90^{th} percentile) of stream flow increasing by 51 percent.

Built Environment Findings

- By as early as 2070 under a high future emissions scenario, for the 100-year event, dramatic increases are observed on Stenner and Old Garden Creeks upstream of the San Luis Obispo Creek confluence and within the downtown area. In both cases, flooding is exacerbated by the capacity of the existing infrastructure to manage historic flooding events. Similar, during the 100-year event, increases in flow within San Luis Obispo Creek increasingly cause flood waters to break out of the channel upstream of the culvert and flow along the Higuera and Marsh Street corridor towards the Stenner Creek confluence
- From the results of the climate-informed flood modeling, areas with the greatest increases in connected floodplain inundation for the 10-year through 100-year events included SLO Creek upstream of the Stenner confluence (including parts of downtown SLO), the SLO Creek – Prefumo Creek confluence area, East Fork and its tributaries upstream of Buckley Road, and Stenner, Brizziolari, and Old Garden Creeks. In the modeling, these areas tended to have greater expanses of floodplain areas, such as the SLO Creek – Prefumo Creek confluence area, or limiting infrastructure, as is the case with the undercity culvert through downtown.
- By as early as 2070 under a high future emissions scenario, for the 100-year event, dramatic increases are observed on Stenner and Old Garden Creeks upstream of the San Luis Obispo Creek confluence and within the downtown area. In both cases, flooding is exacerbated by the capacity of the existing infrastructure to manage historic flooding events. Similar, during the 100-year event, increases in flow within San Luis Obispo Creek increasingly cause flood waters to break out of the channel upstream of the culvert and flow along the Higuera and Marsh Street corridor towards the Stenner Creek confluence.
- Near the San Luis Obispo – Prefumo Creek confluence area near Higuera Street and Madonna Road, large expanses of relatively flat, low-lying land persist between and along the two creeks. During larger storm events (50-year and 100-year storms), flood waters can spill into these areas by crossing Highway 101 near Madonna Road from San Luis Obispo Creek or by escaping the creek channels in the confluence area and causing backwater conditions for upstream reaches.
- The greatest area of impact to local roads during large storm events (100-year storm) would be areas just south of San Luis Obispo Creek through the downtown area with the farthest extent along Santa Barbara Street as far South as Leff Street. The Chorro Street undercrossing at US 101 would be impacted by the 10-year, 100-year, and 500-year floods.
- Extensive flooding from larger storm events also has the potential to limit transit service, thus eliminating transport options for populations in the City dependent on transit, with between 16 to 26 percent of SLO Transit stops being affected depending on the storm size.

Community Resilience Findings

- For all flooding events (i.e., 100-year and 500-year flood events), access to the Southern Gateway of US 101 is compromised due to potential flooding of US 101 and Los Osos Valley Road. However, all centroids under these scenarios are able to access at least one alternative City gateway, which means no portions of the City would be closed off due to roadway network flooding.
- The 500-year flood scenario, illustrated in Figure 42, shows an inability of four census block groups to access either the City gateways or evacuation centers as they experience extensive flooding, isolating their ability to connect to a route.
- There is significant overlap between areas in the City where disadvantaged communities have been identified and the 100- and 500-year floodplain, resulting in potentially disproportionate impacts on these populations in the City during large storm events.

- The area West of South Higuera Street (Census Tract 115.01) is located almost entirely within the 100- and 500-year flood plain which is anticipated to expand in the future due to climate change. This area is particularly vulnerable with high percentage of elderly residents (17 percent) as well as a high percent of disabled residents (15 precent), presenting potential challenges during emergency evacuation events.
- Increased heavy precipitation and flooding will disproportionately impact homeless populations because they occupy marginal areas, they are less able to transport themselves out of flood areas during these events.

Adaptive Capacity: Medium/Low (2.5)

Potential Impact: High (3)

Vulnerability Score: 4.5

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3 VULNERABILITY SCORING SUMMARY

As described in this Report, the City's vulnerability to each identified impact has been assessed based on the magnitude of risk to and potential impacts on Natural Systems, the Built Environment, and Community Resilience. Importantly, the assessment also considers the City's current adaptive capacity to mitigate these climate-related hazards when impacts do occur. Table 23 presents a list of important plans, resources, and documents that already exist and are being used to help mitigate risk from these climate-related hazards.

Table 23 Summary of Existing Plans and Reports

Plan or Report	Climate Change Hazard			
	Increased Temperatures and Extreme Heat	Increased Wildfire Risk	Increased Precipitation and Flooding	Drought and Water Supply
California's Fourth Climate Change Assessment, Central Coast Region Report	✓	✓	✓	✓
City Local Hazard Mitigation Plan Annex		✓	✓	✓
City General Plan		✓	✓	✓
City Emergency Operations Plan		✓	✓	
Waterway Management Plan			✓	
City Community Wildfire Protection Plan		✓		
City Urban Water Management Plan				✓
City Open Space Vegetation Management Plan		✓		

Source: Ascent Environmental 2021

Based on the ratings of potential impacts and adaptive capacity, an overall vulnerability score was determined for each climate change effect. This scoring process can help the City understand which effects pose the greatest threats and should be prioritized in future planning efforts.

As shown in Table 24, increased extreme precipitation and flooding is assigned a vulnerability rating of 4.5 and has the highest vulnerability score. Increases in temperature and extreme heat as well as increase wildfire risk are both given a vulnerability score of 4. Although ranked slightly lower, these climate change effects are also likely to have significant impacts on the City in the near-term and midterm periods. Although a variety of adaptive efforts related to both climate change effects are in place and underway, the magnitude of the impacts posed by these hazards contributes to high vulnerability for the City and its populations. Finally, increased long-term drought is characterized as having a vulnerability rating of 3.5. This climate change effect is currently being addressed adequately based on existing conditions, but additional adaptation and resilience planning will still be required in the future to mitigate impacts and protect the City.

Table 24 Summary of Vulnerability Scoring

Climate Change Effect	Vulnerability Score		
	Adaptive Capacity	Potential Impact	Vulnerability
Increased Extreme Precipitation and Flooding	Medium/Low	High	4.5
Increased Temperatures and Extreme Heat	Low	Medium	4
Increased Wildfire	Medium	High	4
Long-Term Drought	High	Medium	3.5

Source: Ascent Environmental in 2021

Provided below is a summary of impacts that are unique to the City for each of the four climate-related hazards and should be given increased consideration during the adaptation strategy development process are discussed below.

TEMPERATURES AND EXTREME HEAT KEY FINDINGS

Natural System Findings

- Changes in temperature and extreme heat are likely to have negative impacts on the City's tree canopy with some tree species no longer suitable for future minimum and maximum temperatures. Any future policies focused on improving the City's tree canopy or green spaces to mitigate the urban heat island effect should carefully consider what plant and tree species will be suitable for future climate conditions.
- Climate change is projected to encourage the spread of invasive species in the City's open spaces, affecting coastal sage scrub habitats as well as the City's oak species from Sudden Oak Death.
- Regional impacts on agriculture and viticulture industries from shifting temperatures have the potential to impact the City via decreases in wine and vineyard-based tourism, with the City relying heavily on revenue and employment opportunities in these industries. Resilience strategies focused on economic impacts should consider potential impacts on viticulture vineyard-based tourism and potential diversification of the City's tax revenue sources and employment industries.

Built Environment Findings

- The Margarita Avenue Neighborhood (Census Tract 111.03) includes population characteristics that make this area particularly vulnerable to extreme heat and is located in an area of the City with increased urban heat island severity. Resilience strategies that mitigate impacts of the urban heat island effect should focus on supporting this area of the City.
- Shifts in temperature and extreme heat will result in changes in energy demand for cooling in the City, with increased demand in areas experiencing more severe urban heat island hotspots. As the City implements it's recently adopted Climate Action Plan and as well as the Resilient SLO strategies, solutions that both reduce GHG emissions and help the City adapt to impacts of climate change should be prioritized.
- The City's historically moderate climate has, in general, not required the City's existing building stock to be designed or equipped with air conditioning. However, as average temperatures and extreme heat events increase in the future, residents are ill-equipped to prepare for these events. Additionally, increases in temperature and extreme heat will result in increased energy demand for cooling, which underscores the need to support distributed energy resources, customer sited energy storage, demand response, and grid/building connected appliances and vehicles.
- Extreme heat days and heat waves will have a disproportionate impact on electricity demand, with higher electricity demand projected for these events in the future. These projections place an increased urgency on electricity utilities to plan for higher electricity demand during these events in future.

Community Resilience Findings

- The Margarita Avenue Neighborhood (Census Tract 111.03) West of South Higuera neighborhood (Census Tract 115.01) is an area of the city with a particularly vulnerable population in regard to extreme heat, with a high percentage of elderly, disabled, or low-income residents. The West of South Higuera neighborhood (Census Tract 115.01) also includes a high percentage of elderly and disabled residents, making this area particularly vulnerable to extreme heat impact.
- Low-income residents are particularly vulnerable to extreme heat impacts due to a number of factors including a higher reliance on public transit (leaving these residents more exposed to extreme heat during transit use), a higher percentage of income being devoted toward utility bills, and a trend of lower income neighborhoods having less tree cover. Unhoused individuals are also at increased risk from extreme heat events with, generally, less access to places to cool off and healthcare resources during these events.

- The City and the County, in general, have historically served as a destination for summer tourists to escape more extreme summer heat in the San Joaquin Valley and southern California. As extreme heat events continue to increase disproportionately in those areas of the state compared to less severe increases locally, the City may experience increases in this phenomenon placing increased demand on services, impacts on City infrastructure and resources, as well increased pressure on the housing shortage issue in the City from new permanent residents.

LONG-TERM DROUGHT KEY FINDINGS

Natural System Findings

- The City's designated open space areas include a mixture of vegetation types including oak woodland, grassland, coastal sage scrub, and chaparral that are anticipated to be impacted by changes in annual average temperatures, extreme heat, and long-term droughts (OPR et al. 2018b).
- As dry years and long-term droughts become more common in the future, population growth rates of annual plant species will become marginal, and populations are likely to become locally extinct.

Built Environment Findings

- Dramatic shifts from a multi-year dry periods to wet periods, similar to the 2011-2015 drought followed by an above average wet year in the 2016-2017, are known as whiplash events (Swain et al. 2018), and are expected to become more severe in the future. These whiplash events may affect water supply management practices over the long-term, particularly as the swings from multi-year dry to wet periods become more prolonged and more severe, with an emphasis on increasing rainfall storage when it does occur during the wet periods (Persad et al. 2020).
- Buildup of sedimentation that reduces a reservoir's volume available already occurs in the City's water storage system, with the City implementing programs and policies to address this storage loss over the long term. However, landscape disturbances including wildfire, post-wildfire runoff, or landslides after wet winters, are projected to increase sediment yield from watersheds along the Central Coast (OPR et al. 2018b) and with the potential to further reduce the amount of water-storage capacity in dammed Central Coast reservoirs (Smith et al. 2018).
- The City's 2020 UWMP modeled potential impacts on the City's water supplying, finding that changes in precipitation could result in a decrease of as much as 850 AFY to an increase of as much as 160 AFY, accounting for an approximately 8 percent decrease to 2 percent increase in the City's overall water supply (City of San Luis Obispo 2021b).
- With more rapid shifts from dry to wet periods known as "whiplash events," precipitation will occur over shorter more intense periods. This shift has the potential to reduce groundwater recharge which ideally occurs during prolonged wet periods to allow for soil infiltration, deeper percolation, and more effective groundwater recharge. However, increases in the intensity of rainfall events, when they do occur in the wet periods, provides an opportunity to offset potential losses in storage during periods of drought.
- The 2020 UWMP includes a section specially on Water Resiliency Planning which highlights a set of strategies the City has taken to ensure long-term water resiliency and mitigate the impacts from a long-term drought scenario. These strategies include a multi-source water supply; conservative water demand projections; water use efficiency; water recycling; and future groundwater recharge.

Community Resilience Findings

- Increases in temperature and extreme heat events are associated with increases in vector-borne and infectious disease transmission, with future long-term drought scenarios potentially increasing the prevalence of certain vector-borne diseases present on in the central coast region including Lyme disease and valley fever.

WILDFIRE KEY FINDINGS

Natural System Findings

- The increasing frequency of fire on chaparral landscapes have caused coastal sage shrubs and chaparral to shift to grasses, including exotic grasses. Some research has suggested that annual and some perennial grasses have the strongest effects on fire regimes and act as ecosystem transformers.
- Wildfire impacts in riparian zones can reduce canopy cover, resulting in increased water temperatures in creeks and other shaded waterways as well as produce increased sediment flux in stream beds and adjacent areas, affecting the food web of burned stream areas and increasing the density of algae in waterways.
- Post-wildfire runoff and debris flows can be affected by several factors but are generally triggered by one of two processes: surface erosion caused by rainfall runoff, and landslides caused by rainfall seeping into the ground. While it is uncertain the effect climate change will have on post-wildfire runoff and debris flows event, climate change is projected to result in higher intensity rainfall events as well as "whiplash events" with oscillations between extremely dry and extremely wet periods, potentially affecting post-wildfire hazards.

Built Environment Findings

- The risk of wildfire is dependent on a variety of factors not excluding biophysical factors that are affected by climate change including Resources (e.g., land use patterns, vegetation growth), Ignitions (e.g., lightning, accidental ignitions, arson), and Conditions (e.g., precipitation, wind, seasonal variation). Approximately 95 percent of wildfires in the state are caused by human ignition. However, climate change is projected to increase the frequency and severity of wildfires, when they do occur (Mann et al. 2016).
- The combination of dry climate conditions and the seasonal high autumn winds in California can increase the risk of trees or branches falling on transmission lines and causing power outages or wildfires. While these events have occurred historically, the effect of climate change on biophysical features that increase the risk of wildfires (e.g., precipitation, wind, seasonal variation) will increase the frequency and severity of wildfires from transmission line ignitions.
- There was limited development within the WUI in the city for the period of 2001 – 2016, with a few prominent exceptions including the Madonna Area and the Margarita Area to the east of South Higuera Street. However, buildings outside of the WUI are also at risk from ignition due to the spread of firebrands (or embers) that can initiate new spot fires.
- Wildfire events in the VHFHSZ near the Irish Hills Natural Reserve could potentially have immediate impacts to some residential areas on Royal Way, Sterling Lane and Isabella Way. Additionally, areas in the northeast of the City south of US 101 along San Luis Road are at risk from wildfire impacts and could potentially compromise evacuation management when wildfires do occur in this area.

Community Resilience Findings

- The City serves as regional employment center, regional destination for tourism, and home to a university (Cal Poly) with approximately 20,000 students. These factors create an environment in which the City experiences a large influx of daily visitors to the City. If and when a wildfire event were to occur in or near the City during daytime hours, evacuation management would be particularly difficult and pose additional challenges due to this large influx of daily visitors. Additionally, because US 101 serves the main commuter corridor for locations north and south, wildfire events that occur along this route causing route closures (e.g., Cuesta Grade) can have disproportionate impact on employers and employees in the City.
- While the majority of the City is not at high risk from direct wildfire impacts, regional PSPSs events that affect the City will result in a set of potential secondary impacts. Specifically, PSPS events occurring during heat wave events could have considerable public health impacts, leaving residents and businesses without power and air conditioning and create health impacts to those who are reliant of electricity for supplemental oxygen and refrigerated medications.

- The confluence of PSPS, bad air quality, wildfire threat, and high heat days underscores the importance of homes and businesses as places of potential refuge.
- The Sinsheimer Neighborhood (Census Tract 110.01) and the Laguna Lake and Los Osos Valley Road (Census Tract 113) are particularly vulnerable to wildfire impacts with this areas of the City near moderate to very high FHSZs and include the higher percentages of elderly (20 percent) and youth (7 percent) populations as well as the Laguna Lake and Los Osos Valley Road area with a high percentage of households experiencing linguistic isolation (8 percent) which may present issues during emergency evacuation events.

Exposure to wildfire smoke, particularly exposure to vulnerable populations, can result in worsening of respiratory symptoms, increased rates of cardiorespiratory emergency visits, hospitalizations, and even death (Rappold et al. 2017). Wildfires can damage not only buildings and infrastructure, but also the natural environment, including portions of the City and the areas in the County that serve as regional recreation and tourism opportunities, resulting in economic impacts on the tourism and related industries when wildfire smoke impacts occur.

Precipitation Key Considerations

Natural Systems Findings

- Although annual precipitation is anticipated to increase in the City and the larger central coast region, California's climate oscillates between extremely dry and extremely wet periods with annual precipitation varying widely from year to year. These oscillations between extremely dry and extremely wet periods are anticipated to become more severe with rapid shifts from dry to wet periods known as "whiplash events" (Swain et al. 2016). These types of events are estimated to increase by approximately 100 percent in southern California, with increases in frequency occurring largely after 2050 (Swain et al. 2016).
- Based on California's location next to the Pacific Ocean, the state is exposed to the atmospheric river (AR) phenomenon, a narrow corridor of concentrated moisture in the atmosphere. The presence of the AR contributes to the frequency of "wet years" in the state, when there is an above-average number of AR storms and above-average annual precipitation. While research indicates that the frequency of large storms events does increase in these wet years, the most severe flooding from ARs may not be in wet years (Swain et al. 2018). The largest flooding impacts are caused by persistent storm sequences on sub-seasonal timescales (i.e., short time periods, typically 2 weeks to 3 months), which bring a significant fraction of annual average precipitation over a brief period. Based on current climate modeling, the frequency of these large storm sequences over short timeframes is projected to increase noticeably under a future high emissions scenario. It is estimated that a storm similar in magnitude to the Great Flood events is more likely than not to occur at least once between 2018 and 2060 (Swain et al. 2018).
- For very large precipitation events, the capacity of the watershed to absorb incoming rainfall can be quickly exceeded, causing large increases in stream flow within the system. By as early as 2070 under a high future emissions scenario, peak flow rates in the San Luis Obispo Creek watershed are projected to increase, on average, from 17 percent to 38 percent depending on the size of the storm event. By this period, for the storm event with a 50 percent chance of occurring in any given year (2-year storm event), the median peak stream flow is projected to increase by 28 percent with a small likelihood (90^{th} percentile) of stream flow increasing by 51 percent.

Built Environment Findings

- By as early as 2070 under a high future emissions scenario, for the 100-year event, dramatic increases are observed on Stenner and Old Garden Creeks upstream of the San Luis Obispo Creek confluence and within the downtown area. In both cases, flooding is exacerbated by the capacity of the existing infrastructure to manage historic flooding events. Similar, during the 100-year event, increases in flow within San Luis Obispo Creek increasingly cause flood waters to break out of the channel upstream of the culvert and flow along the Higuera and Marsh Street corridor towards the Stenner Creek confluence

- From the results of the climate-informed flood modeling, areas with the greatest increases in connected floodplain inundation for the 10-year through 100-year events included SLO Creek upstream of the Stenner confluence (including parts of downtown SLO), the SLO Creek – Prefumo Creek confluence area, East Fork and its tributaries upstream of Buckley Road, and Stenner, Brizziolari, and Old Garden Creeks. In the modeling, these areas tended to have greater expanses of floodplain areas, such as the SLO Creek – Prefumo Creek confluence area, or limiting infrastructure, as is the case with the undercity culvert through downtown.
- By as early as 2070 under a high future emissions scenario, for the 100-year event, dramatic increases are observed on Stenner and Old Garden Creeks upstream of the San Luis Obispo Creek confluence and within the downtown area. In both cases, flooding is exacerbated by the capacity of the existing infrastructure to manage historic flooding events. Similar, during the 100-year event, increases in flow within San Luis Obispo Creek increasingly cause flood waters to break out of the channel upstream of the culvert and flow along the Higuera and Marsh Street corridor towards the Stenner Creek confluence.
- Near the San Luis Obispo – Prefumo Creek confluence area near Higuera Street and Madonna Road, large expanses of relatively flat, low-lying land persist between and along the two creeks. During larger storm events (50-year and 100-year storms), flood waters can spill into these areas by crossing Highway 101 near Madonna Road from San Luis Obispo Creek or by escaping the creek channels in the confluence area and causing backwater conditions for upstream reaches.
- The greatest area of impact to local roads during large storm events (100-year storm) would be areas just south of San Luis Obispo Creek through the downtown area with the farthest extent along Santa Barbara Street as far South as Leff Street. The Chorro Street undercrossing at US 101 would be impacted by the 10-year, 100-year, and 500-year floods.
- Extensive flooding from larger storm events also has the potential to limit transit service, thus eliminating transport options for populations in the City dependent on transit, with between 16 to 26 percent of SLO Transit stops being affected depending on the storm size.

Community Resilience Findings

- For all flooding events (i.e., 100-year and 500-year flood events), access to the Southern Gateway of US 101 is compromised due to potential flooding of US 101 and Los Osos Valley Road. However, all centroids under these scenarios are able to access at least one alternative City gateway, which means no portions of the City would be closed off due to roadway network flooding.
- The 500-year flood scenario, illustrated in Figure 42, shows an inability of four census block groups to access either the City gateways or evacuation centers as they experience extensive flooding, isolating their ability to connect to a route.
- There is significant overlap between areas in the City where disadvantaged communities have been identified and the 100- and 500-year floodplain, resulting in potentially disproportionate impacts on these populations in the City during large storm events.
- The area West of South Higuera Street (Census Tract 115.01) is located almost entirely within the 100- and 500-year flood plain which is anticipated to expand in the future due to climate change. This area is particularly vulnerable with high percentage of elderly residents (17 percent) as well as a high percent of disabled residents (15 precent), presenting potential challenges during emergency evacuation events.
- Increased heavy precipitation and flooding will disproportionately impact homeless populations because they occupy marginal areas, they are less able to transport themselves out of flood areas during these events.

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Appendix A

Flood Risk Modeling and Wildland Urban Interface Maps