Sonoma County General Plan 2020

SAFETY ELEMENT

Appendices A-C

Sonoma County Permit and Resource Management Department

2550 Ventura Avenue

Santa Rosa, California 95403

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Appendix A
Sonoma County Climate Change Vulnerability Assessment

Sonoma County

Climate Change Vulnerability Assessment

May 2024

Prepared by
Rincon Consultants, Inc.

DISCLAIMER:

Rincon Consultants, Inc. (hereinafter referred to as "Rincon") prepares vulnerability assessments that evaluate climate change hazards, including wildfire, based on numerous sources, including third party consultants, State and Federal mapping resources, and various software modeling programs that are considered industry standard best practices. The Climate Change Vulnerability Assessment prepared for the Safety Element it accompanies, evaluated wildfire hazards based on CAL FIRE's Fire Hazard Severity Zones available at the time the report was prepared. Wildfire is unpredictable, and the specific conditions of wildfire could result in fire behavior that diverges from the assumptions used in this analysis. There is no guarantee that wildfire behavior and specific treatment to avoid such behavior will follow or prevent wildfire impacts. Rincon is not responsible for any damage to life or property that might occur based on the results of the vulnerability analyses in this Climate Change Vulnerability Assessment, and any accompanying recommendations.

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Executive Summary

The Sonoma County Climate Change Vulnerability Assessment provides an evaluation of potential climate change impacts on community members rendered vulnerable by systemic inequities; parks and natural resources; agriculture; and critical facilities, buildings, services, and infrastructure in unincorporated Sonoma County. While there may be overlap of infrastructure and services in incorporated areas, this assessment addresses risks to populations and assets in unincorporated Sonoma County because this is the area the County has land use jurisdiction. However, the impacts of climate change cross jurisdictional boundaries, and strengthening the County's climate resilience requires coordinated effort across local and regional jurisdictions. This assessment is intended to assist the County with developing climate adaptation goals, policies, and implementation programs for an update to the Safety Element of the Sonoma County General Plan.

Climate change is caused by the addition of excess greenhouse gases (GHGs) to the atmosphere, which traps heat near the earth's surface raising global average temperatures in what is referred to as the greenhouse effect. This increase in average temperatures across the globe affects sea level rise, precipitation patterns, the severity of wildfires, the prevalence of extreme heat events, water supply, and ocean temperatures and chemistry. Climate change models[1] indicate that Sonoma County is expected to experience the impacts presented in this assessment by the end of the century (see Figure 1 for a summary of impacts).

Community Engagement

Incorporating input from the community into the development of this Climate Change Vulnerability Assessment provides critical context for how recent climate-driven events in Sonoma County have impacted critical infrastructure and services and community members. It also serves to identify existing government-run programs or initiatives within the county and remaining gaps. Interviews with asset managers, technical experts, community experts, and frontline responding agencies in Sonoma County elicited information on existing and planned efforts to manage climate change impacts now and in the future. The information shared by these stakeholders will further inform climate adaptation policies and programs in the County's Safety Element update and will continue to provide ongoing guidance on implementation strategies that address key community needs and concerns. Detailed summaries of stakeholder interviews can be found included as Appendix A.

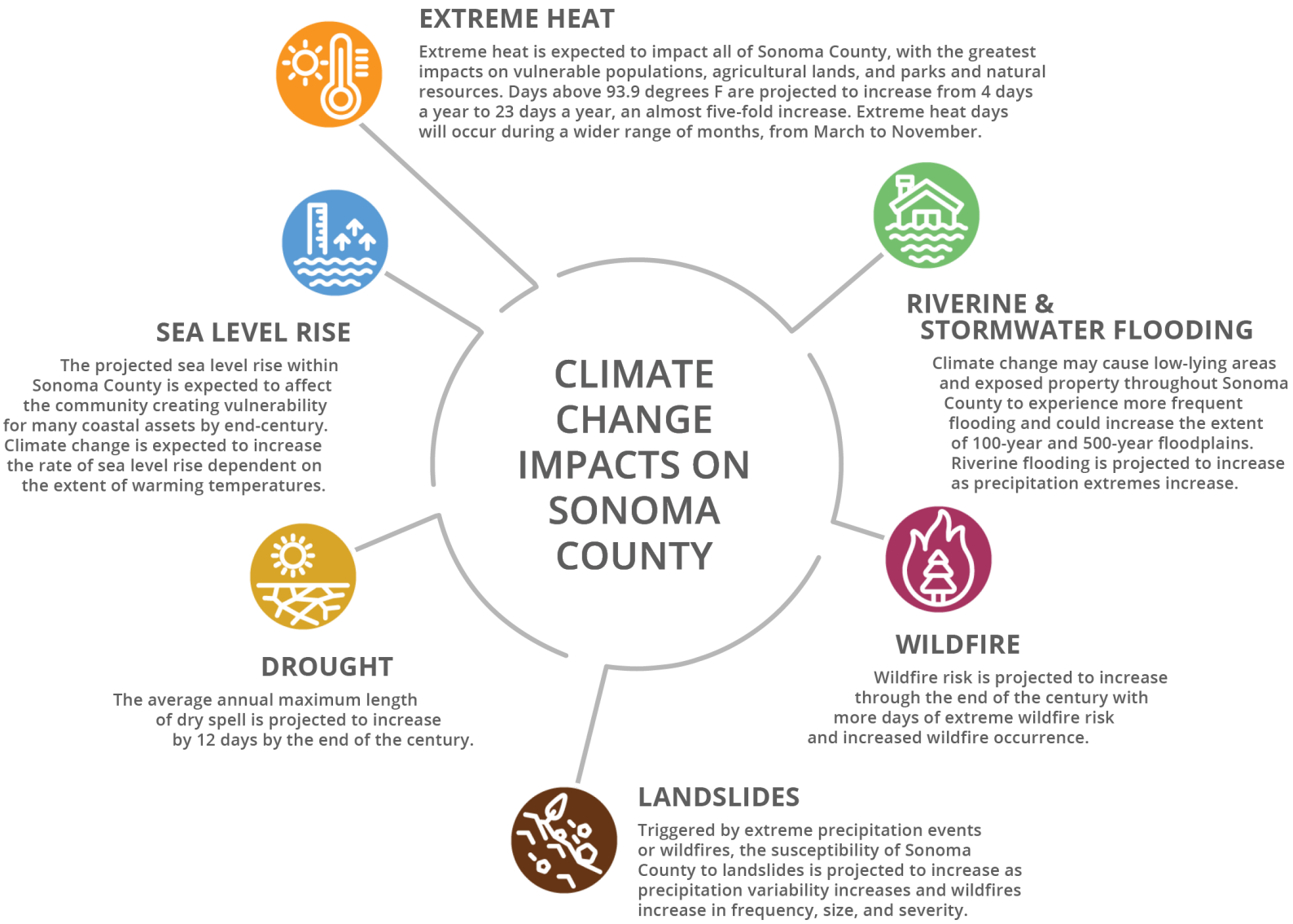
An Equity Working Committee was also formed to help shape environmental justice policies and risk reduction planning for wildfire and other hazards by centering the expertise of under-resourced communities. The Equity Working Committee is an advisory group of community members that are invested in developing climate adaptation and environmental justice solutions that meet the needs of the diverse communities in Sonoma County.

[1] Cal-Adapt 2.0 is an online tool that presents historic and modeled projections based on 10 different global climate models. The tool was developed and is maintained by the University of California, Berkeley Geospatial Innovation Facility with funding and oversight by the California Energy Commission (CEC). This tool was used to present projection data related to minimum and maximum temperature, precipitation, extreme heat, warm nights, drought, and wildfire

The Equity Working Committee provided critical feedback on the following aspects of this assessment: the social sensitivity index and populations made sensitive by systems in Sonoma County.

A public survey was conducted to further guide the development of the Sonoma County Safety Element update. The survey responses provide insight into challenges people face during climate change-related hazard events and what actions they are taking to be better prepared to face those challenges. The survey results were incorporated throughout the assessment and provided key insights to vulnerabilities that Sonoma County residents face. More detailed information about this survey including summaries and responses can be found in Appendix B.

Figure 1 Sonoma County Climate Change Impacts



Overview

The Sonoma County Climate Change Vulnerability Assessment describes the impacts climate change is expected to have on community members, assets, and critical facilities and services, and the degree to which they are susceptible (e.g., vulnerable). Vulnerability is a function of exposure, sensitivity, and potential impact. The Sonoma County Climate Change Vulnerability Assessment also evaluates the ability for the community and assets to recover from and adjust to the consequences of climate change (e.g., adaptive capacity). This assessment explores each of these factors qualitatively then estimates vulnerability for each population or asset at risk.

This assessment is organized as follows:

- **Section 1**, Introduction, describes the purpose of this assessment, community input gathered, key terms, and includes a note on existing County efforts to evaluate climate impacts and increase resiliency.
- **Section 2**, Methodology, explains the methodology used to prepare the Sonoma County Climate Change Vulnerability Assessment and its reliance on the California Adaptation Planning Guide.
- **Section 3**, Exposure to Climate Hazards, provides an overview of projected changes to the climate and the County's exposure to climate hazards.
- **Section 4**, Sensitivity, characterizes the sensitivity of populations, assets, and critical facilities and services in Sonoma County. Sensitivity is the degree to which a species, population, natural system, community, asset, or other associated system may be affected by changing climate conditions. Note that this section received significant input and direction from Equity First.
- **Section 5**, Vulnerability Analysis, evaluates potential impacts and adaptive capacity of sensitive population groups, the County's natural resources and park assets, agriculture, and critical facilities, buildings, services, and infrastructure. Based on a combination of potential impacts and adaptive capacity, the vulnerability of each population group, asset, or critical facility and service is ranked as either high, medium, or low.
- **Section 6,** Vulnerability Summary, presents key findings, including problem statements which characterize the major impacts Sonoma County will experience from climate change.

The following sensitive populations, assets, and critical facilities and services were identified as those that are most susceptible to climate change hazards in Sonoma County and evaluated in this assessment.

Populations

While all people in a community will experience climate change, some are already and will continue to be more harmed by it than others. Systemic inequities render some populations more sensitive to climate change impacts. Populations made sensitive by systems experience heightened risk to climate change and have fewer resources to adapt and recover from climate change impacts. Sonoma County is home to several populations made sensitive by systems, and who have already been disproportionately harmed by climate change, including:

- **Individuals with High Outdoor Exposure.** Outdoor workers, people experiencing houselessness, visitors, people recreating outdoors.
- **Under-Resourced Individuals.** People experiencing poverty, unemployed individuals, individuals with no health insurance, households without a computer, households without broadband internet, households with limited computer skills, renters, individuals without vehicle access, single-female heads of households, individuals with educational attainment of less than 4 years of high school, individuals in overcrowded housing, mobile home households, households experiencing housing burden, households experiencing energy burden.
- **Individuals Facing Societal Barriers.** Black, Indigenous, and People of Color (BIPOC), Native Americans, limited and non-English speakers, immigrants, people who are undocumented.
- **Individuals with Chronic Health Conditions or Health Related Sensitivities**. Seniors, young children, people who are differently abled, individuals with asthma, individuals with cardiovascular disease, military veterans.

Parks and Natural Resources

- Open spaces
- Forested land
- Critical habitat
- Waterways
- Regional parks
- Hillsides
- Vegetation communities

Critical Facilities, Buildings, Services, and Infrastructure

- Fires Stations
- Police Stations
- Hospital/Healthcare Facilities
- Emergency Shelters
- Schools
- Public Libraries
- Airports

Agriculture

- Cropland
- Rangeland

Adaptive Capacity

Adaptive capacity is the ability to recover from and adjust to the consequences of climate change. Types of adaptive capacity include adjustments in behavior, resources, processes, and technologies. Sonoma County has actively taken steps to increase the County's adaptive capacity through various existing policies, plans, programs, and institutions that increase the County's resilience to climate change.

Although there are initiatives in place to mitigate the impacts of wildfire, flooding, and drought on agricultural lands, parks and natural resources, and critical facilities and services, as well as to reduce the impacts of extreme heat, drought, and wildfire on community members, none of the sensitive populations, assets, and critical facilities and services evaluated in this assessment were ranked as having a High adaptive capacity score. The County has the

opportunity to identify additional programs or adjustments to existing programs to improve adaptive capacity as part of the Safety Element update.

The adaptive capacity of the County's sensitive populations, assets, and critical facilities and services are described and scored in Section 5, *Vulnerability Analysis*. A non-exhaustive list of some of the County's most important initiatives to increase adaptive capacity can be found in Appendix C.

Vulnerability Analysis

This assessment evaluates how climate change may impact community members who are rendered vulnerable by climate change and systemic inequities, parks and natural resources, and critical facilities, buildings, services, and infrastructure in Sonoma County. The report provides a prioritized list of population groups in Section 4.1, *Populations*, for which adaptation policies and programs should be developed and implemented to increase resilience.

A complete list of the population groups and other asset categories with high-vulnerability scores is provided in Table 1. The following is a list of key vulnerability findings from this assessment:

- All populations made sensitive by systems are highly vulnerable to all climate hazards, particularly in the case of extreme heat, drought and landslides which had lower adaptive capacity scores.
- Parks and natural resources are highly vulnerable to extreme heat, drought, wildfire, landslides, and sea level rise. Impacts to natural resources include habitat conversions, damage, and mortality, and scarcity of resources for plants and wildlife.
- Critical facilities, buildings, services, and infrastructure are highly vulnerable to wildfire, landslides, extreme heat, and sea level rise. There are many critical facilities, including fire stations and emergency shelters in the County's wildfire hazard zones. Infrastructure and dependent populations experience additional cascading impacts due to power outages from downed utility lines, public safety power shut offs and grid overload. All forms of power outages can affect how emergency services are able to perform their needed functions during an emergency or extreme weather event. Wildfires can result in direct impacts to properties, triggering evacuations and can lead to permanent displacement.
- Sonoma County agriculture is highly vulnerable to drought, extreme heat, wildfires, and landslides. Vulnerability is largely attributed to the potential for high impacts to livestock, crops, and agricultural workers.

This assessment establishes a foundation for identifying adaptation policies and programs that can increase resilience in Sonoma County. The Sonoma County Safety Element will include policies and programs to increase the resilience of the population groups and asset categories with the highest vulnerability to climate change.

Table 1 Vulnerability Analysis of Populations and Asset Groups by Climate Hazard

Climate Hazard	Impact Score	Adaptive Capacity Score	Vulnerability Score
Individuals with High Outdoor Exposure			
Extreme Heat	High	Low	**5-High**
Wildfire	High	Medium	**4-High**
Riverine and Stormwater Flooding	Medium	Low	**4-High**
Under-Resourced individuals			
Extreme Heat	High	Medium	**High-4**
Wildfire	High	Medium	**High-4**
Riverine and Stormwater Flooding	High	Low	**High-5**
Individuals Facing Societal Barriers			
Extreme Heat	High	Medium	**4-High**
Wildfire	High	Medium	**4-High**
Riverine and Stormwater Flooding	Medium	Low	**4-High**
Individuals with Chronic Health Conditions or Health-Related Sensitivities			
Extreme Heat	High	Medium	**4-High**
Wildfire	High	Medium	**4-High**
Landslide	Medium	Low	**4-High**
Riverine and Stormwater Flooding	Medium	Low	**4-High**
Parks and Natural Resources			
Extreme Heat	High	Low	**High-5**
Drought	High	Medium	**High-4**
Wildfire	High	Medium	**High-4**
Landslides	High	Low	**High-5**
Sea Level Rise	High	Medium	**High-4**
Critical Facilities, Buildings, Services, and Infrastructure			
Extreme Heat	Medium	Low	**High-4**
Wildfire	High	Medium	**High-4**
Landslides	High	Medium	**High-4**
Sea Level Rise	High	Low	**High-5**

Climate Hazard	Impact Score	Adaptive Capacity Score	Vulnerability Score
Agriculture			
Extreme Heat	High	Low	**High-5**
Drought	High	Medium	**High-4**
Wildfire	High	Medium	**High-4**
Landslides	High	Low	**High-5**

1 Introduction

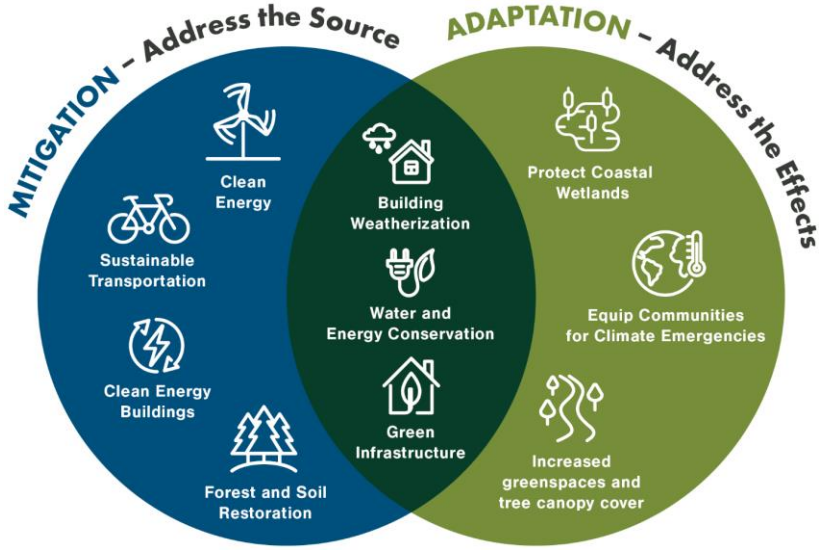
Purpose

This assessment evaluates how climate change will continue to impact vulnerable community members, natural resources and parks and open spaces, agriculture, critical facilities, buildings, services, and infrastructure in unincorporated Sonoma County. Government Code § 65302, as amended by Senate Bill (SB) 379, requires cities and counties across California to prepare a Climate Change Vulnerability Assessment that informs updates to the Safety Element of the General Plan. Understanding Sonoma County's vulnerabilities to climate change provides a foundation to develop required climate adaptation goals, policies, and implementation programs for the Safety Element. The guiding methodology used in this assessment is based on the California Adaptation Planning Guide, which is discussed in Section 2, *Methodology*. Climate change can also be addressed by mitigating the production of greenhouse gas emissions through reduction measures. The difference between climate mitigation and adaptation is further explained in Figure 2.

Causes of Climate Change

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

Figure 2 Climate Change Mitigation and Adaptation



Sonoma County Snapshot

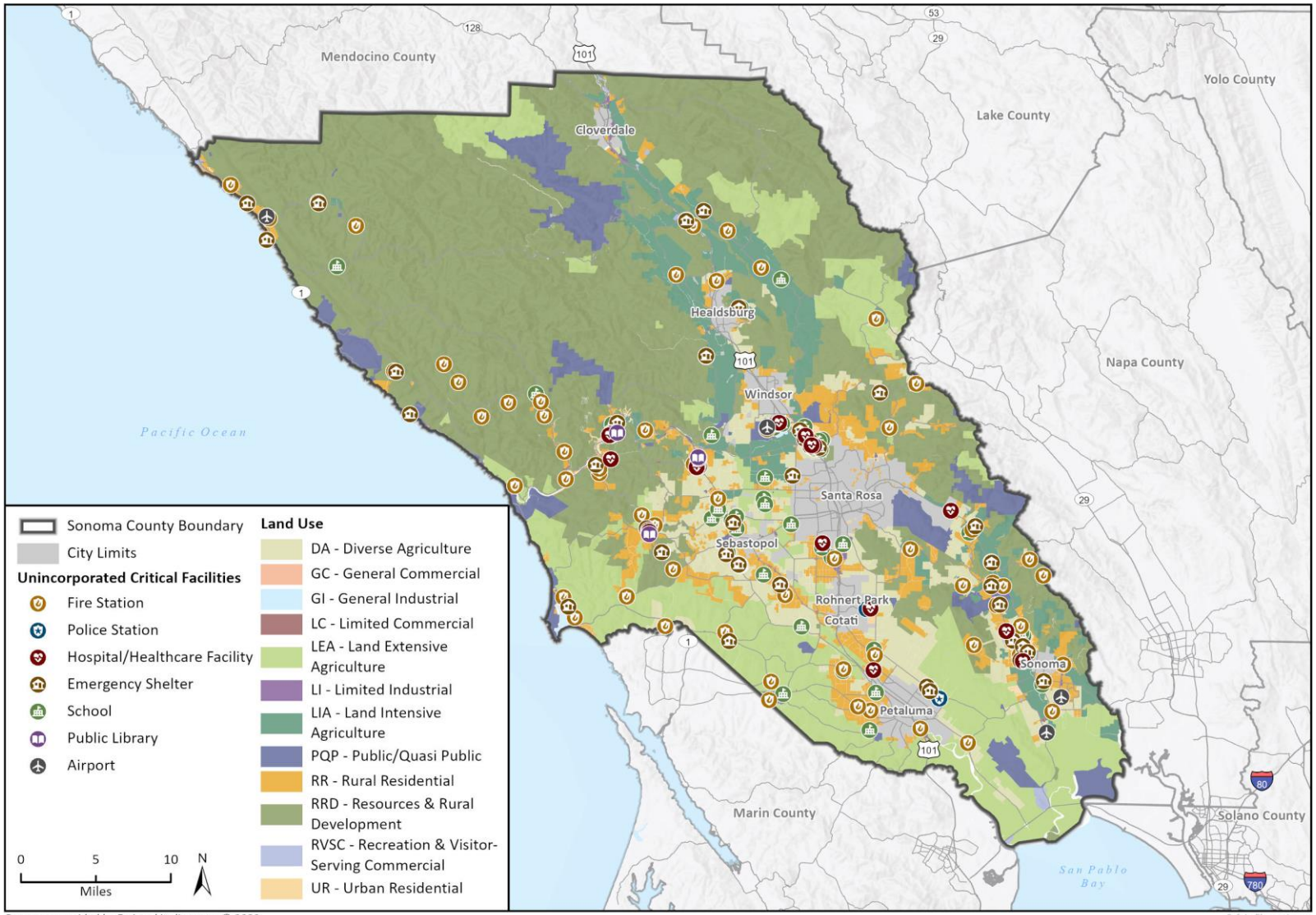
Sonoma County is located at the northern-most edge of the greater San Francisco Bay Area region. The County's 1,515 square miles contain nine incorporated municipalities and 13 unincorporated communities. Sonoma County has the 17th largest County population of California's 58 counties at approximately 494,336 people with major population centers in the cities of Santa Rosa, Petaluma, and Rohnert Park. Sonoma County borders Marin County and San Pablo Bay to the south, Solano, Napa and Lake Counties to the east, Mendocino County to the north, and the Pacific Ocean to the west. U.S. Highway 101 is the main highway in the county, running north to south through the county's center. Other major roadways are State Highways 12, 37, 116, 121 and 128. Airports include Charles M. Schulz–Sonoma County Airport in Santa Rosa and the Sonoma Valley Airport and Sonoma Skypark in the City of Sonoma. Sonoma County Transit buses run countywide. The SMART Train (Sonoma–Marin Area Rail Transit) carries passengers from the Charles M. Schulz–Sonoma County Airport to Larkspur in Marin County; future extensions as far north as Cloverdale are planned.

The County is home to federally owned lands including parks, wildlife areas and other public lands (Sonoma County 2022). The General Plan designates the vast majority of unincorporated Sonoma County as Resources and Rural Development or Agriculture, as can be seen in Figure 3. Existing critical facilities are also shown in Figure 3 and represent facilities necessary for a community's response to and recovery from emergencies. Critical facilities must continue to operate during and following a disaster to reduce the severity of impacts on the community and accelerate recovery.

The following critical facilities are included in this assessment:

- Fires Stations
- Police Stations
- Hospital/Healthcare Facilities
- Emergency Shelters
- Schools
- Public Libraries
- Airports

Figure 3 Sonoma County Critical Facilities and General Plan Land Use Designations



Glossary

Several words and phrases are used throughout the report to illustrate climate vulnerabilities within Sonoma County.

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

Community and Stakeholder Engagement

Incorporating input from the community into the development of this Climate Change Vulnerability Assessment provides critical context for how recent climate-driven events in Sonoma County have impacted critical infrastructure and services and community members. It also serves to identify existing government-run programs within the county and remaining gaps. Interviewing asset managers, technical responders, and frontline responders in Sonoma County elicited information on existing and planned efforts to manage climate change impacts now and in the future. Information shared by stakeholders will further inform climate adaptation policies and programs in the County's Safety Element update and will continue to provide ongoing guidance on implementation strategies that address key community concerns.

Stakeholder Focus Group Interviews

Sonoma County hosted three stakeholder focus group interview sessions to guide and support the development of this assessment. Equity First Consulting hosted a fourth focus group interview to gain insight and knowledge from community experts who were directly involved in serving communities impacted by recent disasters within Sonoma County. Each stakeholder focus group brings unique expertise within Sonoma County. Incorporating this knowledge is critical in understanding the breadth of impacts, vulnerabilities, and existing adaptive capacity in the county. Members from Sonoma County departments, community-based organizations, state and regional partners, and other local key entities include:

- CAL FIRE
- Community Organizations Active in Disaster (Prior Staff)
- Dutton Ranch
- Generation Housing
- Gold Ridge Resource Conservation District
- Greenbelt Alliance
- Health Action Together
- La Luz Sonoma Valley (Prior Staff)
- La Plaza
- North Bay Jobs with Justice
- North Bay Organizing Project
- PG&E (Pacific Gas & Electric)
- Permit Sonoma
- Roseland Community Building Initiative
- Santa Rose-Sonoma County NAACP (National Association for the Advancement of Colored People)
- Sonoma County Climate Action and Resiliency Division
- Sonoma County Community Development Commission
- Sonoma County Department of Health Services
- Sonoma County Economic Development Board
- Sonoma County Emergency Operations Center
- Sonoma County Farm Bureau
- Sonoma County Fire District
- Sonoma County Permit & Resource Management Department
- Sonoma County Public Infrastructure
- Sonoma County Regional Climate Protection Authority
- Sonoma County Regional Parks
- Sonoma County Sheriff's Office
- Sonoma Immigrant Services

- Sonoma Resource Conservation District
- Sonoma Valley Community Health Center
- Sonoma Water
- Transportation Land Use Coalition

The stakeholder focus group interviews were hosted on December 12, 2022, December 20, 2022, January 20, 2023, and August 22, 2023. The County provided the focus group attendees with an overview of climate change projections. Attendees provided input on their primary climate hazards of concern, experiences during recent regional climate hazard events, barriers faced when preparing for and/or responding to climate hazards, and plans, programs, and resources they engage with that increase their adaptive capacity. This assessment includes key findings from the stakeholder focus group interviews, which are integrated primarily in Section 5, *Vulnerability Analysis*. Summaries of the stakeholder focus group interviews are included as Appendix A.

Equity Working Committee

Sonoma County assembled an Equity Working Committee to help shape environmental justice policies and risk reduction planning for wildfire and other hazards by centering the expertise of under-resourced communities. The Equity Working Committee is an advisory group of community members that are invested in developing climate adaptation and environmental justice solutions that meet the needs of the diverse communities in Sonoma County. The Equity Working Committee provided critical feedback on the social sensitivity index and populations made sensitive by systems in Sonoma County, which are discussed in Sections 4 and 5 below.

Safety Element Survey

A safety element survey was distributed to the public to understand how the community has been impacted by climate change, their perceptions of climate change, how they are preparing, and what barriers they have faced to preparing for more extreme weather events as the result of climate change. The survey responses provided insight into the community's understandings and perceptions of climate change. Common themes from the survey are incorporated primarily in Section 5, *Vulnerability Analysis*. Summaries and responses for each survey question can be found in Appendix C.

Existing Climate Efforts and Alignment

The Sonoma County Board of Supervisors adopted a Climate Change Action Resolution on May 8, 2018 (Resolution Number 18-0166). This Resolution is intended to support a countywide framework for coordinated implementation of greenhouse gas reduction measures. The Resolution identifies that monitoring climate change, and its effects is an important action to help Sonoma County in its goal to increase resilience. This assessment supports that directive. It builds upon and complements the County's earlier climate efforts with a focus on understanding local vulnerabilities to inform the development of adaptation and resilience strategies for the Sonoma County General Plan Safety Element update.

Current climate action work within the County organization is largely guided by the Sonoma County Regional Climate Protection Authority (RCPA) and the County Administrator's Office Climate Action and Resiliency Division (CARD). The RCPA was formed in 2009 through locally sponsored State legislation to coordinate countywide climate protection efforts among Sonoma County's nine incorporated jurisdictions and multiple countywide agencies. The

RCPA coordinates the activities of local jurisdictions with regional, state, and federal entities at both policy and administrative levels across three primary areas of focus: decarbonization, carbon sequestration, and resilience. The RCPA performs a variety of important functions including advocacy, project management, planning, finance, grant administration, and research. CARD helps the County organization implement the goals and objectives within the Climate Action and Resiliency Pillar of the County's 2021-2026 Strategic Plan.

CARD's Climate Resilient Lands Strategy helped inform this assessment. The Climate Resilient Lands Strategy centers on increasing the resilience of the County's natural and working lands through conservation, land management, restoration, and more. It provides useful information on potential climate impacts on natural and working lands through an ecological lens and can be used in complement to this assessment for a more comprehensive understanding of the County's vulnerability to climate change. Where relevant, this assessment notes when the Climate Resilient Lands Strategy can provide additional information.

The County's Multi-Jurisdictional Hazard Mitigation Plan (MJHMP), updated in 2021, provides a comprehensive overview of hazard risk and exposure countywide, describes adaptive capacity, and identifies ways to minimize risks. While the MJHMP's primary focus is the current risk that hazards pose, it also provides a brief discussion on how climate change will exacerbate existing hazard risk. The MJHMP informed aspects of the exposure, impacts, and adaptive capacity components of this assessment.

2 Methodology

Introduction

This section describes the methodology used to develop the Sonoma County Climate Change Vulnerability Assessment. It includes reference to key guidance documents and data used to inform this assessment. The methodology used to generate the Social Sensitivity Index is discussed, as well as the vulnerability scoring approach used to rank the vulnerability of community members, assets, and critical facilities and services.

California State Law on Climate Change

Government Code Section 65302 (as amended by Senate Bill 379) requires cities and counties to prepare a climate change vulnerability assessment as part of an update to the General Plan Safety Element. The information that must be included in a climate change vulnerability assessment is stipulated in Section 65302 (g)(4)(A)(ii), and included below:

- Information from the internet-based Cal-Adapt tool.
- Information from the most recent version of the California Adaptation Planning Guide.
- Information from local agencies on the types of assets, resources, and populations that will be sensitive to various climate change exposures.
- Information from local agencies on their current ability to deal with the impacts of climate change.
- Historical data on natural events and hazards, including locally prepared maps of areas subject to previous risk, areas that are vulnerable, and sites that have been repeatedly damaged.
- Existing and planned development in identified at-risk areas, including structures, roads, utilities, and essential public facilities.
- Federal, state, regional, and local agencies with responsibility for the protection of public health and safety and the environment, including special districts and local offices of emergency services.

This assessment follows the requirements per Government Code Section 65302.

California Adaptation Planning Guide

This assessment follows the vulnerability assessment process recommended by the California Governor's Office of Emergency Services, as documented in the 2020 California Adaptation Planning Guide (Cal APG). The adaptation planning process outlined by the Cal APG consists of four phases, illustrated in Figure 4 below, with Phase 1 and 2 focused on the vulnerability assessment process (Cal OES 2020). The Sonoma County Climate Change Vulnerability Assessment is prepared consistent with applicable portions of Phase 1 as well as the entirety of Phase 2 of the Cal APG and is composed of the sections outlined in Figure 5. The County's development of climate adaptation strategies for incorporation into the General Plan's Safety Element will occur consistent with Phase 3. The County's implementation of the policies and programs in the General Plan's Safety Element is associated with Phase 4 and will continue until the County's next update to the General Plan Safety Element.

Figure 4 California Adaptation Planning Guide Phases

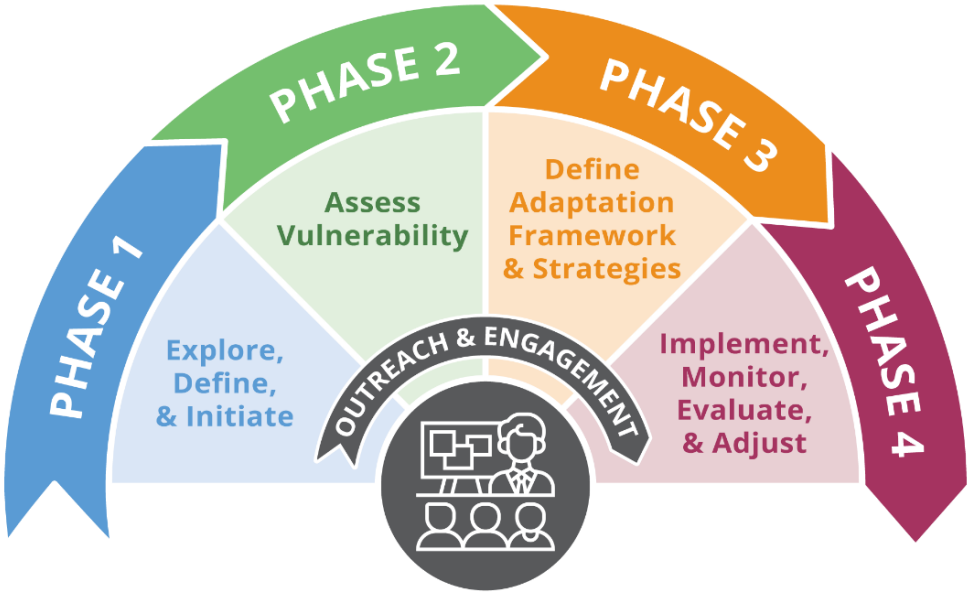
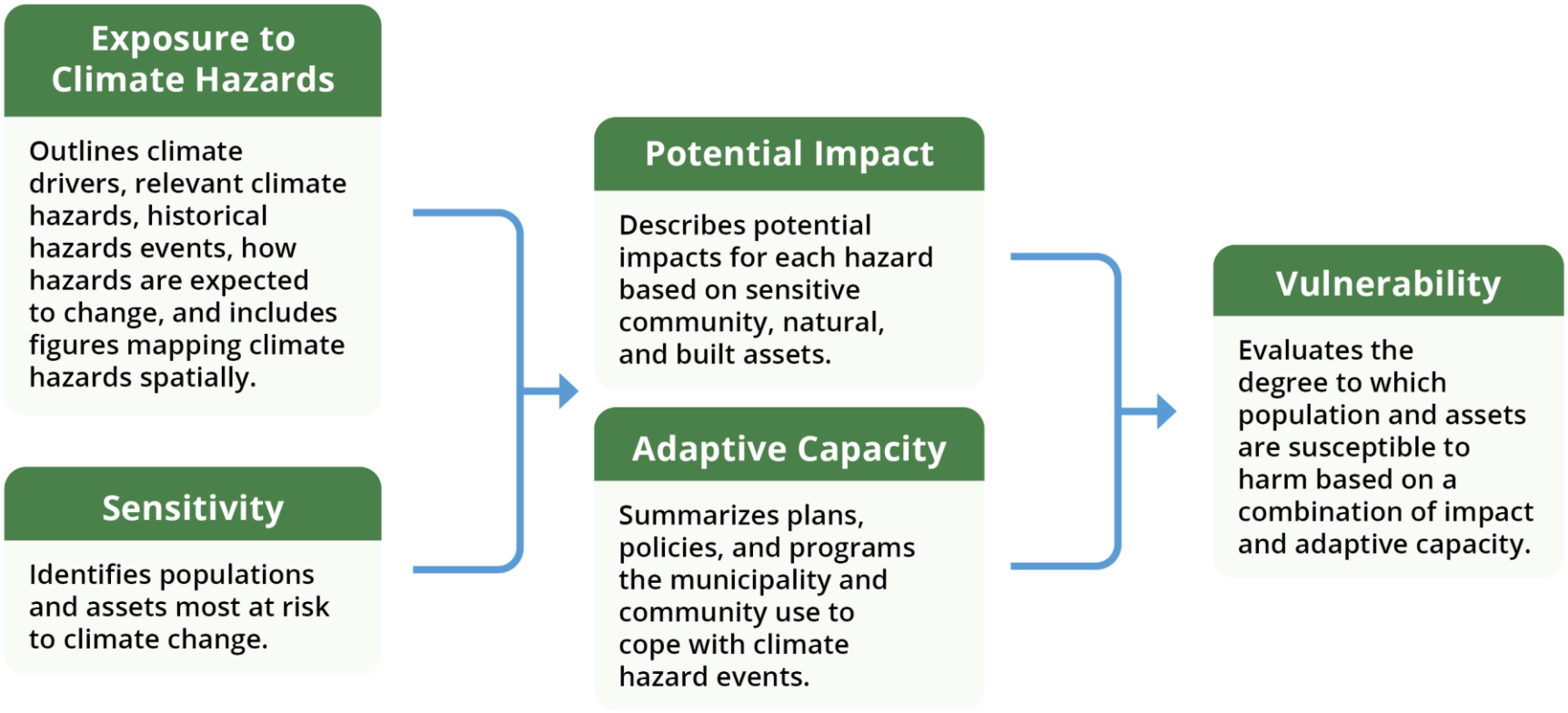


Figure 5 Steps under Phase 2 Assess Vulnerability of Cal APG



Key Data Sources

The following data sources and tools, many of which are recommended within the Cal APG, were used in preparation of this assessment.

- **Cal-Adapt 2.0** is an online tool that presents historic and modeled projections based on 10 different global climate models. The tool was developed and is maintained by the University of California, Berkeley Geospatial Innovation Facility with funding and oversight by the California Energy Commission (CEC). This tool was used to present projection data related to minimum and maximum temperature, precipitation, extreme heat, warm nights, drought, and wildfire (CEC 2021).
- **California's Fourth Climate Change Assessment** was developed by the CEC and other State of California coordinating agencies to present up-to-date climate science, projections and potential impacts associated with climate change. The CEC and coordinating agencies developed nine regional reports to provide regional-scale climate information to support local planning and action. The San Francisco Bay Area Region Summary Report (2018) presents an overview of climate science, regional projections, specific strategies to adapt to climate impacts, and key research gaps needed to spur additional progress on safeguarding the San Francisco Bay Area Region from climate change. The San Francisco Bay Area Region Summary Report was used to understand regional changes that may affect Sonoma County both directly and indirectly (Ackerly et al. 2018).
- **Sonoma County Climate Resilient Lands Strategy** is a non-regulatory framework for how the County and its partners can conserve, manage, and restore natural and working lands to build climate resilience. The Strategy provides an overview of climate hazards, describes Sonoma County land types and eco-regions, and offers recommendations and guidance for the planning, design, and implementation of resilience-related projects. The Strategy was used as background…
- **Sonoma County Multi-Jurisdictional Hazard Mitigation Plan** presents information on existing processes and plans in place that address Sonoma County's ability to prepare for climate change impacts and informed the adaptive capacity discussion of this assessment. The Multi-Jurisdictional Hazard Mitigation Plan (2021) was also used to identify recent historical events, determine hazard exposure, and characterize the vulnerability of certain assets. It also contains sites in Sonoma County that have been repeatedly damaged by climate hazards, as required by Government Code 65302 (g)(4) (A)(ii).
- **U.S. Census, 2021 American Community Survey** presents demographic data by census tract. U.S. Census data was used to identify the Sonoma County population and household statistics that correspond with the Social Sensitivity Index and people made sensitive by systems (see more information below).
- **The Center for Disease Control's (CDC) PLACES Health Data (2021)** presents health demographic data by census tract. CDC PLACES Health Data was used to identify the Sonoma County population health statistics that correspond with the Social Sensitivity Index and people made sensitive by systems.
- **United States Geological Survey Costal Storm Modeling System** is used for future scenarios related to sea level rise, coastal flooding, storm flooding, and erosion. The tool is intended to provide publicly accessible information for increased public resilience, mitigation efforts, and management of resources along the coast.
- **U.S. Department of Energy Low-Income Energy Affordability Data (LEAD)** presents population data on low- and moderate-

income households that carry a disproportionate energy burden, as included in the Social Sensitivity Index.

- **U.S. Department of Housing and Urban Development Comprehensive Housing Affordability Strategy (CHAS)** data was used to identify housing burdened households in Sonoma County, as included in the Social Sensitivity Index.

Data Limitations

The limitations of this assessment and analysis stem from gaps in data availability and completeness of data methods. Census data can miss portions of the population (e.g., homeless populations, undocumented immigrants), which results in general demographic information not fully identifying the extent of populations vulnerable to climate change (Cantwell 2021). Federal Emergency Management Agency (FEMA) 100-year and 500-year flood plains do not account for climate change projections; zones are instead based on historical information. The California Department of Forestry and Fire Protection (CalFire) Hazard Severity Zones are based on vegetation, fire history, and terrain but also have similar limitations in not projecting fire zones into the future based on changing climate conditions (OSFM 2022). Extrapolating landslides in the context of climate change is difficult and the estimates of exposure to these hazards are likely to be underestimated (Fernandez-Bou et al. 2021).

The data presented in Cal-Adapt tools are projections, or estimates, of future climate conditions. The limitation in these projections is that the long-term behavior of the atmosphere is expressed in averages – for example, average annual temperature, and average monthly rainfall. The averages discussed often downplay the extremes by which daily weather events occur and when presented as an average, only show moderate changes within the climate. What is often lost in averages is that the frequency of extremes, like atmospheric rivers, may increase while low-moderate intensity weather events decrease through the end of the century. In instances of modeled precipitation projections, it maintains an average similar to historic levels which does not account for anticipated fluctuations in extremes (CEC 2021).

Social Sensitivity Index Methodology

The presence and overall distribution of sensitive populations in unincorporated Sonoma County were identified based on U.S. Census ACS data and CDC PLACES Health data. This assessment follows Cal APG's methodology for identifying and analyzing sensitive populations.

A social sensitivity index was developing using 23 population data indicators (e.g., race, income status) listed in Table 4 in the Sensitivity section below. To develop the social sensitivity index, an analysis was conducted to identify the concentration of each indicator within unincorporated Sonoma County census tracts. Each indicator statistic was compared against the state-wide average and then standardized into a Z-score for each census tract. A z-score is a statistical measurement that describes a value's relationship to the mean of a group of values. Z-score is measured in terms of standards deviations[2] from the mean[3]. If a Z-score is 0, it indicates that the data point's score is identical to the mean score. If a Z-Score is 1, it indicates that the data point is one standard deviation from the mean. Z-scores were averaged for each census tract and then converted into the social sensitivity index percentile, which

[2] Standard deviation is a statistic that measures the dispersion of a dataset relative to its mean and is calculated as the square root of the variance.

[3] Mean refers to the average of a set of values.

ranges from 0% to 100%. Using a Z-Score methodology shows where each census tract is positioned within the data distribution of social sensitivity in Sonoma County. Unincorporated County census tracts with high proportions of populations made sensitive by systems, relative to State statistics, have higher percentile rankings on the 0% to 100% scale.

In addition to the social sensitivity index, census tracts identified as Environmental Justice Communities are included in this assessment. The methodology for identifying Environmental Justice Communities can be found in the Environmental Justice Technical Report (Sonoma County Environmental Justice Technical Report 2023).

Vulnerability Scoring Methodology

The vulnerability score is a combination of the impact score and adaptive capacity score. The impact and adaptive capacity scores are developed using a qualitative methodology outlined in the Cal APG, as shown in the scoring rubric in Table 2. Impact and adaptive capacity scores are identified for community members, assets, and critical facilities and services for each climate hazard.

The vulnerability score is prepared by combining the impact score and the adaptive capacity score as demonstrated in Table 3. The range of potential impacts spans 1 through 5 with 1 being low, 2-3 being medium, and 4-5 being high vulnerability. Vulnerability scores are assigned by hazard under each asset group in Section 5, *Vulnerability Analysis*.

Table 2 Impact and Adaptive Capacity Scoring Rubric

Score	Impact	Adaptive Capacity
Low	Impact is unlikely based on projected exposure; would result in minor consequences to public health, safety, and/or other metrics of concern.	The population or asset lacks capacity to manage changes; major changes would be required due to a lack of adopted Sonoma County or utility plans and programs.
Medium	Impact is somewhat likely based on projected exposure; would result in some consequences to public health, safety, and/or other metrics of concern.	The population or asset has some capacity to manage climate impact; some changes would be required. There are some adopted Sonoma County or utility plans and programs, but strategies are not specific.
High	Impact is highly likely based on projected exposure; consequences to public health, safety, and/or other metrics of concern.	The population or asset has high capacity to manage climate impact; minimal to no changes are required. Sonoma County and utilities have adopted plans and programs in place that include specific strategies and projects that are actively being implemented.

Source: Cal OES 2020

The impact and adaptive capacity scores are combined to form the vulnerability score based on the approach presented in Table 3, which is consistent with methodology from Cal APG.

Table 3 Vulnerability Score Matrix

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

Source: Cal OES 2020

3 Exposure to Climate Hazards

Climate change is a global phenomenon that can impact local health, natural resources, parks, infrastructure, emergency response, and many other aspects of society. Projected changes to the climate are dependent on location. The Cal-Adapt tool provides climate data from global scale models that have been localized (downscaled) to 3.7 mile by 3.7-mile grids (CEC 2021). The data in Cal-Adapt specific to Sonoma County is combined with information from the California Fourth Climate Change Assessment San Francisco Bay Area regional report to describe projected future changes for specific types of hazards. Projections throughout this section are presented consistent with the Governor's Office of Planning and Research (OPR) using Representative Concentration Pathway (RCP) 8.5 as a conservative approach to assessing and adapting to climate change (CEC 2021). RCP 8.5 is a high greenhouse gas emissions scenario in which global emissions continue to rise through the end of the 21st century.

Additionally, projections are forecasted to mid-century (2035-2064) and end-of-century (2070-2099) as 30-year averages and are compared to a modeled historical baseline (1961-1990) (CEC 2021). Sea-level rise projections are presented based on United States Geological Survey CoSMoS data, consistent with the California Coastal Commission's most recent 2018 Sea Level Rise Policy Guidance document.

The Methodology section provides a more detailed discussion of data sources used to inform the preparation of this assessment.

This section presents information on temperature and precipitation, which are characterized as climate drivers. The Hazard Exposure section provides information on projected changes to extreme heat, drought, wildfire, landslides, riverine and stormwater flooding, and sea level rise resulting from changes to the climate drivers. Chapter 3 and Appendix E of the Sonoma County Climate Resilient Lands Strategy similarly outlines historical and projected impacts of a warming climate, changing rainfall patterns, drought, wildfire, and sea level rise, with a particular emphasis on ecosystems. The projections in the Resilient Lands Strategy and this Vulnerability Assessment both align with models that assume the RCP 8.5 emissions scenario.

Climate Drivers

In Sonoma County, the climate drivers of concern include Temperature and Precipitation.

Temperature

Sonoma County has an average baseline maximum temperature of 69.2°F and an average baseline minimum temperature of 42.8°F (CEC 2021). The average maximum and minimum temperatures are expected to increase, which will shift the temperature range by up to 3.9°F by mid-century projections shown in Figure 6, and 7.0°F (RCP 8.5) through the end of the century as shown in Figure 7 (CEC 2021). Change in temperature is observed spatially with greatest increases occurring mainly in central Sonoma County, roughly east of highway 101.

Temperature increases influence extreme heat, drought, and wildfire (discussed under Hazard Exposure below).

Figure 6 Change in Annual Average Maximum Temperature, Mid-Century

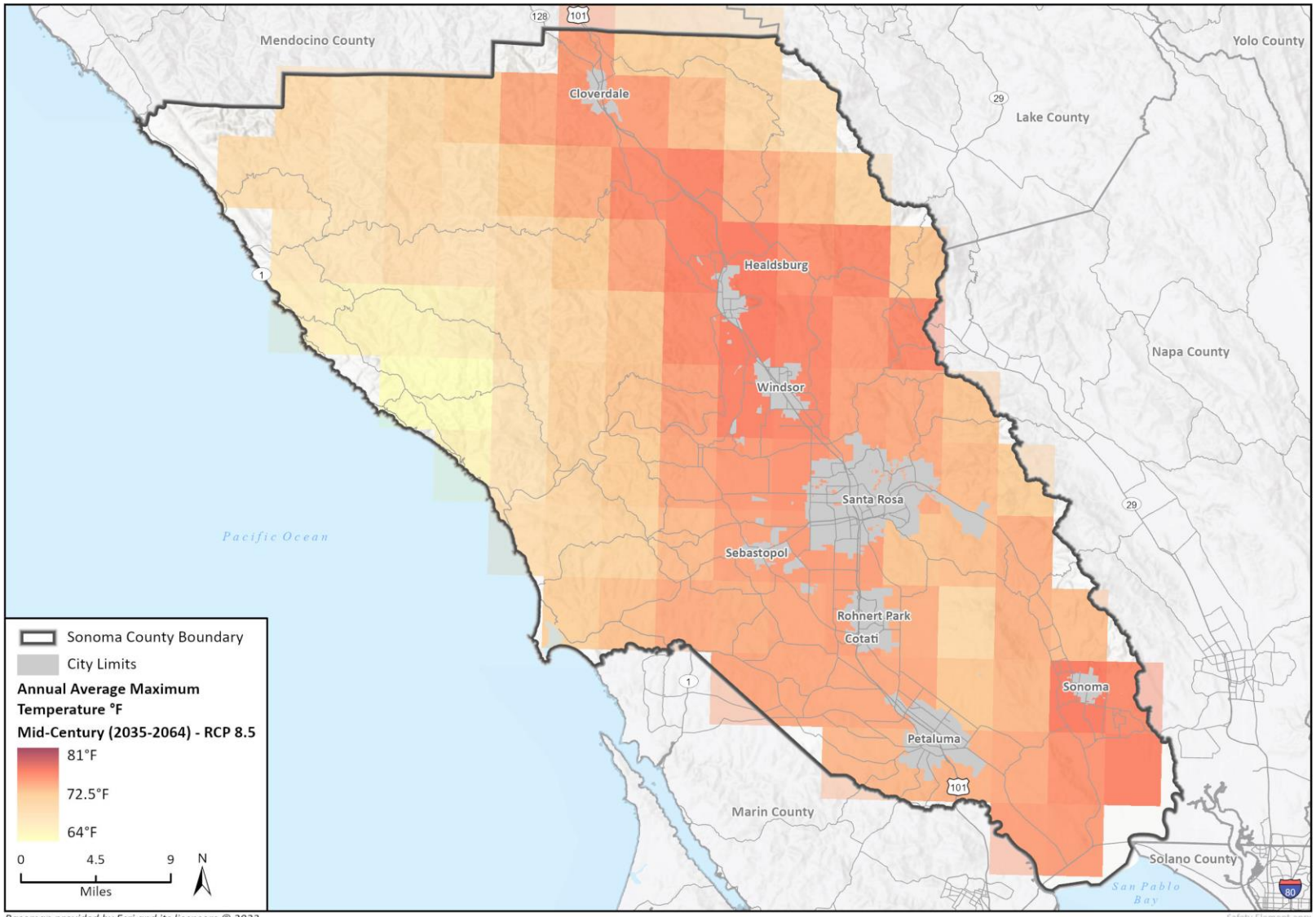
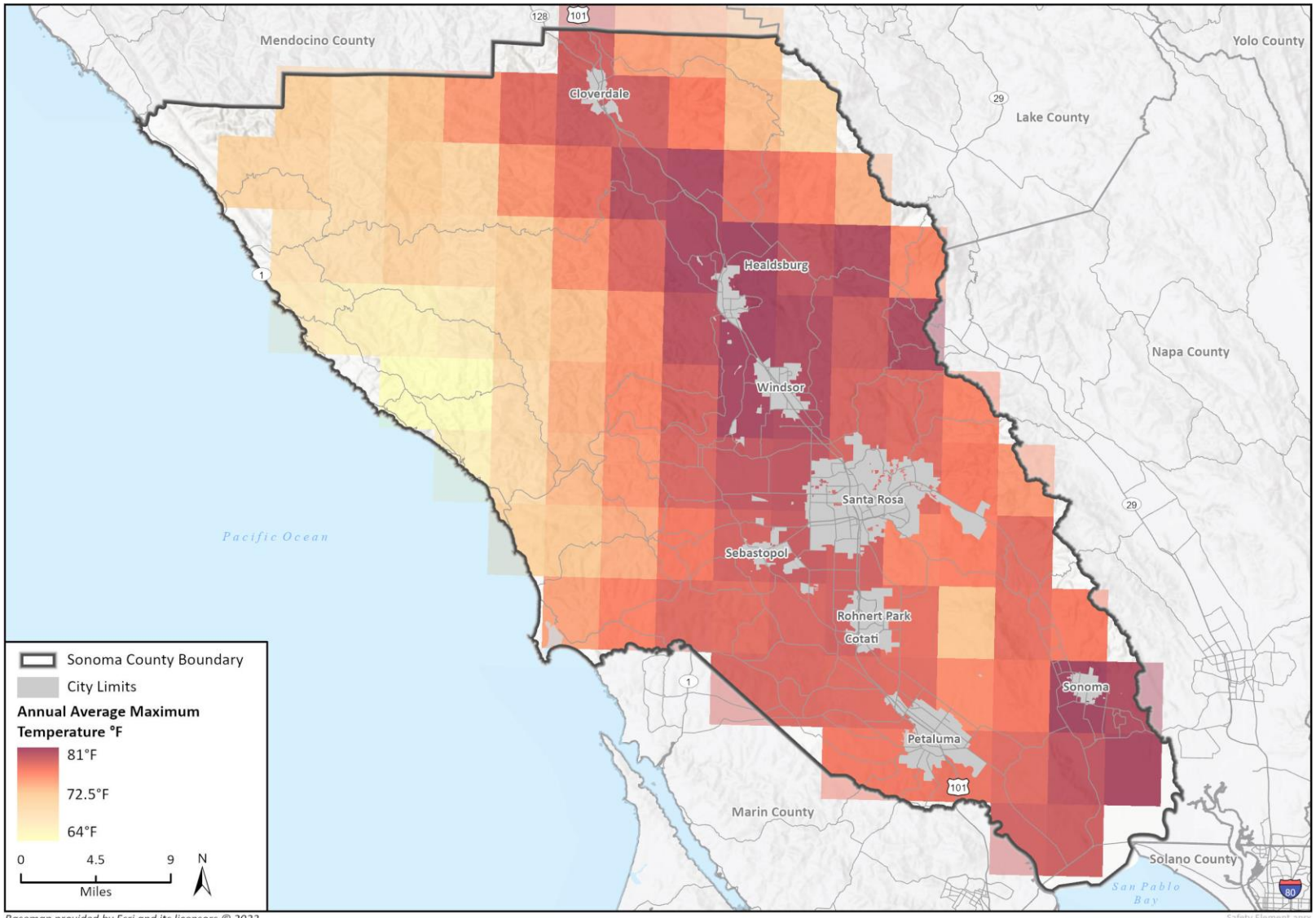


Figure 7 Change in Annual Average Maximum Temperature, End-of-Century



Precipitation

Increased intensity of precipitation events is expected for the greater San Francisco Bay Area, including Sonoma County, through the end of the century. It is projected that more precipitation will occur during extreme storms with wet extremes occurring more often and with greater intensity (Ackerly et al. 2018). The projections show that there will be more dry periods punctuated by increased precipitation intensities of the largest storms or wet periods, producing little net change in precipitation totals but more extreme conditions (Ackerly et al. 2018). Precipitation changes are expected to affect the occurrence of hazards events, including wildfire, drought, landslides, and riverine stormwater flooding. Historically, the northern coastal mountains of Sonoma County experience the largest precipitation events across the San Francisco Bay Area region and can expect up to a 37% increase in rainfall volume by the end of the century (Ackerly et al. 2018).

Sonoma County precipitation projections under RCP 8.5 demonstrate a 1.6-inch mid-century increase and a 3.7-inch end century increase in annual precipitation totals (CEC 2021). However, as already observed in recent decades precipitation changes are largely experienced as more extreme variability with intensely wet years followed by extreme droughts (Ackerly et al. 2018). It is projected that the wettest day every year will reflect an increase in rain volume by the end of the century in the San Francisco Bay Area region (Ackerly et al. 2018).

This translates into longer dry seasons with less precipitation on average that may lead to increased groundwater pumping to compensate for the diminished surface water supplies.

Hazard Exposure

Changes in temperature and precipitation are expected to influence the frequency, duration, and magnitude of the following climate hazards. The following pages present key climate data in both graph and map formats based on Cal-Adapt, USGS, CAL FIRE, FEMA, and US Census data. Information is also included on major historical events. High level impacts on key assets and community members are provided, however refer to see Section 5, *Vulnerability Analysis*, for a more detailed impacts discussion.

The Sonoma County Multi-Jurisdictional Hazard Mitigation Plan (Volume 1) includes more quantitative details on the exposure of population, property, and critical facilities to various hazards countywide. The Resilient Lands Strategy also provides a percentage breakdown of hazard exposure by ecoregion (e.g., Bodega Coastal Hills, Sonoma-Mendocino Mixed Forest) as they are defined within the Strategy.


Extreme Heat


Drought


Wildfire


Landslides


Riverine and Stormwater Flooding

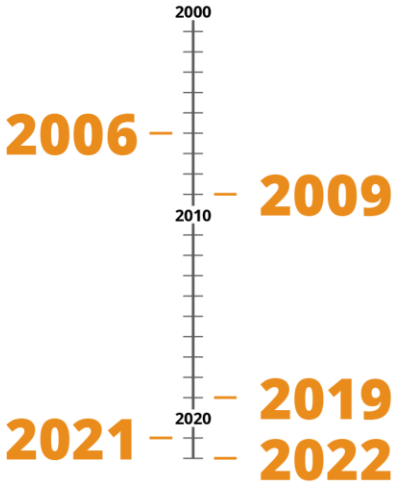

Sea Level Rise

EXTREME HEAT

PAST

Extreme heat events across the state have presented historic challenges for all communities (Sonoma County MJHMP 2021a).

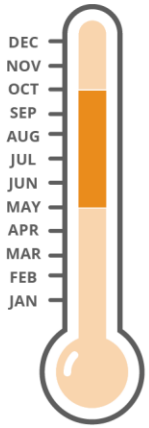
Extreme Heat Events



PRESENT

Extreme heat events are presently defined as days in which the temperature exceeds the 98th percentile of 93.9°F. Current extreme heat days occur between the months of May to October while the 30-year baseline average is 4 days annually (CEC 2021).

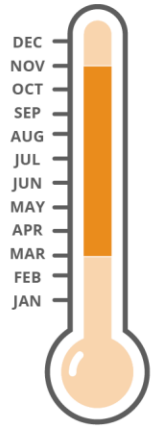
Extreme Heat Months
(Baseline Years)



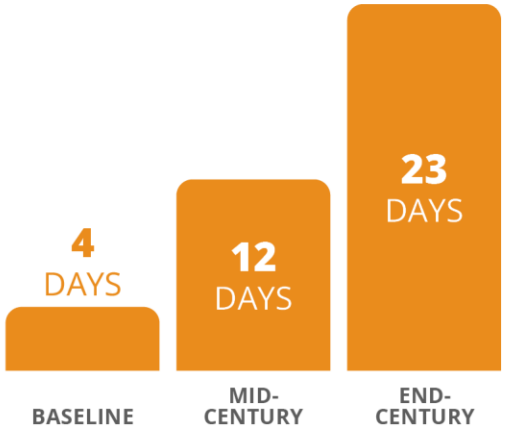
FUTURE

Extreme heat is expected to impact all of Sonoma County, with the greatest impacts on vulnerable populations, agricultural lands, and parks and natural resources. Days above 93.9 degrees F are projected to increase from 4 days a year to 23 days a year, an almost five-fold increase. Extreme heat days will occur during a wider range of months, from March to November (CEC 2021).

Extreme Heat Months
(Mid & End-century Years)



Projected Annual Average of Extreme Heat Days



IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT

- REDUCED CROP YIELD
- CRACKED PAVEMENT
- GRID OVERLOAD
- VEGETATIVE STRESS
- STRAINED EMERGENCY SERVICES

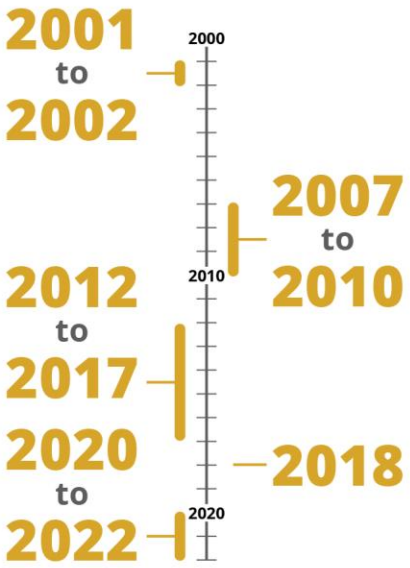
IMPACTS ON ENVIRONMENTAL JUSTICE COMMUNITIES AND OTHER COMMUNITY MEMBERS

- DEHYDRATION
- HEAT STROKE
- HEALTH-RELATED MORTALITY
- HEART DISEASE
- RESPIRATORY ILLNESS
- MENTAL AND BEHAVIORAL HEALTH

DROUGHT

PAST

Over the past two decades, Sonoma County has experienced more frequent and longer contiguous droughts (NOAA 2023).



PRESENT

All of Sonoma County is vulnerable to droughts which have the potential to impact all community members through water restrictions, economic losses, and increased energy costs (Sonoma County MJHMP 2021a).

During the Fall of 2022

483,878

People in Sonoma County were Affected by Drought

74% **Community Categorized as D2**

26% **Community Categorized as D3**

D0 ABNORMALLY DRY

D1 MODERATE DROUGHT

D2 SEVERE DROUGHT

D3 EXTREME DROUGHT

D4 EXCEPTIONAL DROUGHT

FUTURE

The average annual maximum length of dry spell is projected to increase by 12 days by the end of the century (CEC 2021).

Projected Annual Average Dry Spell Duration

IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT

- VEGETATIVE STRESS
- WATER SCARCITY
- HABITAT LOSS

IMPACTS ON ENVIRONMENTAL JUSTICE COMMUNITIES AND OTHER COMMUNITY MEMBERS

- FOOD SECURITY
- AIR QUALITY DECLINES
- RESPIRATORY ILLNESS
- MENTAL AND BEHAVIORAL HEALTH
- INCOME LOSS

ADDITIONAL AFFECTED ASSETS

- PUBLIC WATER SYSTEMS
- SMALL WATER SYSTEMS
- PRIVATE WELLS

WILDFIRE

PAST

The frequency and intensity of wildfires have increased significantly within Sonoma County over the past two decades (Sonoma County MJHMP 2021a).

Sonoma County Fires Since 1996

Year	Fire Name	Acres Burned	Structures Burned
2020	Glass	67,484	661
2020	LNU Lightning Complex *(Wallbridge and Meyers)*	57,563	303
2019	Kincade	77,753	371
2017	Tubbs	36,807	5,643
2017	Sonoma Complex Fires *(Tubbs, Nuns, Pocket, Presley, Young)*	86,039	5,636
2015	Valley	76,067	1,955
2013	McCabe	3,505	-
2008	Pine	989	0
2008	85	322	0
2004	Geysers	12,000	6
2000	Berryessa	5,731	15
1999	Geyser Road	1,300	0
1996	Cavedale	2,100	0
1996	Porter Creek	300	0

PRESENT

Wildfires can be catastrophic, damaging forests and habitat, destroying homes and businesses, disrupting Essential Services, and damaging critical infrastructure (Sonoma County MJHMP 2021a). There are 13 Environmental Justice Community census tracts and 3 Environmental Justice Tribal Communities that overlap State Responsibility Area Fire Hazard Severity Zones in the County.

Number of People in Wildfire Hazard Areas

220,253

Number of Households in Wildfire Hazard Areas

88,072

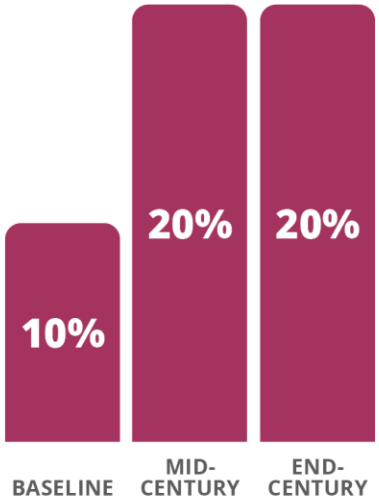
Exposed Structures in Fire Hazard Severity Zones

	Moderate, High, Very-High
Number of Buildings Exposed	32,218
Total Exposed Value as % of Planning Area Total	28.4%

FUTURE

Wildfire risk is projected to increase through the end of the century with more days of extreme wildfire risk and increased wildfire occurrence (CEC 2021).

Projected Annual Wildfire Probability



IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT

- WORSENING AIR QUALITY
- WORSENING WATER QUALITY
- POWER DELIVERY DISRUPTION
- STRUCTURE & PROPERTY DAMAGE
- PUBLIC HEALTH & SAFETY RISKS
- HABITAT LOSS
- STRAINED EMERGENCY SERVICES
- REDUCED CROP YIELDS

FACTORS AFFECTING WILDFIRES

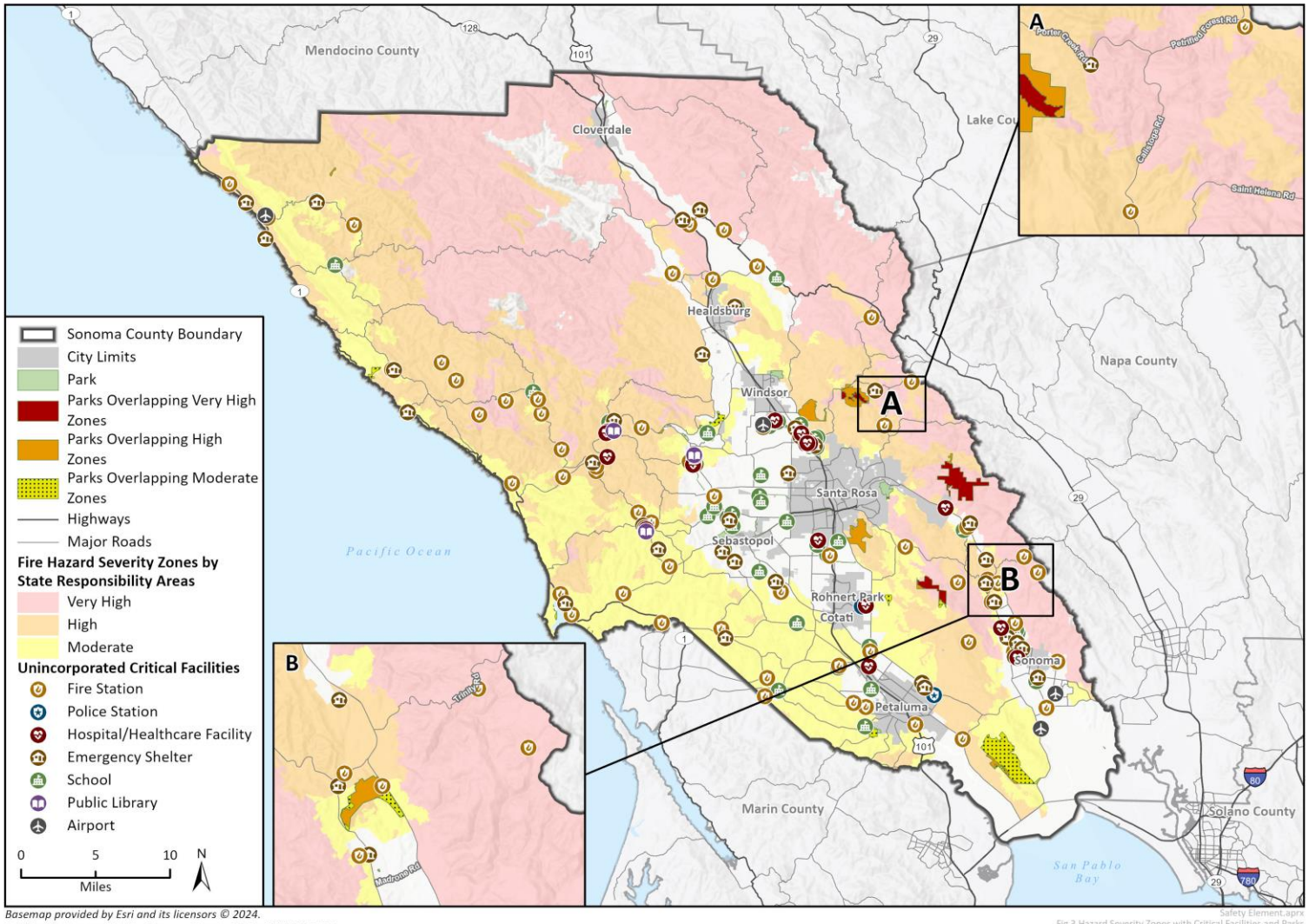
- WEATHER
- TOPOGRAPHY
- VEGETATION AND FUELS
- FIREFIGHTING RESOURCES

PROJECTED CHANGE IN ANNUAL AVERAGE AREA BURNED

BASELINE	MID-CENTURY	END-CENTURY
3,907 ACRES	5,790 ACRES	7,476 ACRES

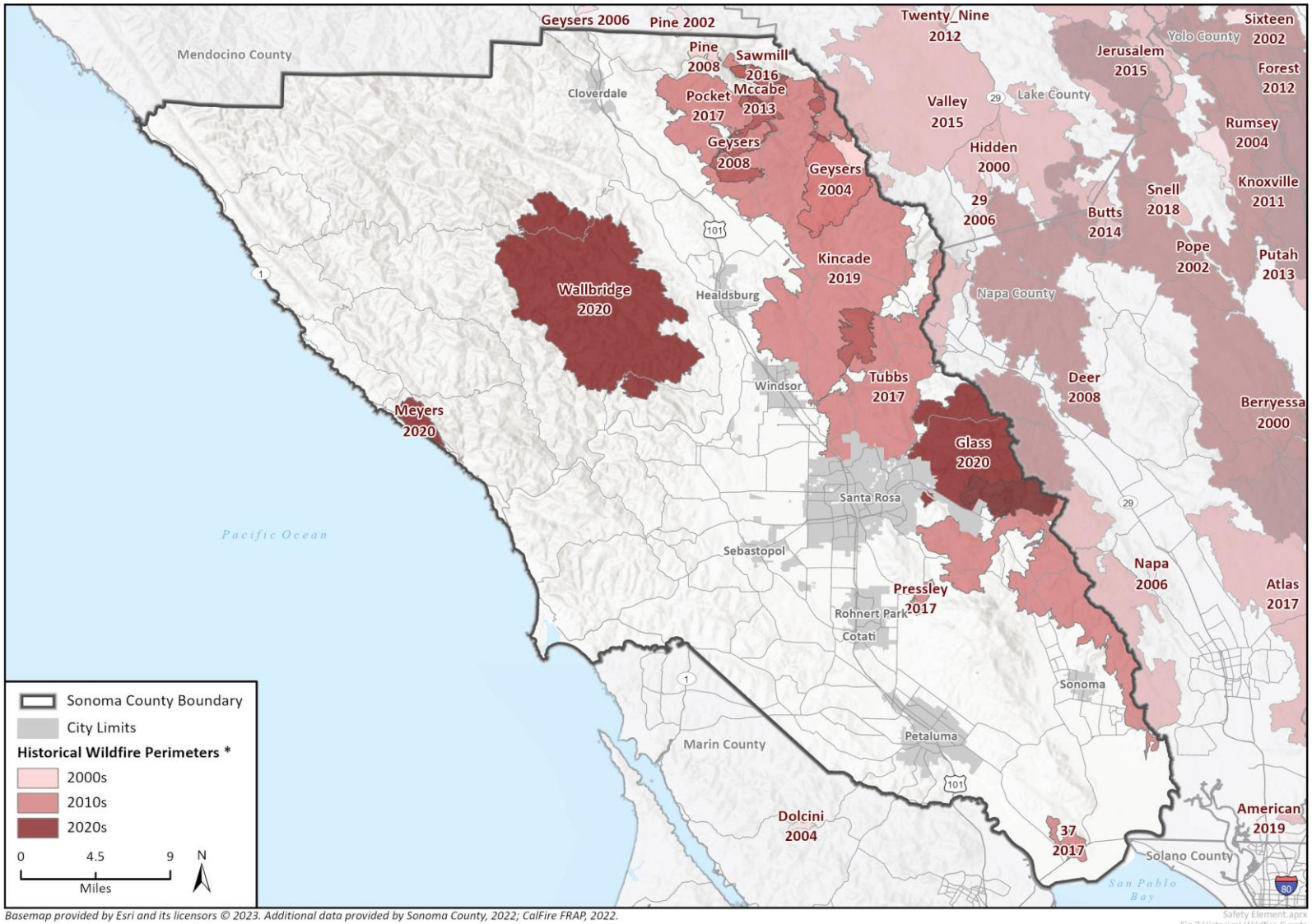
The majority of Sonoma County is at risk to wildfire with varying severity of risk. Sonoma County Communities within Very High Fire Hazard Severity Zones are: Cloverdale, Geyserville, Glen Ellen, Kenwood, and Stewarts Point (CEC 2021).

Figure 8 CALFIRE Wildfire Hazard Severity Zones in Sonoma County[1]



[1] CALFIRE's Fire Hazard Severity Zones Map is utilized to depict fire hazard in this Vulnerability Assessment to align with state law requirements for Safety Elements. Other local tools to evaluate wildfire hazard and risk include the Sonoma County Wildfire Hazard Index and Wildfire Risk Index developed in part to support the recent update to the County's Community Wildfire Protection Plan.

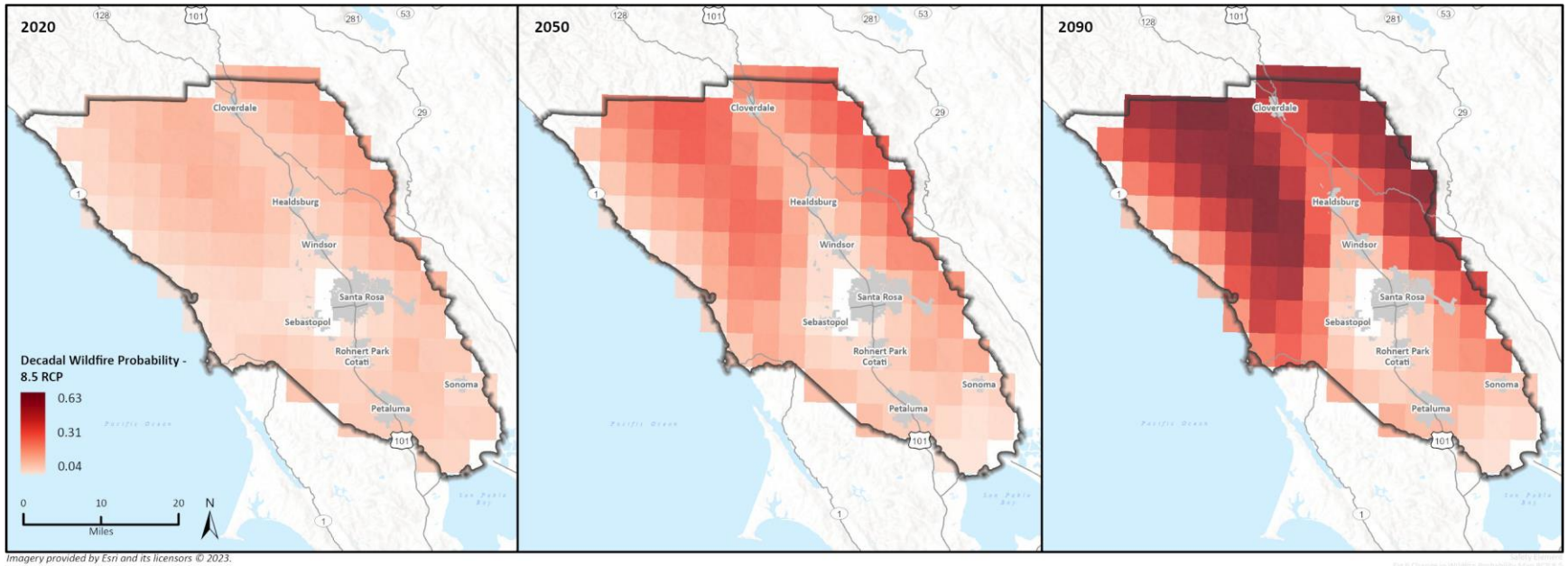
Figure 9 Historical Wildfire Perimeters in Sonoma County



Basemap provided by Esri and its licensors © 2023. Additional data provided by Sonoma County, 2022; CalFire FRAP, 2022.
** Fires less than 200 acres were excluded.*

Safety Element.aprx
Fig 7 Historical Wildfire Events

Figure 10 Change in Decadal Wildfire Probability in Sonoma County



LANDSLIDES

PAST

Landslide occurrences have historically affected Sonoma County during extreme precipitation events preceded by intense wildfire (Sonoma County MJHMP 2021a).

Major Landslide Occurrences by Year

2005	1
2006	1
2012	2
2017	2
2019	1

PRESENT

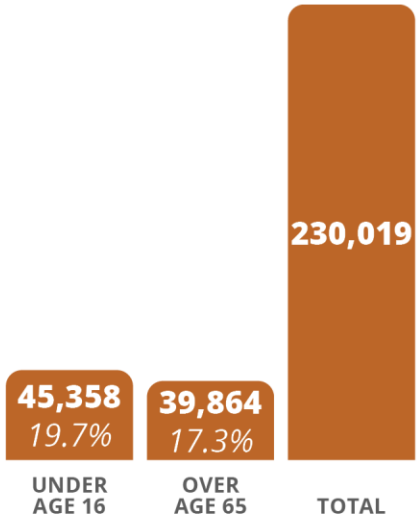
The highest risk of landslides are in areas with steep geography, as mapped by the California Department of Conservation. Wildfires can trigger heightened short-term landslide or mudflow risk in fire-scarred areas (Sonoma County MJHMP 2021a).

Population Exposed	Number of Buildings Exposed
54,240 Moderate Landslide Risk	**21,473** Moderate Landslide Risk
51,796 High Landslide Risk	**24,283** Moderate Landslide Risk
6,919 Very High Landslide Risk	**3,173** Moderate Landslide Risk

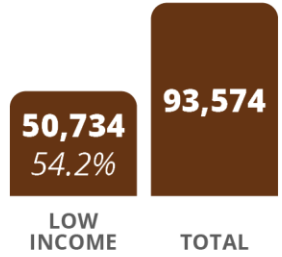
FUTURE

Triggered by extreme precipitation events or wildfires, the susceptibility of Sonoma County to landslides is projected to increase as precipitation variability increases and wildfires increase in frequency, size, and severity (CEC 2021, Sonoma County MJHMP 2021a).

Number of People Susceptible to Deep-seated Landslides



Number of Households Susceptible to Deep-seated Landslides



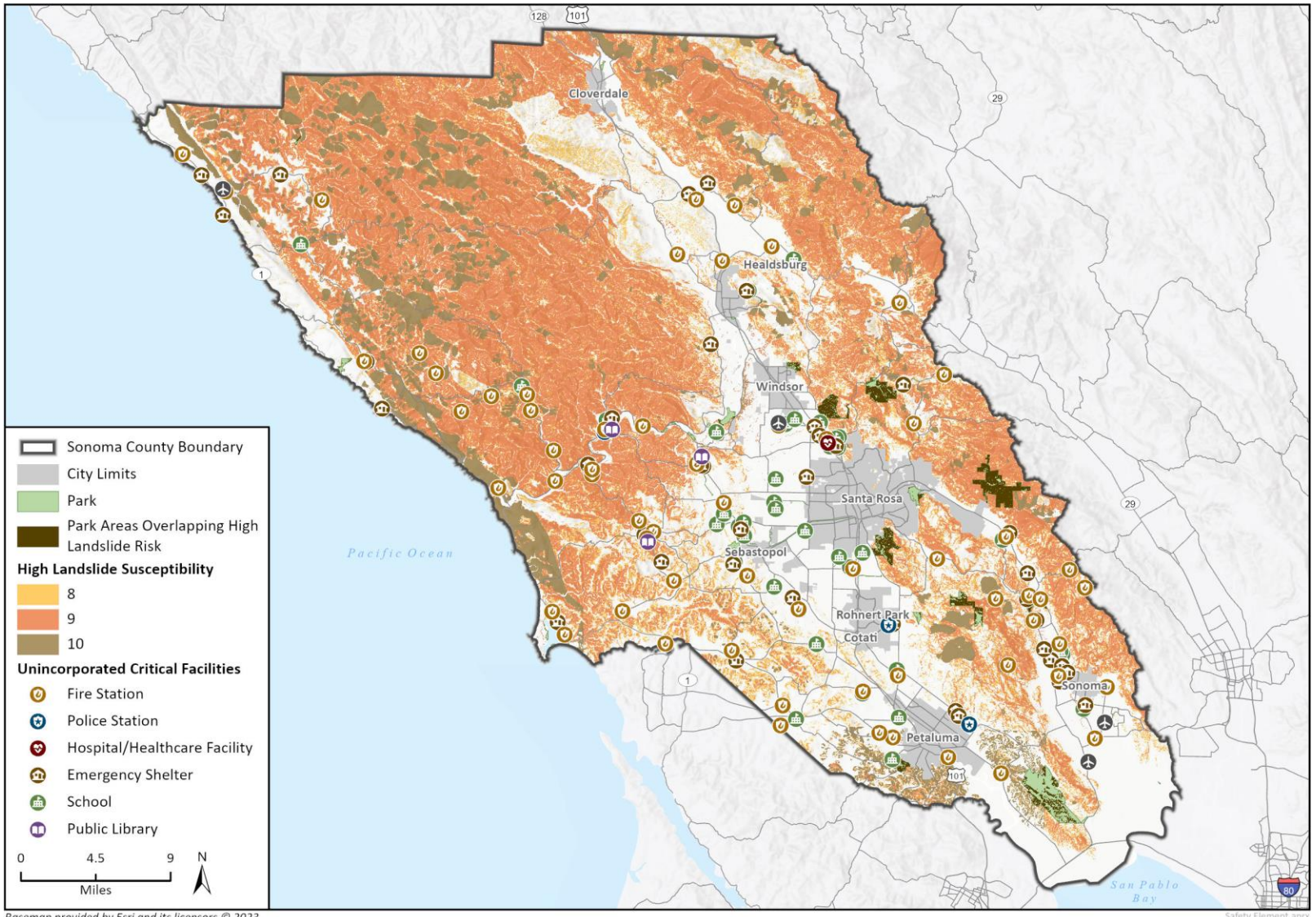
IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT

- HABITAT LOSS
- EROSION
- PROPERTY DAMAGE
- HUMAN INJURY
- STRAINED EMERGENCY SERVICES

IMPACTS ON ENVIRONMENTAL JUSTICE COMMUNITIES AND OTHER COMMUNITY MEMBERS

- FATAL & NONFATAL INJURY
- MENTAL AND BEHAVIORAL STRESSORS
- INCOME LOSS

Figure 11 Landslide Susceptibility in Sonoma County

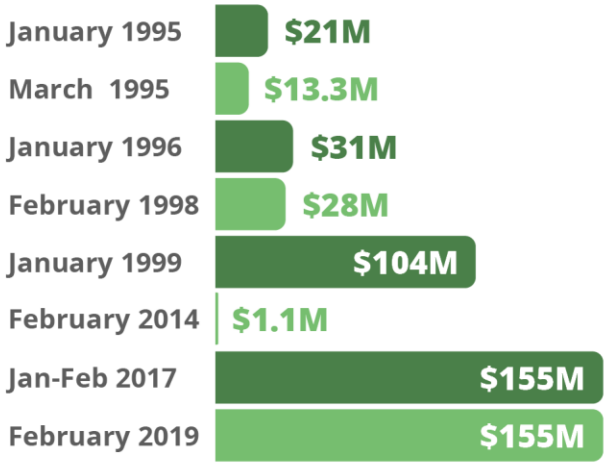


RIVERINE AND STORMWATER FLOODING

PAST

Historically, major flood events in Sonoma County are associated with the Russian River, Sonoma Creek, Petaluma River, and the Laguna de Santa Rosa. There have been several riverine and stormwater flooding events since 1995, which typically occur during winter (Sonoma County MJHMP 2021a).

Historic Flooding Events and Estimated Loss



PRESENT

Current exposure to flooding in the 100-year and 500-year floodplains includes 969 repetitive loss properties, several critical facilities, and up 3.7% of the County's population (Sonoma County MJHMP 2021a).

Repetitive Loss Properties in Sonoma County

Jurisdiction	Repetitive Loss Properties	Total Payments
Healdsburg	8	$358,237
Morro Bay	3	$107,144
Petaluma	39	$3,418,911
Santa Rosa	2	$27,135
Sebastapol	9	$1,319,635
Sonoma *(City)*	4	$207,314
Sonoma County	904	$85,487,431
Total	**969**	**$90,925,808**

Population Living Within the 100-year Flood Zone

7,768

(1.6% of Planning Area Population)

Population Living Within the 500-year Flood Zone

17,861

(3.7% of Planning Area Population)

FUTURE

Climate change may cause low-lying areas and exposed property throughout Sonoma County to experience more frequent flooding and could increase the extent of 100-year and 500-year floodplains. Riverine flooding is projected to increase as precipitation extremes increase.

As shown below exposed property in existing flood hazard zones may experience more intense and frequent flood events (CEC 2021, Sonoma County MJHMP 2021a).

Flood Zone Exposure

	100-year Chance Flood Zone	500-year Chance Flood Zone
Acres of Inundation Area	58,495	64,542
Number of Buildings Exposed	4,570	8,416
Total Exposed Property Value	$12,344,495,994	$17,587,549,317

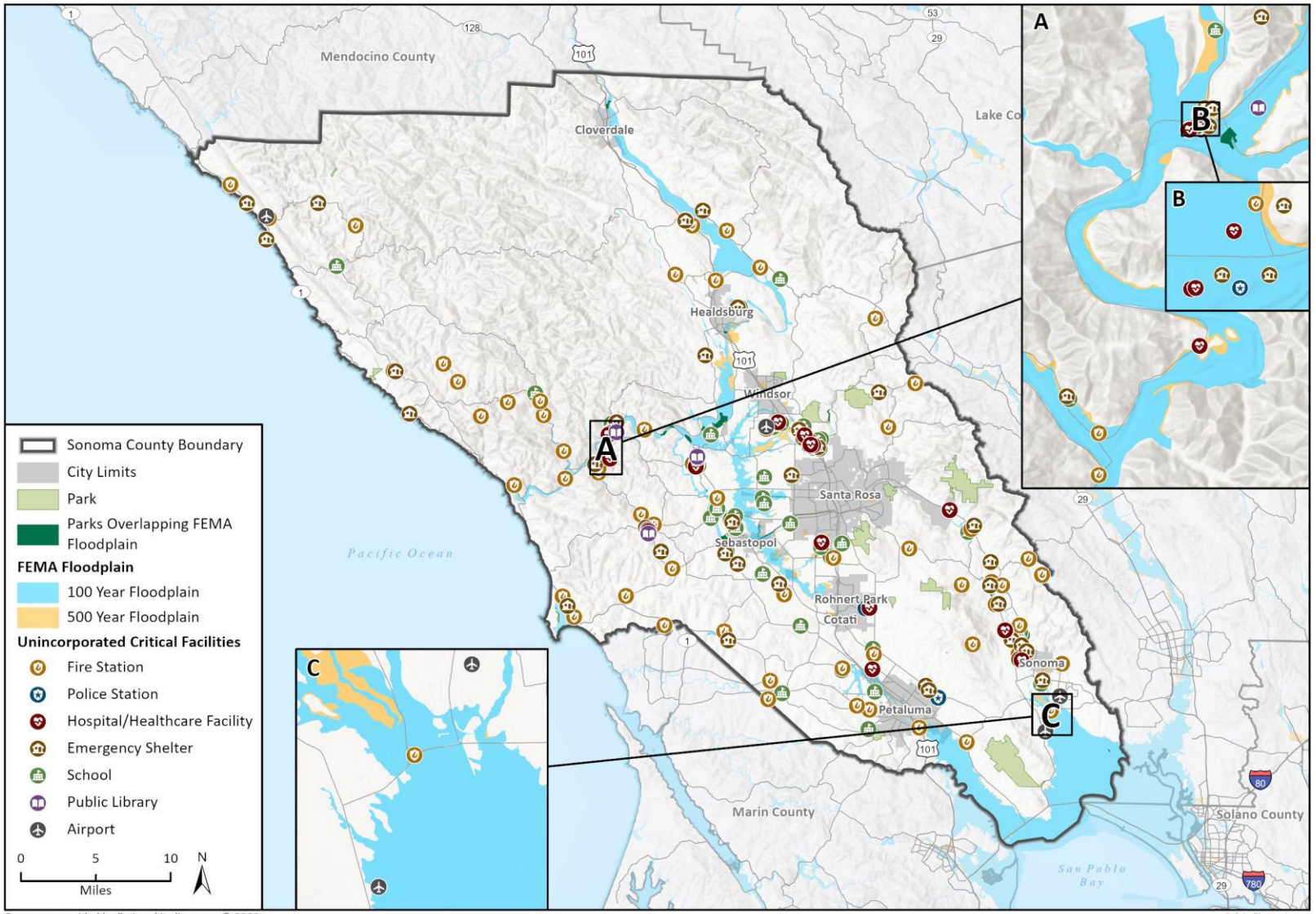
IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT

- STRAINED EMERGENCY SERVICES
- STRESSED WATER DRAINAGES
- PROPERTY DAMAGE
- HABITAT LOSS

IMPACTS ON ENVIRONMENTAL JUSTICE COMMUNITIES AND OTHER COMMUNITY MEMBERS

- FATAL & NONFATAL INJURY
- WATER-BORNE DISEASE
- MENTAL AND BEHAVIORAL STRESSORS
- INCOME LOSS

Figure 12 100-Year and 500-Year Floodplains in Sonoma County



SEA LEVEL RISE

PAST

The mean sea level has risen over the past decade and there are recent examples of coastal flooding events in Sonoma County (Sonoma County MJHMP 2021a).

In 2017 & 2019 Highway 37 was flooded due to high tides.

In 2021 the town of Jenner was placed under high surf advisory, low-lying areas were flooded along the Russian River.

In 2022 the entirety of the Sonoma Coast experienced a king tide affecting roadways, coastal trails, and loss of beach access.

PRESENT

Sea level rise (SLR) can negatively impact the coastal area of Sonoma County through regular tidal inundation, erosion, and storm flooding (Sonoma County MJHMP 2021a).

Current Population Exposed to 7 feet of SLR **1,106**

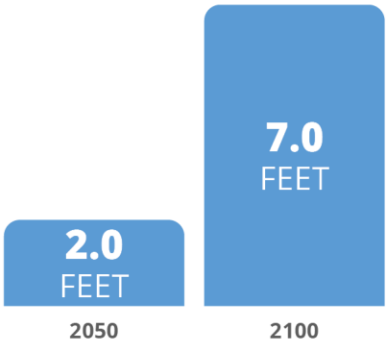
Current Number of Facilities Exposed to 7 feet of SLR

- Transportation: **25**
- Energy: **2**
- Communications: **2**
- Hazardous Material: **17**
- Health & Medical: **6**
- Safety & Security: **11**
- Food, Water, Shelter: **2**

FUTURE

The projected sea level rise within Sonoma County is expected to affect the community creating vulnerability for many coastal assets by end-century. Climate change is expected to increase the rate of sea level rise dependent on the extent of warming temperatures. Sonoma County tide gauge-specific projections reach up to 2 feet and 7 feet of sea level rise by 2050 and 2100 (USGS 2022).

Projected Sea Level Rise



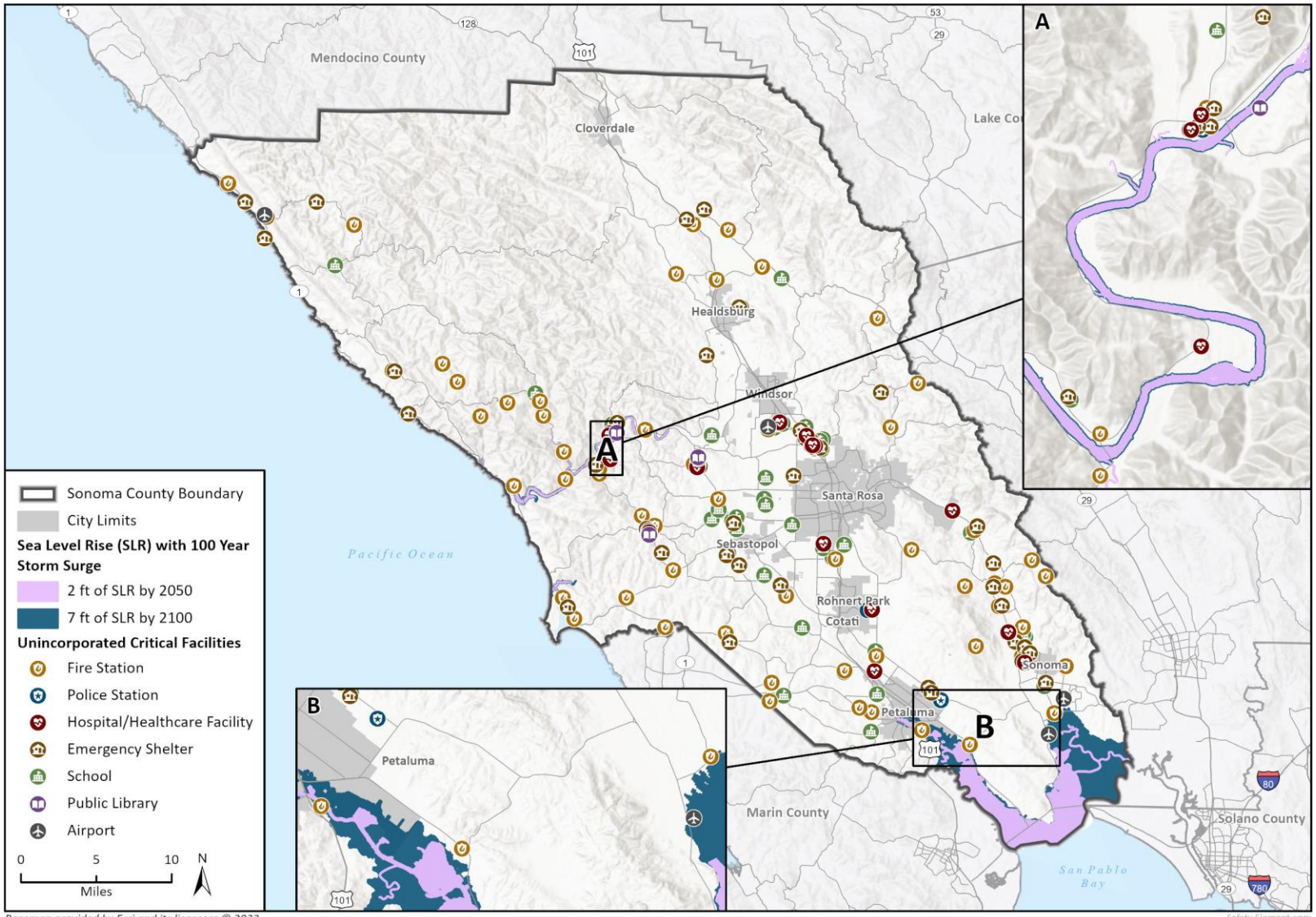
IMPACTS ON THE BUILT AND NATURAL ENVIRONMENT

- BLUFF AND BEACH EROSION
- CRITICAL INFRASTRUCTURE DAMAGE
- COASTAL FLOODING
- STRAINED EMERGENCY SERVICES
- HABITAT LOSS

IMPACTS ON ENVIRONMENTAL JUSTICE COMMUNITIES AND OTHER COMMUNITY MEMBERS

- FATAL & NONFATAL INJURY
- MENTAL AND BEHAVIORAL STRESSORS
- INCOME LOSS
- WATER-BORNE DISEASE

Figure 13 Two and Seven Feet of Sea Level Rise with 100-Year Storm Surge in Sonoma County



4 Sensitivity

Populations and assets are affected by climate change depending on their sensitivity to climate hazards. This section identifies Sonoma County's sensitivities across the following populations and assets:


Populations Made Sensitive by Systems


Parks and Natural Resources


Critical Facilities, Buildings, Services, and Infrastructure


Agriculture

Potential impacts from the climate hazards of concern, assessments of adaptive capacity, and vulnerability scores of populations and assets are presented in Section 5, *Vulnerability Analysis*.

Populations

Systemic inequities render some populations more sensitive to climate change impacts. While all people in a community will experience climate change, some are already and will continue to be more harmed by it than others. For example,

Relationship to Environmental Justice

Low-income communities along with communities of color are often disproportionately burdened with pollution and its associated health risks. In 2016, the State of California signed Senate Bill 1000 (SB 1000) into law, aiming to address inequitable distribution of pollution and its associated health risks specifically in low-income communities and communities of color. SB 1000 amended Government Code Section 63502, requiring both cities and counties to incorporate Environmental Justice (EJ) policies and programs into their general plan if two or more elements are being updated and/or revised concurrently and if the jurisdiction identifies any environmental justice communities present within the jurisdiction's planning area boundaries.

The County has identified Environmental Justice Communities, based on mapping tools including the CalEnviroScreen 4.0 provided by the California Environmental Protection Agency (Cal EPA). This process involved the characterization of the major challenges that Sonoma County's Environmental Justice Communities face who have been systemically disadvantaged, such as disproportionate exposure to adverse air quality or water quality caused by industrial activities. In many cases, climate hazards exacerbate pollution burdened communities. These Environmental Justice Communities are identified as higher risk due to systemic inequities and therefore vulnerable to the adverse effects of climate change. Environmental justice Communities are identified on Figure 14.

Through the policy development process, the County will develop strategies and programs to address issues that adversely affect Environmental Justice Communities.

older adults and young children may be more at-risk than the general population for heat illness during an extreme heat event. Several factors influence sensitivity to climate hazards, but all of them begin with systemic inequities. The unwillingness of government to systemically prioritize a safe environment over economic growth; the lack of sufficient, affordable/free, and culturally responsive healthcare systems and structures; the inequitable distribution of economic and educational resources; and housing segregation; among other structural inequities, render folks navigating chronic health conditions, seniors and young children, differently abled folks, people experiencing poverty, people who identify as BIPOC (Black, Indigenous, and People of Color), and others as particularly sensitive to increasing climate hazards (Cal OES 2020). Populations made sensitive by systems experience heightened risk to climate change and have fewer resources to adapt and recover from climate change impacts. Sonoma County is home to several populations made sensitive by systems, and who have already been disproportionately harmed by climate change (Table 2).

A social sensitivity index was created to understand where in Sonoma County concentrations of population groups who are systemically vulnerable to climate are present.

Social Sensitivity Index Score

A social sensitivity index was developed using data across 23 population data indicators listed in Table 4. Each indicator represents a characteristic that increases a person's physiological sensitivity to climate hazards, the ability of an individual to prepare for, cope with or recover from climate hazards, or a combination of both. Selected indicators are consistent with guidance in the Cal APG (Cal OES 2020). Four additional indicators (people experiencing houselessness, people who are undocumented, immigrants, and visitors) for which data was not available to be included in the index, are included in Table 4 For more information on why these population types are considered sensitive to climate change impacts, see Section 4.1, Populations.

The following population data indicators were included in the social sensitivity index based on feedback provided by the Equity Working Committee: mobile home households, households experiencing housing burden, and households experiencing energy burden.

Table 4 Populations Made Sensitive By Systems in Sonoma County

Population Type	Population Description	Percentage of Total Population/Household Type
People experiencing poverty	Household incomes less than 80 percent the State median household income	24%
People experiencing houselessness[1]	Individuals who currently lack fixed, regular, and adequate housing	0.6%
People who are undocumented[2]	Individuals residing in the United States without legal documentation	6%
Immigrants[3]	Individuals residing in the United States with legal documentation	Not Available
Unemployed	Percentage of population aged 18-64 who are unemployed	3%
Seniors	Individuals 65 years or older	27%

Population Type	Population Description	Percentage of Total Population/Household Type
Young children	Individuals 5 years and younger	4%
Single female heads of household with kids	Households with kids supported by a single female	25%
Miliary Veterans	Individuals who have served but are not currently serving in the US Armed Forces	7%
BIPOC	All individuals who do not identify as white	28%
Native Americans	Individuals who identify as American Native and Alaskan Native	0.1%
Renters	Housing units that are renter occupied	30%
Outdoor Workers	Individuals who are employed, 16 and older, and work outdoors	7%
Limited or non-English speakers	Households with individuals who are non or limited English-speaking	7%
People who are differently abled	Individuals with access and functional needs (physical and mental)	12%
Individuals with asthma	Individuals diagnosed with asthma	10%
Individuals with cardiovascular disease[4]	Individuals diagnosed with coronary heart disease	6%
Individuals without vehicle access	Individuals without access to a vehicle	3%
Individuals with no health insurance	Individuals aged 18 to 64 years old currently uninsured	5%
Individuals with education attainment less than four years of high school	Percent of people over age 18 without a high school education or higher	4%
Visitors[5]	Individuals who are not residents and are visiting the study area for a limited time	Not Available
People recreating outdoors[6]	Residents or visitors who recreate outdoors in Sonoma County	Not Available
Individuals in overcrowded households	Household with more than one person per room	4%
Mobile home households	Housing units that are mobile homes	4%
Households experiencing housing burden	Percentage of gross household income spent on housing costs	48%
Households experiencing energy burden	Percentage of gross household income spent on energy costs	2%
Households without a computer	Households without access to a computer	5%
Households without broadband internet	Households without access to broadband internet	9%

[1] People experiencing houselessness percentage includes data for incorporated Sonoma County from the County's 2022 Point in Time count. Data for this group was not available at the Census tract level for Sonoma County and therefore was not included in the Social Sensitivity Index.

[2]People who are undocumented percentage includes data for incorporated Sonoma County and is sourced from the California Immigrant Data Portal. Data for this group was not available at the Census tract level for Sonoma County and therefore was not included in the Social Sensitivity Index.

[3] Data for immigrants was not available at the Census tract or County level for Sonoma County and therefore was not included in the Social Sensitivity Index.

[4]Cardiovascular disease data for Sonoma County is currently unavailable, therefore coronary health disease data from CDC's PLACES Health Data was used as a proxy.

[5] Data for visitors was not available at the Census tract or County level for Sonoma County and therefore was not included in the Social Sensitivity Index.

[6] Data for people recreating outdoors was not available at the Census tract or County level for Sonoma County and therefore was not included in the Social Sensitivity Index.

Source: The percentages used in this table were acquired from the U.S. Census, 2016-2020- American Community Survey (ACS), and CDC's PLACES Health Data.

The above indicators were used to assess the geographic spread and proportion of populations made sensitive by systems within the County who may be more impacted by climate hazards. Data for these indicators was obtained from the Census Bureau's American Community Survey 2016-2020 and CDC's PLACES Health Data.

An analysis was conducted to identify the concentration of each population group in each unincorporated Sonoma County census tract. Figure 14 displays social sensitivity in unincorporated Sonoma County by census tract. Unincorporated County census tracts with high proportions of populations made sensitive by systems, relative to state statistics, have higher percentile rankings on the 0% to 100% scale.

Figure 14 also shows census tracts identified as Environmental Justice Communities, as identified in the Sonoma County Environmental Justice (EJ) Technical Report. The EJ Technical Report identifies 24 Environmental Justice Communities as well as three Environmental Justice Tribal Communities in Sonoma County. Environmental Justice Communities are areas that are low-income and are disproportionately affected by environmental pollution and other hazards. These communities are more likely to experience negative health effects, pollution and hazard exposure, and environmental degradation (Sonoma County Environmental Justice Technical Report 2023).

The areas of Sonoma County with the greatest concentration of populations made sensitive by systems are in the Cloverdale area, directly southwest of Santa Rosa, and around Fetters Hot Springs-Agua Caliente. Figure 14 denotes the location of federally recognized tribal land, including Stewart's Point Rancheria and Kashia Coastal Reserve, located northeast of Healdsburg, and Dry Creek Rancheria, located south of Point Arena. These tribal lands are identified as disadvantaged communities by Senate Bill 535 and are also highly socially sensitive due to existing systems and structures.

Figure 14 also shows locations of Environmental Justice Communities in the County. Environmental Justice Communities are located throughout the County, with most located in west, central, and south County. All high social sensitivity census tracts overlap with Environmental Justice Communities, except for two census tracts: one directly east of Santa Rosa and another near Graton. Stewart's Point Rancheria, Kashia Coastal Reserve, and Dry Creek Rancheria are also considered to be EJ Tribal Communities in Sonoma County.

Populations made sensitive by systems within Sonoma County are organized into four separate groups for the purposes of this assessment. Grouping populations allows the County to understand what systems and structures contribute to increased sensitivity to climate change hazards. Through identification of factors that contribute to population sensitivity, adaptation solutions can be developed that specifically address those contributing factors. Population groupings are as follows:

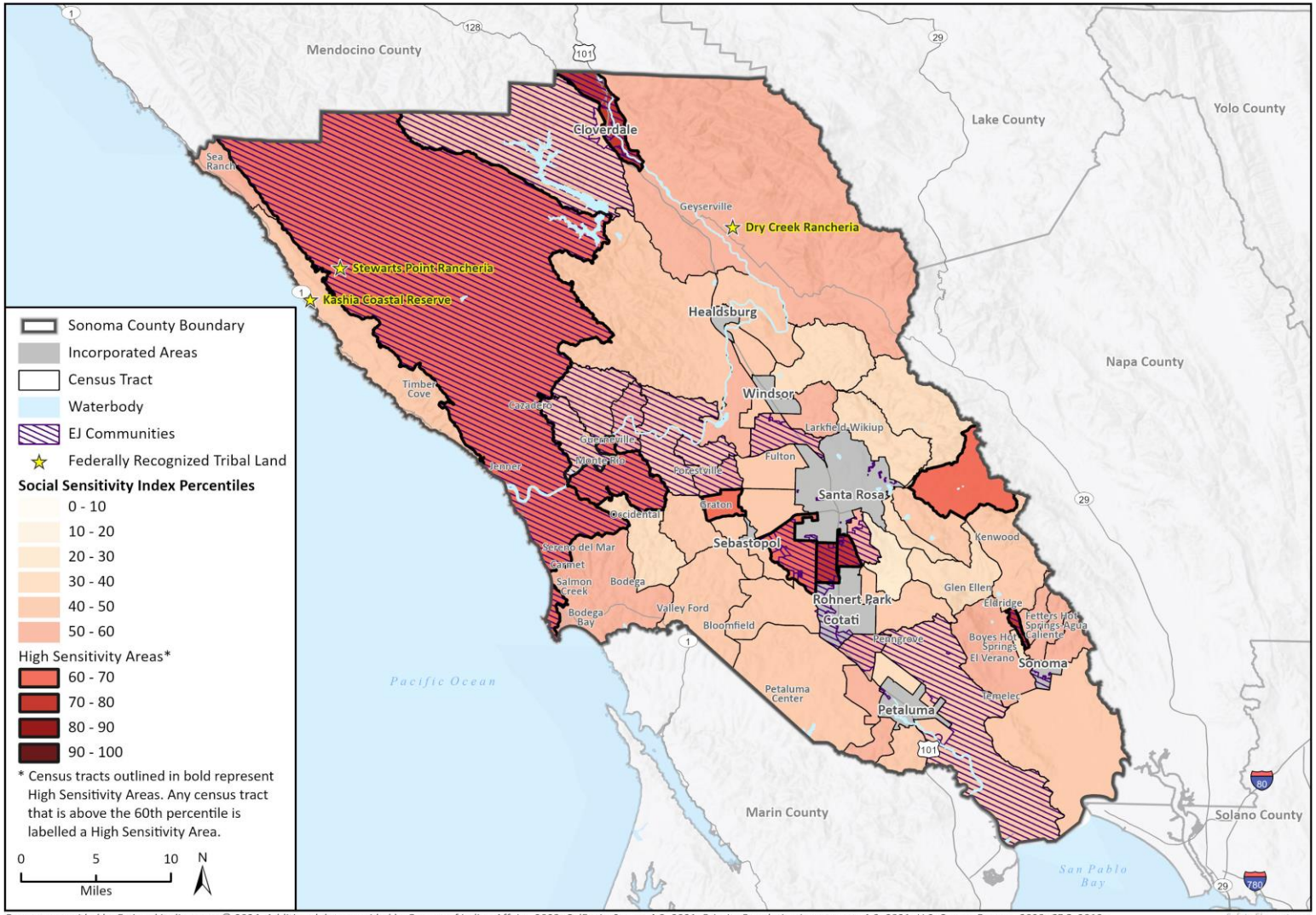
1. **Individuals with High Outdoor Exposure.** Outdoor workers, people experiencing houselessness, visitors, and people recreating outdoors.
2. **Under-Resourced Individuals.** People experiencing poverty, unemployed individuals, Individuals with no health insurance, households without a computer, households without a broadband internet, renters, individuals without vehicle access, single-female heads of households, individuals with educational attainment of less than 4 years of high school, individuals in overcrowded housing, mobile home households, households

experiencing housing burden, and households experiencing energy burden.

3. **Individuals Facing Societal Barriers.** BIPOC, Native Americans, limited and non-English speakers, immigrants, and people who are undocumented.
4. **Individuals with Chronic Health Conditions or Health Related Sensitivities.** Seniors, young children, people who are differently abled, individuals with asthma, individuals with cardiovascular disease, and military veterans.

Environmental Justice Communities, as identified in the EJ Technical Report, are determined based on a set of population characteristics (i.e., health conditions, education, housing burden, linguistic isolation, poverty, and unemployment) and level of pollution burden. Several of the population characteristics used to identify Environmental Justice Communities are also used in the social sensitivity analysis of this assessment to identify people made sensitive by systems. As these population characteristics are already assessed in the social sensitivity analysis, a separate sensitivity analysis and vulnerability analysis is not included for Environmental Justice Communities in this assessment.

Figure 14 Populations Made Sensitive to Climate Change by Systems and Environmental Justice Communities in Sonoma County



Basemap provided by Esri and its licensors © 2024. Additional data provided by Bureau of Indian Affairs, 2023; CalEnviroScreen 4.0, 2021; Priority Population Investments 4.0, 2021; U.S. Census Bureau, 2020; CDC, 2010; American Community Survey (ACS) 2017-2021 5-year estimates, Table(s) B25070, B25091 & ACS, LEAD tool, 2018; Social Sensitivity Percentile Scores calculated by Rincon Consultants, Inc., 2022.

Safety Element.aprx
Fig X Social Sensitivity Analysis

Parks and Natural Resources

Across the 1,515 square miles of Sonoma County there is a diverse landscape of parks and natural resources varying in biomes and topography. Each combination of microclimate, vegetation, and wildlife presents a different type of sensitivity to climate change (SCRLS 2022). Parks and natural resources within Sonoma County include waterways, regional parks, hillsides, and critical habitats. These various resources provide habitat, ecosystem services, sources of community resilience, recreation, and economic productivity to the County. These resources are spread throughout the County and face various levels of exposure to climate hazards. The dispersal of Parks can be found overlayed with the wildfire, landslide, and flood maps in Figure 8, Figure 11, and Figure 12. Land Cover Types and Federally Designated Critical Habitats are found below in Figure 17.

Primary vulnerabilities for parks and natural resources are typically associated with extreme heat and drought related stressors, increasing wildfire frequency and severity, with impacts such as species mortality and loss of habitat. Compounding climate hazards stresses natural ecosystems past their ability to absorb individual climate hazards, which can cause wildlife to shift towards more favorable habitats, such as parks and open spaces where people recreate (USDA 2020). Parks and recreation areas used by both wildlife and community members may also experience climate hazard stressors creating competing needs for safe habitats for wildlife as well as impacting the ability for community members to recreate.

Critical Facilities, Buildings, Services, and Infrastructure

Climate change is expected to amplify extreme weather and climate hazards in Sonoma County. A jurisdiction's vulnerability increases when buildings and facilities are not designed, operated, and/or maintained to function effectively under more extreme weather conditions or can be damaged by more extreme weather conditions. The functionality of critical facilities, buildings, services, and infrastructure is essential to the County's livelihood and economy. The following County critical facilities, buildings, services, and infrastructure components would be sensitive to climate change: fires stations, police stations, hospital/healthcare facilities, emergency shelters, schools, public libraries buildings, educational facilities, residential and commercial development, roadways and transportation facilities, airfields, and communication facilities.

The sensitivities presented in this asset category are critical to the County's health, quality of life, safety, security, and economy. Sonoma County depends on well-functioning roadways, water supplies, and utility infrastructure systems. Currently, overall funding levels and replacement of aging infrastructure are below what is necessary to keep up with maintenance needs. Climate impacts can increase the costs of keeping these critical elements functioning at necessary levels (Cornwall et.al, 2014). Figure 3 displays the locations of critical facilities, buildings, services, and infrastructure across the County.

Agriculture

Agricultural land cover seen in Figure 16 encompasses the majority of central Sonoma County. As the main source of economic productivity for the County, this asset category is particularly essential to the community when gauging sensitivities to climate change. According to the 2020 Sonoma County Agricultural Report, production of crops and livestock declined slightly in 2020 compared to 2019 to $3,476,093,000, which was primarily attributed to market changes and supply chain challenges associated with the COVID-19 pandemic. The agricultural industry struggles with labor shortages during peak harvest periods, increased production expenses, and climate hazard-related losses. Sonoma County's top 10 commodities by value are found in Figure 15 below.

The agricultural lands of Sonoma County experience sensitivity to climate change from direct exposures to climate hazards. Croplands and rangelands within fire, landslide, or flood zones are exposed and subsequently sensitive to climate change. The entirety of agricultural operations are dependent on outdoor based activities which can be significantly hindered by climate hazards or halted all together. Different hazards may limit agricultural operations in different ways. Based on the location of agricultural lands in relation to hazard zones, different areas of the county may encounter varied issues (Cornawall et.al., 2014). Per the Sonoma County Resilient Lands Strategy much of the County's land use is agriculture with compounding sensitivity as the hottest parts of the county are co-located with intensive agriculture areas (SCRLS 2022).

Nearly 70% of California's existing area of wine production will be vulnerable under future climate change projections by mid-century. As described in the California Fourth Climate Change Assessment regional report, the sensitivities of agriculture are primarily related to extreme temperatures and temperature-related water scarcity (Ackerly et al. 2018). Changes in rainfall and precipitation dynamics create sensitivities for rangeland vegetation, plant production, and wine production (Ackerly et al. 2018).

Figure 15 Sonoma County Agricultural Report, Top Ten Commodities by Economic Value

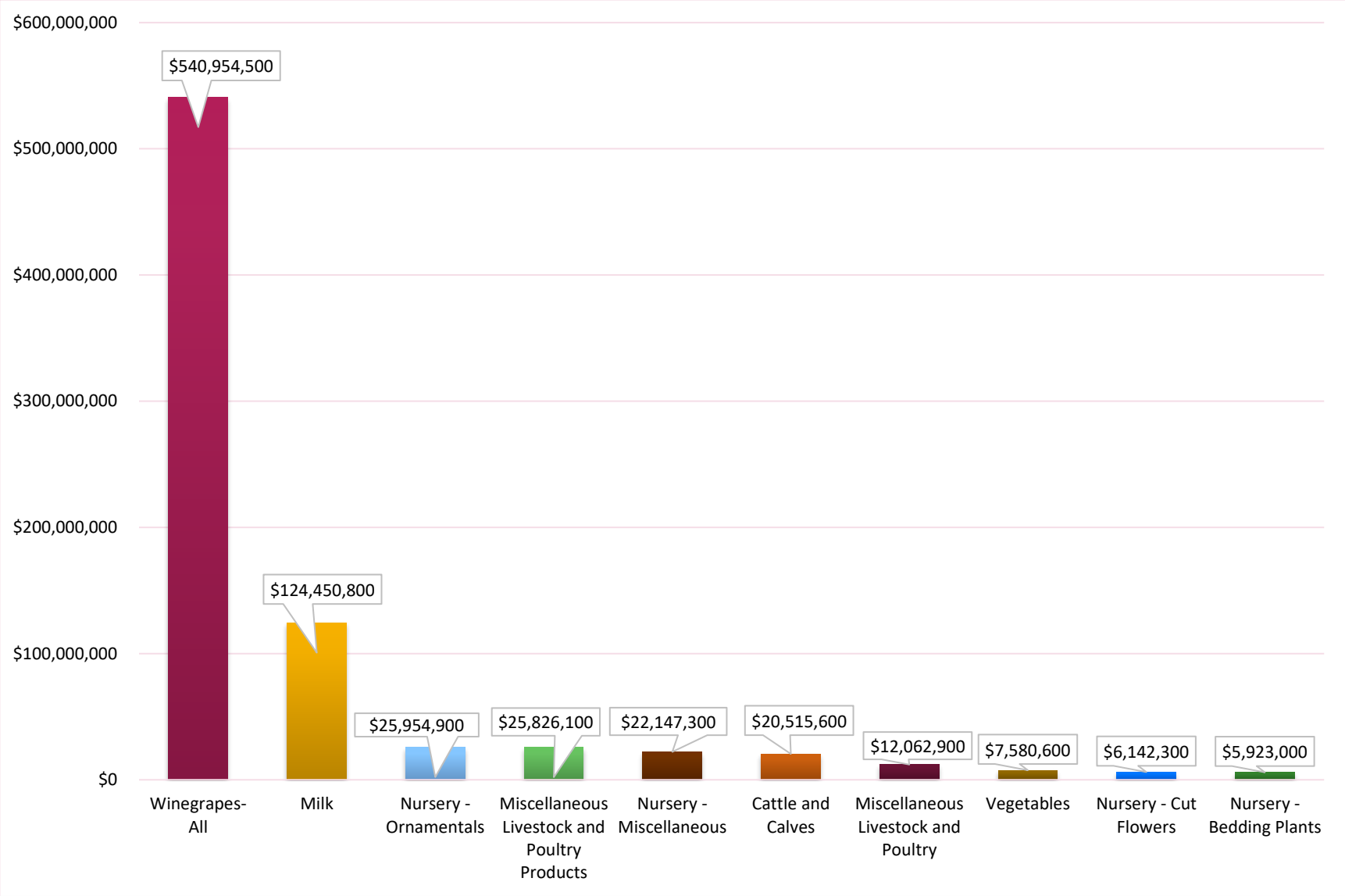


Figure 16 Sonoma County Regional Parks, by Land Cover Type and Total Acreage (Sonoma County Regional Parks 2023)

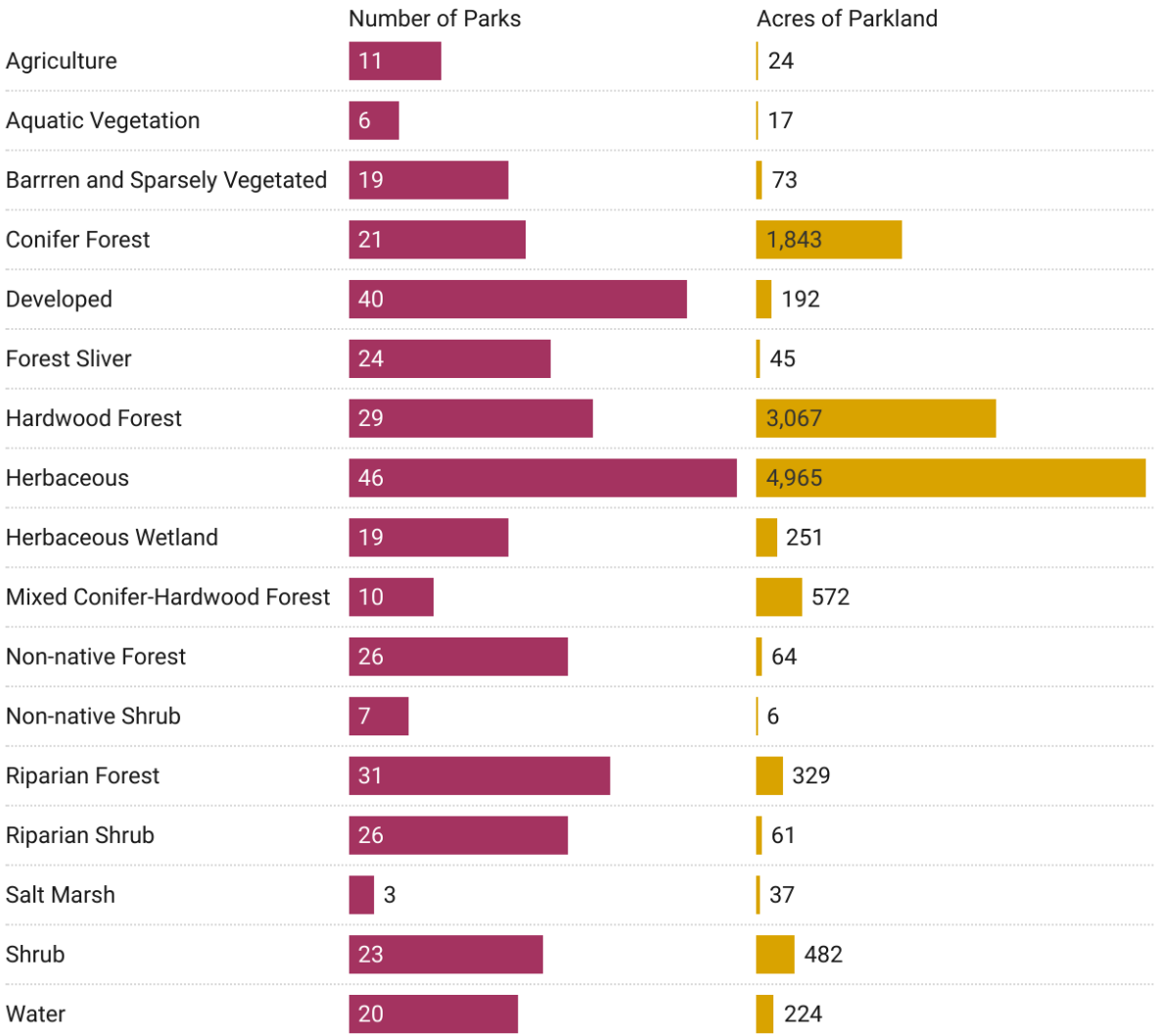
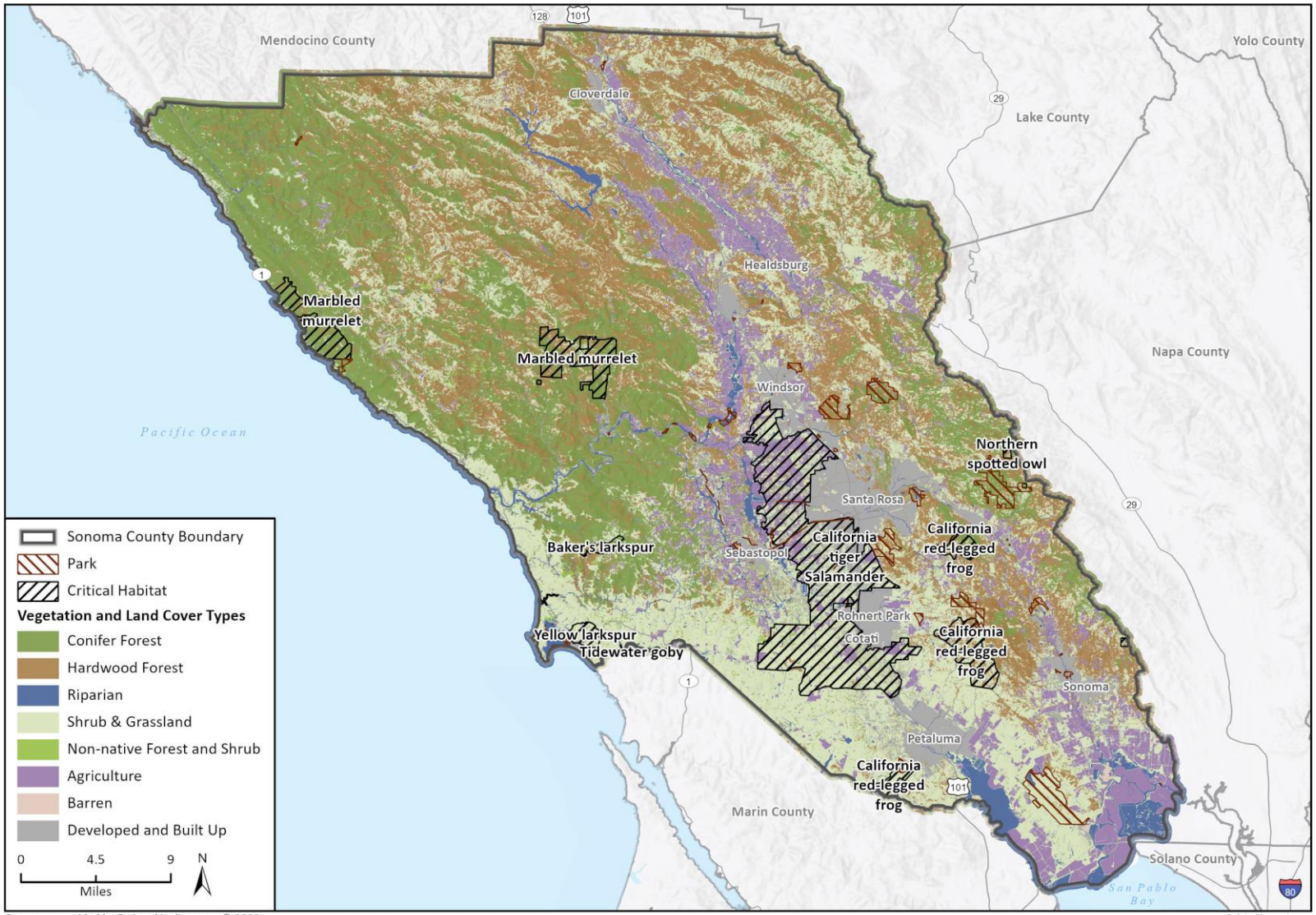


Figure 17 Sonoma County Land Cover Types and Federally Designated Critical Habitats



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Additional data provided by Sonoma County, Fine Scale Vegetation and Habitat Map, 2013; USFWS, 2021.

Safety Element.aprx
Fig 10 Natural Resources with Vegetation, Critical Habitats, and Parks

5 Vulnerability Analysis

Vulnerability is the propensity or predisposition of a certain asset or population group to be adversely affected by climate change impacts. In this assessment, it is based on the combination of potential impacts and adaptive capacity. The results of the analysis detail how climate change may impact community members made vulnerable by systemic inequities. It also details how climate change may impact parks and natural resources, critical facilities, buildings, services, and infrastructure, and agriculture in Sonoma County. The vulnerability assessment will inform the development and prioritization of adaptation policies and programs to increase community and ecosystem resilience as part of the Sonoma County General Plan Safety Element update.

The following section outlines the impacts each climate hazard has on populations and assets identified in Section 3, *Sensitivity*. A detailed summary of the County's adaptive capacity organized by climate hazard can be found in Appendix B. An impact score and an adaptive capacity score is identified for each asset by climate hazard, along with an overall vulnerability score consistent with the scoring methodology provided in the Methodology section. Vulnerability scoring helps the County understand which climate effects pose the greatest threats and should be prioritized in adaptation planning and policy.

Adaptive capacity was almost exclusively evaluated based on existing County and utility-led plans and programs. There are other forms of adaptive capacity that are led by institutions (e.g., schools, religious institutions), community-based organizations, non-profits, special districts, and other nongovernmental entities. Communities also form their own informal adaptive capacity efforts to prepare for, weather, and recover from climate hazards. According to the safety element survey, almost 60% of respondents indicated that they would first turn to friends and family, as opposed to community organizations or the County, for resources during an emergency, indicating the importance of interpersonal support systems during hazard events. This assessment focused on County-led programs and policies in alignment with the focus of the Safety Element which is part of the County's General Plan.

Populations

Overview

As climate change impacts occur, virtually all populations in a community will be affected; however, some individuals are more sensitive due to inequitable systems and structures and therefore will be disproportionally impacted by climate hazards, which will vary depending on the hazard type and magnitude of sensitivity. Overlaying population sensitivity, Environmental Justice Communities, and potential climate impacts helps to determine the level of vulnerability.

Figure 10 displays social sensitivity in unincorporated Sonoma County by census tract. As described in Section 3.1, *Populations*, the areas of Sonoma County with the greatest concentration of social sensitivity are in the Cloverdale area, directly southwest of Santa Rosa, and around Fetters Hot Springs-Agua Caliente. Figure 10 also displays Environmental Justice Communities which are located throughout the County but concentrated in west, south, and central County.

Areas near Fetters Hot Springs-Agua Caliente, southwest of Santa Rosa, Forestville, Cloverdale, and south of Windsor have a combination of high temperature exposure by end-of-century, high social sensitivity, and a concentration of Environmental Justice Communities, as displayed on Figure 18.

Areas near the Russian River, around Cloverdale, and in most of northwest County have a combination of high wildfire exposure, high social sensitivity, and a concentration of Environmental Justice Communities including Environmental Justice Tribal Communities, as displayed on Figure 19.

Areas near the Russian River, around Cloverdale, and in most of northwest County have a combination of high landslide susceptibility, high social sensitivity, and a concentration of Environmental Justice Communities, as displayed on Figure 20.

Areas near the Russian River, directly southwest of Santa Rosa, around Cloverdale, and in most of northwest County have a combination of high flood exposure, high social sensitivity, and a concentration of Environmental Justice Communities, as displayed on Figure 21.

Areas of the County south of Petaluma but north of San Pablo Bay are designated as Environmental Justice communities and face exposure to two feet of sea level rise by 2050 and seven feet by 2100. Areas along the Russian River and south of Jenner are designated as Environmental Justice communities, high socially sensitive areas, and face exposure to two feet of sea level rise by 2050 and seven feet by 2100.

Populations made sensitive by systems are grouped below into four categories of social sensitivity:

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

The vulnerability of each population group is assessed based on potential impact and adaptive capacity. According to the safety element survey, responses to the question asking who is most impacted by climate change-related hazards correlate with these four groupings. When asked about which community groups the County should prioritize with assistance, the responses also closely correlated with these four categories of social sensitivity. This assessment acknowledges how the intersectionality of systems compound individuals' sensitivity across multiple factors at once; however, for the purpose of this assessment, analysis was conducted based on the systemic sensitivity that increases an individual's risk to the greatest degree. Compounding sensitivities are further explained for each population group below.

Adaptive Capacity of Populations

There are existing Sonoma County plans, policies, programs, and resources in place to help populations made sensitive by systems to mitigate and adapt to multiple climate hazards; however there remain significant gaps in adequately preparing community members to be able to prepare for, cope and recover from climate impacts. The existing plans, policies, and programs identified in this assessment do not address the systemic issues that render certain populations more vulnerable to climate change. They largely focus on mitigating climate change impacts rather than addressing the root causes of disproportionate sensitivity.

- **Sonoma County Cooling Centers:** provides cooling centers for County residents during periods of extreme heat and/or poor air quality. In recent years, cooling centers have been located in

Cloverdale, Sonoma, Santa Rosa, Petaluma, and Healdsburg (Sonoma County 2022).

- **Sonoma County Climate Change and Health Profile Report**: details climate projections and related climate hazards, climate-health related risks, and populations in the County most vulnerable to climate change impacts including individuals facing societal barriers. The report outlines high-level public health strategies, near-term actions, and long-term actions that County agencies may consider implementing to mitigate climate change impacts on people made vulnerable by systems (CDPH 2017).
- **The Climate Ready Sonoma Report** assesses existing vulnerability and adaptive capacity efforts for populations including individuals facing societal barriers (Sonoma County 2014)
- **The Sonoma County Operational Area Emergency Plan** includes several annexes on topics including community alert & warning, evacuation, and mass care & shelter. There are protocols and resources included specifically for individuals facing societal barriers (Sonoma County 2021)
- **Sonoma County Multi-Jurisdictional Hazard Mitigation Plan** identifies mitigation strategies that reduce or eliminate long-systems including individuals facing societal barriers (Sonoma County 2021)
- **KBBF 89.1 FM** is a bilingual public radio station that serves the north San Francisco Bay Area and Sonoma County. According to the North Bay Organizing Project, the radio station has historically provided critical emergency and evacuation information to Spanish-speaking residents during past hazard and evacuation scenarios.
- **Community Rating System** is a voluntary program within the National Flood Insurance Program (NFIP) that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions. However, under-resources individuals are often uninsured and face disproportionate flood impacts (FEMA 2023).
- **Sonoma County Energy Independence Program (SCEIP)** offers financing for permanent energy, water, wildfire safety, and seismic strengthening improvements through the property tax system. Financing is available for residential, commercial, industrial, agricultural, multi-family and certain non-profit projects (Sonoma County 2022).
- **Sonoma County Home Resilience Guide.** The County of Sonoma, in partnership with the Bay Area Regional Energy Network (BayREN), developed a guidebook to educate homeowners on improvements they can make for a more energy efficient, safe, comfortable, and resilient home, including energy efficient technologies, water saving features, and ways to protect homes from wildfires, earthquakes, and more.
- **PG&E Medical Baseline Program:** provides eligible customers with a medical need for electricity (for oxygen, dialysis, etc.) with extra notifications (i.e., calls, texts, or door-bell rings) in advance of a public safety power shutoff. Public safety power shutoffs may occur during an extreme heat event (PG&E 2021). This program particularly helps individuals with chronic health conditions or health related sensitivities mitigate impacts from public safety power shutoffs.
- **PG&E Self-Generation Incentive Program:** pays for all costs associated with procuring battery storage for eligible customers. Medical Baseline Program customers qualify for full benefits of the program (PG&E 2020). This program particularly

helps individuals with chronic health conditions or health related sensitivities mitigate impacts from power service disruptions.

The Safety Element Survey was conducted to better understand how the community has been impacted by climate change, how they are preparing, and what barriers they have faced to preparing for more extreme weather events as the result of climate change. When asked what precautionary measures respondents had taken to prepare for wildfires, a majority of respondents indicated that they had signed up for emergency alerts, prepared an emergency supply kit and maintained vegetation around their home. Very few respondents felt that they did not need to take any precautionary measures. When asked a similar question about flood readiness, most respondents had signed up for emergency alerts, some had prepared an emergency response kit, and over 30% believed they did not need to take any precautionary measures, a sharp drop from the number of people concerned for wildfire risk. When asked why they had not signed up for emergency alerts, Spanish speaking respondents indicated that they did not know the emergency alert system existed and were unsure if the alerts were available in Spanish. These results are indicative of a language barrier as these concerns were not prevalent for English speaking respondents. Another question targeted renters asking if they had asked their landlords to make improvements to prepare for wildfires and flooding. Most respondents indicated that they had not asked their landlord to make improvements and cited worries that their landlord would get mad or raise rent and not knowing what improvements landlords should make. Respondents were also asked to indicate how important they thought it was to prepare for climate change. Over 60% of respondents believed it was very important to prepare while very few said it was not very important. When surveying about barriers respondents face to preparing for climate change-related hazards, over 40% indicated financial constraints as a concern and 28% cited no barriers and believed themselves to be adequately prepared. Another set of questions asked respondents about which members of the community had been most impacted by climate change hazard events and in what ways, and to which community groups should the County prioritize with assistance. Many responses listed people with low incomes, people experiencing homelessness, seniors, people with disabilities, farm workers, people who speak languages other than English, undocumented people, people with inadequate access to transportation, renters, and people located in hazard zones as the most impacted and most in need of County aid. They cited that people were most impacted by extreme heat, fires, power outages, floods, and being out of work.

1. Individuals with High Outdoor Exposure

- Outdoor workers
- People experiencing houselessness
- Visitors
- People recreating outdoors

Outdoor workers, people experiencing houselessness, visitors, and people recreating outdoors face high outdoor exposure, which increases exposure to potential climate hazards. A significant portion of Sonoma County's local economy is associated with viniculture and agriculture (Sonoma County MJHMP 2021a). The significant number of outdoor workers in these sectors face high risk to climate hazards. This high risk from climate hazards is compounded by the fact that a large percentage of viniculture and agricultural workers are immigrants, speak languages other than English, and/or are undocumented.

Sonoma County has an estimated 2,893 people experiencing houselessness in 2022 (Sonoma County Point-in-Time Count Results

2022). There is a concentrated number of homeless camps along the Russian River near Guerneville (Waterkeeper Alliance 2023). People experiencing houselessness often suffer from high rates of respiratory conditions, mental illness and other chronic health conditions and therefore are more sensitive to climate hazards (CDPH 2020).

Sonoma County is also a popular tourist destination with many people visiting the coast and wineries. Visitors are at risk because they may not receive warning during emergency events and are more likely to be unsure of how or where to receive help, or how to evacuate. Visitor deterrence, which could occur during and following climate hazards, would have a notable negative impact on the local economy (Gamble et al. 2016).

Many residents and visitors engage in various outdoor recreation activities, including biking, hiking, golfing, water sports, equestrian activities, and camping, in Sonoma County. In 2018, outdoor recreation added $731 million a year to Sonoma County's economy (The Press Democrat 2018). People recreating outdoors are more likely to face high exposure during climate hazard events. They may be geographically isolated and face challenges evacuating hazardous areas.

Potential Impacts

Extreme Heat and Warm Nights

Individuals with high outdoor exposure are at risk of health impacts from extreme heat. Outdoor workers are often subject to strenuous work conditions and are vulnerable during extreme heat events. People experiencing houselessness and displaced individuals are exposed to the health-related impacts associated with extreme heat because they have limited access to shelter and air conditioning. The primary health impacts to these populations are heat-related illnesses, such as heat stress, heat stroke, and dehydration, which can be life-threatening (CDPH 2020). Visitors are particularly at risk during extreme heat events because they may not be keyed into local heat warning communications and are less likely to know where to seek refuge. People that recreate outdoors are also susceptible to health impacts from extreme heat.

Drought

Unless there are major water shortages in the county, individuals with high outdoor exposure are most likely not at disproportionate risk to drought.

Wildfire

Some outdoor workers, including fire fighters and emergency personnel, may be exposed to hazardous work conditions during wildfire events and may become injured from smoke inhalation or burns. Outdoor workers in the viniculture and agricultural sectors also risk exposure to hazardous work conditions during wildfire events, which often overlap with harvest season. Workers are impacted by air quality and loss of wages, especially where hazard pay is unavailable. Many agricultural workers in the county live on agricultural operation premises and lack transportation needed during wildfire evacuations. Additionally, undocumented outdoor workers are unable to access Federal reimbursement should their housing or personal belongings get destroyed or damaged by fire. People experiencing houselessness are particularly at-risk during wildfire events as they often suffer from respiratory conditions, mental illness, and chronic health conditions that may be exacerbated from physical contact with wildfire or poor air quality. People experiencing houselessness have limited access to shelter and often do not have access to transportation to evacuate from smoke engulfed areas (CDPH 2017). Visitors and people recreating outdoors may not have access

to emergency public health warnings and may not know of appropriate evacuation routes or where to get emergency evacuation information in the event of a wildfire. Additionally, wildfire risk may deter visitors, impacting Sonoma County's economy (Gamble et. al 2016).

Landslide

Some outdoor workers, including emergency personnel, may be exposed to hazardous work conditions during landslide events and may become injured from debris, rocks, or damaged infrastructure or facilities. Undocumented outdoor workers are unable to access Federal reimbursement should their housing or personal belongings get destroyed or damaged by a landslide. People experiencing houselessness are particularly at-risk during landslides because they have limited access to shelter and often do not have access to transportation to evacuate from hazardous areas (CDPH 2017). According to the focus group interviews, this is a particular risk in areas around the Russian River where there are both high concentrations of people experiencing houselessness and high landslide susceptibility. Visitors and people recreating outdoors may not have access to emergency public health warnings and may not know of appropriate evacuation routes or where to get emergency evacuation information in the event of a wildfire. Additionally, landslide risk may deter visitors, impacting Sonoma County's economy (Gamble et. al 2016).

Riverine and Stormwater Flooding

Outdoor workers may be exposed to hazardous work conditions during flooding events and therefore are vulnerable to health impacts (CDPH 2020). Many agricultural workers in the county live on agricultural operation premises and will also be subjected to flood-related damage to their homes. People experiencing houselessness are disproportionately at risk of health impacts during flood events because they often live in flood hazard areas and do not have access to transportation to evacuate inundated areas. They may also have their personal belongings destroyed or damaged during a flood event (Ramin & Svoboda 2009). Impacts of flooding are likely to result in minimal impact to visitors, although visitors to and people recreating in areas along the Russian River could be impacted (Gamble et. al 2016).

Sea Level Rise

Outdoor workers, particularly those working along the coastline, may be exposed to hazardous work conditions during sea level rise storm surge events and are vulnerable to health impacts (CDPH 2020). Impacts of sea level rise are likely to result in direct impacts to visitors and people recreating outdoors, though disappearing beaches may deter or inhibit these individuals and impact the county's economy (Gamble et. al 2016).

Vulnerability Score – Individuals with High Outdoor Exposure

Climate Hazard	Impact Score	Adaptive Capacity Score	Vulnerability Score
Extreme Heat	High	Low	**5-High**
Drought	Low	Medium	**2-Low**
Wildfire	High	Medium	**4-High**
Landslide	Medium	Medium	**3-Medium**
Riverine and Stormwater Flooding	Medium	Low	**4-High**
Sea Level Rise	Low	Medium	**2-Low**

2. Under-resourced Individuals

- People experiencing poverty
- Unemployed individuals
- Individuals with no health insurance
- Households without a computer
- Households without a broadband internet
- Households with limited computer skills
- Renters
- Individuals with educational attainment of less than 4 years of high school
- Single female heads of household
- Individuals in overcrowded housing
- Mobile home households
- Households experiencing housing burden
- Households experiencing energy burden

Under-resourced individuals have inequitable access to resources with which to prepare for, cope with, and recover from climate change impacts. Individuals who are unemployed or people experiencing poverty often face financial barriers when preparing for and recovering from climate change hazards. Individuals in these groups often live in homes that are less protected against climate hazards, and/or are renters so they are unable to make needed home improvements. People experiencing poverty may not be able to take time off work to address health concerns either caused by or exacerbated by climate hazards. People experiencing poverty in conjunction with food and housing insecurity are rendered systematically more vulnerable than the general population to many co-morbid health issues.

Single female heads of households, as defined by the U.S. Census as female householders with children under 18-years-old and no spouse/partner present, are often subjected to high levels of work-life conflict and financial hardship, which can make preparing for, coping with, and recovering from climate hazards difficult. They are also more likely to serve as the primary caretaker of children which can make evacuating during a hazard scenario difficult (Flanagan et al. 2011). Additionally, women's wages, on average, are lower than their male counterparts. According to U.S. Census Bureau data, in 2020, women earned 84 percent of what men earned (Pew

Research Center 2021). This disparity is even more extreme for black women who earned on average 64 percent of what white, non-Hispanic men earned in 2020 (Bleiweis et al. 2021).

Individuals with educational attainment of less than four years of high school usually have lower earning potential and are twice as likely to be unemployed than those with a high school degree (Association of Public and Land-Grant Universities n.d.). Individuals with low educational attainment are more likely to work in outdoor and/or labor-intensive environments thus increasing the impact of climate events (CDPH 2017). Under-resourced individuals are less likely to have access to transportation, healthcare, and other basic needs. Under-resourced individuals often lack the financial resources to evacuate from a climate hazard and/or find a safe and affordable place to evacuate to.

Households without a computer or broadband internet, or that lack computer skills may be less likely to receive emergency alerts or governmental guidance before or during a climate hazard event, making them particularly vulnerable in evacuation scenarios. Individuals without health insurance are more likely to have undiagnosed pre-existing health conditions and inadequate access to preventative care and treatment, which may make them more vulnerable to health impacts from climate hazards (Gamble et al. 2016).

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

Households experiencing housing cost or energy cost burden are less likely to have financial resources to prepare for, respond to, or recover from impacts. Individuals living in overcrowded housing are more likely to face health and safety concerns. The U.S. Census defines an overcrowded unit as one occupied by 1.01 persons or more persons per room. Individuals in these groups are more likely to face financial barriers when preparing for and recovering from climate hazards (CA Department of Housing and Community Development 2022).

Potential Impacts

Extreme Heat and Warm Nights

Under-resourced individuals may not be able to pay for adequate air conditioning or fans, increasing their exposure to extreme heat. Individuals without vehicles may face challenges traveling to cooling centers or temporary shelters during extreme heat events (Cooley et al. 2012). Households without a computer or broadband internet may not receive heat advisory warnings or governmental guidance, causing them to experience health impacts from extreme heat exposure (CDPH 2017). Under-resourced individuals are less likely to receive medical care for illnesses triggered or exacerbated by extreme heat, or if treatment is received, they are likely to face a significant medical cost burden and related financial stress.

Drought

During periods of prolonged drought, under-resourced individuals are more likely to experience the cost burden associated with increased water rates (Feinstein et al. 2017). These individuals may struggle to access clean and affordable drinking water which may cause financial strain (Gamble et al. 2016). Droughts often trigger cascading economic impacts through the agricultural sector, decreasing job availability and leaving people

experiencing poverty particularly vulnerable to financial hardships (Howitt et al. 2015). According to the stakeholder focus group interviews, Gold Ridge Resource Conservation District noted that rural areas of the community that rely on local water resources have faced significant challenges of water reliability and water quality during recent periods of drought (Jensen 2023). Sonoma County and the North Coast Regional Water Quality Control Board have found that falling groundwater levels due to drought conditions may increase levels of naturally occurring minerals in shallow groundwater that supplies drinking water to private wells. This can pose increased health and safety risks to individuals relying on local groundwater resources (Sonoma County MJHMP 2021a).

Wildfire

Under-resourced individuals may experience injuries or death from smoke inhalation or burns and are likely to experience financial burden associated with medical treatment (CDPH 2017). These individuals may have their belongings and homes damaged by a wildfire. If this occurs, under-resourced individuals are less likely to be covered by insurance and more likely to suffer from the cost burden. Individuals without vehicle access are vulnerable during wildfires because they may have a more difficult time evacuating safely. Renters have limited control over home hardening and improvements that may protect against fire and smoke. Individuals living in mobile homes may also face disproportionate risk if their homes are not adequately hardened and weatherized. Subsequently, they may experience economic and health impacts and a greater loss of belongings than homeowners (Gamble et al. 2016).

Landslide

Under-resourced individuals may experience injuries or death from landslides and are likely to experience financial burden associated with medical treatment (CDPH 2017). These individuals may have their belongings and homes damaged by a landslide. If this occurs, under-resourced individuals are less likely to be covered by insurance and more likely to suffer from the cost burden. Individuals without vehicle access are vulnerable during landslides because they may have a more difficult time evacuating safely. Renters have limited control over home hardening and improvements that may protect against landslides. Individuals living in mobile homes may also face disproportionate risk if their homes are not adequately hardened and weatherized. Subsequently, they may experience economic and health impacts and a greater loss of belongings than homeowners (Gamble et al. 2016).

Riverine and Stormwater Flooding

Under-resourced individuals may experience injuries or death from high velocity flooding and are less likely to receive medical treatment (CDPH 2017). Individuals in these groups may experience cost burdens if their belongings and homes are damaged from floodwater inundation. Individuals without vehicle access are vulnerable during flooding because they may not have access to transportation to evacuate. Households without a computer or internet may not receive communications and emergency alerts to safely evacuate from hazard areas (CDPH 2020). Renters have limited control over home improvements that may protect against flood damage. Individuals living in mobile homes may also face disproportionate risk if their homes are not adequately weatherized. Subsequently, they may experience economic and health impacts and a greater loss of belongings than homeowners (Gamble et al. 2016).

Sea Level Rise

Sea level rise could impact housing needs in Sonoma County due to populations in search of areas to relocate as they move from areas impacted by sea level rise. Populations living in coastal areas may be negatively impacted economically due to loss of property and land because of levee failure, coastal erosion, or inundation due to storm surges. Furthermore, sea level rise can negatively impact individuals living in low-lying areas along the coast and in formerly tidal portions of southern Sonoma County. Saltwater intrusion into aquifers could render water wells unusable which could impact under-resourced individuals relying on wells for potable water.

Vulnerability Score – Under-resourced Individuals

Climate Hazard	Impact Score	Adaptive Capacity Score	Vulnerability Score
Extreme Heat	High	Medium	**4-High**
Drought	Low	Medium	**2-Low**
Wildfire	High	Medium	**4-High**
Landslide	Low	Medium	**2-Low**
Riverine and Stormwater Flooding	High	Low	**5-High**
Sea Level Rise	Low	Medium	**2-Low**

3. Individuals Facing Societal Barriers

- BIPOC
- Limited or non-English speakers
- Immigrants
- People who are undocumented
- Native Americans

Individuals facing societal barriers are those who are directly impacted by systemic social and economic challenges. These challenges create educational, resource, economic, and health disparities that leave communities extremely vulnerable to climate change impacts (Baird 2008). When looking at the intersectionality and compounding impact of these societal barriers, these communities are more likely to face high outdoor exposure, be systematically under-resourced, be subjected to toxic stress and/or have chronic health conditions, live in high-hazard risk areas, and are less likely to be homeowners. These systemic factors make them disproportionately vulnerable to climate hazards. In the county, many of these individuals face compounding risks associated with linguistic and income barriers. Immigrants and people who are undocumented are often deprived of access to medical services, quality housing, and basic needs, as well as access to social and economic services that would allow them to prepare for, respond to, and cope with climate hazards. If evacuation and/or advisory notices, hazard preparedness material, or governmental guidance are not provided in their preferred language, these individuals may

not be able to prepare for, cope with, or recover from a climate hazard (Gamble et al. 2016). Additionally, historical mistreatment and underserving by government leads to distrust, which compounds the lack of access to resources even when they do exist.

Sonoma County is located on the ancestral lands of the Pomo, Coast Miwok, and Wappo tribes. Most Native Americans experience some degree of the implications of colonial violence, cultural erasure, and social marginalization, and as a result, they are more likely to be under-resourced and experience poverty (Lynn et al. 2011). Not all county residents who identify as Native American have ties to tribal communities or come from tribes that are not federally recognized within Sonoma County, which affects the ways in which climate hazards impact individuals. In 2020, one in three Native Americans across the United States were living in poverty (Northwestern Institute for Policy Research 2020). Native Americans often experience worse health outcomes and lower life expectancies compared to other populations due to a variety of systemic factors including toxic stress due to regularly experiencing racism and other systemic harms, disproportionate poverty, and discrimination in the delivery or accessibility of health services. Native Americans are also less likely to have health insurance, which may limit their ability to seek medical care for injuries or illnesses caused or exacerbated by climate change impacts (Indian Health Services 2019). Native Americans are more likely to live in high-hazard risk areas and less likely to be homeowners, which leaves them vulnerable to climate impacts (Gamble et al. 2016). Within the vulnerability analysis, potential impacts to Native American populations are discussed in the context of BIPOC.

The close relationship some tribal communities have with their surrounding ecosystems and natural resources leaves these populations particularly at risk to climate change impacts because the natural systems their livelihoods may be dependent on are rapidly changing (Baird 2008). Climate change impacts can disrupt traditional ways of life for some tribal communities by threatening the health of local plants, animals, and ecosystems that play a critical role in the maintenance of their cultural traditions, and climate hazards may damage or destroy a tribal community's cultural resources and sacred land (Karuk Tribe Department of Natural Resources 2016). Additionally, tribal communities are often geographically isolated, making accessing healthcare services difficult.

Potential Impacts

Extreme Heat and Warm Nights

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

Drought

Drought conditions and declining stream flows may negatively impact tribal fisheries along the Sonoma County coast which may disrupt tribal cultural traditions and tribal eco-tourism economies (Karuk Tribe Department of Natural Resources 2016).

Wildfire

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

Tribal elders may have limited or reduced mobility, making it difficult for them to seek medical treatment or evacuate from a wildfire. Wildfires may damage or destroy a tribal community's cultural resources and sacred land. Western management practices that have historically centered around fire suppression often generate extremely severe and dangerous fires. Conversely, tribal communities have developed and implemented low-intensity fires to manage eco-cultural resources and reduce the buildup of fuels, decreasing the number of extreme fire events. Tribal communities often rely on local natural resources for economic opportunities. These communities may face economic impacts if natural resources are damaged or destroyed from a wildfire (Karuk Tribe Department of Natural Resources 2016).

Landslide

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

Tribal elders may have limited or reduced mobility, making it difficult for them to seek medical treatment or evacuate from a landslide hazard area (Karuk Tribe Department of Natural Resources 2016).

Riverine and Stormwater Flooding

BIPOC and people who are undocumented are more likely to live in flood hazard areas and in housing with insufficient protection against riverine and stormwater flooding. Limited or non-English speakers may not be offered flood warning or governmental guidance in their language, potentially causing them to experience greater exposure to flooding. Individuals in these groups may face

systemic and/or cultural barriers (including racism and other forms of discrimination) when seeking access to resources needed to safely evacuate hazard areas (Gamble et al. 2016). Individuals in these groups may experience injuries or death from high velocity flooding (CDPH 2017). People who are undocumented may not have access to medical services to treat injuries (Mendez et al. 2020). Tribal communities may face similar impacts from flooding as from wildfire.

Sea Level Rise

Populations in this group are less likely to live in coastal areas due to the high cost of living. Limited or non-English speakers may not have access to hazard-related communication in their language and therefore may not be able to prepare for and cope with sea level rise (Cooley 2012). Individuals in these groups may face systemic and/or cultural barriers in accessing resources needed to safely evacuate or avoid sea level rise hazard areas (Gamble et al. 2016). People who are undocumented may not have access to medical services to treat flood related injuries (Mendez et al. 2020). Tribal communities may face similar impacts from sea level rise as from wildfires.

Vulnerability Score – Individuals Facing Societal Barriers

Climate Hazard	Impact Score	Adaptive Capacity Score	Vulnerability Score
Extreme Heat	High	Medium	**4-High**
Drought	Low	Medium	**2-Low**
Wildfire	High	Medium	**4-High**
Landslide	Low	Medium	**2-Low**
Riverine and Stormwater Flooding	Medium	Low	**4-High**
Sea Level Rise	Low	Medium	**2-Low**

4. Individuals with Chronic Health Conditions or Health Related Sensitivities

- Seniors
- Young children
- People who are differently abled
- Individuals with asthma
- Individuals with cardiovascular disease
- Military veterans

Individuals with chronic health conditions or health related sensitivities are socially and physiologically vulnerable to climate change impacts and hazards. Seniors and people who are differently abled may have limited or reduced mobility, mental function, or communication abilities, making it difficult to evacuate during or prepare for a climate hazard event. They may also have medical needs for electricity which may be impacted during a public safety power shutoff or climate hazard event. Individuals in these groups are more likely to have pre-existing medical conditions or chronic illnesses that may exacerbate the risk of illnesses and medical problems from climate hazards. In the stakeholder focus group interviews, the Disability Services and Legal Center noted that people who are differently abled often also experience financial hardships as they may be reliant on federal income programs. These resource constraints may decrease the ability of people who are differently abled to mitigate and recover from climate hazard events. Individuals with asthma and individuals with cardiovascular disease are more likely to experience health impacts from climate hazards because of pre-existing conditions or diseases. Seniors often face challenges regulating their temperature due to medications or underlying conditions related to age. Young children are socially and physiologically vulnerable to climate hazards. They often have limited understandings of climate hazards and insufficient resources to independently prepare for and safely respond during a climate hazard event. Young children are reliant on their guardians and/or caregivers to ensure their health, safety, and wellbeing. Young children have not fully physiologically developed and are therefore more vulnerable to health effects of climate change impacts (Kenney et al. 2014). Military veterans may have been exposed to a variety of environmental, physical, and chemical stressors during military service which may have caused physiological or psychological health conditions, illnesses, or different abilities that make them particularly vulnerable to climate hazards (Olenick et al. 2015).

Potential Impacts

Extreme Heat and Warm Nights

Individuals with chronic health conditions or health related sensitivities are particularly at risk of heat related illnesses during extreme heat events. Differently abled folks, seniors, and children may have difficulty affording or accessing air conditioning or traveling to cooling centers during extreme heat events. Extreme heat events can also trigger power outages which are particularly dangerous for individuals who are electricity-dependent, either for their mobility, communication, or medical devices. Extreme heat conditions can exacerbate asthma, cardiovascular disease, certain different abilities, and other respiratory and cardiovascular conditions, potentially causing heat-related illnesses such as heat stress, heat stroke and dehydration, which can be-life threatening (CDPH 2020). Children are still physiologically developing which means that they are less able to regulate their bodies during extreme heat events (Kenney et al. 2014). Young children and seniors are especially at risk of dehydration as their bodies are not able to regulate as well (Kenny

et al. 2014). Dehydration may exacerbate underlying health conditions and illnesses.

Drought

Individuals with chronic health conditions or health related sensitivities are at risk to drought conditions and associated cascading impacts. Prolonged drought conditions can lead to water scarcity and individuals may need to rely on poor quality water supplies.

Wildfire

Individuals with chronic health conditions or health related sensitivities may be more susceptible to injuries or death from smoke inhalation or burns (CDPH 2017). These populations are particularly at risk of respiratory health impacts associated with smoke inhalation of wildfire smoke pollutants. Seniors and military veterans are vulnerable to health impacts from wildfire smoke pollutants because they are more likely to have underlying respiratory and/or cardiovascular conditions and illnesses. Young children may experience respiratory health impacts from wildfire smoke because their respiratory systems are not fully developed and are sensitive to stressors. Individuals with cardiovascular disease may experience severe cardiovascular health impacts if exposed to wildfire smoke pollutants. Individuals with asthma may experience severe respiratory health impacts such as difficulty breathing if exposed to wildfire smoke pollutants. Individuals with disabilities, young children, and seniors may have difficulty evacuating from wildfires, increasing the risk of health impacts from wildfire smoke inhalation or fire burns (EPA 2022).

Landslide

Individuals with chronic health conditions or health related sensitivities may be more susceptible to injuries or death from a landslide (CDPH 2017). Individuals with disabilities, young children, and seniors may have difficulty evacuating from landslides, increasing the risk of health impacts and geographical isolation (EPA 2022).

Riverine and Stormwater Flooding

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

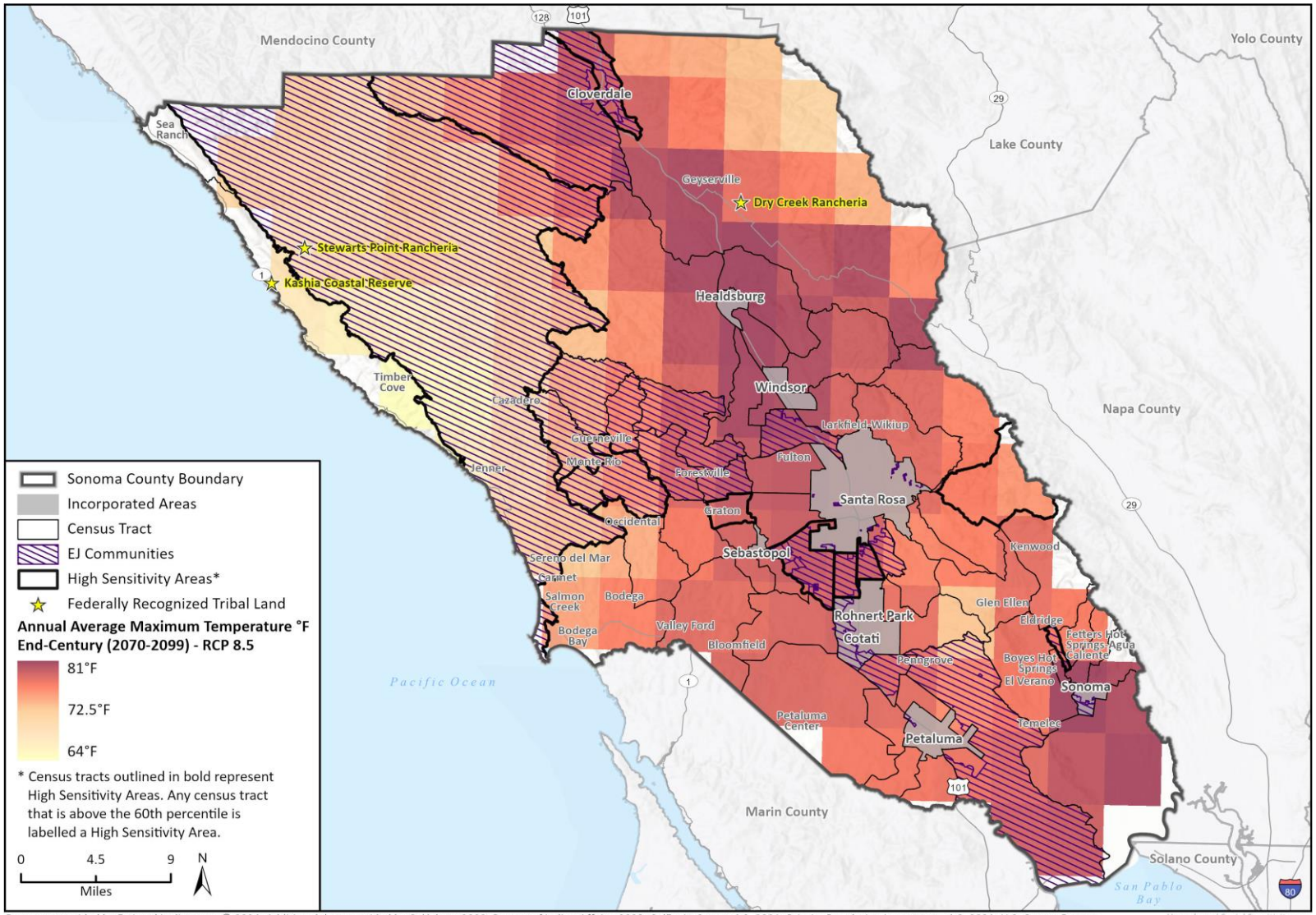
Sea Level Rise

Seniors, people who are differently abled, and individuals with chronic health conditions or illnesses may be less able to safely evacuate hazard areas.

Vulnerability Score – Individuals with Chronic Health Conditions or Health Related Sensitivities

Climate Hazard	Impact Score	Adaptive Capacity Score	Vulnerability Score
Extreme Heat	High	Medium	**4-High**
Drought	Low	Medium	**2-Low**
Landslide	Medium	Low	**4-High**
Wildfire	High	Medium	**4-High**
Riverine and Stormwater Flooding	Medium	Low	**4-High**
Sea Level Rise	Medium	Low	**3-Medium**

Figure 18 Sonoma County High Social Sensitivity Areas and Annual Average Maximum Temperature, End-Century



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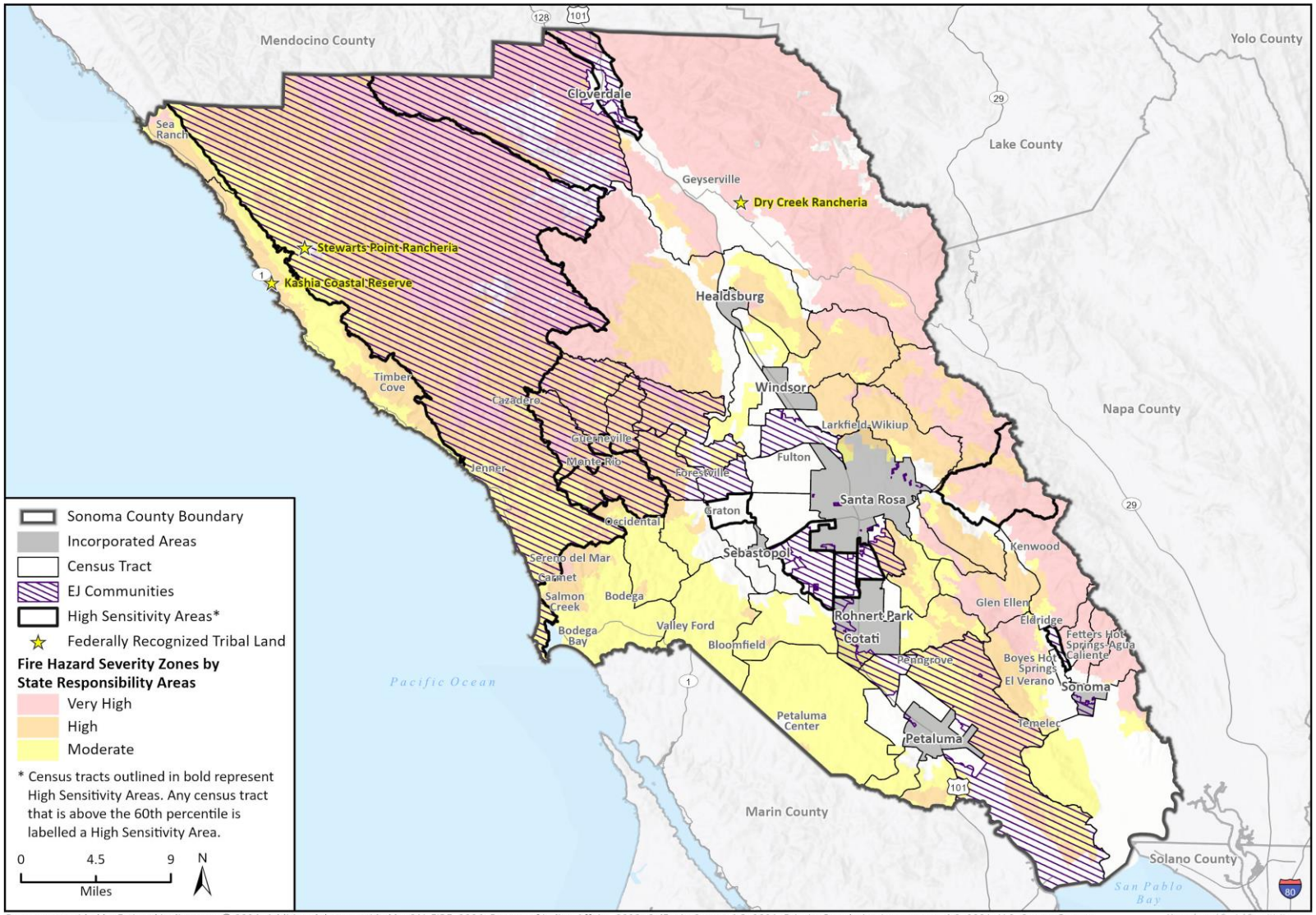
Hazards and Social Sensitivity.aprx
Fig X End-Century Average Max Temp and Social Sensitivity

Figure 19 Sonoma County High Social Sensitivity Areas and Wildfire Hazard Severity Zones



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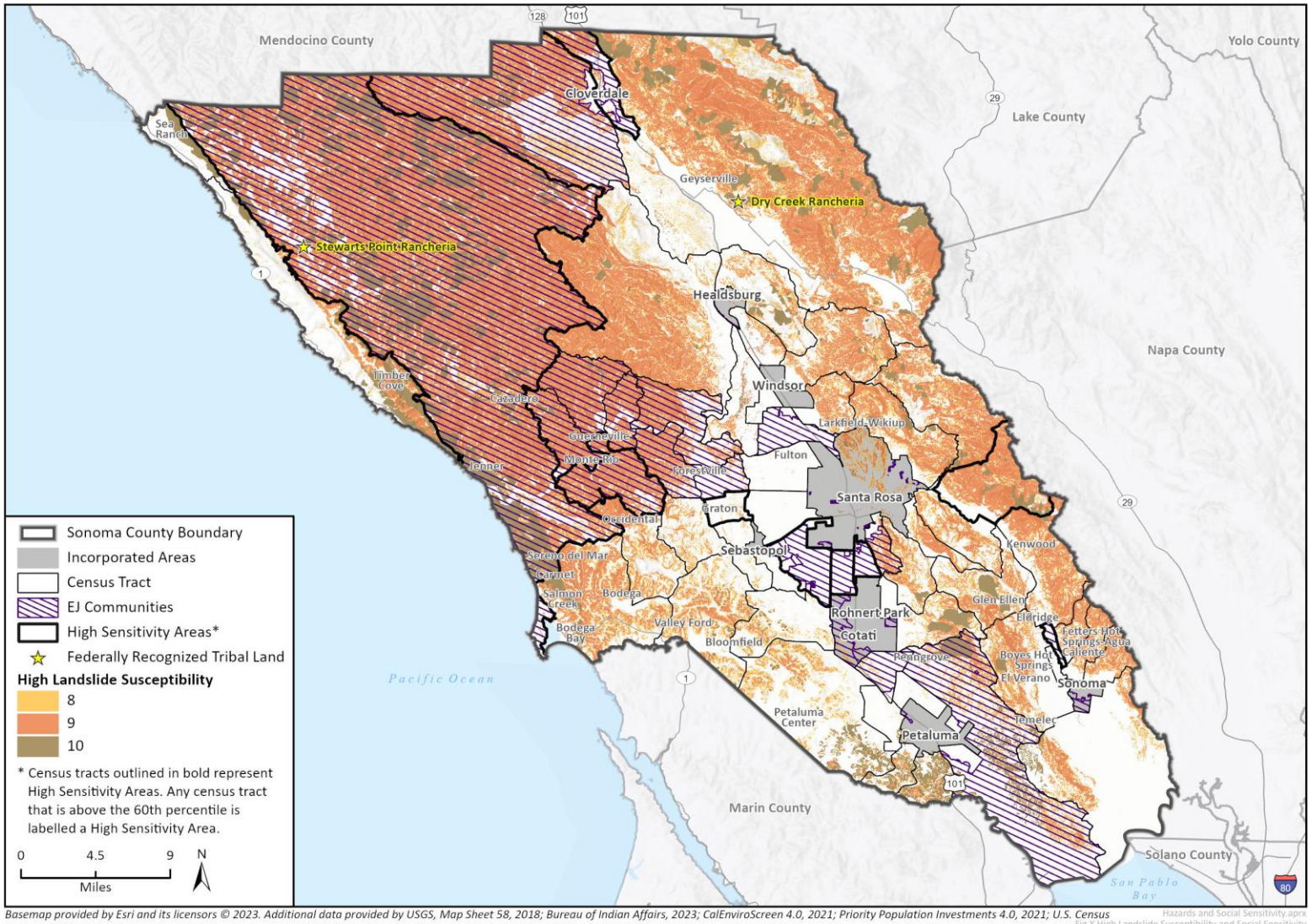
Hazards and Social Sensitivity.aprx
Fig X Fire Hazard Severity Zones and Social Sensitivity

Figure 20 Sonoma County High Social Sensitivity Areas and Landslide Susceptibility Areas



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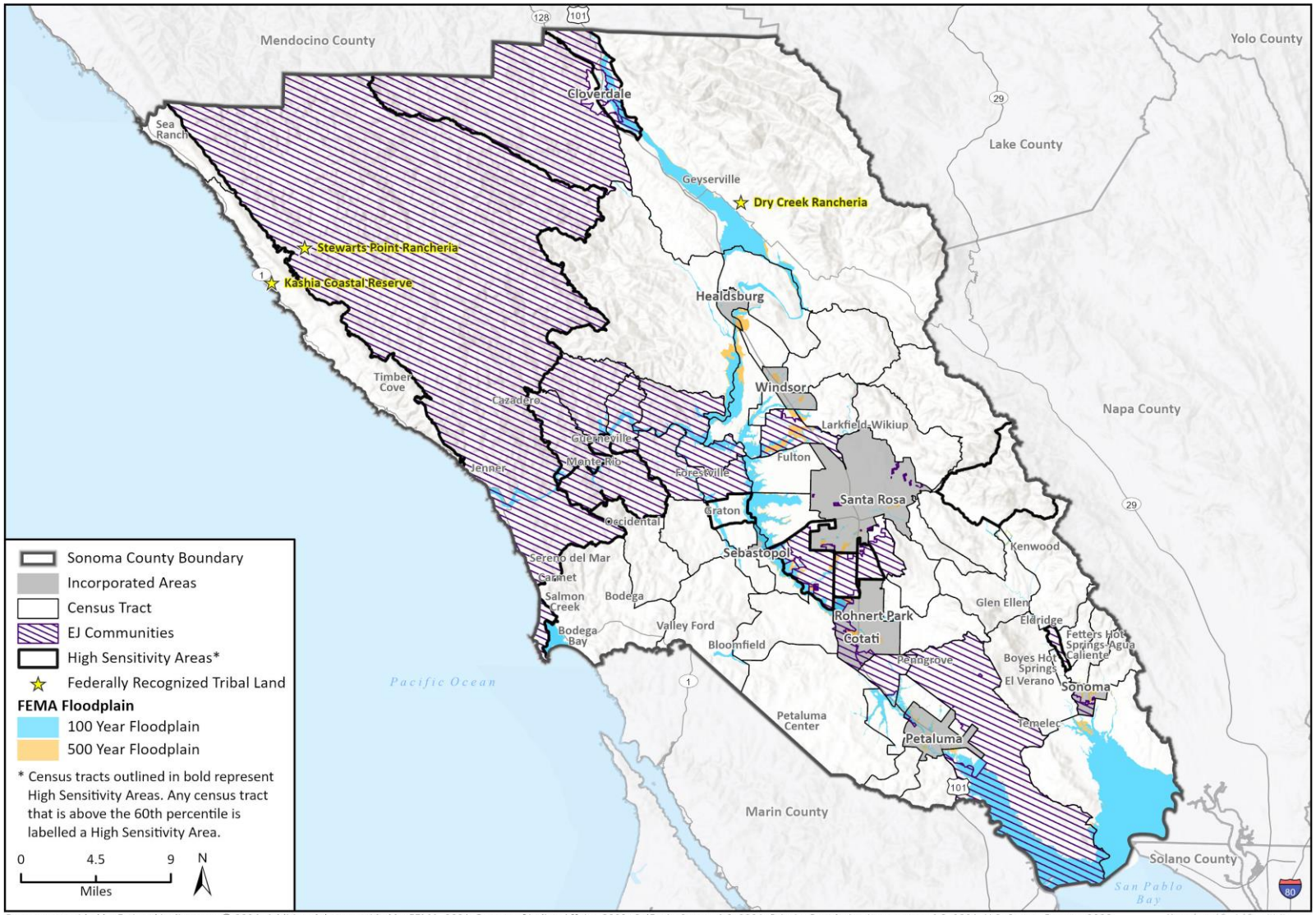
Hazards and Social Sensitivity.aprx
2022 High Landslide Susceptibility and Social Sensitivity

Figure 21 Sonoma County High Social Sensitivity Areas in 100-Year and 500-Year Floodplains



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Hazards and Social Sensitivity.aprx
Fig X FEMA Flood Hazard and Social Sensitivity

Parks and Natural Resources

Parks and natural resources within Sonoma County include County regional parks, open spaces, forested land, critical habitats, vegetation communities, rivers and streams, waterbodies, wetlands, and wildlife (Sonoma County MJHMP, 2021a). Natural resources correspond to varying land cover types found throughout the County, as depicted in Figure 16. Federally designated Critical Habitat for multiple species are displayed in Figure 17.

Sonoma County Regional Parks categorized the park system that they manage by land cover type and acreage which are displayed on Figure 16 . Sonoma County critical habitats, parks, and land cover types are depicted in Figure 17. The information in Figure 17 was used in combination with Figure 7, Figure 8, Figure 12, and Figure 13 to identify affected vegetation communities within each hazard zone and the scope of affected habitats associated with certain vegetation types.

This section provides a general discussion of potential impacts to parks and natural resources. The Sonoma County Climate Resilient Lands Strategy provides further characterization of the impacts of climate hazards on natural and working lands. The Climate Resilient Lands Strategy divides the County into nine ecoregions that have distinctive physical and biological features, and provides detailed information on each ecoregion's unique qualities, land use, demographics, critical assets, impacts from climate change, and resilience indicators. The Napa–Sonoma–Russian River Valleys ecoregion is in the middle of the County and most of the county parks are located in this ecoregion, including Crane Creek and Tolay Lake Regional Parks and part of Spring Lake Regional Park (SCRLS 2022).

Potential Impacts

Extreme Heat and Warm Nights

The impacts from extreme heat and warm nights are similar to impacts experienced by vulnerable populations. Wildlife under these conditions face impacts of heat stress and heat related illness as well as disrupted reproductive cycles, and compounding risks associated with early and extended seasonal temperature increases (Backlund 2008). Because it is seasonally warmer earlier in the year, species can emerge early with no food source and potentially face a delayed cold front which increases mortality rates. Timing of seasonal warmth may not overlap with food sources and extreme heat may stress dependent vegetation communities and wildlife (Dale, 1997, Hamerlynck 1995, Maclean 2011). Plants are more likely to experience heat stress and drying, and species' habitat ranges may shift. Some pests can proliferate more easily with warmer temperatures (Hamerlynck 1995), and some plants and animals ill-suited to the new warmer conditions may suffer increased mortality rates (Ackerly et al. 2018). Parks and natural resources are highly exposed to extreme heat and warm nights. As shown in Figure 7, central Sonoma County may experience significant increases in temperature and subsequently extreme heat events. The natural resources at risk include California Red Legged Frog and California Tiger Salamander Critical Habitat areas, as well as hardwood forest, and shrub and grasslands as shown in Figure 17. Both mid- and end- of century projections depict dramatic increases in extreme heat days (CEC 2021).

Drought

Impacts from drought include water scarcity and availability, particularly for land covers, parks, and natural resources that are dependent on higher amounts of rainfall. Drought will disrupt habitats and the ability for wildlife to survive from dehydration and unreliable food sources. Extended or variable drought conditions affect the amount and duration water is available in ephemeral and permanent waters sources, impacting plants and wildlife dependent on those aquatic resources. Sonoma County is home to several State and Federally listed threatened or endangered species dependent on rivers, streams, lakes, and wetlands for survival per the County's General Plan 2020 Environmental Impact Report (Sonoma County EIR 2023).

Wildfire

The largest direct impacts to parks and natural resources are caused by wildfires. There is direct mortality and loss of resources and wildlife from wildfire as well as indirect mortality due to loss of habitat area and available food sources and seed bank (Backlund 2008). The severity and frequency of wildfires can exacerbate these impacts further through habitat conversions resulting in vegetation communities that no longer support the species using that habitat (Bell et.al 1999, Stephenson et.al 1999, Coop et al. 2020). As discussed within the Exposure to Climate Hazards section, projected annual burned acreage is expected to increase as are the decadal probabilities of wildfire shown in Figure 10. Figure 8 shows the eastern and northern edges of Sonoma County within wildfire zones with Hood Mountain Regional Park & Open Space Preserve completely exposed and several partially exposed parks interspersed along the County jurisdictional edges. Increased wildfire probabilities and expansion of wildfire zones shown in Figure 10 may lead to increased park and natural resource exposure to wildfires (Sonoma County 2022). Wildfire impacts on parks can also cause prolonged closure of park facilities, limiting access to important recreational areas and facilities for the public. Potentially affected land cover types can be seen in Figure 17 and primarily include conifer and hardwood forests along with some shrub and grasslands.

Landslides

Landslide susceptibility directly overlaps with parks and natural resource areas throughout the County affecting nine separate park areas as shown in Figure 11. In the event of a landslide, there is potential for loss of lands, habitat, and disruption of waterbodies in areas of debris flow. The susceptibility of parks and natural resource lands in Sonoma County to landslides is high, therefore, there is risk around loss of topsoil and habitat conversions. Wildlife and plants face a compounding risk to landslide events because it creates both habitat displacement and increased mortality risk. Potentially affected land cover types can be seen in Figure 17 and primarily include conifer and hardwood forests.

Riverine and Stormwater Flooding

There are several major rivers that run through Sonoma County as well as many creeks. FEMA flood zones are identified alongside most of these rivers and creeks (Figure 12). A majority of the flood-prone areas throughout the County are part of the Russian River (Sonoma County MJHMP 2021a). Flooding impacts include erosion and the detrimental effects flooding can have on water quality, especially to aquatic and fish species dependent on water quality for survival (Talbot 2018). Riverine and stormwater flooding will mostly affect sensitive species of plants and wildlife that are not upland. Other impacts include damage from inundation

within storm flooded areas, such as habitats and lands around streams and waterbodies in the County. Floodplains across the County primarily could impact the following land cover types: riparian, shrub, and grasslands as shown in Figure 17.

Sea Level Rise

The direct effects of sea level rise on natural resources are the losses of prime recreational and natural areas. Bodega Bay may be almost completely flooded by 2100. The negative impacts of sea level rise include the risks of squeezing and permanently submerging coastal habitats, which could lead to losses in the biodiversity of habitats and shrinking the area between habitats and human developments. As sea level rises, it can inundate the County's natural land and open spaces, which in certain areas serve as natural protections against flooding, further decreasing coastal habitat values. In addition, saltwater intrusion into freshwater due to sea level rise may alter coastal habitat and ecosystems (Sonoma County MJHMP, 2021a).

Sea level rise will result in increasing shoreline and bluff erosion, which will narrow the beach. impacting tourism resources for Sonoma County. Coastal erosion due to sea level rise could make some beaches inaccessible and it may become much more costly to maintain. It will also negatively impact dune habitats and coastal wetlands areas such as the ones south of the Russian River mouth, where sea level rise will intensify flooding, changing the depositional environment and altering the stability of the natural berm (Sonoma County MJHMP, 2021a). The shifts in coastal processes will affect the management of the freshwater lagoons in the Russian River estuary (Sonoma Water CAP, 2021).

Adaptive Capacity

There are existing plans, policies, and programs in place to help alleviate climate impacts on parks and natural resources particularly related to wildfire and drought. Many of the existing plans, policies, and programs in place are collaborative efforts at the local level. It should be noted that many local entities may not have the staff, resources, or jurisdiction to fully implement strategies.

- **Sonoma County Climate Resilient Lands Strategy** is a non-regulatory framework for how the County and its partners can conserve, manage, and restore natural and working lands to build climate resilience. The Strategy provides an overview of climate hazards, characterizes Sonoma County land types and ecoregions, and offers recommendations and guidance for the planning, design, and implementation of resilience-related projects.
- **Sonoma County Vital Lands Initiative** is a long-range comprehensive plan to prioritize the land conservation activities of Sonoma County Agricultural Preservation and Open Space District. The plan includes goals, priorities, and strategies for conservation, and identifies climate resilience as a co-benefit of conservation.
- **Sonoma County Multi-Jurisdictional Hazard Mitigation Plan** identifies hazard exposures to natural resources and potential actions for mitigating damage.
- **Sonoma County Climate Mobilization Strategy.** Includes strategies to increase the resilience of natural and working lands throughout the county.
- **Sonoma Valley, Petaluma, and Santa Rosa Plain Groundwater Subbasin Groundwater Sustainability Plans.** Describes the County's policies for groundwater management such as protecting groundwater recharge areas, managing land use that

has an impact on groundwater use and quality, and developing alternative mechanisms for integrated groundwater management strategies.

- **Sonoma County Operational Area Contingency Plan: Wildfire Burn Scar Debris Flow Response.** The Plan establishes guidelines for local government and entities within Sonoma County to reduce threats of debris flow in areas in recent wildfires including parks and natural resource areas.
- **Sonoma County Operational Area Emergency Operations Plan Annex: Russian River Flood Plan.** The Plan outlines procedures and responsibilities for emergency response to flood conditions on the Russian River and its tributaries. The Plan outlines flooding and response scenarios on the Russian River.
- **Community Rating System** is a voluntary program within the National Flood Insurance Program (NFIP) that encourages floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk resulting from community actions.
- **Sonoma County Energy Independence Program (SCEIP)** offers financing for permanent energy, water, wildfire safety, and seismic strengthening improvements through the property tax system. Financing is available for residential, commercial, industrial, agricultural, multi-family and certain non-profit projects.

Vulnerability Score – Parks and Natural Resources

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

Critical Facilities, Buildings, Services, and Infrastructure

Overview

Within Sonoma County, there is an interdependent network of critical facilities, buildings, services, and infrastructure vulnerable to climate change. The following discussion of this asset category explains the cascading impacts of climate hazards as they affect the ability of the community to receive emergency and essential services. Infrastructure dependencies are also explored in this analysis. Assets within this category and identified in the Figures throughout this assessment include:

- Fires Stations
- Police Stations
- Hospital/Healthcare Facilities
- Emergency Shelters
- Schools
- Public Libraries
- Airports

Additional critical facilities and service infrastructure throughout the County that are not identified in the Figures within this assessment include:

- Public utilities, including water, wastewater, and power
- Public transportation and roadways
- Energy and communications facilities
- Storm drainage and flood protection facilities
- Solid and hazardous waste and recycling facilities

Vulnerabilities to this asset category primarily concern physical exposure and damage to facilities from exposure to various climate hazards subsequently affecting operations of critical services. The Sonoma County Multi-Jurisdictional Hazard Mitigation Plan (Volume 1) includes additional technical detail on the exposure and vulnerability of critical facilities to various hazards. According to the safety element survey, respondents faced many communication and evacuation challenges during hazard events. Many respondents noted losing power and internet access as major communication barriers during previous hazard events. There were also many people who did not know where to find information about what to do in a hazard event or could not properly access the information due to a language barrier. Other evacuation challenges respondents mentioned included heavy traffic on evacuation routes, confusion about which evacuation routes to take and which ones were affected by the hazard, trouble finding and paying for a place to stay while evacuated, and some people with disabilities noted having additional challenges in terms of health exposure during the pandemic and finding accessible lodging.

Potential Impacts

Extreme Heat and Warm Nights

Extreme heat could impact occupants of buildings and facilities that are not adequately weatherized for increased temperatures. Additionally, as temperatures increase, roadways, transportation routes, and railroads are vulnerable to damages through sustained heat such as buckled railroad ties and cracked surfaces (Ackerly et al. 2018). Increased emergency service calls could strain medical services and emergency responders. Electrical infrastructure could be overwhelmed by peaks in demand and result in blackouts or public safety power shutoffs instituted by energy providers to avoid impacts to electrical facilities. Power outages have significant cascading impacts on communication networks, water conveyance, and vulnerable populations. The ability for critical service providers to fully function during power outages could be significantly impaired (Sonoma County MJHMP 2021a). Central and southern Sonoma County may experience the greatest increases in temperature by the end of the century as shown in Figure 7.

Drought

Drought will have minimal direct physical impact on buildings and facilities across Sonoma County. However, drought can impact water reliability and water infrastructure. The recent multi-year drought significantly strained the County's water supply systems, which resulted in water storage levels sinking to

historic lows. This led to mandatory water use restriction impacting day to day activities and local economies. Low water supply also led to new reliability investments by water agencies, putting additional strains on their financial systems, which may influence future water supply rate adjustments. Regionally it has also been found that drought and subsequent overuse of groundwater has exacerbated unsafe drinking water in rural areas (Ackerly et al. 2018). Sonoma County has multiple sources of water including public systems, small water systems, private wells, and surface water. To maintain effectiveness, critical facilities must maintain operations during projected droughts while service providers like Sonoma Water will have to overcome obstacles with supply (Sonoma County MJHMP 2021a). Projected changes in snowpack, temperature, and precipitation rates from climate change across California will result in potentially enhanced water scarcity through the end of the century (Sonoma County MJHMP 2021a).

Drought impacts can create service strain for emergency and medical services. Cracked pavements from drought compounded with extreme heat impacts roadways and transportation routes (Samuel et al. 2019).

Wildfire

Structures and buildings located within wildfire hazard zones are at risk of direct structural damage from wildfires. There are many critical facilities in wildfire hazard zones, including fire stations, evacuation shelters, schools, and airports as displayed in Figure 8. Areas of high exposure include the eastern and northeastern parts of the County with some exposure along the northwestern portions of the county. Wildfire hazard zones may expand by end-of-century which could lead to more critical facilities at risk of structural damage. Per the Sonoma County Community Wildfire Protection Plan, the risk of large wildfires in California is expected to increase up to 50% by the end of the century (Permit Sonoma Fire Prevention Division 2023). Additionally, electricity distribution lines as well as natural gas and oil lines are interdependent systems for the County. Above ground or just below-grade utility lines have the potential to be damaged in wildfire hazard zones, resulting in oil and gas leaks and power outages, which can cause fires or explosions. Utility lines under certain high wind conditions can also trigger wildfires through downed power lines (Ackerly et al. 2018). Additionally, public safety power shut offs in response to wildfire risk can affect power service reliability.

The potential impacts that arise from increased wildfire exposure of buildings and service lines can create cascading risks. Residential and commercial buildings not properly weatherized may experience wildfire smoke more directly as well as heightened risks of building exposure without fuel reduction and best practice building standards (Permit Sonoma Fire Prevention Division 2023). Additional risks include the displacement of communities exposed to wildfires causing service strains and needs for additional community safety services. Areas exposed include communities along the eastern span of the County as well as the northwestern areas of the county. Increased frequency of wildfires in areas shown in Figure 9 can place strain on fire and emergency services. Evacuation routes could be disrupted during a wildfire event limiting emergency responders' access and the ability for people to evacuate. Wildfires can also impact water quality downstream through cascading risks associated with post-fire effects. Soil erosion and slope instability that lead to sedimentation of watersheds negatively impacts drinking water while simultaneously creating flood risks (Permit Sonoma Fire Prevention Division 2023).

In the stakeholder focus group interviews, the Sonoma County Community Development Commission noted that loss of housing

stock, due to wildfire impacts, has led to increased displacement and houselessness in the county.

Landslides

Pipelines for water, electrical distribution lines, and roadways are vulnerable to landslide impacts which could occur in sloped areas that extend into wildfire zones. Because there is high landslide susceptibility along roadways in the western end of the County, shown in Figure 10, and in areas where there are several critical facilities including fire stations, schools, and emergency shelters, there is a risk of emergency service disruption and impacts to evacuation (CDOC 2021).

Riverine and Stormwater Flooding

Impervious surfaces can impede the absorption of water and augment stormwater flooding in areas of Sonoma County. There is risk of damage to critical facilities from increased extreme precipitation events including erosion, washouts, and sinkholes. Storm drainage and flood protection services for the County may be impacted by these events and potential areas of impact can be found in Figure 11.

In the stakeholder focus group interviews, the Sonoma County Community Development Commission noted that flooding damage has led to loss of housing stock, increasing displacement and houselessness in the county. Additionally, it was also noted that there has been increased damage to and flooding of rural roads that have not been adequately maintained or hardened to mitigate impacts. This has previously caused several rural communities in Sonoma County to be temporarily isolated (Carlton 2023).

Sea Level Rise

Storm surges and wave run-up are already threatening coastal infrastructure. Sea level rise will exacerbate this issue and expose over 50 additional critical facilities to inundation. This includes waste facilities that may pose risks to the immediate community and increase public health concerns. Furthermore, rising seas will impact storm drainage systems, which may experience stormwater backups as a result of tidal flooding (Sonoma County MJHMP, 2021a). Saltwater intrusion can affect drinking wells adjacent to the coast and San Pablo Bay. Sea level rise will threaten Sonoma Valley wastewater treatment plants, affecting collection systems, and reclamation systems, as well as, the operation of Hudeman Slough's tide gate, and roads and levees adjacent to the wetlands management units (Sonoma Water CAP, 2021). The combination of sea level rise and storm surges can cause temporary closures to the County's roads and bridges, including Highway 1 and Highway 37, which are at risk of failure due to sea level rise. In addition, sea level rise will increase the likelihood of breaching levees that protect roads and highways adjacent to San Pablo Bay.

Adaptive Capacity

Several plans and programs are in place to adapt Sonoma County critical facilities, buildings, services, and infrastructure, including plans related to utility and emergency services reliability. Most plans and programs address extreme heat and wildfire hazards.

- **Sonoma Water Local Hazard Mitigation Plan.** This plan evaluates the natural hazard risks and vulnerabilities facing Sonoma Water's infrastructure and services. The LHMP describes hazard exposure and potential impacts of coastal erosion, coastal storm, flooding, landslides, severe winter storms, wildfire, and drought.

- **Sonoma Water Urban Water Management Plan.** The Plan details water supply sources, historical, and projected water use, and potential future water supplies during normal, single-dry, and multiple-dry years. The Plan describes climate change impacts on water supplies and endangered and threatened species. Proposed demand management strategies center around metering, water conservation public education and outreach programs, asset management, and wholesale supplier assistance programs.
- **Sonoma County Community Wildfire Protection Plan.** The Plan describes wildfire risk in Sonoma County. Assets, ecosystems, and resources at risk in the County are identified and assessed. The Plan details response entities, mitigation strategies, and potential risk reduction projects
- **Sonoma-Lake-Napa Unit Strategic Fire Plan.** The Plan identifies and prioritizes wildfire mitigation and recovery strategies aimed at reducing risk within the Sonoma-Lake-Napa Unit.
- **Pacific Gas & Electric (PG&E) Climate Change Vulnerability Assessment and Resilience Strategies** Evaluates how climate hazards have the potential to impact PG&E's assets and services, including disadvantaged communities' reliance on the delivery of continuous power, PG&E outlines its approach to engagement, emergency preparedness, and response planning.
- **Pacific Gas & Electric (PG&E) Community Wildfire Safety Program** implements improvements within Sonoma County energy infrastructure to reduce wildfire risk and increase resilience to climate hazards including strong storms and wildfire.
- **Sonoma County Multi-Jurisdictional Hazard Mitigation Plan** includes the broad goal of protecting critical facilities, utilities, and services from hazard impacts.
- **Sonoma County Operational Area Emergency Operations Plan and Annexes.** The Plan provides guidance on all phases of an all-hazards emergency management process including preparedness, response, recovery, and mitigation. It outlines the systems and roles of responsible entities, alert and warning systems, public information communications, mutual aid agreements, and a hazard analysis summary in alignment with the County's current Hazard Mitigation Plan
- **Sonoma County Energy Independence Program (SCEIP)** offers financing for permanent energy, water, wildfire safety, and seismic strengthening improvements through the property tax system. Financing is available for residential, commercial, industrial, agricultural, multi-family and certain non-profit projects.

Vulnerability Score – Critical Facilities, Buildings, Services, and Infrastructure

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

Agriculture

Overview

A large portion of Sonoma County's economy is based in agriculture and is valued at nearly $830 million in 2021 (Sonoma County Crop Report 2021). The potential climate change impacts to the County's agricultural sector could be far reaching. The 2021 Sonoma County Agricultural Report states that the largest obstacle faced was drought related losses (Sonoma County Crop Report 2021). Some of the top economically profitable crop or rangeland types in Sonoma County are:

- Winegrapes
- Milk
- Nursery
- Poultry Products
- Cattle and Calves
- Vegetables
- Sheep and Lambs
- Rye and Oat Hay Crops
- Apples

Potential Impacts

Extreme Heat and Warm Nights

A greater number of extreme heat events and warmer nights could cause declines in crop yields due to increased heat stress (Parker et.al. 2020). Lower crop yields associated with extreme heat could increase costs and ultimately decrease agriculture profitability. Livestock operations are potentially less viable during extreme heat events as livestock may suffer from heat related illness. Livestock and poultry are vulnerable to extreme heat conditions, leading to mortality, which, in turn, may impact rendering plant capacity (Sonoma County 2019a). Agricultural workers are particularly vulnerable to health risks from high-outdoor exposure to an increased number of extreme heat days. These individuals typically are under-resourced, face societal barriers, and may have chronic conditions due to on-farm exposure to dust and farm chemicals. As a result, extreme heat may impact agricultural operations by reducing worker availability and productivity.

Drought

Higher temperatures will decrease the statewide snowpack and raise the snowline, decreasing important surface water reserves for agriculture (Ackerly et al. 2018). Like extreme heat and warm nights, drought is linked to declines in crop yields, increasing costs, and decreasing crop profitability. Drought can result in regional losses of crops and can stress the statewide water supply. A majority of the County's agricultural water is drawn from the Russian River watershed, which supplies Lake Sonoma and Lake Mendocino. These lakes have experienced drought related reduction in capacity. In 2009, Lake Sonoma was at 74% capacity and Lake Mendocino was at 38% capacity (Sonoma County MJHMP, 2021a).

Crops reliant on high depths of water and subsequently higher water intensity needs are most impacted by drought (Cooley et al. 2015). In 2022, all of Sonoma County was in a Severe or Extreme Drought (NOAA 2023). According to NOAA, extreme drought conditions result in the following impacts:

- Livestock need expensive supplemental feed; cattle and horses are sold; little pasture remains; fruit trees bud early; and producers begin irrigating in the winter.
- Fire season lasts year-round; fires occur in typically wet parts of state; and burn bans are implemented.
- Water is inadequate for agriculture, wildlife, and urban needs; reservoirs are extremely low; and hydropower is restricted.

Wildfire

Sonoma County has experienced a significant number of severe wildfires in the past 5 years, as shown in Figure 9. Wildfires can destroy crops and disrupt rangeland operations while wildfire smoke may stress the health of crops and livestock. Agricultural land cover overlaps very high fire hazard severity zones mainly at the eastern and northern edges of the County as shown in Figure 22. Moderate fire hazard severity zones overlap agriculture throughout the entire county particularly in the southwestern portion of the County and southeast of Healdsburg. The probability of wildfires across Sonoma County is expected to increase by the end of the century in areas throughout the County with significant new exposures of agriculture lands in the east, north, and west jurisdictional ends of the county.

Landslides

There are high degrees of overlap with landslide susceptible areas and agricultural lands shown in Figure 10. Almost all agricultural lands are located in a deep-seated landslide susceptible area. Landslide impacts on agricultural lands include mainly rangelands at the base of landslide susceptible areas. In the event of a landslide, agricultural operations may be fully halted and the viability of the land for continued use may be limited by the time it takes to restore. Landslides can create vulnerabilities for livestock with risk of mortality as well as habitat displacement.

Riverine and Stormwater Flooding

Agricultural Land overlapping flood plains occurs in areas throughout central Sonoma County next to the Russian River and the North Bay Area, as shown in Figure 22. Operations in these areas along the rivers that run through the County have the potential to be disrupted during flood events and could result in reduction in crop yields. Agricultural worker residences could also be inundated.

Sea Level Rise

Sea level rise can impact farmlands located in low-lying areas due to saltwater contamination since rising seas will increase saltwater pollution of the State's delta and levee systems (Sonoma County MJHMP, 2021a). The impacts of saltwater intrusion due to sea level rise is one of the primary climate change concerns for agricultural practices in Sonoma County bordering the San Pablo Bay to the south. Agricultural lands in reclaimed tidal areas in southern Sonoma County will be at risk of inundation due to the risk of levee breaches and failure (Climate Ready Sonoma County, 2014). Additionally, privately maintained pumps and levees that do not meet current construction standards expose the county to greater risk of levee breaches. Antiquated private systems in south county meant to protect those areas from tides can be a source of vulnerability for the county.

Figure 22 Sonoma County Agricultural Land in Wildfire Hazard Severity Zones

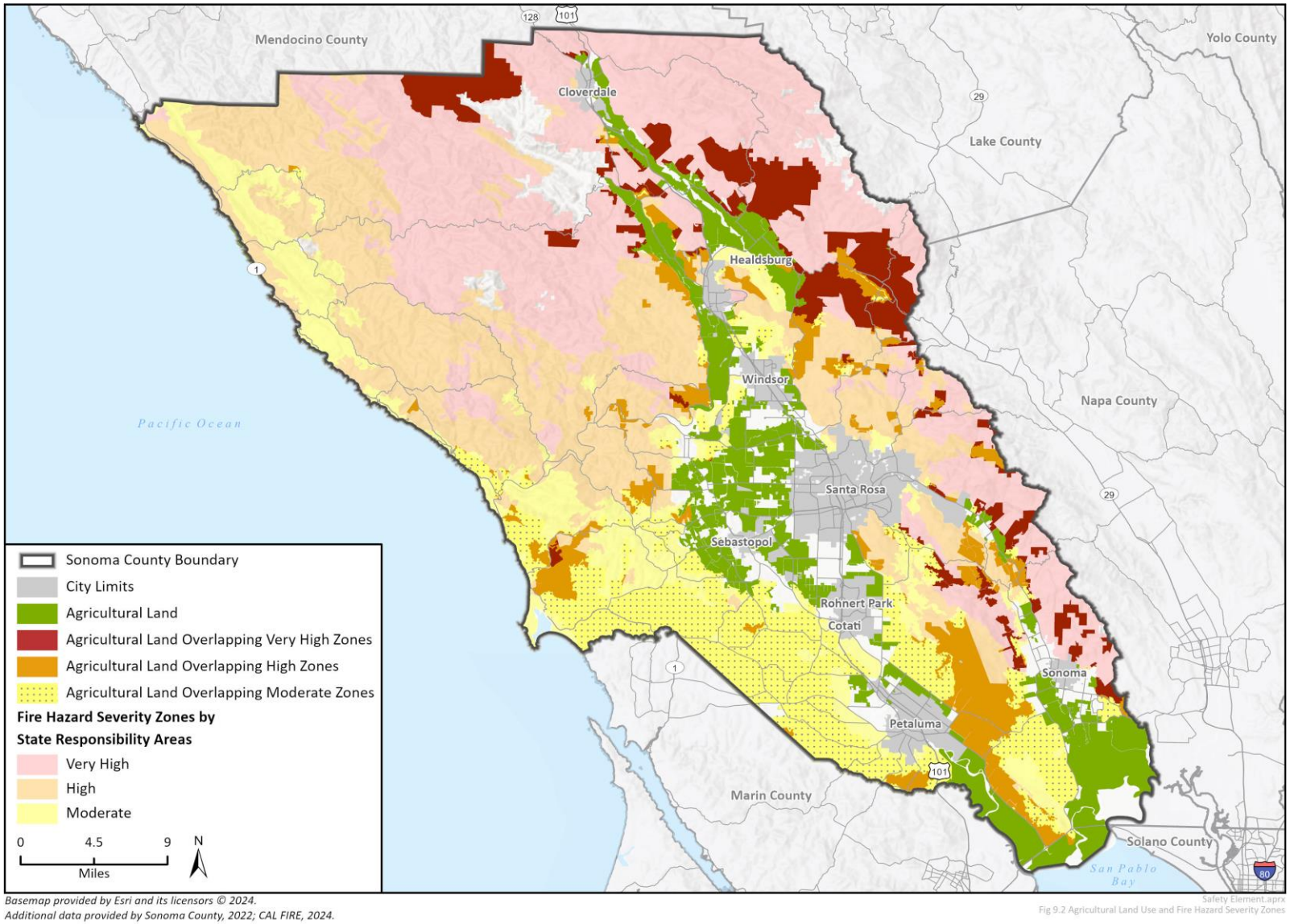
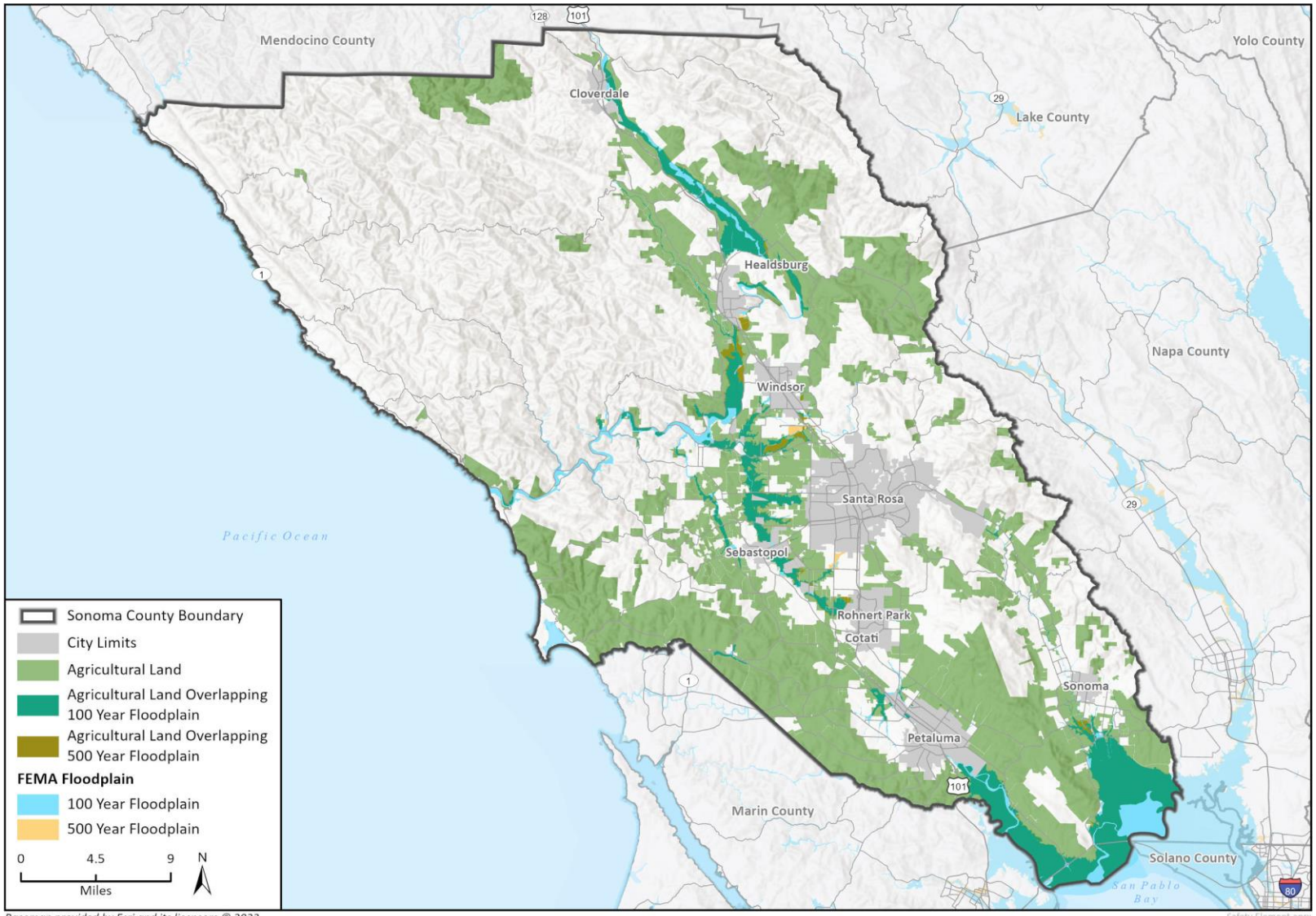


Figure 23 Sonoma County Agricultural Land in 100- and 500-Year Floodplains



Adaptive Capacity

- **Sonoma County General Plan 2020.** Some agricultural-specific adaptive capacity is present within the County as part of the Sonoma County General Plan Land Use Element and the Agricultural Resources Element. Both elements establish agricultural land protection policies.
- **Sonoma County Climate Resilient Lands Strategy** is a non-regulatory framework for how the County and its partners can conserve, manage, and restore natural and working lands to build climate resilience. The Strategy provides an overview of climate hazards, characterizes Sonoma County land types and eco-regions, and offers recommendations and guidance for the planning, design, and implementation of resilience-related projects. Agricultural lands are identified as important opportunities to adapt to climate change, reduce climate risks, and sequester and store carbon at a meaningful scale.
- **Sonoma County Crop Report.** The annual report summarizes the total value and production of crops and agricultural commodities in Sonoma County. The 2021 Report summarizes the impacts of drought on recent agricultural production.
- **A Roadmap for Climate Resilience in Sonoma County, California.** The Report prepared by the North Bay Climate Adaptation Initiative details climate projections and related climate hazards, climate-related health risks, and the populations in Sonoma County that are most vulnerable to climate change impacts. Goal 6 of the Roadmap specifically addresses the promotion of food system security and agricultural climate preparedness.
- **Sonoma County Multi-Jurisdictional Hazard Mitigation Plan.** The Plan assesses hazards within the County and identifies mitigation strategies that reduce or eliminate long-term risks to people and property from those hazards. Climate hazards planned for include drought, flood, landslide, sea level rise, severe weather (e.g., extreme heat), wildfire. The MJHMP includes specific goals and actions to reduce flood exposure of agricultural lands and increase resources for water conservation among agricultural producers.
- **Sonoma Valley, Petaluma, and Santa Rosa Plain Groundwater Subbasin Groundwater Sustainability Plans** lay out a management process for ensuring a sustainable groundwater supply in the future for each respective subbasin by improving the understanding of groundwater resources, measuring progress through metrics that will be monitored, actively implementing projects, adopting policy and management actions in response to groundwater conditions if they decline unacceptably, and developing the funding needed for long-term implementation.
- **Agricultural Resilience in the Face of Extreme Dry Conditions: A Marin and Sonoma Partnership Response and Recommendations.** This assessment shares the details of the Marin and Sonoma agricultural communities' collaborative and independent efforts to mitigate drought impacts, organized by specific adaptation practices. The report provides background on efforts and progress, and identifies needed advancements for each mitigation practice, with the intent to galvanize the community resilience already achieved and strengthen it into the future.

Vulnerability Score - Agriculture

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

6 Vulnerability Summary

Key climate change vulnerabilities on community members rendered vulnerable by systemic inequities; parks and natural resources; agriculture; and critical facilities, buildings, services, and infrastructure in unincorporated Sonoma County is provided in this section. Consistent with Phase 3 of the Cal APG, major problem statements are also provided to characterize the overall climate impacts Sonoma County may experience. These problem statements will be utilized to frame and generate climate adaptation policies and programs for the Sonoma County General Plan Safety Element update.

Vulnerability Analysis

Climate change is expected to have far-reaching impacts in Sonoma County on public health, parks, natural resources, infrastructure and critical facilities, emergency response, and agriculture. Understanding local climate risks and impacts allows communities to prepare for the future and increase their resilience.

Vulnerability scores were determined by the overlay of impact scores and adaptive capacity scores assigned within the previous section. Vulnerability scoring helps the County understand which climate change effects pose the greatest threats and should be prioritized in adaptation planning and policy development.

Populations

- **Extreme Heat.** An increased number of extreme heat days will result in increased public health risks through heat-impacted diseases and air quality degradation. Individuals with high outdoor exposure, low education, under-resourced individuals, individuals facing societal barriers (racial segregation, low social support, poverty, and income inequality) and individuals with chronic health conditions are all vulnerable to extreme heat due to system inequities. Areas near Fetters Hot Springs-Agua Caliente, southwest of Santa Rosa, Forestville, Cloverdale, and south of Windsor have a combination of high temperature exposure by end-of-century, high social sensitivity, and a concentration of Environmental Justice Communities.
- **Wildfire.** Populations who live in the more isolated areas of the County may be more likely to live in very high wildfire hazard severity zones and experience complications with evacuations. Additionally, populations with high exposure or sensitivity may experience injuries, illness, or death from prolonged exposure to smoke or direct contact with flames and are less likely to receive medical treatment. Areas near the Russian River, around Cloverdale, and in most of northwest County have a combination of high wildfire exposure, high social sensitivity, and a concentration of Environmental Justice Communities, including Environmental Justice Tribal Communities.
- **Landslides.** Populations susceptible to injuries or death from landslides includes individuals with chronic health conditions or health related sensitivities. Additional vulnerabilities for populations relate to difficulty evacuating and subsequent risks of health impacts and geographic isolation. Individuals with disabilities, young children, and seniors may have difficulty evacuating from landslides. Areas near the Russian River, around Cloverdale, and in most of northwest County have a combination of high landslide susceptibility, high social

sensitivity, and a concentration of Environmental Justice Communities.

- **Riverine and Stormwater Flooding.** Outdoor workers may be exposed to hazardous work conditions during riverine and/or stormwater flooding events and therefore are vulnerable to health impacts. People experiencing houselessness are disproportionately at risk of health impacts during flood events because they often live in flood hazard areas and do not have access to transportation or resources needed to evacuate inundated areas. Areas near the Russian River, directly southwest of Santa Rosa, around Cloverdale, and in most of northwest County have a combination of high flood exposure, high social sensitivity, and a concentration of Environmental Justice Communities

Parks and Natural Resources

- **Extreme Heat.** Wildlife may face increased heat stress and heat related illness as well as disrupted reproductive cycles, and compounding risks associated with early and extended seasonal temperature increases. Because it is seasonally warmer earlier in the year species can emerge early with no food source and potentially face a delayed cold front which increases mortality rates. Timing of seasonal warmth may not overlap with food sources and extreme heat may stress dependent vegetation communities and wildlife. Plants are more likely to experience heat stress and drying, species' habitat ranges may shift. Some pests can proliferate more easily with warmer temperatures, and some plants and animals ill-suited to the new warmer conditions may suffer increased mortality rates. Parks and natural resources are highly exposed to extreme heat and warm nights.
- **Drought.** Impacts from drought involve risks associated with water scarcity and availability for reliant natural resources. Drought will disrupt habitats and wildlife abilities to survive from dehydration and reliable food sources. Extended or variable drought conditions affect the amount and duration water is available in ephemeral and permanent waters sources, impacting plants and wildlife dependent on those aquatic resources. Sonoma County includes several State and federally listed threatened or endangered species dependent on aquatic resources (rivers, streams, lakes, wetlands) for survival. These species have already been identified as vulnerable to extinction due to habitat loss or other disrupters which will be further compounded by drought.
- **Wildfire.** The largest direct impacts to parks and natural resources are caused by wildfires. There is direct mortality and loss of resources and wildlife from wildfire as well as indirect mortality due to loss in habitat area and loss of available food sources and seed bank. The severity and frequency of wildfires can exacerbate these impacts further through habitat conversions resulting in vegetation communities that no longer support the species using that habitat. Projected annual burned acreage are expected to increase along the eastern edge of Sonoma County within existing and new wildfire zones with Hood Mountain Regional Park & Open Space Preserve completely exposed and several partially exposed parks interspersed along the County edges. Increased wildfire probabilities and expansion of wildfire zones may lead to increased park and natural resource exposure to wildfires.
- **Landslides.** Landslide susceptibility directly overlaps with parks and natural resource areas throughout the County including 9 separate park areas with landslide susceptibility. In the event of a landslide there is potential for loss of lands, habitat, and disruption of waterbodies in areas of debris flow. The

susceptibility of parks and natural resource lands in Sonoma County to landslides is high, therefore, there is risk around loss of topsoil and habitat conversions. Wildlife and plants face a compounding risk when presented with landslide events because it creates both habitat displacement and increased mortality risk.

- **Sea Level Rise.** The direct effects of sea level rise on natural resources are the losses of prime recreational and natural areas, Bodega Bay, may be almost completely flooded by 2100. The negative impacts of sea level rise include the risks of squeezing and permanently submerging coastal habitats, which could lead to losses in the biodiversity of habitats and shrinking the area between habitats and developments. As sea level rises, it can inundate the County's natural land and open spaces, which in certain areas serve as natural protections against flooding, further decreasing coastal habitats values. In addition, saltwater intrusion into freshwater due to sea level rise may alter coastal habitat and ecosystems.

Critical Facilities, Buildings, Services, and Infrastructure

- **Extreme Heat.** Extreme heat could impact occupants of buildings and facilities that are not adequately weatherized for increased temperatures. Additionally, as temperatures increase, roadways, transportation routes, and railroads are vulnerable to damages through sustained heat such as buckled railroad ties and cracked surfaces. Additional impacts from extreme heat are associated with increased emergency service calls which could strain health and medical services and emergency responders. Electrical infrastructure could be overwhelmed by peaks in demand and result in blackouts or power safety shutoffs instituted by energy providers to avoid impacts to electrical facilities. Power outages have significant cascading impacts on communication networks, water conveyance, and vulnerable populations. The ability for emergency providers to fully function during power outages could be significantly impaired (Sonoma County 2022). Areas of central and southern County may experience the greatest increases in temperature by the end of the century.
- **Wildfire.** The structures and buildings that occupy wildfire hazard zones are at risk of direct structural damage from wildfires. There are many critical facilities in wildfire hazard zones, including fire stations, evacuation shelters, schools, and an airport. Areas of high facility exposure include the eastern and northeastern parts of the County with some exposure along the northwestern portions of the county as well. Wildfire hazard zones may expand by end-of-century which could lead to more facilities at risk of structural damage. Additionally, electricity distribution lines as well as natural gas and oil lines are interdependent systems for the County that are present throughout the County.
- **Landslides.** Pipelines for water, electrical distribution lines, and roadways are vulnerable to landslide impacts which could occur in sloped areas that extend into wildfire zones. With high landslide susceptibility along roadways in the western end of the County as well as several critical facilities including fire stations, schools, and emergency shelters, there is a risk of emergency service disruption and impacts to evacuation.
- **Sea Level Rise.** Storm surges and wave run-up are already threatening coastal infrastructure. Sea level rise will exacerbate this issue and expose over 50 additional critical facilities to inundation. This includes waste facilities that may pose risks to the immediate community and increase public health concerns. Furthermore, rising seas will impact storm drainage systems,

which may experience stormwater backups as a result of tidal flooding. Saltwater intrusion can affect drinking wells adjacent to the coast and San Pablo Bay. Sea level rise will threaten Sonoma Valley wastewater treatment plants, affecting collection systems, and reclamation systems, as well as the operation of Hudeman Slough's tide gate, and roads and levees adjacent to the wetlands management units. The combination of sea level rise and storm surges can negatively impact County's roads and bridges temporarily closing them during these events, such as Highway 1 and Highway 37, which are at risk of failure due to sea level rise. In addition, sea level rise will increase the likelihood of breaching levees that protect roads and highways adjacent to San Pablo Bay.

Agriculture

- **Extreme Heat.** A greater number of extreme heat events and warmer nights could cause declines in crop yields due to increased heat stress. Lower crop yields associated with extreme heat could increase costs and ultimately decrease agriculture profitability. Livestock operations are potentially less viable during extreme heat events as livestock may suffer from heat related illness. Livestock and poultry are vulnerable to extreme heat conditions, leading to mortality, which, in turn, may impact rendering plant capacity. Agricultural workers are particularly vulnerable to health risks from high-outdoor exposure to increased number of extreme heat days. These individuals typically are under-resourced, face societal barriers, and may have chronic health conditions due to on-farm exposure to dust and farm chemicals. As a result, extreme heat may impact agricultural operations by reducing worker availability and productivity.
- **Drought.** Higher temperatures will decrease the statewide snowpack and raise the snowline, decreasing one of the most important surface water reserves for agriculture. Like extreme heat and warm nights, drought is linked to declines in crop yields, increasing costs, and decreasing crop profitability. Drought can result in regional losses of crops and can stress the statewide water supply. A majority of the County's agricultural water is drawn from the Russian River watershed, which supplies Lake Sonoma and Lake Mendocino. These lakes have experienced drought related reduction in capacity. In 2009, Lake Sonoma was at 74% capacity and Lake Mendocino was at 38% capacity.
- **Wildfire.** Sonoma County has experienced a significant number of severe wildfires in the past 5 years. Wildfires can destroy crops and disrupt rangeland operations while wildfire smoke may stress the health of crops and livestock. Agricultural land cover overlaps fire hazard severity zones mainly at the eastern and northern edges of the County. The probability of wildfires across Sonoma County is expected to increase by the end of the century in areas throughout the County with significant new exposures of agriculture lands in the east, north, and west ends of the county.
- **Landslides.** There are high degrees of overlap with landslide susceptible areas and agricultural lands. Almost all agricultural lands are located in a deep-seated landslide susceptible area. Landslide impacts on agricultural lands include mainly rangelands at the base of landslide susceptible areas.

Problem Statements

The following problem statements are intended to guide the development of adaptation policies and programs for the County's General Plan Safety Element Update.

- **Equitable Community Safety.** As climate change impacts occur, virtually all populations in a community will be affected; however, some individuals will be disproportionally impacted by climate hazards due to inequitable systems and structures. Areas of Sonoma County with the greatest concentration of socially sensitive populations are in the Cloverdale area, directly southwest of Santa Rosa, and around Fetters Hot Springs-Agua Caliente. Inequitable access to, and distribution of resources, critical services, and resilient infrastructure systems decreases the ability for sensitive populations to prepare for, cope and recover from climate impacts. Safety Element Survey respondents identified the following barriers to adequately preparing for climate change: financial constraints, fear of rent increases if requesting home upgrades, physical limitations or disabilities or illness, social isolation, and language barriers.
- **All Hazards Awareness and Capacity Building**. Community climate hazard awareness and capacity building are important ways to increase emergency preparedness and response to all climate hazards. Climate change hazards are increasing the need for emergency response and management throughout Sonoma County and will continue to strain the capacity of government and community-based organization operations to support the community during and after climate hazard events. Barriers to hazards awareness at the neighborhood scale can stem from inequitable access and distribution of educational resources. Several stakeholder focus group interview participants noted that limited awareness and resources prevent residents from adequately preparing for hazard events. This includes needing resources in languages beyond English and Spanish, such as Fijian, Nepalese, and Filipino, and representation of these communities in safety related leadership roles and positions of authority before disasters happen. Several stakeholder focus group interview participants noted limited funding and staff constraints were barriers that limited the ability of the County to prepare for and respond to hazards. Having sufficient County emergency response staffing resources can become difficult when there are multiple concurrent or back-to-back emergencies. During responses, County staff may postpone day-to-day work, including important public education and outreach, preparation, and planning efforts that prepare the county and the community for the next emergency. After responding to an emergency, County staff may also continue to devote time to the incident through various recovery responsibilities, further decreasing staff capacity.
- **Alerts and Evacuation**. Emergency communications and timely evacuations are an essential part of emergency operation planning and community safety. Barriers to evacuation can stem from deficiencies in the electrical grid, transportation system, telecommunication systems, emergency facilities and services, evacuation locations, as well as inequitable access and distribution of resources. Inability to evacuate in a timely fashion during a hazardous event can create direct impacts to health and safety and exacerbate chronic health problems with socially sensitive populations and EJ communities at highest risk. Most Safety Element Survey respondents reported having taken steps to prepare for wildfires; however, over 40% reported financial constraints as one of the largest barriers to adequate preparation. Historically there have been several climate hazard events that prompted evacuations including but not limited to recent fires of Walbridge, Glass, and Kincade. Wildfire evacuations have typically affected northeast and eastern portions of the County.
- **Recovery and Reconstruction**. Recovery and reconstruction efforts following large scale climate change-induced disasters, such as wildfires and floods, can cause substantial economic

strain on communities, especially under-resourced and undocumented communities, as well as operational constraints for County staff. Safety Element Survey respondents identified a need to better connect people and communities with recovery funds available and providing technical support to obtain these funds. Stakeholder focus group interview participants noted that the organizations receiving the majority of emergency-related funding do not have strong relationships with the communities most impacted by disasters, which has resulted in these communities not receiving the support they need to recover and rebuild following disasters. Undocumented workers in particular are unable to access Federal reimbursement should their housing or personal belongings get destroyed or damaged by fire. Stakeholder focus group interview participants expressed concern related to recovery after wildfire due to high effort and long timelines, as well as a lack of integration of lessons learned from past disasters to mitigate impacts of upcoming ones. When in disasters or emergency declarations, contracting and funding moves very quickly, however, when in recovery, or preparation mode, contracting processes include red tape and gatekeeping, which results in funds not getting into impacted communities and harms efforts to build relationships with community-based organizations. The overarching need identified by stakeholder focus group participants is for the County to invest more in preparation before disasters by developing relationships with communities most impacted by systemic inequities within the context of climate change. **Extreme Heat and Air Quality Protection**. All communities in Sonoma County will experience poor air quality from wildfire smoke, with socially sensitive populations and Environmental Justice (EJ) Communities experiencing disproportionate impacts because of the systemic inequities that they face. Changes in annual average maximum temperature by the end of the century will increase across the entire County with more frequent incidences of extreme heat. Impacts from extreme heat events are expected to compound poor health outcomes already being experienced by sensitive populations and EJ communities, particularly for those located near Fetters Hot Springs-Agua Caliente, southwest of Santa Rosa, Forestville, Cloverdale, and south of Windsor. Impacts include heat-related illness, such as heat stress, heat stroke, and dehydration, which can be life threatening. During poor air quality and extreme heat events, cooling centers, hospitals, and emergency personnel are in high demand and these critical resources may be affected by power reliability, staffing, and inequitable community access to emergency facilities.

- **Water Reliability and Consumption**. Water supply infrastructure, such as pipelines and pump stations, can be damaged by climate hazards, impacting water reliability throughout the County which has direct implications on wildfire mitigation, community members, agricultural production, and critical services. Extended drought conditions that impact availability of water supply can increase the cost of water and affect water quality, resulting in disproportionate impacts to socially sensitive populations and EJ communities. Water levels in groundwater basins throughout the County have declined in recent years due to lower-than-average rainfall and in some cases overdraft. This can result in reduced water availability, problems with existing wells, higher concentrations of water pollutants, and in some cases, intrusion of seawater into the aquifer, mainly along the southernmost parts of the County. Groundwater users that are not within a basin subject to the California Sustainable Groundwater Management Act (SGMA) may have fewer options to address diminished groundwater resources.

- **Parks, Natural Resources, and Watershed Protection**. Parks, natural resources, and watersheds in Sonoma County are at high risk due to the effects of climate change. The increase in extreme heat and warm nights can cause heat stress and illnesses in wildlife, disrupting their reproductive cycles, facilitating pest propagation, and increasing mortality rates. Similarly, seasonal warmth occurring earlier and lasting longer than usual can lead to food scarcity for early-emerging species, stress vegetation communities, and potentially cause a shift in species' habitat ranges. In addition, Sonoma County's parks, natural resources, and watersheds are also vulnerable to the impacts of drought, landslides, and flooding. Drought conditions can disrupt habitats and pose survival challenges for wildlife due to dehydration and unreliable food sources. Landslides pose a high risk to parks and natural resource lands, leading to potential loss of lands, habitat disruption, and increased mortality risk for wildlife and plants. Flooding, especially in the FEMA-identified flood zones alongside the major rivers and creeks in the county, can cause erosion, have detrimental effects on water quality, and impact sensitive plant and wildlife species. Sea level rise would also exacerbate coastal erosion potentially impact beach access and recreational areas such as coastal trails along Sonoma County's shoreline. The hazards caused by climate change would threaten critical habitat areas, hardwood forests, shrubs, and grasslands in the County. They also pose a significant threat to aquatic and fish species that are dependent on water quality for survival, including several state and federally listed threatened or endangered species.
- **Flood Protection**. Riverine and stormwater flooding affects a wide range of communities in Sonoma County. FEMA flood zones are identified alongside most of the rivers and creeks that run through Sonoma County. A majority of the flood-prone areas throughout the County are part of the Russian River. Currently, 3.7 percent of the Sonoma County population is exposed to the 100-year and 500-year flooding. Flooding can result in property damage and direct impacts to the health and welfare of individuals, particularly those that are in substandard living conditions, people experiencing houselessness, those who are unable to evacuate quickly or safely, agricultural workers, as well as individuals without vehicle or in households without a computer. About 969 properties in the County have already experienced repetitive losses. The estimated losses due to flooding events that occurred from January 1995 to February 2019 are about $400 million. Moreover, flooding can impact the County's economy, infrastructures, and critical facilities, including fire and police stations, hospital and healthcare facilities, emergency shelters, and airports. The County's agricultural lands within floodplains are also at risk of disruption during flood events and natural resources are expected to experience more frequent and extreme flooding, including erosion, which would have detrimental effects on water quality and sensitive species of plants and wildlife. Impervious surfaces can exacerbate stormwater flooding, posing a risk to critical facilities and storm drainage and flood protection services in Sonoma County. Flooding damage has already led to the loss of housing stock, increasing displacement and houselessness in the county, and has caused damage to rural roads isolating several rural communities. **Sea Level Rise Safety and Resiliency**. Sea level rise is a significant threat to the safety and well-being of various population groups in Sonoma County particularly those situated close to the Pacific Ocean coastline, the Bodega Bay, and the San Pablo Bay shoreline. Certain communities such as the ones living in the Petaluma Airport/Arroyo Park and Jenner/Cazadero neighborhoods (census tracts 1506.12 and

1543.04), would be disproportionately affected by its impacts, particularly socially sensitive populations, and EJ communities. The direct effects of sea level rise, such as the loss of recreational areas and potential flooding of Bodega Bay by 2100, threaten the county's natural resources and habitats. Housing needs could be impacted due to populations relocating from areas affected by sea level rise, potentially leading to economic losses due to property and land damage. Coastal erosion would be exacerbated by sea level rise, which could render some beaches inaccessible, impacting tourism resources and altering coastal habitats and ecosystems. Critical facilities, including Sonoma Valley wastewater treatment plants and storm drainage systems, are at risk of inundation, posing public health concerns. The county's agricultural lands are also threatened due to the risk of saltwater intrusion into farmlands located in low-lying areas. are also threatened due to the risk of saltwater intrusion into farmlands located in low-lying areas.

- **Wildfire Resilient Landscapes**. Parks, natural resources, and agricultural land in Sonoma County are highly vulnerable to wildfire. Since 2015, wildfires have burned over 400,000 acres in Sonoma County. Projected annual burned acreage is expected to increase along the eastern edge of Sonoma County within existing and new wildfire zones. Increasing wildfire frequency and severity will result in species mortality, loss of habitat, and loss of available food sources and seed bank. Habitat loss may not recover depending on the type of land cover that is destroyed in a wildfire and quick succession fires can prevent or delay the recovery of natural systems. Potentially affected land cover types primarily include conifer and hardwood forests along with some shrub and grasslands. Hood Mountain Regional Park & Open Space Preserve is located entirely within a very high fire hazard severity zone and several parks interspersed along the County edges are located within moderate and high fire hazard severity zones. Agricultural land that is most at risk to wildfire is located mainly at the eastern and northern edges of the County. Other agricultural areas at risk to wildfire are located throughout the County and southeast of Healdsburg. Wildfires can destroy crops and disrupt rangeland operations while wildfire smoke may stress the health of crops and livestock. These impacts to crop yield and livestock can impact Sonoma County's economy, and directly negatively impact the livelihoods of agricultural workers and operators.
- **Agricultural Operations.** A large portion of Sonoma County's economy is based in agriculture and the potential climate change impacts from drought, extreme heat, wildfires, and landslides to the County's agricultural sector could be far reaching. Livestock and crop yields can experience stress and declines. Rangelands located at the base of landslide susceptible areas in the county are highly vulnerable to landslides. Impacts to livestock, crops, and agricultural workers can lead to decreased agriculture profitability. Agricultural workers are particularly vulnerable to health risks from high-outdoor exposure to an increased number of extreme heat days and hazardous work conditions during wildfire events, which often overlap with harvest season. These workers are impacted by air quality and loss of wages, especially where hazard pay is unavailable. Agricultural workers are typically under-resourced, face societal barriers and may have chronic health conditions due to on-farm exposure to dust and farm chemicals.
- **Resilient Infrastructure**. Sonoma County's infrastructure resilience will face significant challenges due to climate change, particularly in the context of emergency preparedness response. For example, extreme heat would impact occupants of buildings that are not adequately weatherized. This would lead to increased emergency service calls and put a strain on

medical services and emergency responders. With climate change, the electrical infrastructure could be at risk of being overwhelmed by peaks in demand, resulting in blackouts or public safety power shutoffs. These power outages have significant cascading impacts on communication networks and vulnerable populations and would impair the ability of critical service providers to function effectively. In addition, the County is vulnerable to the impacts of wildfires, landslides, and flooding, which could also impact emergency preparedness response in Sonoma County. Wildfires, for instance, would pose a risk of direct structural damage to buildings located within wildfire hazard zones, including critical facilities such as fire stations and evacuation shelters. Damage to communication infrastructure, such as cell towers, during wildfires or landslides, would hinder emergency communications, potentially impacting the health and safety of emergency personnel and community members. Landslides, flooding, and sea level rise could damage major arterial routes, impacting evacuation routes, and thus, emergency evacuation could be adversely impacted. These climate risks could impact the ability of community members to evacuate during emergency orders and prevent emergency personnel from entering emergency evacuation zones.

- **Resilient Buildings.** Building stock, including commercial, industrial, residential, institutional, and government facilities, is essential to effectively deliver services and resources to the community. In Sonoma County, building stock is highly vulnerable to extreme rain events, wildfires, landslides, and flooding, which could result in direct damages or impacts to building occupants. In addition, the County's building stock may not provide adequate respite during extreme variability in temperatures. For example, extreme heat could impact the occupants of buildings and facilities that are not adequately weatherized for increased temperatures, which could lead to discomfort and potential health risks, especially for socially sensitive populations and EJ communities. Wildfires are another significant threat to the resilience of Sonoma County's buildings since a significant number of buildings are currently situated in very-high fire hazard zones as well as in areas exposed to moderate and high fire hazards. As the risk of large wildfires is expected to increase up to 50 percent by the end of the century, more buildings will potentially be at risk of structural damage. Moreover, an increase in wildfires could also increase exposure to landslides for the numerous buildings currently at risk in the County. Additionally, the projected increase in flooding frequency due to climate change in Sonoma County could intensify the impact on the County's buildings, where some of which have already experienced repetitive losses due to flooding.

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Appendix B
Evacuation Routes and Locations Assessment (AB 747)

FEHR PEERS

Memorandum

Date: September 30, 2024

To: Reema Shakra and Lauren Collar, Rincon Consultants

From: Ian Barnes, PE, Terence Zhao, and Grace Chen, Fehr & Peers

Subject: Sonoma County Safety Element Update – AB 747 Assessment

WC23-3966

Fehr & Peers is conducting a general, programmatic assessment of emergency evacuation routes for the Safety Element Update of the Sonoma County General Plan. This assessment is consistent with requirements under section 65302.15 of the Government Code, as legislated by Assembly Bill (AB) 747 and AB 1409.

This document describes the methodology for an assessment of roadway capacity and time needed to evacuate a designated study area under described evacuation scenarios. Please note that emergency evacuations can occur due to any number of events. Additionally, any emergency movement is unpredictable because it has an element of individual behavior related to personal risk assessment for each hazard event. As such, this assessment is intended to provide the jurisdiction with a broad understanding of the transportation system capacity during an evacuation scenario; it does not provide a guarantee that evacuations will follow the same modeling used for analysis purposes, nor does it guarantee that the findings are applicable to any or all situations.

Moreover, as emergency evacuation assessment is an emerging field, there is no established standard methodology. Fehr & Peers has adopted existing methodologies in transportation planning that, in our knowledge and experience, we believe are the most appropriate within the limits of the tools and data available and the budgetary and time constraints in the scope of work, and by current knowledge and state of the practice.

While this assessment should help the jurisdiction better prepare for hazard related events and associated evacuations, the jurisdiction should take care in planning and implementing any potential evacuation scenario. Fehr & Peers cannot and does not guarantee the efficacy of any of the information garnered from this assessment, as doing so would be beyond our professional duty and capability.

Legislative Requirements

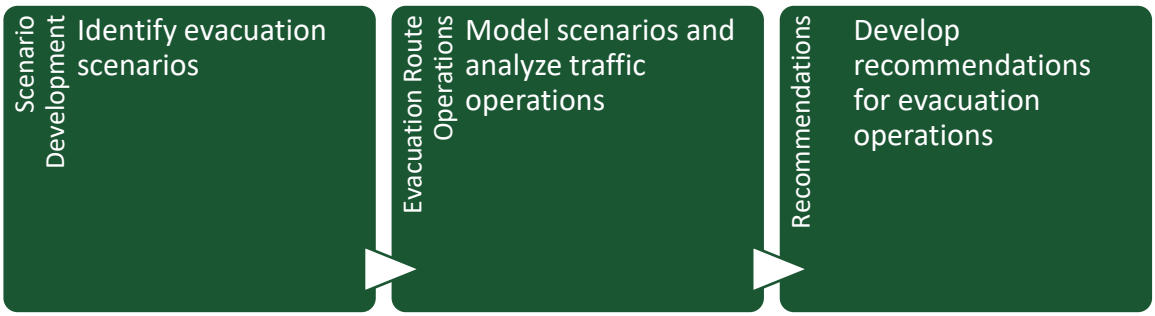
Section 65302.15 of the Government Code requires that the safety element be reviewed and updated to identify evacuation locations and routes, as well as their capacity, safety, and viability under a range of emergency scenarios. This is a requirement for all safety elements and updates to a Local Hazard Mitigation Plan (LMHP) completed after January 2022.

It should be noted that the relevant statute requires a general, programmatic assessment of emergency evacuation locations and routes. This is a lower standard of granularity than analysis that is required by CEQA, where quantitative evacuation travel time assessments to study a project's effect on evacuation times for the surrounding area was required. this effort is a general, programmatic assessment of emergency evacuation routes to inform potential policies and strategies for the updated Safety Element, rather than a deeper, more granular CEQA level analysis where the purpose is to quantify project specific impacts.

AB 747 Approach

For this AB 747 Capacity Assessment, Fehr & Peers consulted with Sonoma County staff to identify an analysis approach and three evacuation scenarios to analyze. The analysis approach illustrated below in **Exhibit 1** was developed to study evacuation traffic conditions and identify improvements. There are an infinite amount of emergency events and evacuation scenarios that can occur in the County. Given the geography and topology of the County, three scenarios based on historic wildfire events and key considerations to address for those events were developed in coordination with County staff and first responders. The following section explains each of the three steps in the emergency evacuation analysis process in greater detail.

Exhibit 1. Emergency Evacuation Analysis Process



Scenario Development

We began the scenario development process by first creating a sector system that identifies all areas of Sonoma County that are most likely to evacuate under an emergency scenario, and then groups these areas into large sectors considering historic fire patterns as well as cohesion from a geographic and transportation system perspective. The locations of the sectors are presented in **Figure 1**.

After reviewing the County's evacuation, LHMP, and previous work around identifying evacuation zones, we worked with the County to identify three evacuation scenarios based on direction from County and Fire Department staff. Each of these scenarios would be general and assumed to be caused by an unspecified emergency (although it is accepted that wildfires are the events most likely to cause such a large-scale evacuation), which has necessitated evacuation in a set of affected sectors, requiring everyone to leave (i.e., not shelter-in-place). The three scenarios are:

- **Scenario 1** – An emergency in which sectors 1, 2, and 3, consisting of the mountainous western portions of the County from the coast to the valley floor, must evacuate. The evacuation destinations (or evacuation destinations, as they are referred to in statute) are presumed to be along State Route 1 northwards towards Mendocino County and southwards towards Marin County, eastwards along Skaggs Springs Road towards Cloverdale, and eastwards along River Road and State Route 116 towards Santa Rosa.
- **Scenario 2** – An emergency in which sectors 4, 5, and 6, consisting of the mountainous areas in the northeastern portion of the County, consisting of Alexander Valley and the Sonoma Mountains north of Mark West Springs, must evacuate. The evacuation destinations are presumed to be northwards along US-101 towards Mendocino County and southwards towards Santa Rosa.
- **Scenario 3** – An emergency in which sectors 7, 8, and 9, consisting of the southeastern portions of the County, including Sonoma Valley, parts of Santa Rosa east of Farmers Lane, and the Sonoma Mountains south of Mark West Springs, must evacuate. The evacuation destinations are presumed to be the urban cores of the cities of Petaluma, Rohnert Park, and Santa Rosa, as well as gateways near the shoreline in the south of Sonoma County towards Marin and Napa Counties.

Each of the scenarios was selected with geography and likelihood of evacuation events in mind. The affected area is purposefully established with a large footprint to use the analysis to stress test the roadway network during an evacuation event.

For all three scenarios, we will be modeling the evacuations based on the assumptions that evacuation orders are to be issued at 4:30PM on a Friday preceding a holiday weekend. This timing would take advantage of two stress tests for the roadway network: first, the presence of a

significant number of visitors and tourists in Sonoma County; and second, the presence of peak hour traffic on a weekday.

For all three scenarios, we are assuming that background traffic (i.e., through trips without an origin or destination in the study area) continues to use evacuation routes from 4:30 PM to 6:00 PM. It is noted that background traffic demand could stop shortly after 4:30 PM as it is unlawful to enter an area under an Evacuation Order. However, it is uncertain that police resources would be available for traffic control as the early priorities after an evacuation order are giving area notification to residents and assisting in the evacuation of residents who are unable to evacuate on their own. As such, the evacuation assessment conservatively assumes that background through traffic would not end at the time of the 4:30 pm evacuation order. Thus, the analysis includes background traffic on evacuation routes beyond what might be expected. The evacuation demand loading by time period, which represents the time at which individual evacuation trips begin, is as follows:

- 20% from 4:30 PM to 4:45 PM
- 40% from 4:45 PM to 5:00 PM
- 25% from 5:00 PM to 5:15 PM
- 15% from 5:15 PM to 5:30 PM

For all three scenarios, the evacuation assessment is based on roadway capacities from the Sonoma County Transportation Authority (SCTA) Travel Demand Model ("SCTA model") with a 10% reduction in capacity to account for the various incidents that may occur during an emergency scenario that might limit or reduce the capacities of these roadways (i.e. presence of debris or other hazards). Evacuation trips will not be assigned to any unpaved roads other than unpaved driveways that are the only point of egress to evacuation routes. The free-flow speeds of roadways will be set as their speed limits. Evacuation elapsed time ends when the network returns to an uncongested state (all links with 15-minute volume-to-capacity ratio of 0.75 or less).

Table 1 presents assumptions for evacuation destination patterns for each sector, where specific percentages of traffic will be assigned from each sector towards the evacuation destinations named in each evacuation scenario. These percentages will be used to define the destinations of evacuating traffic in the analysis model. Evacuation destinations, as discussed and identified in this analysis, are not assumed to be the final destination of evacuees. Instead, evacuation destinations are external gateways, or roadways that lead to outside of the boundaries of the study area. As such, they are not destinations themselves but serve as a proxy for trips leaving the study area. They should be interpreted as the gateways to safe shelter. Assumptions of evacuation destinations and percentages were based on County Department staff qualitative experience and understanding of local traffic patterns. Quantitative data to inform these assumptions was not available for this analysis.

Table 1: List of Destinations and Percentage Distributions for Evacuation Sectors

Scenario	Sector Number	Sector Name	Assumed Evacuation Destinations
1	1	Coastal	Mendocino County – 20% Marin County or Petaluma – 50% Santa Rosa– 30%
	2	Skaggs Springs - Lake Sonoma	Cloverdale – 50% Mendocino County – 5% Marin County or Petaluma – 15% Santa Rosa – 30%
	3	Russian River	Mendocino County – 5% Marin County or Petaluma – 10% Santa Rosa – 85%
2	4	Cloverdale - Healdsburg - Alexander Valley	Mendocino County – 30% Santa Rosa – 40% Napa County – 20%
	5	Geysers	Mendocino County – 30% Santa Rosa – 50% Lake County – 20%
	6	Windsor - Kellogg/Knights Valley - Mark West Springs	Napa County – 35% Santa Rosa – 60% Mendocino County – 5%
3	7	Santa Rosa - Valley of the Moon	Cloverdale – 5% Santa Rosa – 85% Napa County – 5% Marin County – 5%
	8	Kenwood - Bennett Valley	Santa Rosa – 50% Rohnert Park – 40% Napa County – 5% Marin County – 5%
	9	Sonoma Valley	Santa Rosa – 10% Rohnert Park – 5% Petaluma – 40% Napa County – 30% Marin County – 15%

Evacuation Operations Analysis

The emergency evacuation operations analysis will be conducted using the Fehr & Peers EVAC+ tool, which is a modeling workflow that extracts the study area from the Sonoma County Transportation Authority (SCTA) travel demand model to estimate vehicle demand and levels of congestion in 15-minute intervals during an evacuation window. The EVAC+ workflow can be broken down into three modules:

1. Subarea module: Preparing the sub-area network representing the study area and the associated background trip tables.
2. Evacuation module: Estimating evacuation trips during the evacuation scenarios.
3. Dynamic traffic assignment (DTA) module: Assigning trips (dynamically) to the sub-area network.

The following sub-sections discuss each of these modules.

Subarea Module: Preparing the Sub-Area Network and Associated Trip Tables

Supply and demand are two major aspects of any travel demand modeling exercise. In a travel demand model, the demand is usually derived from people having to perform some activity, for example going to work or evacuating during an emergency. The resulting travel demand can be estimated from socio-economic data of the individuals whose travel constitutes such demand. The supply is based on roadway capacity and travel speeds that determine how many vehicles can travel through a certain section of the roadway per unit of time. The total travel taking place during an evacuation period can be conceptualized as a sum of background travel, the kind that will happen irrespective of an evacuation, and the evacuation traffic that will enter the roads only because there has been an evacuation order creating the need to travel. This subsection discusses the development of the sub-area network and background trips for the purpose of our analysis.

SCTA Model and Sub-Area Network

In order to obtain the background travel demand, we will run the SCTA model with the most up-to-date socio-economic data for Sonoma County. Since the evacuation areas for the three evacuation scenarios are a subset of the entire SCTA model area, we will extract a subset of the model area that represents the area that needs to evacuate as defined in each scenario, as well as the area that would be largely impacted by the evacuation. With this sub-area, we will obtain the trip tables associated with the network that contain all the vehicle trips between each traffic analysis zone (TAZ) and the external gateways (which are the evacuation destinations). The external gateways are roadways that lead outside of the boundaries of the study area. As such, they are not destinations themselves, but serve as a proxy for trips leaving the study area.

Trip tables are a series of matrices that store trips between origin and destination pairs. A conventional travel demand model looks at travel aggregated in time periods. In the case of the SCTA model these time periods are for daily, AM peak 1 hour, and PM peak 1 hour. Since this analysis is based on the assumptions that evacuation orders are to be issued at 4:30PM on a Friday preceding a holiday weekend, PM peak 1 hour trip table will be used as our initial background trip table.

Big Data Adjustments

Since travel models estimate trips during a normal weekday, further adjustments are required to accurately reflect traffic on a Friday before a holiday weekend. To achieve this, location-based services (LBS) "Big Data"[1] traffic counts from August 30, 2019 (which was the last Friday before a Labor Day that was not affected by the COVID-19 pandemic) as well as 2019 weekday average traffic counts were pulled to understand how the traffic volumes differ on a Friday before a holiday weekend compared to a normal weekday.

In addition, a background trip table will be used to represent the traffic conditions before and during the evacuation. The background trip table will be expanded to 2:30PM until midnight based on the traffic volumes on August 30, 2019, according to LBS big data traffic counts.

Finally, from an evacuation standpoint, more disaggregated time intervals than what travel models typically estimate are desired to develop a better understanding of travel during an evacuation order lasting just a few hours with a large number of trips evacuating swiftly. Therefore, a 15-minute disaggregation of the trip tables was completed based on LBS big data to allow for greater granularity enabling traffic assignment in 15-minute intervals.

Background Trip Tables

Based on the SCTA travel model outputs and the big data adjustments, background trip tables for every 15-minute from 2:30PM to midnight were developed to feed into the dynamic traffic assignment model. When evacuation starts, trips that do not end in evacuation zones are assumed to continue their normal activity regardless of if the evacuation order has been given. Trips that end in the evacuation zone after the evacuation order is given do not travel and stay in the original zone, but will travel to a gateway of the evacuation study area.

[1] LBS data is provided from devices, primarily smart phones, which run applications and connect to cellular, WiFi, and/or GPS networks. LBS data is carrier-neutral and uses multiple location technologies, providing few gaps in coverage and high spatial precision.

Evacuation Module: Estimate Resident and Work Trips During an Evacuation Event

The traffic generated due to an evacuation by residents and employees of an evacuation area is the other portion of the total travel. This subsection discusses how the evacuation trips will be estimated.

Evacuation Traffic

To estimate the trips originating in each scenario study area that will result due to an evacuation, we need to know how many vehicles will be evacuated for each scenario. Traffic Analysis Zone (TAZ) geographies from the SCTA model are used to represent neighborhoods in each sub-area. The number of vehicle trips generated by each household was informed by the land use and socio-economic data (SED) in each TAZ. The SED includes a variety of information based on the SCTA land use data and U.S. census data, including persons per household, number of employees, and auto ownership per household. The SED information is used to determine the number of vehicles per household that would be evacuating during an evacuation event.

It should be noted that the dynamic traffic assignment model only reflects personal vehicle traffic. Due to the nature of this model, travel made by walking or biking are not considered. However, based on the characteristics of Sonoma County and especially each of the evacuation areas, these trips will be negligible during an evacuation, and the evacuation model assumes (that is, assuming the largest possible number of vehicle trips) that all households will evacuate using their personal vehicle. Also, each household is assumed to be evacuating together, and the evacuation trip is made directly to the evacuation destination (i.e., shelter or external gateway). Households with more than one vehicle likely would not be able to utilize all vehicles during an evacuation event (e.g., homes with three or four vehicles, but only two licensed drivers). A post evacuation survey of Santa Rosa residents that evacuated during the 2017 Tubbs Fire indicated that a weighted average of 1.75 vehicles evacuated per household. We will forecast trips evacuating from households based on household demographic data for each evacuation study area, conservatively assuming that 100% households will be at home and evacuating. Lastly, we will take the conservative assumption that all workers within the evacuation areas drive to work alone and will also evacuate, and that each worker will take one personal vehicle.

The estimated evacuation demand for each scenario, quantified in number of vehicles, are documented in **Appendix A**.

Evacuation Departure Time

The departure timing for people leaving the evacuated areas, after the evacuation notice is issued, varies by the timing and nature of the event. For events where ample notice is given, less time is needed to prepare for the evacuation. On the other hand, when little notice of an event is given, the time required to prepare for an evacuation is typically longer as residents need to pack belongings, collect their animals, and other activities that require coordination before beginning

their evacuation trip. The evacuation time for a trip in this analysis is based on the time *after* the evacuation trip is loaded on the road network.

Evacuation Demand Loading Window

The evacuation time window is the time between when the evacuation begins (assumed to be at 4:30 PM as previously noted) and how many hours the evacuation zones require to be fully evacuated, based upon the evacuation order (with the assumption that the evacuation zones are fully evacuated when the roadway network within the evacuation area returns to an uncongested state). The distribution across the evacuation time windows for the three evacuation scenarios are stated in the Scenario Development section. Although this is the assumed distribution for the EVAC+ model, it should be noted that emergency scenarios are often unpredictable, and driver behavior can be disorderly.

The capacity assessment of the network also changes the time needed for an evacuation. For example, scenarios where a 2-hour time window is assumed for evacuation (generally representing the time from evacuation order to the time most people begin their trip to leave the area), the total time needed for evacuation can be longer due to congestion and total distance traveled into/out of the area. The evacuation analysis applies roadway capacities from the SCTA model, but with a 10% reduction in capacity to account for the various incidents that may occur during an emergency scenario that might limit or reduce the capacities of these roadways (i.e. presence of debris or other hazards). Any unpaved roads are not included in the evacuation network. The free-flow speeds of roadways are set as their speed limits.

Evacuation Destinations

Trips departing evacuation zones are allocated to model gateways representing the destinations outside of the model area. The capacity of each use within the model area and the shelter opportunities represented at the gateways are used to determine the destination of evacuation trips. The share of trips assumed to end in each evacuation destination are shown in **Table 1**.

DTA Module: Dynamically Assign Trips to the Sub-Area Transportation Network

The sub-area extracted network, the background trips tables, and the evacuation trip tables are inputs of the Dynamic Traffic Assignment (DTA) model. A DTA model estimates traffic and levels of congestion in 15-minute intervals and, as link congestion builds (i.e., roads fill with cars), it dynamically reassigns traffic to less congested routes. This process helps identify congested locations on the network that should be considered during an evacuation event and alternative routes people may use due to congested conditions. In this analysis, we assume the evacuation elapsed time ends when the roadway network within the evacuation area returns to an uncongested state (all links with 15-minute volume-to-capacity ratio of 0.75 or less).

Additional Considerations

Facilitating evacuation of people with access and functional needs (AFNs), such as those who do not have access to or cannot operate a vehicle, is not analyzed as part of this study. The evacuation analysis does not include a detailed assessment of people in the study areas that have AFNs and how this may impact evacuation. However, this is a critical consideration for emergency personnel to ensure that complete evacuation is carried out. Further research into possible means of evacuating people with AFNs is recommended. As noted in the County's existing Emergency Operations Plan Evacuation Annex and Mass Care and Shelter Plan, options for assisting with evacuation in such situations could include, but not be limited to, the following:

- Promotion of County registry to ensure emergency responders know where to look for people who cannot self-evacuate
- Neighborhood "buddy" program to link people needing assistance with people willing to assist
- Coordination with local school districts to provide school bus access
- Partnership with transportation network companies (TNCs, like Uber and Lyft) to provide reduced-rate access
- Increased coordination with emergency services personnel to assist with accessibility

AB 747 Modeling Results

The EVAC+ tool, as described in the Approach and Methodology section, was used to estimate traffic conditions and operations during each of the three evacuation scenarios. The assignment results for each scenario in 15-minute interval are summarized below.

The resulting plots are color-coded by volume-to-capacity ratio, which measures the amount of traffic on a given roadway relative to the amount of traffic the roadway was designed to accommodate, from green to red (green being free-flow traffic and red being heavily congested), while the width of the lines represents traffic volume. For the purposes of this analysis, return to a volume-to-capacity ratio of 0.75 or lower indicates that the evacuation facilities have returned to free flow conditions and have served the vast majority of evacuation demand, with the remaining vehicles in the system representing evacuees who evacuated late.

The results of each scenario are described in the following sections.

Scenario 1

Scenario 1 is an emergency in which sectors 1, 2, and 3, consisting of the mountainous western portions of the County from the coast to the valley floor, must evacuate.

The modeling results for Scenario 1 for the Base Year 2019 and Future Year 2040 scenarios are presented in **Figure 2A** and **2B**. This scenario includes the coastal and mountainous west of Sonoma County, which has a limited number of roadways, and most of the evacuation traffic uses SR-1 to head north or south (and exiting via Valley Ford Road, as indicated by the model. Skaggs Spring Road and SR-116, which connects the coast with points east, sees some evacuation traffic from the coast, but most of the traffic uses SR-1. In the Green Valley area on the southeast portion of the evacuation area, every east-west oriented roadway in the area experiences heavy eastbound flows out of the evacuation area. However, the number of such roadways (in contrast to the mountainous and coastal areas in the west) and the relative proximity of the exit gateways of the study area means there is no single bottleneck for eastbound evacuation traffic.

The Year 2019 analysis indicates that evacuation area roadways would return to uncongested operations about 3.00 to 3.25 hours after the evacuation begins. The Year 2040 analysis indicates that study area roadways would return to uncongested operations about 3.00 to 3.25 hours after commencement of the evacuation. However, with the exception of the eastern exit gateways, the rest of the evacuation area's congestion clears significantly earlier. For reference, the model predicts an 51.4% growth in residential population and a 23% growth in employment population over the same period.

Scenario 2

Scenario 2 is an emergency in which sectors 4, 5, and 6, consisting of the mountainous areas in the northeastern portion of the County, consisting of Alexander Valley and the Sonoma Mountains north of Mark West Springs, must evacuate.

The modeling results for Scenario 2 for the Base Year 2019 and Future Year 2040 scenarios are presented in **Figure 3A** and **3B**. The area analyzed for Scenario 2 includes US-101 between Geyserville and just north of Santa Rosa (although the evacuation area does not), as background traffic along US-101 at the time of evacuation is expected to contribute to the challenges of this evacuation scenario, especially since US-101 is expected to be a primary evacuation route.

The model indicates that at the time of evacuation, there will already be significant traffic on the network, especially on US-101 near Windsor and Santa Rosa, and there is extremely heavy flows of traffic (both evacuation and background traffic) in both directions of US-101 through much of the evacuation period, with southbound traffic towards Santa Rosa being heavier than northbound traffic. The relatively high capacity of US-101 allows this traffic to clear relatively

quickly compared to secondary flows of traffic along several other non-controlled access roadways, including Chalk Hill Road, SR-128, Porter Creek Road, Franz Valley Road, Petrified Forest Road, and St. Helena Road towards Napa County, and Calistoga Road towards Santa Rosa, all of which see traffic flows take longer to clear.

The Year 2019 analysis indicates that evacuation area roadways would return to uncongested operations about 2.75 to 3.00 hours after the evacuation begins. The Year 2040 analysis indicates that evacuation area roadways would return to uncongested operations about 4.00 to 4.25 hours after commencement of the evacuation. For reference, the model predicts an 18.2% growth in residential population and a 57.5% growth in employment population over the same period.

Scenario 3

Scenario 3 is an emergency in which sectors 7, 8, and 9, consisting of the southeastern portions of the County, including Sonoma Valley, parts of Santa Rosa east of Farmers Lane, and the Sonoma Mountains south of Mark West Springs, must evacuate.

The modeling results for Scenario 3 for the Base Year 2019 and Future Year 2040 scenarios are presented in **Figure 4A** and **4B**. This scenario represents, by far, the largest population of residents and employees in the evacuation zone amongst the three scenarios, with significant populations in Valley of the Moon, Kenwood, and Sonoma Valley. The model indicates expected heavy traffic along both of the major arterials through Sonoma Valley, SR-12 and Arnold Drive, as evacuation traffic moves towards evacuation destinations at the northern and southern ends of the evacuation area. In the north, SR-12 and, to a lesser degree, Bennett Valley Road, carry significant traffic. In the south, significant traffic flows occur on SR-12 towards Napa and on SR-121 towards SR-37. However, the heaviest flows are observed along SR-116 / Stage Gulch Road. As Petaluma is the closest population center to much of the evacuation area, it is expected to be a major evacuation destination. SR-116 between Old Adobe Road in the west and Watmaugh Road in the east is the sole route between Petaluma and the Sonoma Valley with many roadways feeding into it on either end, making this stretch the largest capacity bottleneck.

The Year 2019 analysis indicates that evacuation area roadways would return to uncongested operations about 4.00 to 4.25 hours after the evacuation begins. The Year 2040 analysis indicates that evacuation area roadways would return to uncongested operations about 4.50 to 4.75 hours after commencement of the evacuation. For reference, the model predicts an 8% growth in both residential and employment populations over the same period.

Recommendations

Given topographic and roadway network constraints, Sonoma County has limited options to manage evacuation demand during an emergency scenario. The three emergency evacuation scenarios analyzed as part of this emergency evacuation assessment highlight the significance of US 101, SR 116, SR 12, SR 128, SR 121, and SR 1 as key evacuation routes, along with key local and regional roadways under maintenance by the County and surrounding jurisdictions.

Despite these constraints and challenges, the County can build upon previously completed local and regional evacuation planning efforts and incorporate additional strategies that may improve the efficiency of evacuation operations. Based on the modeling results, we developed recommendations to facilitate evacuation traffic operations. These recommendations consider a combination of permanent improvements, such as installing signage, changes to traffic control devices, or modifying roadway widths on key routes, and temporary improvements that can be quickly implemented during an evacuation event, such as traffic control officers, triggered evacuation warnings, or diversion of through traffic to maximize capacity for evacuation vehicles.

Broadly, these strategies can be organized into three categories, and are detailed further in this section below.

- **Demand**: when, how, and where people evacuate in an emergency.
- **Supply**: the physical and operational infrastructure that facilitates an emergency evacuation.
- **Policy**: how information is shared and received in an emergency.

Demand

- Develop a traffic control plan that identifies how signal backup will commence or key locations that traffic control officers will disperse to.
- Work with fire districts and departments to strategically stage emergency response vehicles in coordination with the evacuation warnings/orders.
- Encourage residents to take only one or two vehicles (based on household size) to reduce the number of evacuating vehicles. Offer off-site parking facilities to safely store secondary vehicles in advance of an emergency event.
- Encourage residents to evacuate in a timely manner, or in a phased evacuation, to reduce last-minute evacuations and concentrated demand on the roadway network. Coordinate with school districts to build awareness regarding school evacuation protocols which include sheltering in place or evacuating off-site using school buses or local transit.
- Require new developments or residential construction projects to consider worker evacuation needs as part of their construction permits.
- Underground utilities to prevent downed wires on main evacuation routes.

Supply

- Identify routes where reversible lanes could be considered during an evacuation based on the existing right-of-way and infrastructure.
- Develop a catalog of sample cross-sections for temporary conversion and best practice treatments to enable two-lane egress as well as safe pedestrian egress and emergency response ingress.
- Pursue redundancy of critical transportation infrastructure to allow for continued access and movement in the event of an emergency, including vulnerabilities of traffic signals/traffic control centers, to reduce impact and response time for outages that may occur during emergency events (e.g., signals losing power due to high winds or active fire).
    - Prioritize traffic signals in vulnerable areas for improvements and connect signals to the Traffic Management Center, with contingency plans for loss of power and communications grids.
    - Investigate adaptive signal control (ASC) systems that can adjust traffic signal timing to account for high volumes that occur during hazard events. Provide redundancy in the form of a static evacuation coordination plan in case of ASC system disruption.
- Ensure that Fire departments have complete access to all locations in the County, including gated communities and critical infrastructure that is within the County's jurisdiction.
- Require new developments and redevelopments to provide adequate access (ingress, egress) and a minimum of two roadways with widths and lengths. Inventory and assess existing development that is within the County's jurisdiction to understand whether changes to access (ingress/egress), circulation, or vehicle storage patterns could provide additional community benefit during evacuation events.
- Require new developments and redevelopments to incorporate resilience amenities (e.g., community cooling center, emergency supplies, and backup power) to be used by residents and businesses within a quarter-mile distance.
- Continue to develop and maintain evacuation options for populations with Access and Functional Needs (AFNs) as well as other vulnerable populations (such as those without sufficient access to a vehicle to evacuate all people in their household), as the County has done in its existing Emergency Operations Plan, Emergency Operations Plan Evacuation Annex, and Mass Care and Shelter Plan.
- Provide one-tenth mile markers for assisting travelers and emergency responders with location, mainly when communications grids are down.
- Designate safety zones (points of last refuge) or shelter-in-place locations as potential places of refuge when evacuation routes become blocked.

Policy

- Establish a redundant and resilient public communications system that builds on existing communications tools and systems (such as the Wireless Emergency Alert, Nixle, and Everbridge) to ensure uninterrupted emergency communications such as through solar photovoltaic systems and battery storage, phone/text alerts, radio, sirens/loudspeaker, and signage.
- Consider countywide evacuation drills for residents so that they are aware of what to expect during an evacuation event and are prepared in such a scenario. Conduct regular evacuation training with single-access community HOAs and residents; encourage residents in single-access communities to maintain emergency supplies for 3-10 days.
- Create a registry to accurately document where "Access & Functional Needs" populations are located, along with the location of other potentially vulnerable populations throughout the unincorporated County, such as senior housing facilities and schools, and others without access to a personal vehicle (such as tourists), particularly in very high wildfire risk zones.
- Maintain and regularly update the County's Local Hazard Mitigation Plan (LHMP) and the Sonoma County Operational Area Emergency Operations Plan (EOP) to maintain eligibility for grant funding.
- Adopt an Urban Forestry Plan that includes proper landscaping, planning, and management guidance for County staff and first responders in maintaining clear routes for evacuation.
- Provide Community Emergency Response Training (CERT) to increase disaster preparedness training to the community at the neighborhood level.
- Provide multi-lingual (English and Spanish at a minimum) public health, emergency preparedness, and evacuation information and signage to citizens through libraries, the County website, radio, schools, and other social media platforms.
- Promote a culture of preparedness for residents and businesses to increase resilience to hazard events.
- Improve coordination between frontline emergency personnel, media sources, and school districts to ensure accurate and clear information is being disseminated.
- Coordinate with agencies operating or managing dam facilities on operations, maintenance, and training activities, and provide Emergency Action Plans annually.
- Provide evacuees with guidance on evacuation route conditions along with dynamic rerouting information to decrease travel times and reduce congestion on highly traveled roads (for example, GPS routing systems).
- Monitor traffic using intelligent transportation system (ITS) technology to identify accidents and problem areas, determine the effectiveness of responses, and change responses as needed.

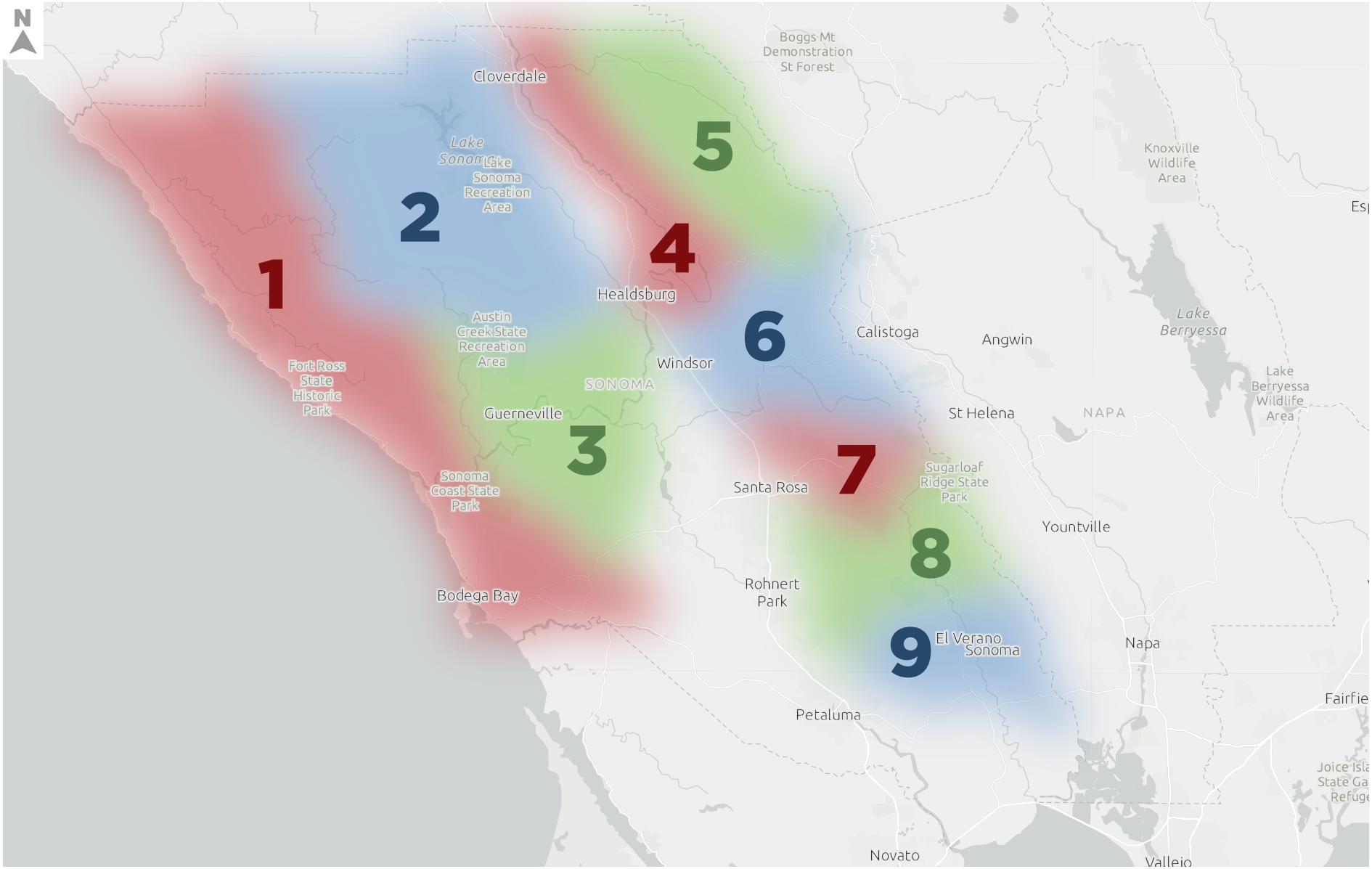


Figure 1

Evacuation Sectors

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Figure 2.2

Scenario 1 Base Year Model Run - 2:45 PM

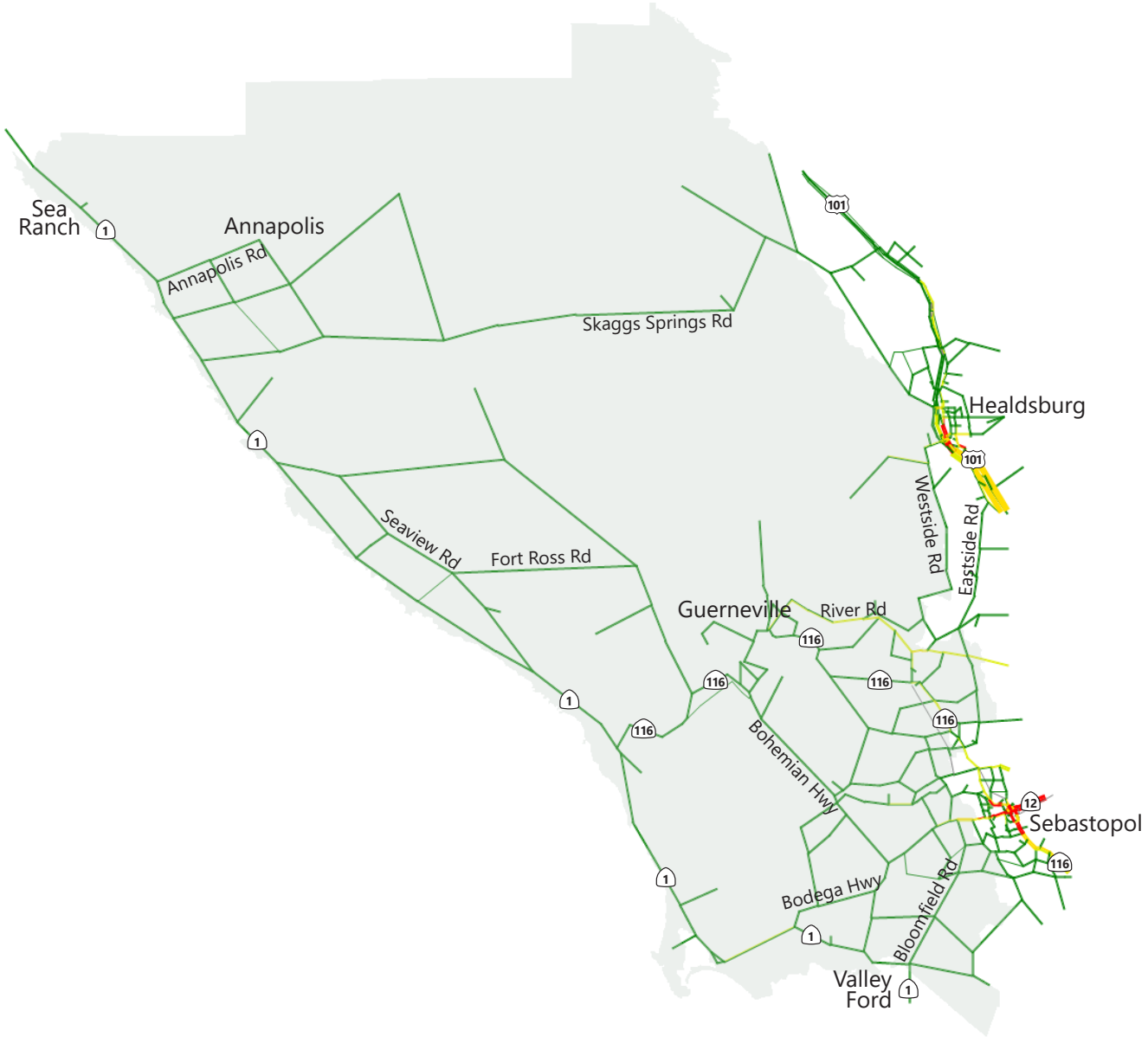


Figure 2.3

Scenario 1 Base Year Model Run - 3:00 PM

Figure 2.4

Scenario 1 Base Year Model Run - 3:15 PM

Figure 2.5

Scenario 1 Base Year Model Run - 3:30 PM

Figure 2.6

Scenario 1 Base Year Model Run - 3:45 PM

Figure 2.7

Scenario 1 Base Year Model Run - 4:00 PM

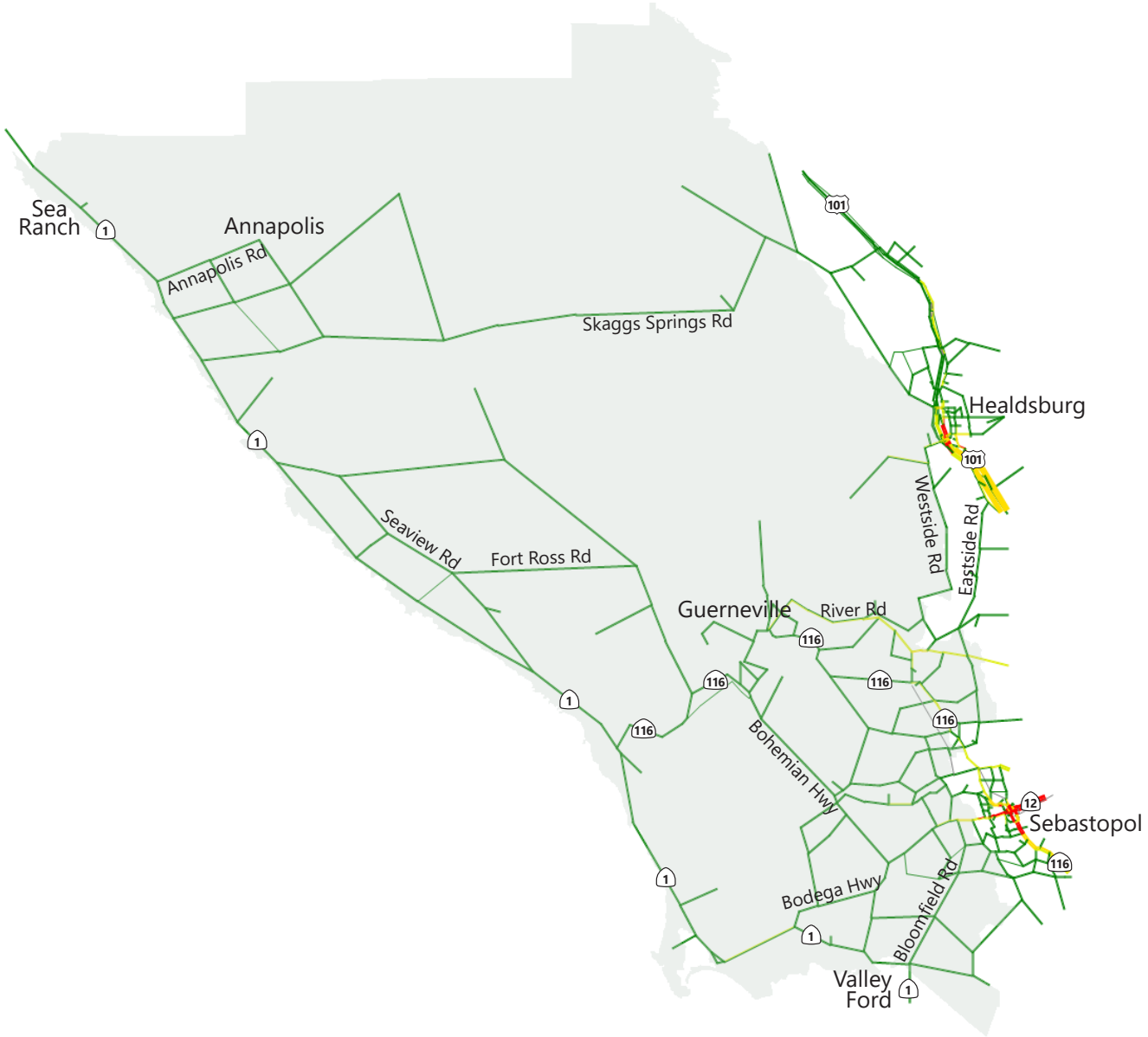


Figure 2.8

Scenario 1 Base Year Model Run - 4:15 PM

Figure 2.9

Scenario 1 Base Year Model Run - 4:30 PM (start of evacuation)

Figure 2.10

Scenario 1 Base Year Model Run - 4:45 PM

Figure 2.11

Scenario 1 Base Year Model Run - 5:00 PM

Figure 2.12

Scenario 1 Base Year Model Run - 5:15 PM

Figure 2.13

Scenario 1 Base Year Model Run - 5:30 PM

Figure 2.14

Scenario 1 Base Year Model Run - 5:45 PM

Figure 2.15

Scenario 1 Base Year Model Run - 6:00 PM

Figure 2.16

Scenario 1 Base Year Model Run - 6:15 PM

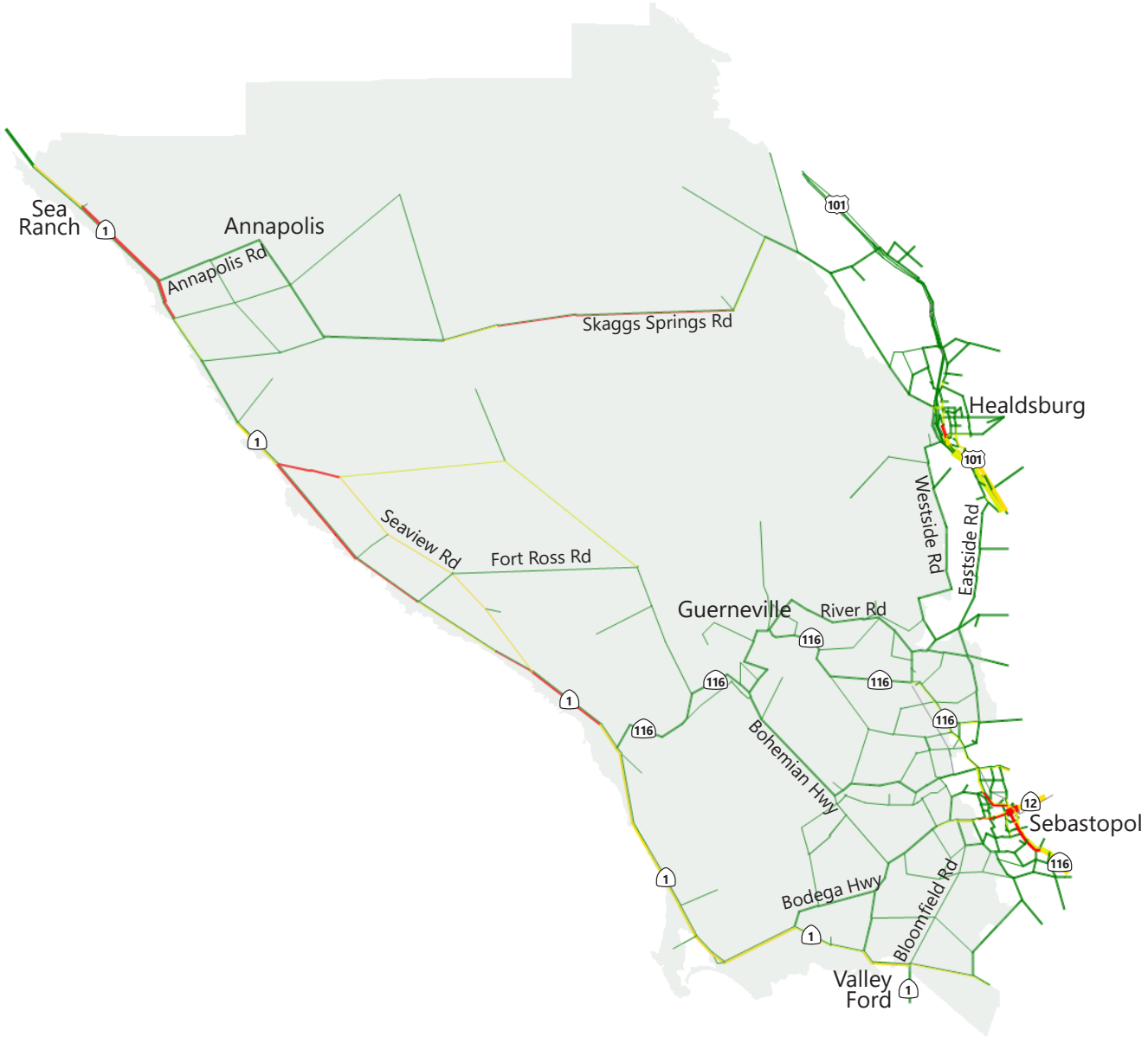


Figure 2.17

Scenario 1 Base Year Model Run - 6:30 PM

Figure 2.18

Scenario 1 Base Year Model Run - 6:45 PM

Figure 2.19

Scenario 1 Base Year Model Run - 7:00 PM

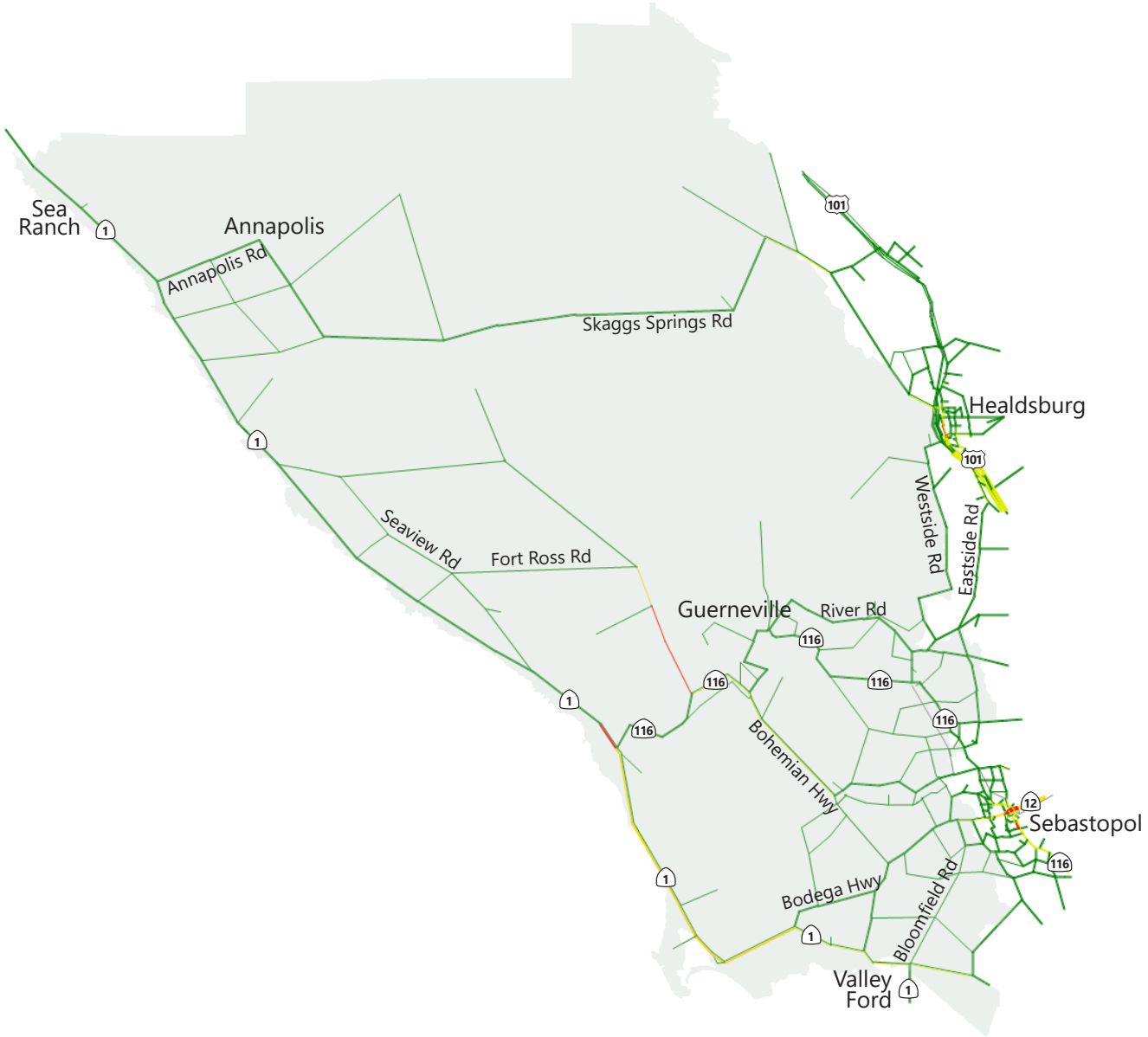


Figure 2.20

Scenario 1 Base Year Model Run - 7:15 PM

Figure 2.21

Scenario 1 Base Year Model Run - 7:30 PM

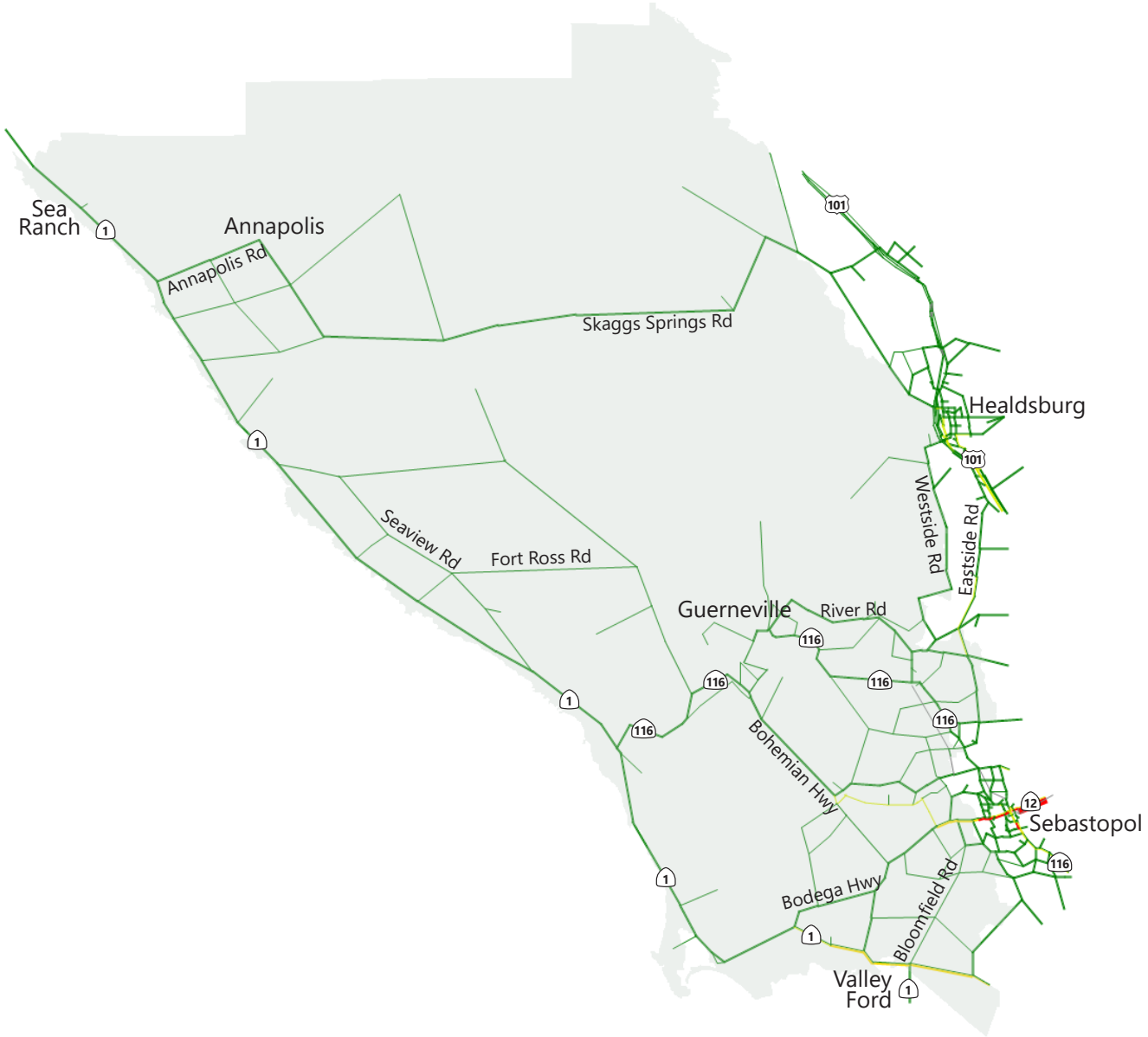


Figure 2.22

Scenario 1 Base Year Model Run - 7:45 PM

Figure 2.23

Scenario 1 Base Year Model Run Results

Figure 3.1

Scenario 1 Future Year Model Run - 2:30 PM

Figure 3.2

Scenario 1 Future Year Model Run - 2:45 PM

Figure 3.3

Scenario 1 Future Year Model Run - 3:00 PM

Figure 3.4

Scenario 1 Future Year Model Run - 3:15 PM

Figure 3.5

Scenario 1 Future Year Model Run - 3:30 PM

Figure 3.6

Scenario 1 Future Year Model Run - 3:45 PM

Figure 3.7

Scenario 1 Future Year Model Run - 4:00 PM

Figure 3.8

Scenario 1 Future Year Model Run - 4:15 PM

Figure 3.9

Scenario 1 Future Year Model Run - 4:30 PM (start of evacuation)

Figure 3.10

Scenario 1 Future Year Model Run - 4:45 PM

Figure 3.11

Scenario 1 Future Year Model Run - 5:00 PM

Figure 3.12

Scenario 1 Future Year Model Run - 5:15 PM

Figure 3.13

Scenario 1 Future Year Model Run - 5:30 PM

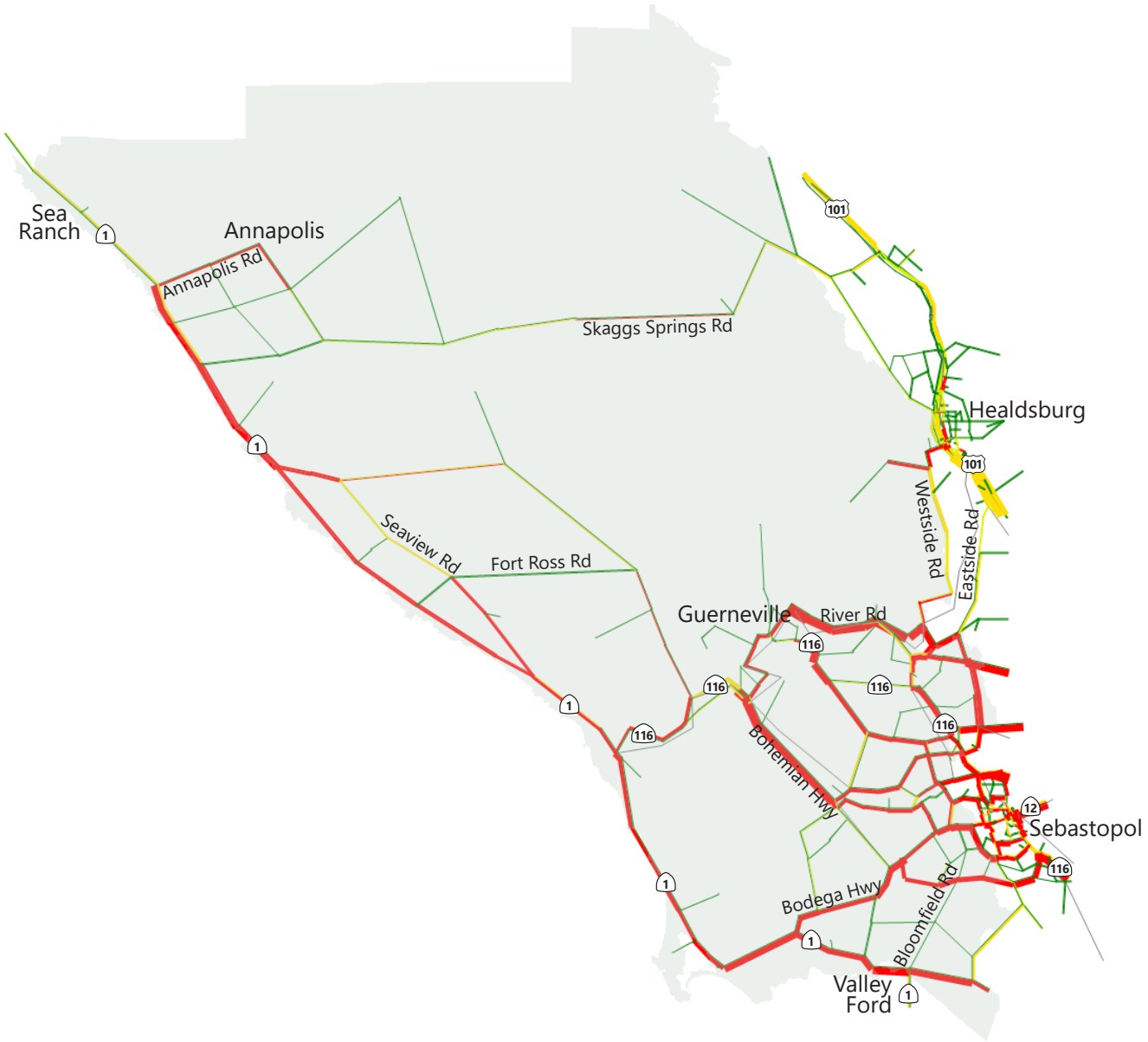


Figure 3.14

Scenario 1 Future Year Model Run - 5:45 PM

Figure 3.15

Scenario 1 Future Year Model Run - 6:00 PM

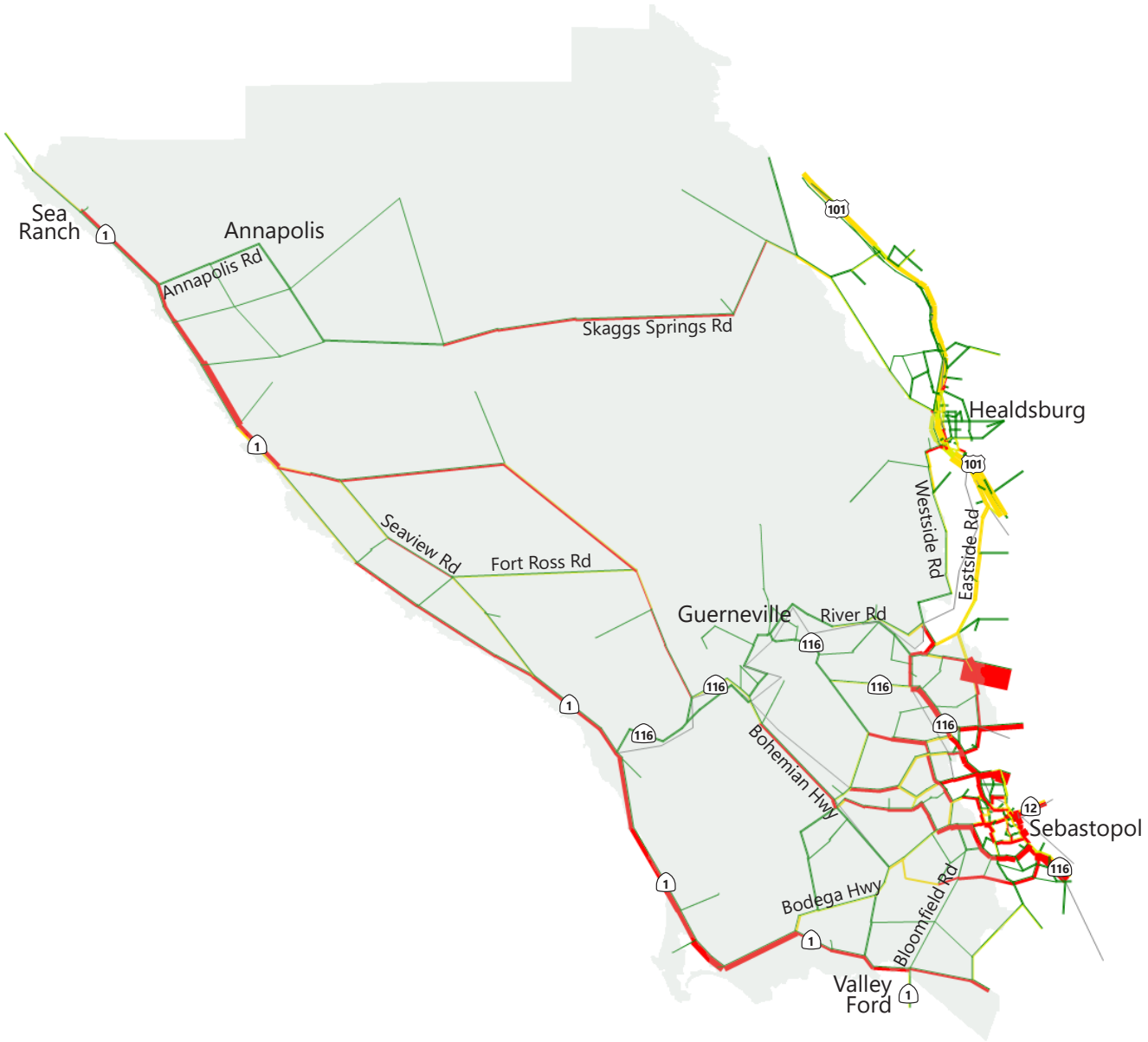


Figure 3.16

Scenario 1 Future Year Model Run - 6:15 PM

Figure 3.17

Scenario 1 Future Year Model Run - 6:30 PM

Figure 3.18

Scenario 1 Future Year Model Run - 6:45 PM

Figure 3.19

Scenario 1 Future Year Model Run - 7:00 PM

Figure 3.20

Scenario 1 Future Year Model Run - 7:15 PM

Figure 3.21

Scenario 1 Future Year Model Run - 7:30 PM

Figure 3.22

Scenario 1 Future Year Model Run - 7:45 PM

Figure 3.23

Scenario 1 Future Year Model Run Results

Figure 4.1

Scenario 2 Base Year Model Run - 2:30 PM

Figure 4.2

Scenario 2 Base Year Model Run - 2:45 PM

Figure 4.3

Scenario 2 Base Year Model Run - 3:00 PM

Figure 4.4

Scenario 2 Base Year Model Run - 3:15 PM

Figure 4.5

Scenario 2 Base Year Model Run - 3:30 PM

Figure 4.6

Scenario 2 Base Year Model Run - 3:45 PM

Figure 4.7

Scenario 2 Base Year Model Run - 4:00 PM

Figure 4.8

Scenario 2 Base Year Model Run - 4:15 PM

Figure 4.9

Scenario 2 Base Year Model Run - 4:30 PM (start of evacuation)

Figure 4.10

Scenario 2 Base Year Model Run - 4:45 PM

Figure 4.11

Scenario 2 Base Year Model Run - 5:00 PM

Figure 4.12

Scenario 2 Base Year Model Run - 5:15 PM

Figure 4.13

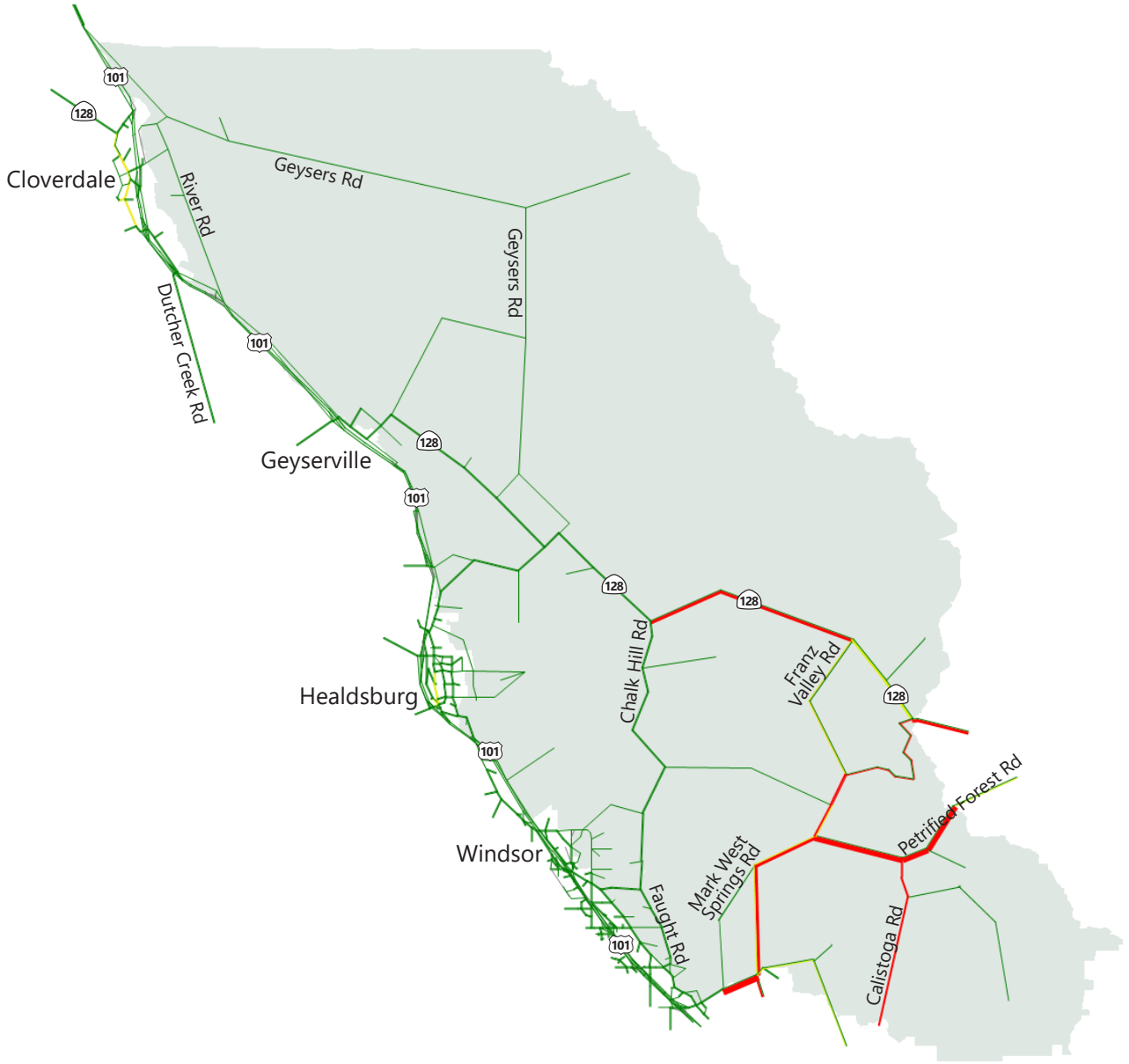
Scenario 2 Base Year Model Run - 5:30 PM

Figure 4.14

Scenario 2 Base Year Model Run - 5:45 PM

Figure 4.15

Scenario 2 Base Year Model Run - 6:00 PM



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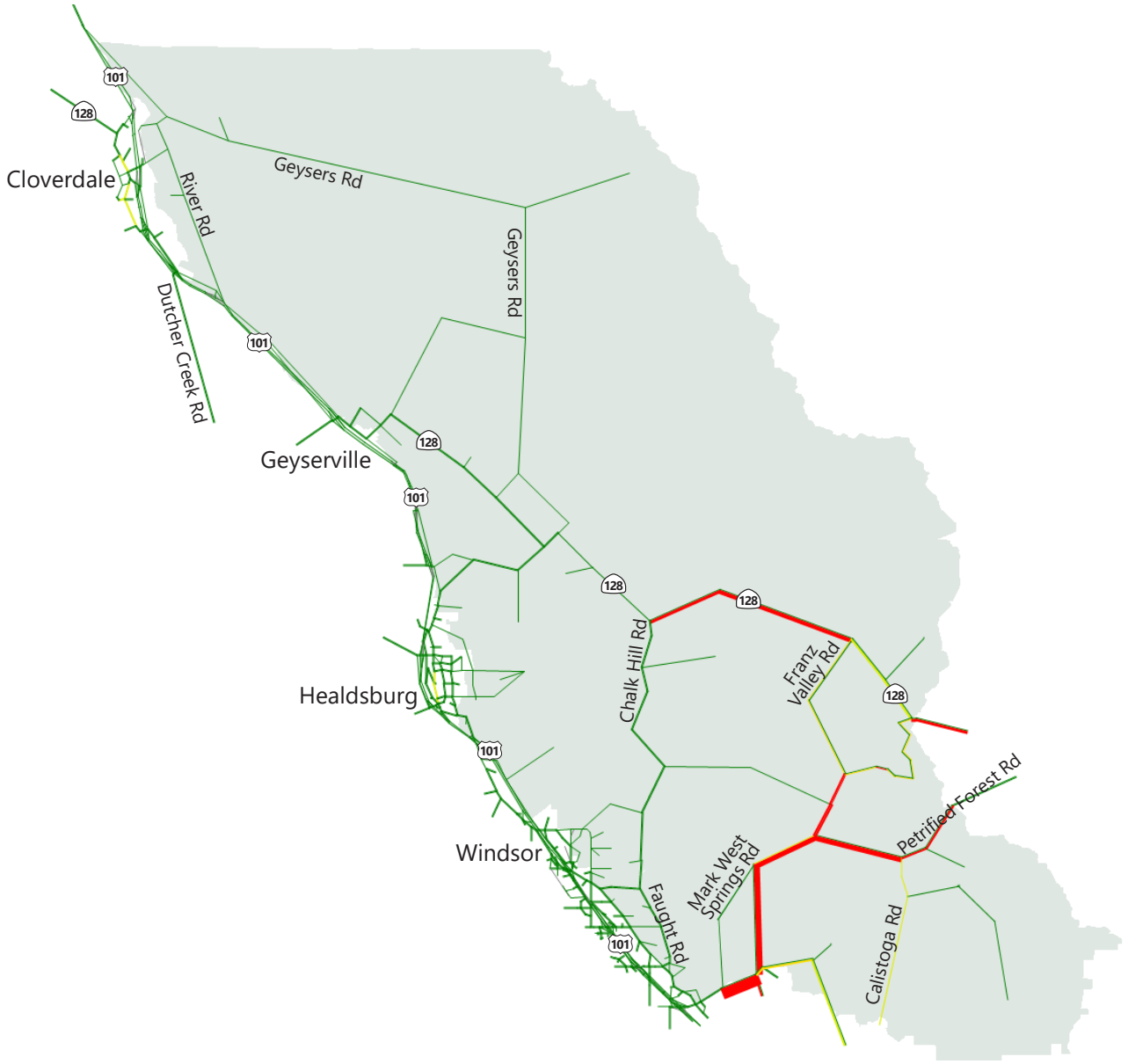
Scenario 2 Base Year Model Run - 6:15 PM



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Scenario 2 Base Year Model Run - 6:30 PM

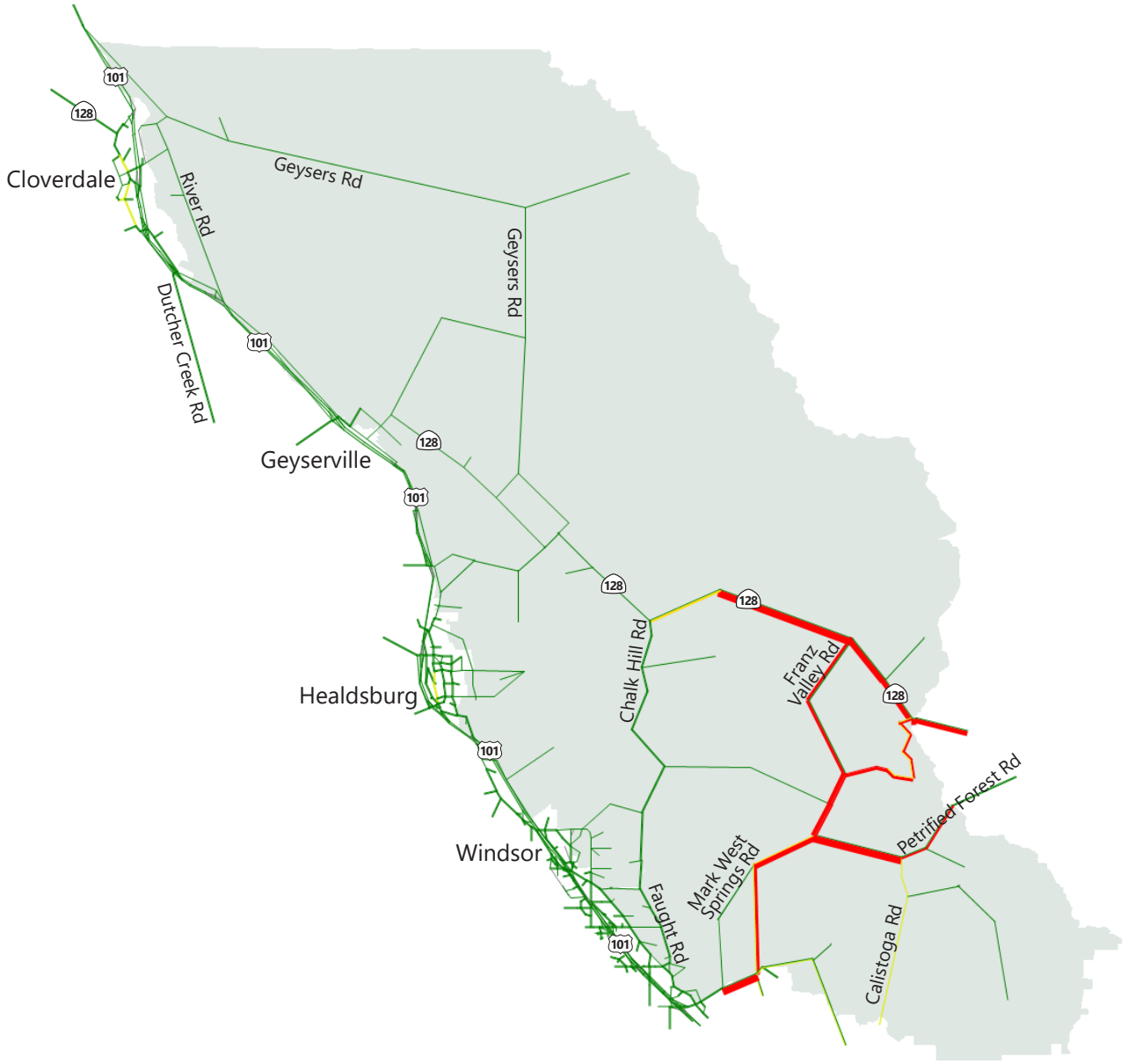


Figure 4.18

Scenario 2 Base Year Model Run - 6:45 PM

Figure 4.19

Scenario 2 Base Year Model Run - 7:00 PM

Figure 4.20

Scenario 2 Base Year Model Run - 7:15 PM

Figure 4.21

Scenario 2 Base Year Model Run - 7:30 PM

Figure 4.22

Scenario 2 Base Year Model Run - 7:45 PM

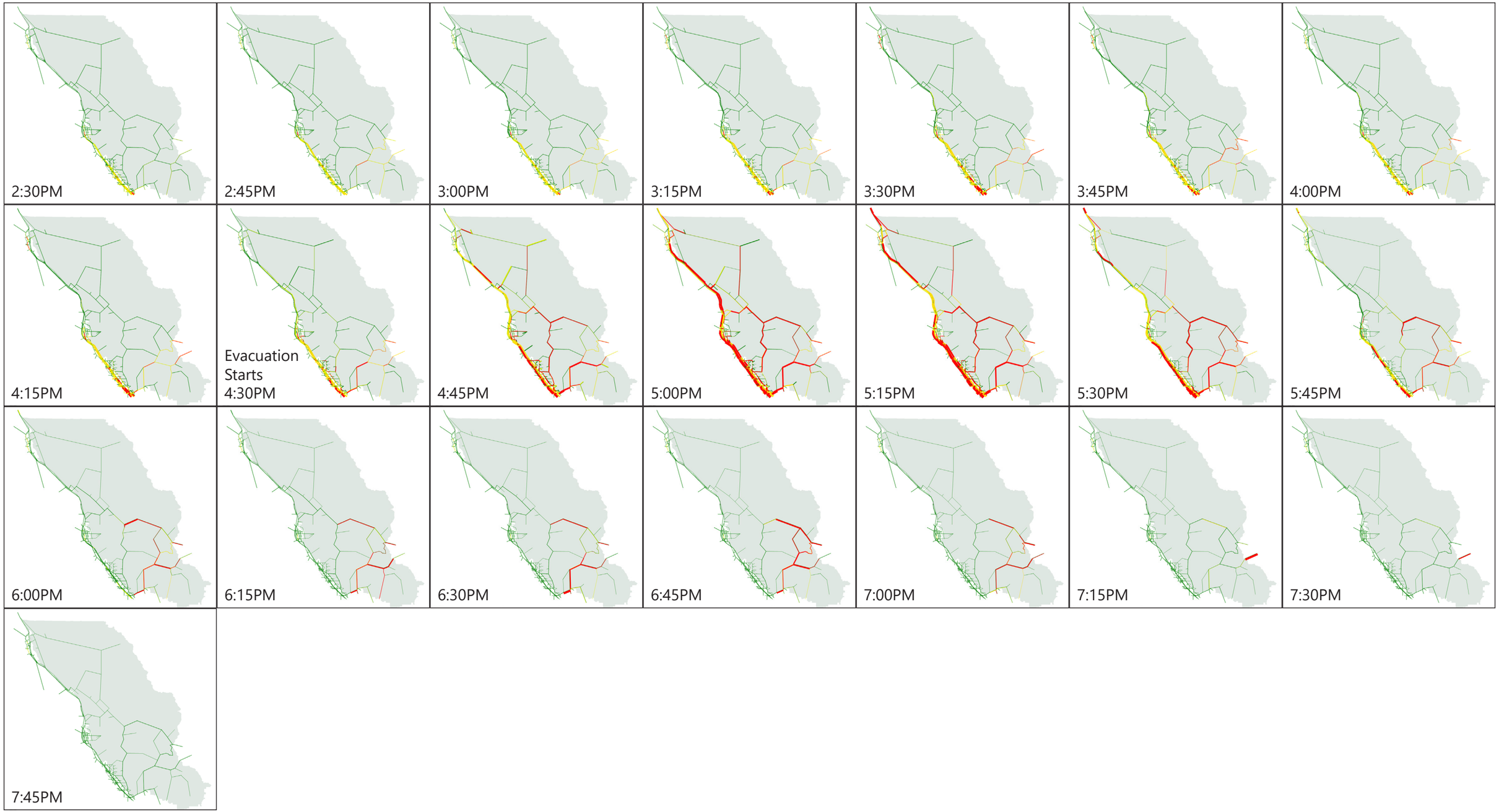


Figure 4.23

Scenario 2 Base Year Model Run Results

Figure 5.1

Scenario 2 Future Year Model Run - 2:30 PM

Figure 5.2

Scenario 2 Future Year Model Run - 2:45 PM

Figure 5.3

Scenario 2 Future Year Model Run - 3:00 PM

Figure 5.4

Scenario 2 Future Year Model Run - 3:15 PM

Figure 5.5

Scenario 2 Future Year Model Run - 3:30 PM

Figure 5.6

Scenario 2 Future Year Model Run - 3:45 PM

Figure 5.7

Scenario 2 Future Year Model Run - 4:00 PM

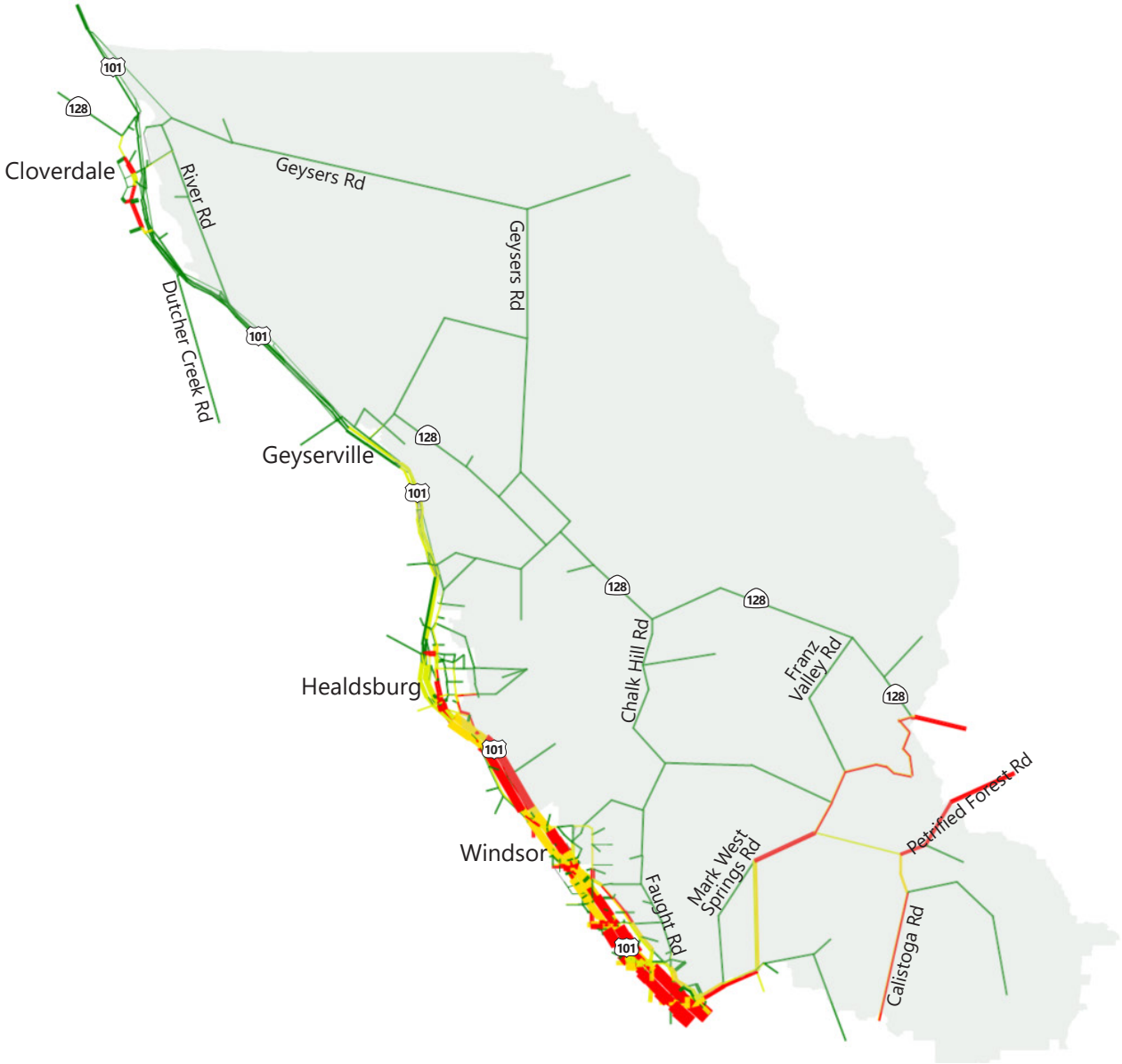


Figure 5.8

Scenario 2 Future Year Model Run - 4:15 PM

Figure 5.9

Scenario 2 Future Year Model Run - 4:30 PM (start of evacuation)

Figure 5.10

Scenario 2 Future Year Model Run - 4:45 PM

Figure 5.11

Scenario 2 Future Year Model Run - 5:00 PM

Figure 5.12

Scenario 2 Future Year Model Run - 5:15 PM

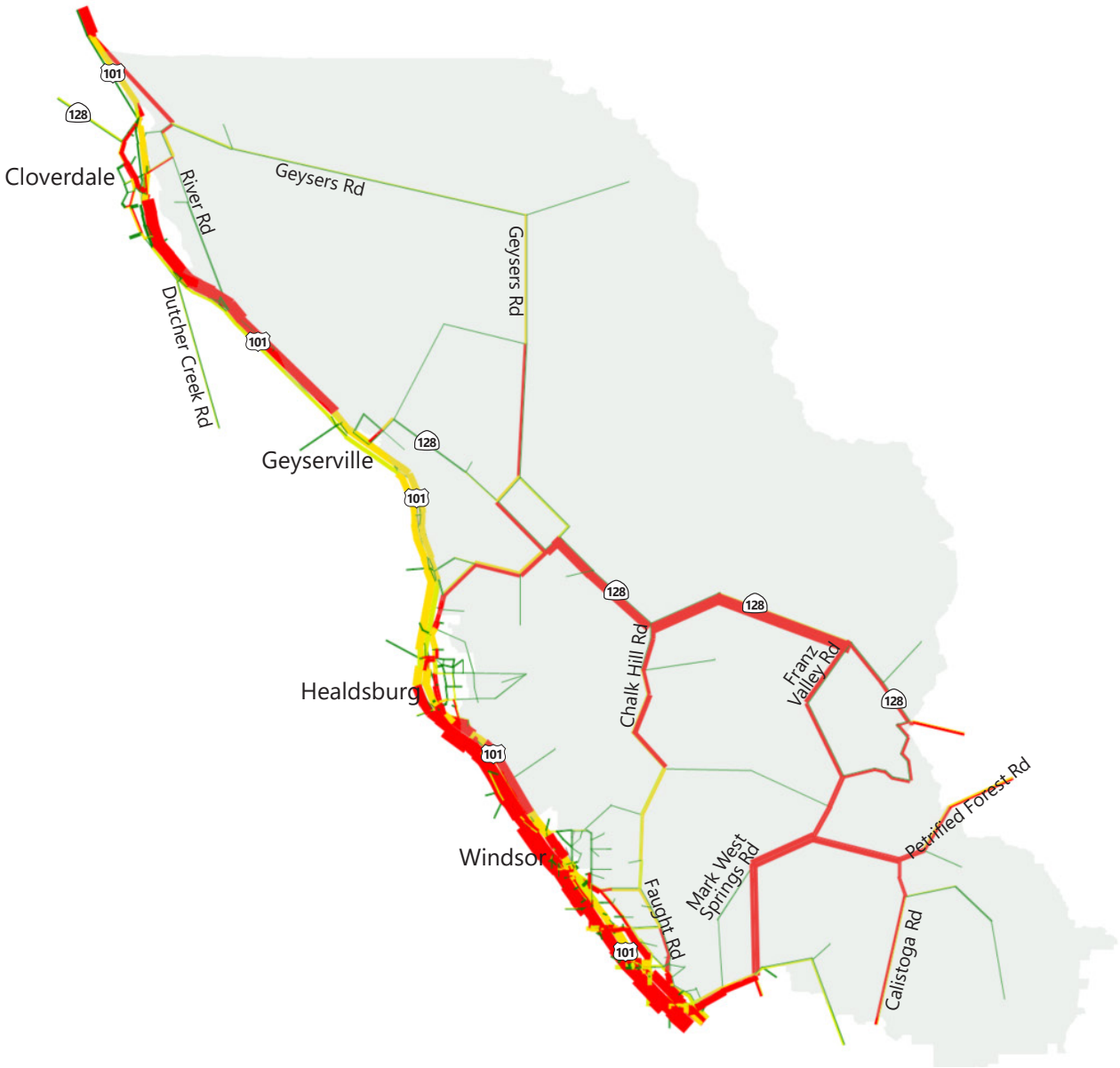


Figure 5.13

Scenario 2 Future Year Model Run - 5:30 PM

Figure 5.14

Scenario 2 Future Year Model Run - 5:45 PM

Figure 5.15

Scenario 2 Future Year Model Run - 6:00 PM

Figure 5.16

Scenario 2 Future Year Model Run - 6:15 PM

Figure 5.17

Scenario 2 Future Year Model Run - 6:30 PM

Figure 5.18

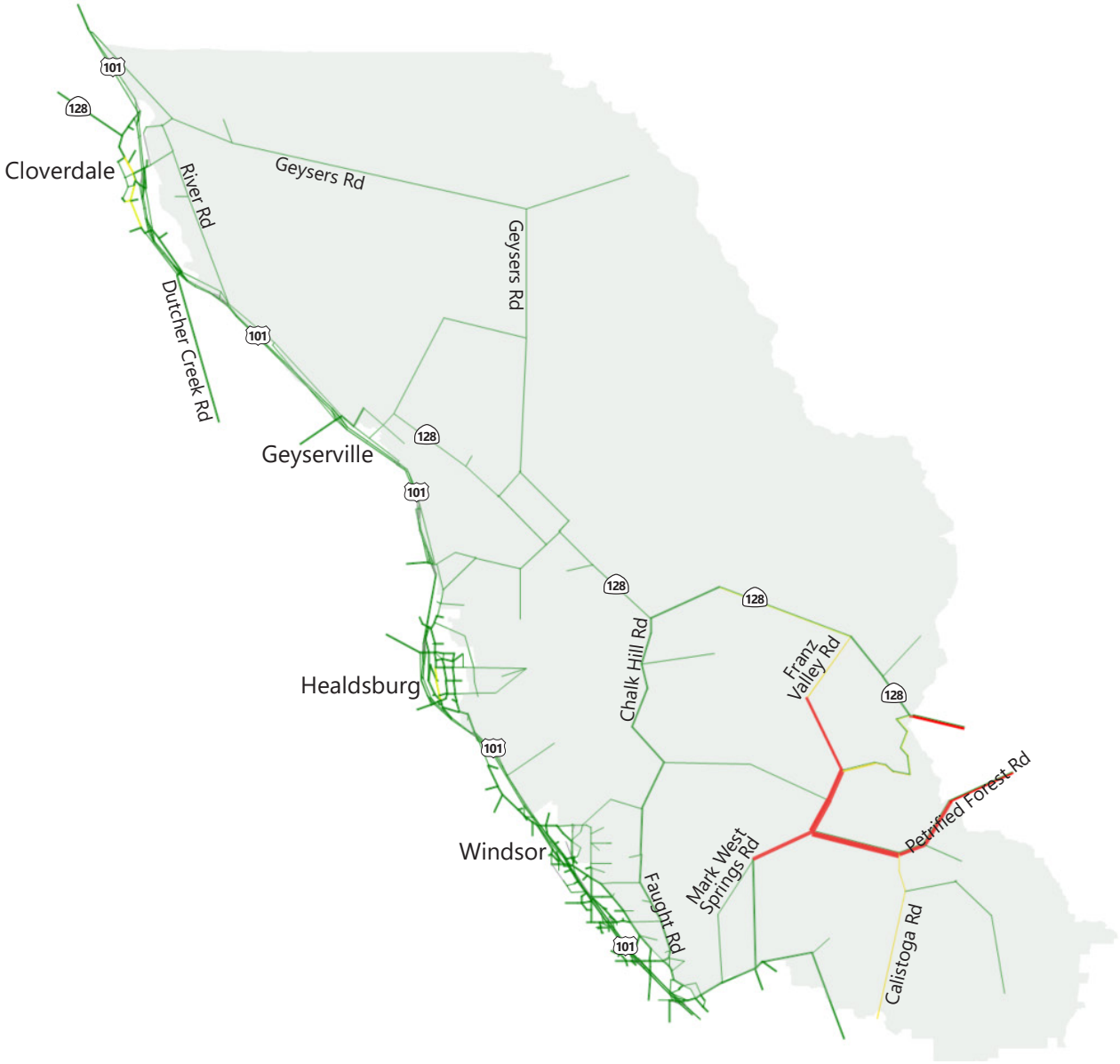
Scenario 2 Future Year Model Run - 6:45 PM

Figure 5.19

Scenario 2 Future Year Model Run - 7:00 PM

Figure 5.20

Scenario 2 Future Year Model Run - 7:15 PM



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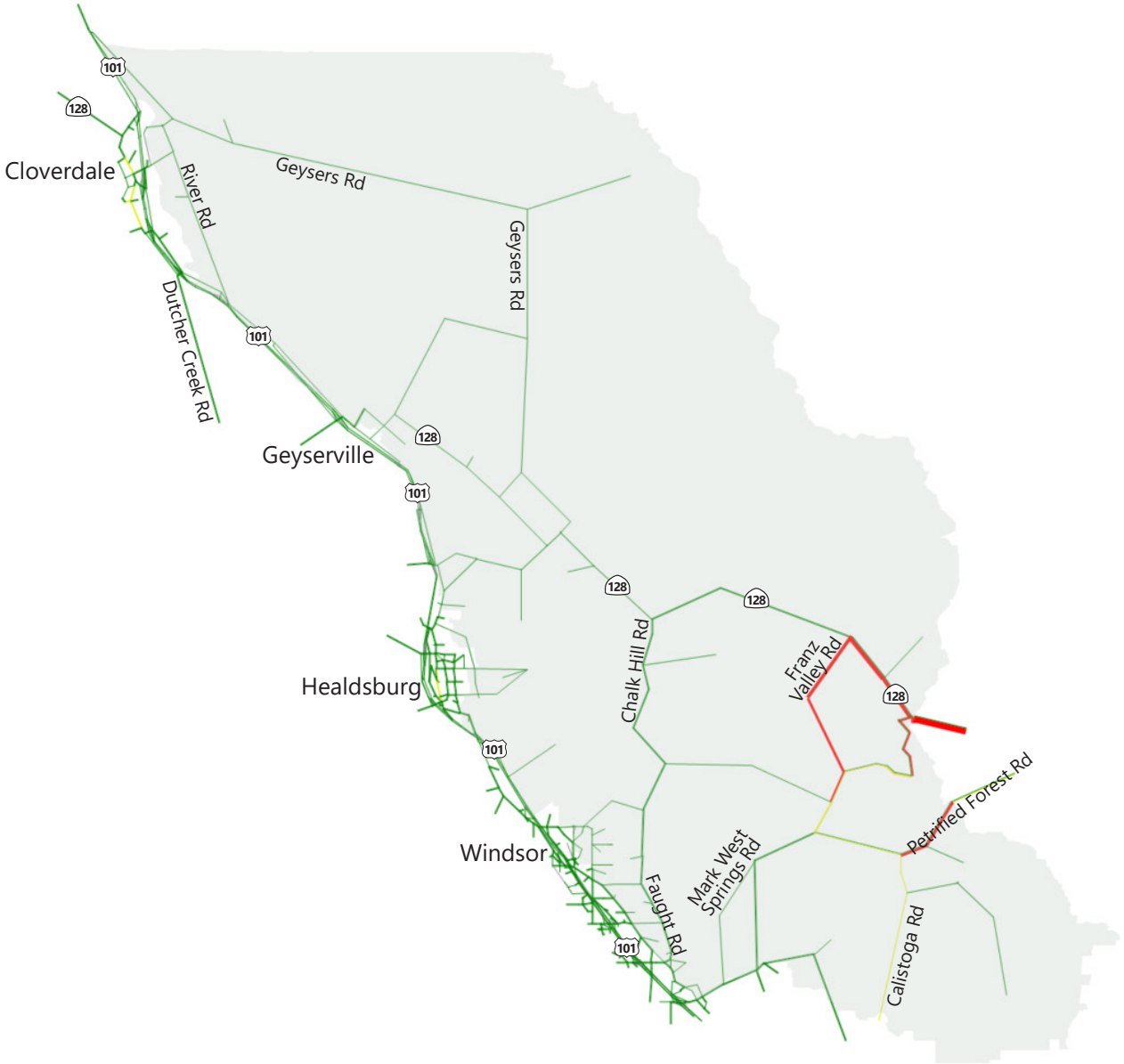


Figure 5.22

Scenario 2 Future Year Model Run - 7:45 PM

Figure 5.23

Scenario 2 Future Year Model Run - 8:00 PM

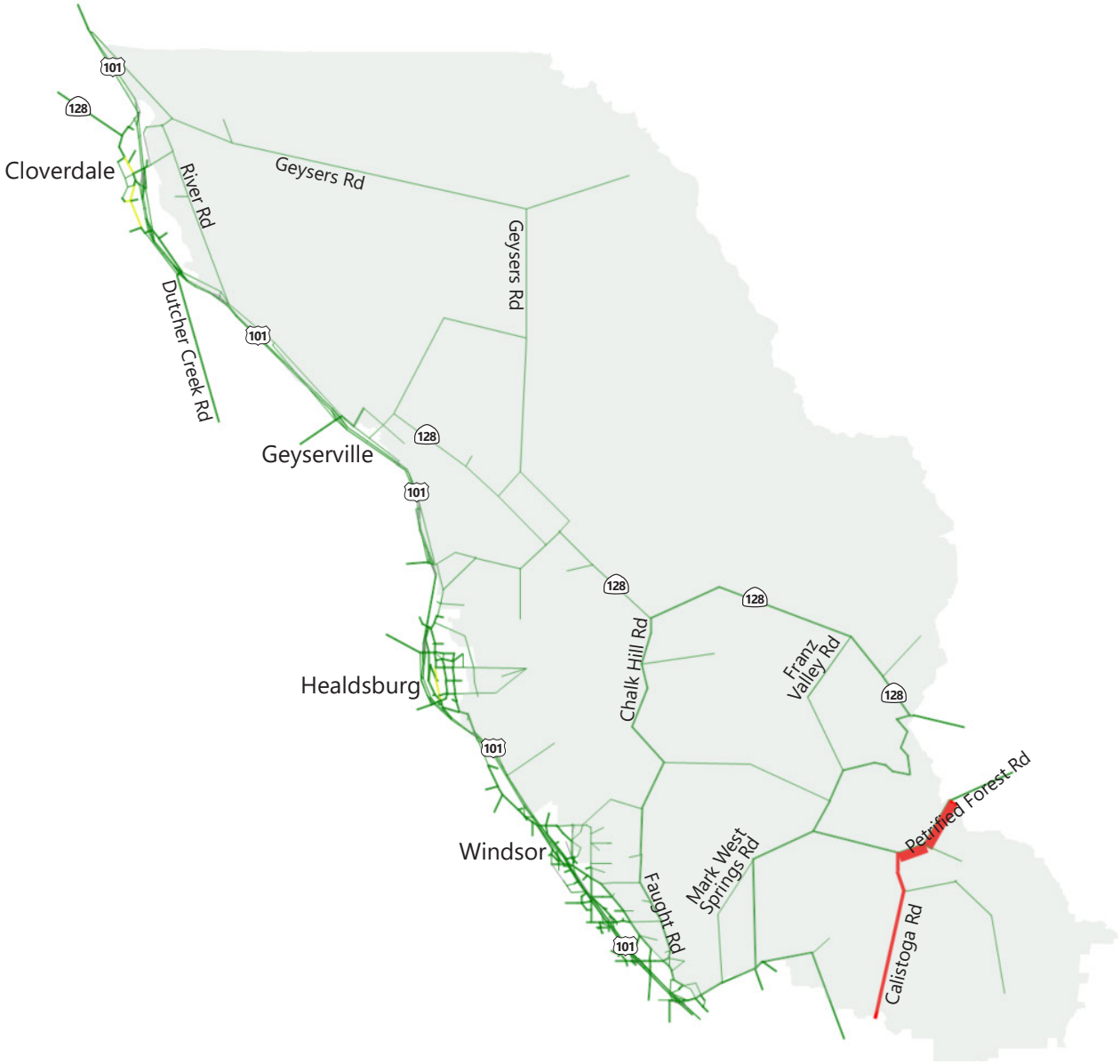


Figure 5.24

Scenario 2 Future Year Model Run - 8:15 PM

Figure 5.25

Scenario 2 Future Year Model Run - 8:30 PM

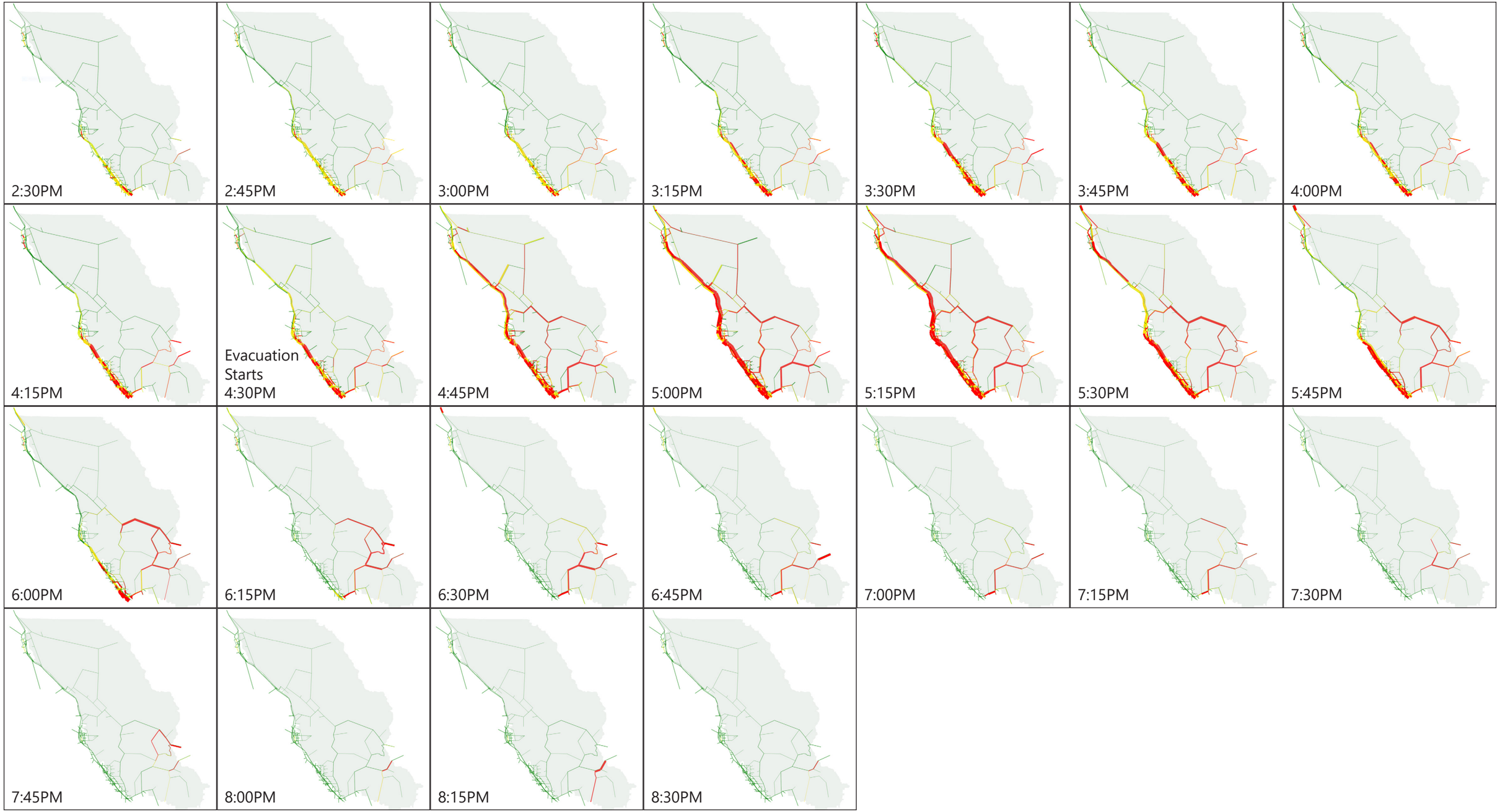


Figure 5.26

Scenario 2 Future Year Model Run Results

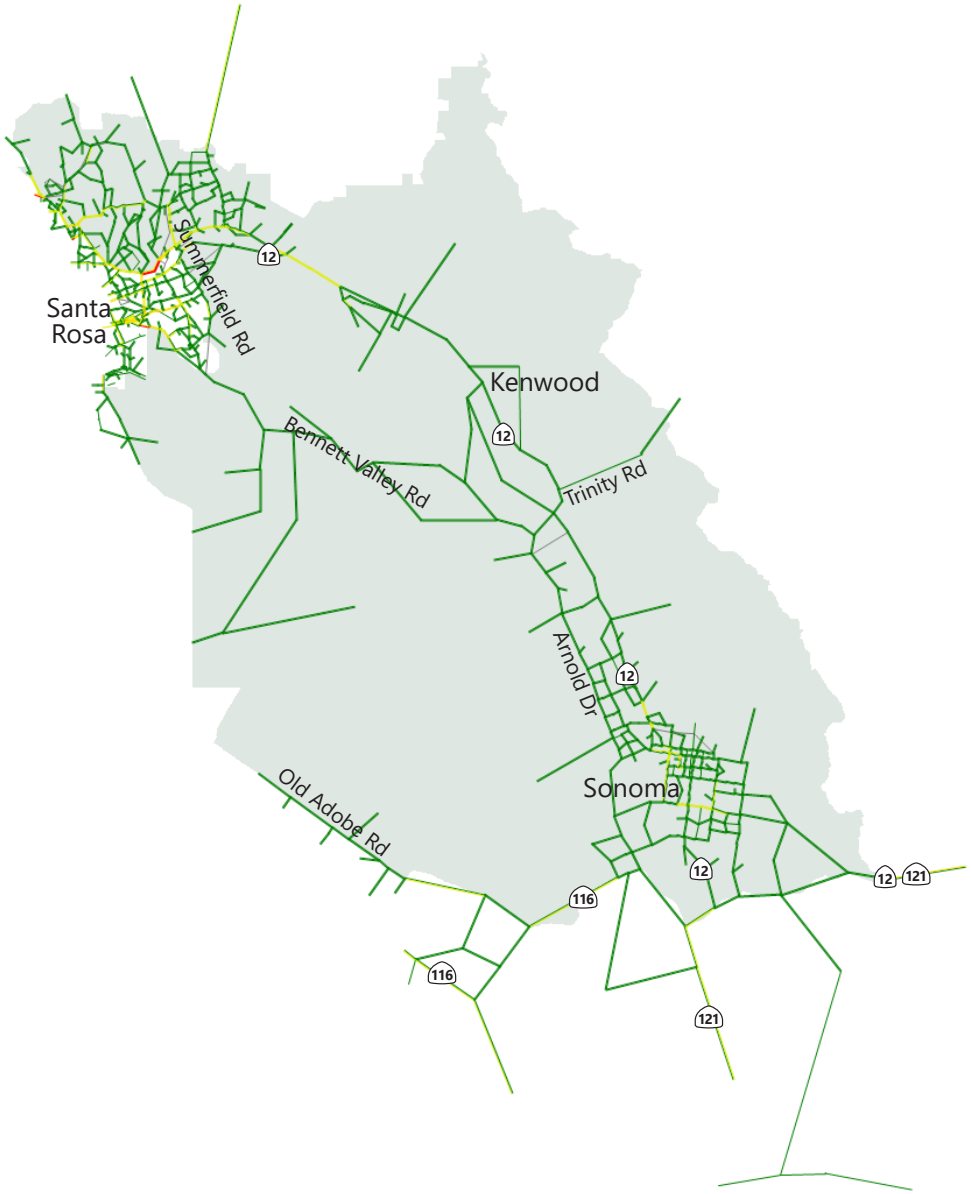


Figure 6.1

Scenario 3 Base Year Model Run - 2:30 PM

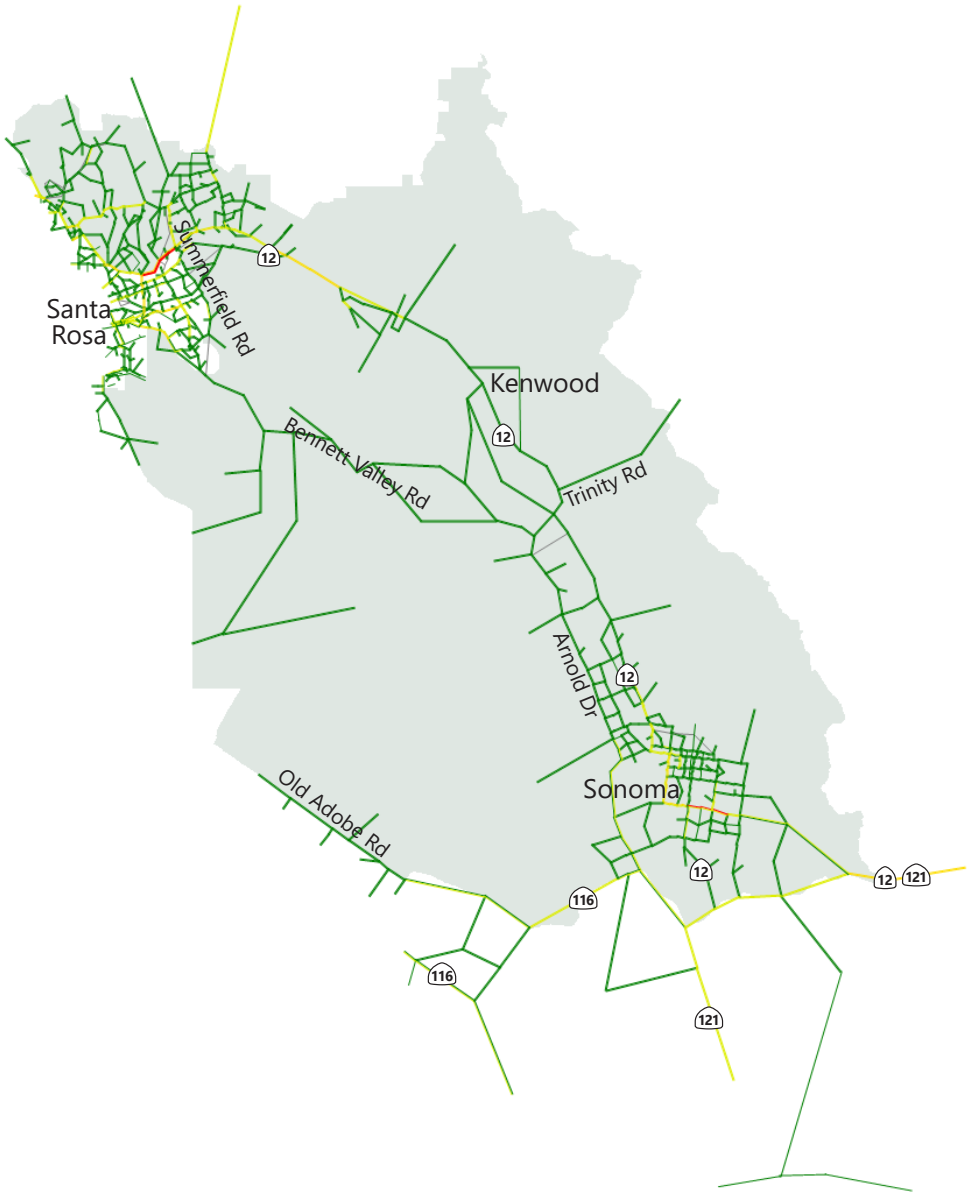


Figure 6.2

Scenario 3 Base Year Model Run - 2:45 PM

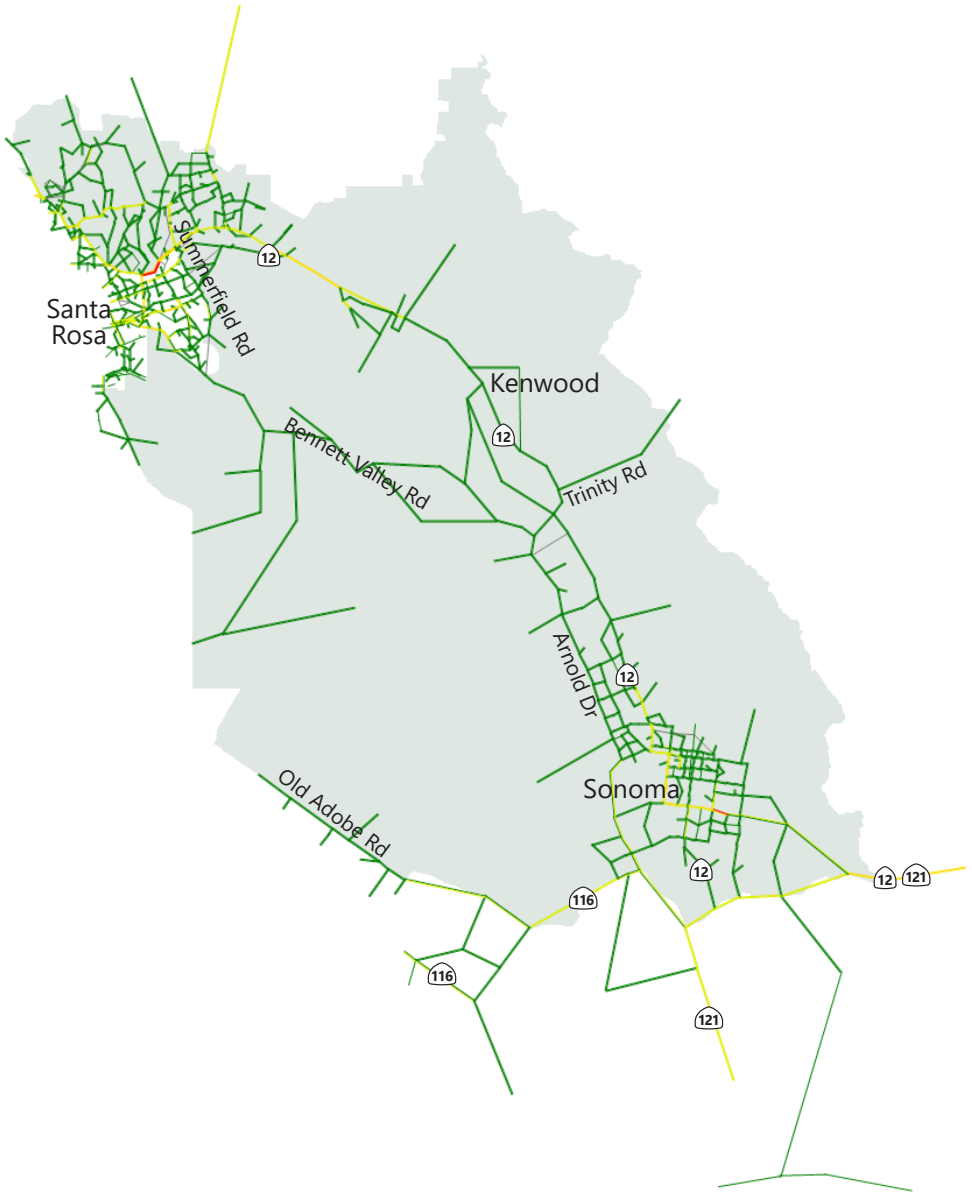
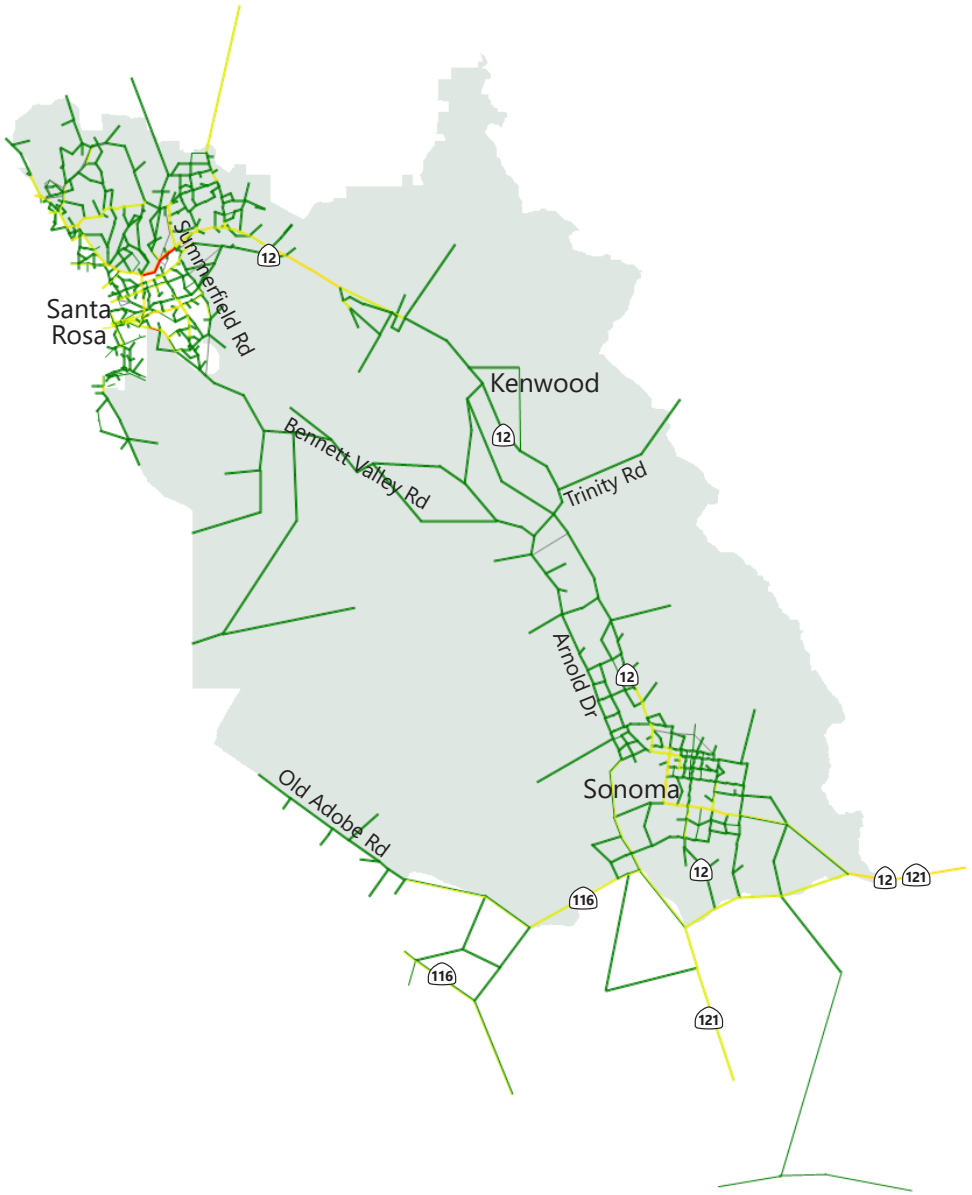


Figure 6.3

Scenario 3 Base Year Model Run - 3:00 PM



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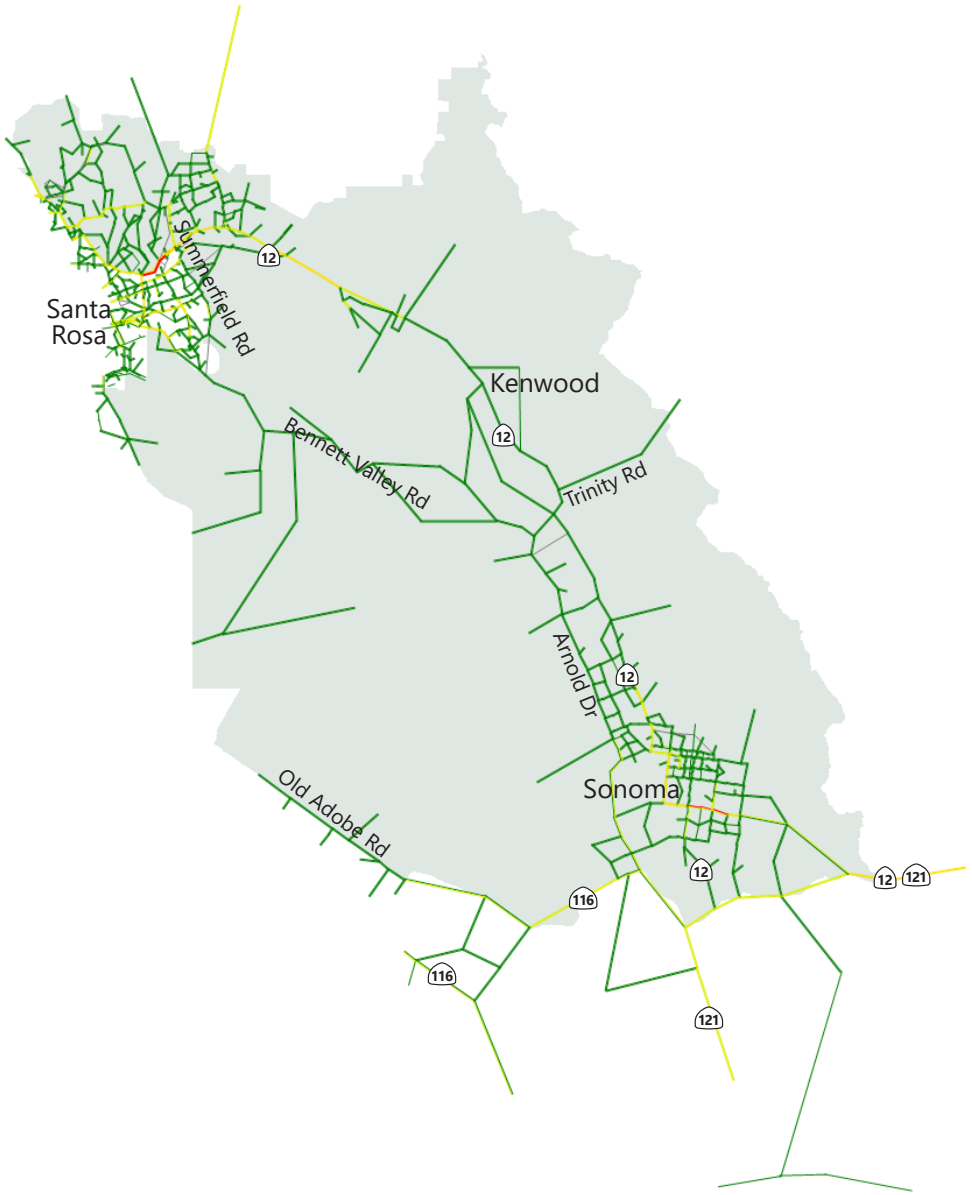

Figure 6.5

Scenario 3 Base Year Model Run - 3:30 PM

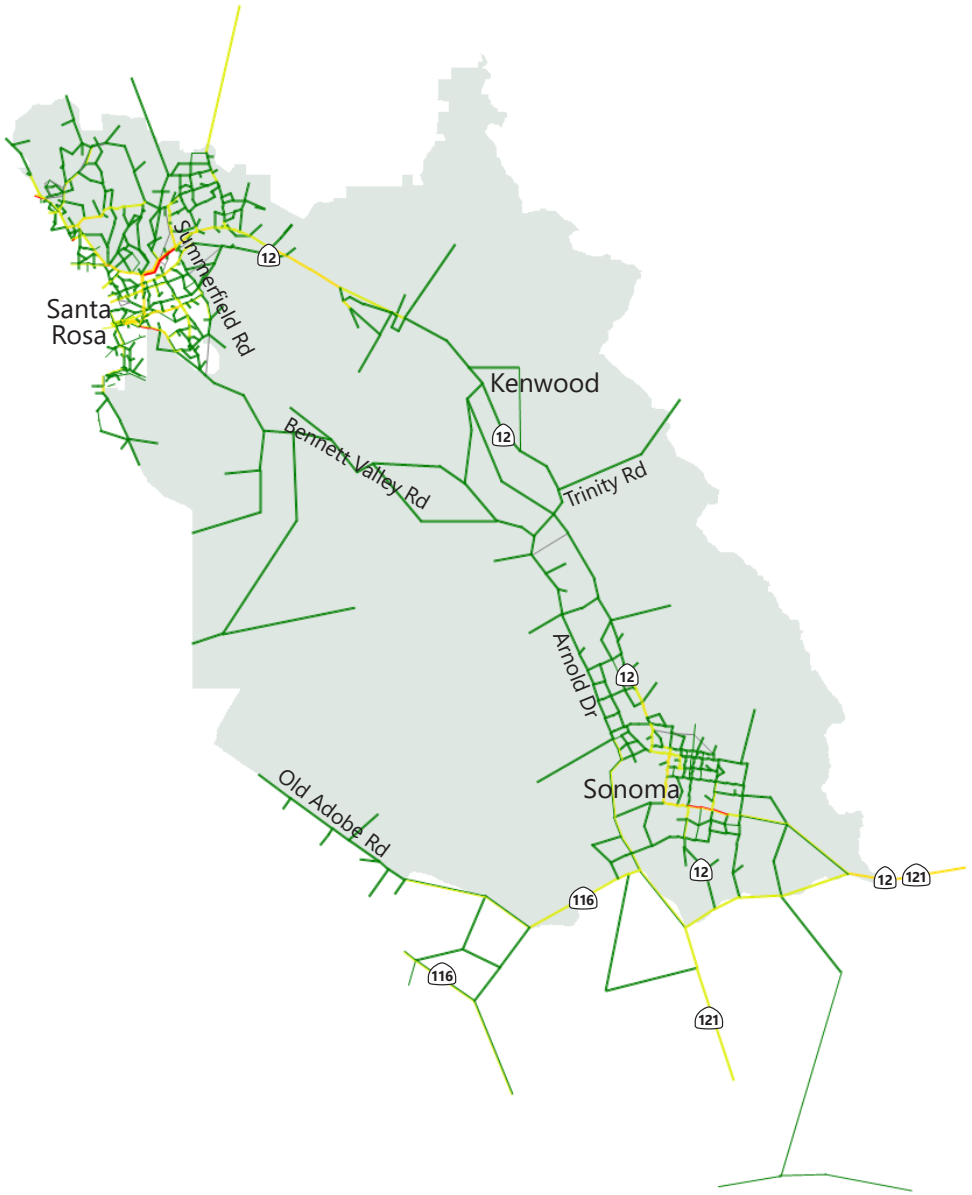

Figure 6.6

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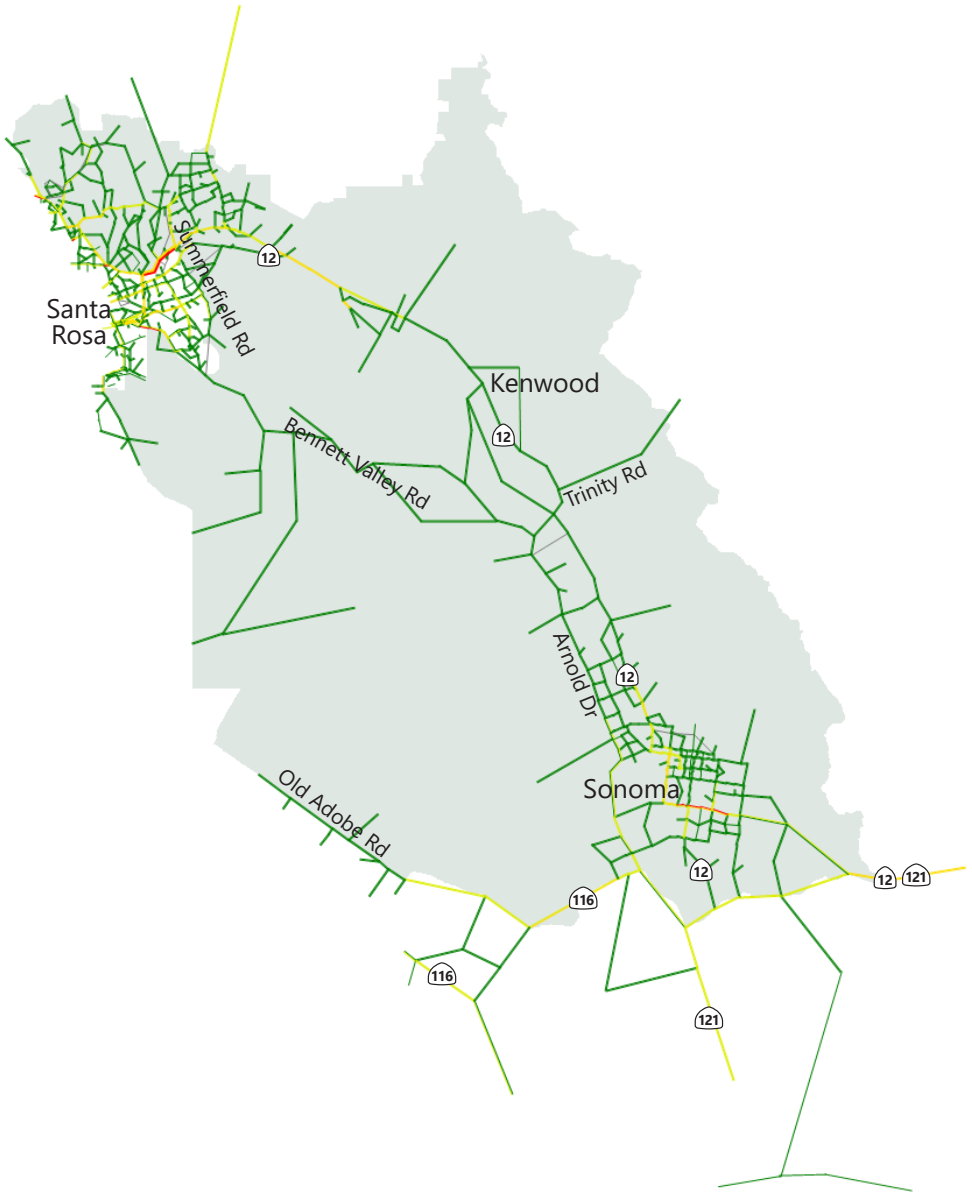


Figure 6.7

Scenario 3 Base Year Model Run - 4:00 PM

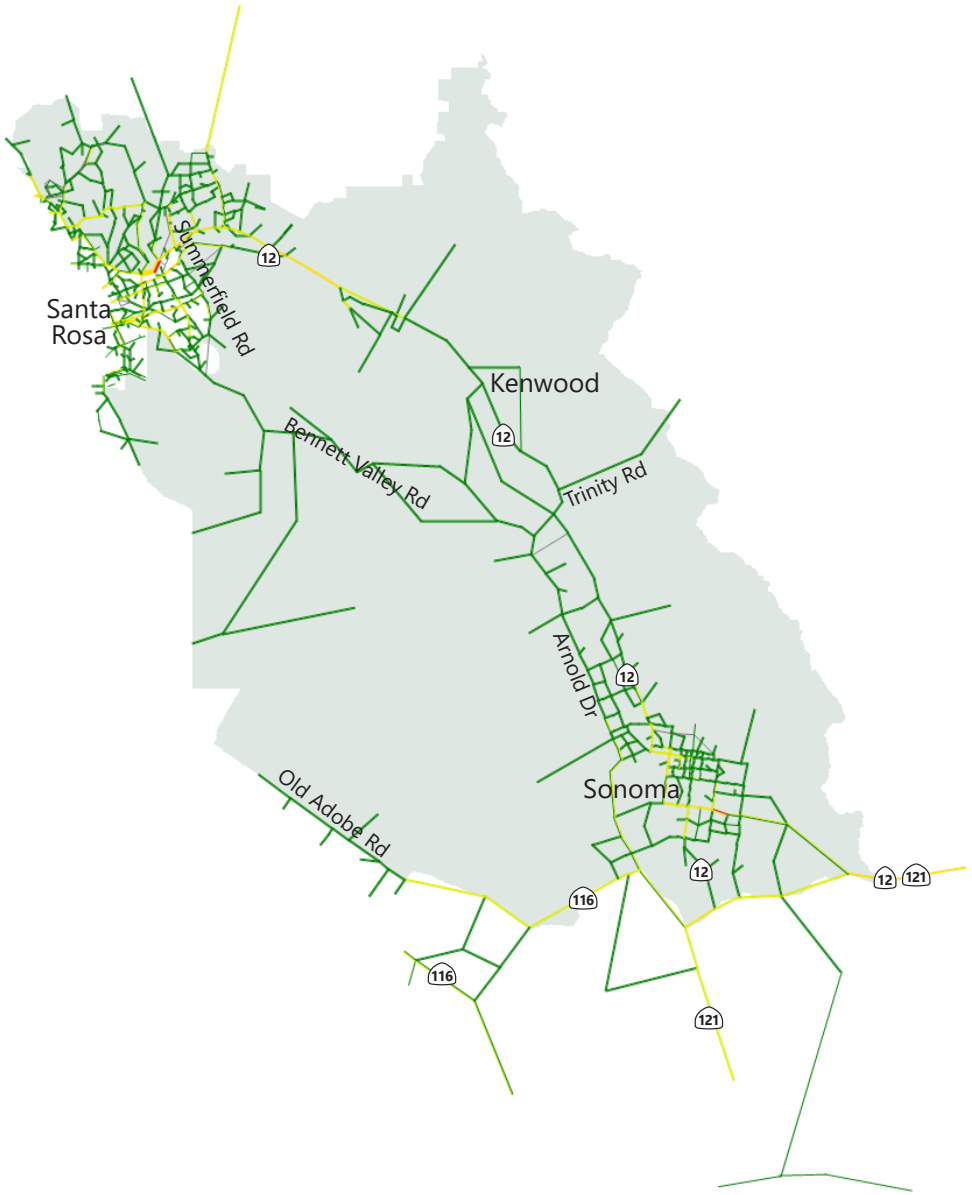


Figure 6.8

Scenario 3 Base Year Model Run - 4:15 PM

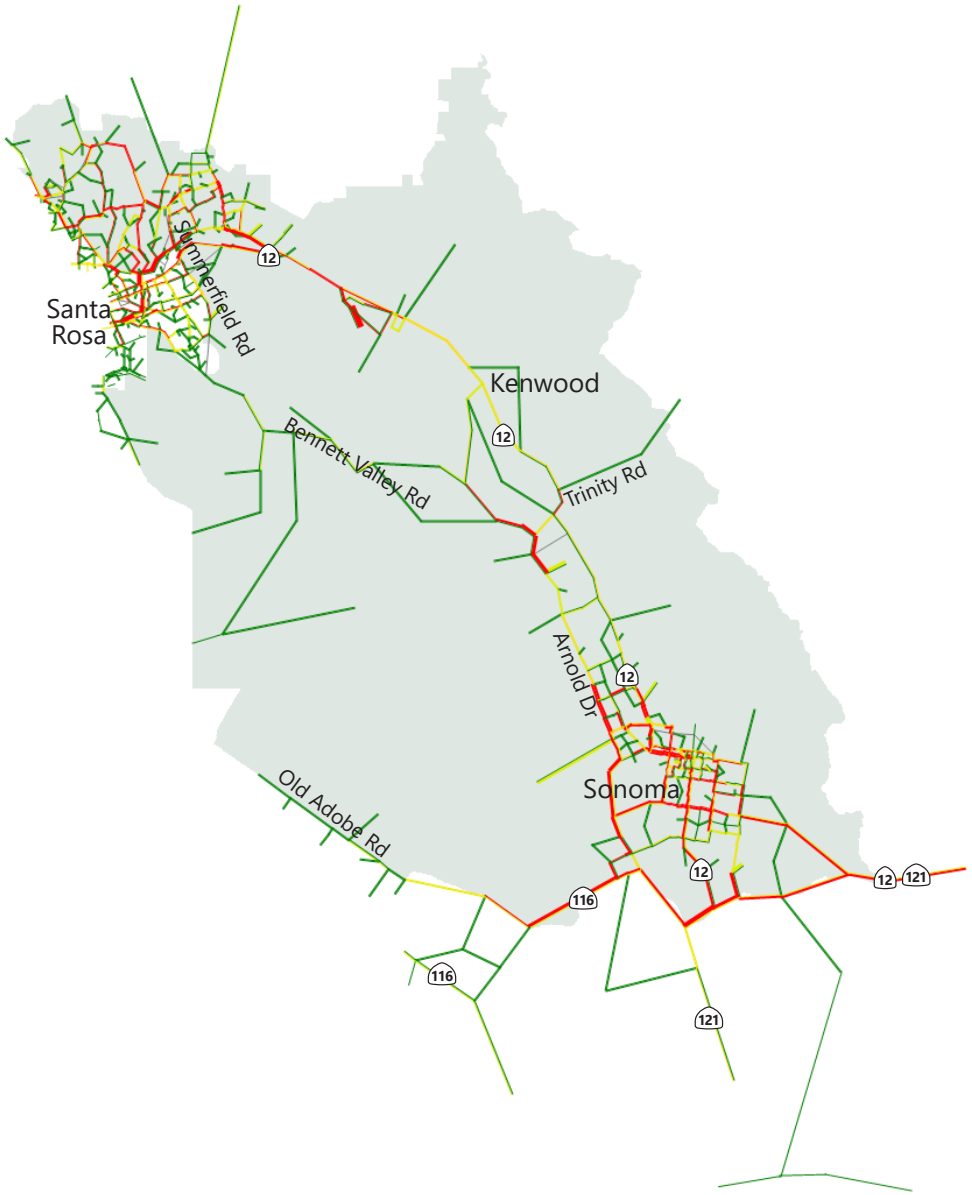


Figure 6.9

Scenario 3 Base Year Model Run - 4:30 PM (start of evacuation)

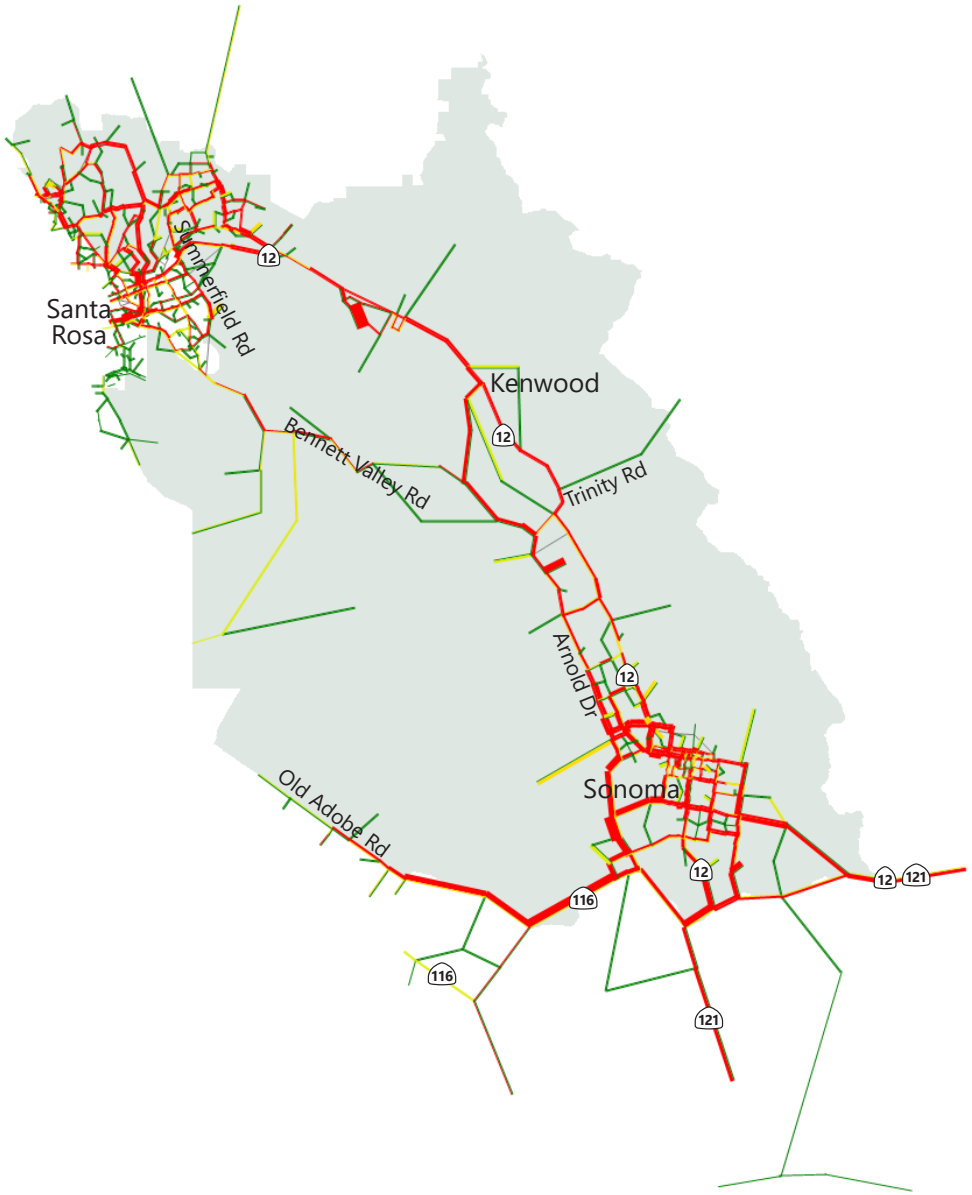


Figure 6.10

Scenario 3 Base Year Model Run - 4:45 PM

Figure 6.11

Scenario 3 Base Year Model Run - 5:00 PM

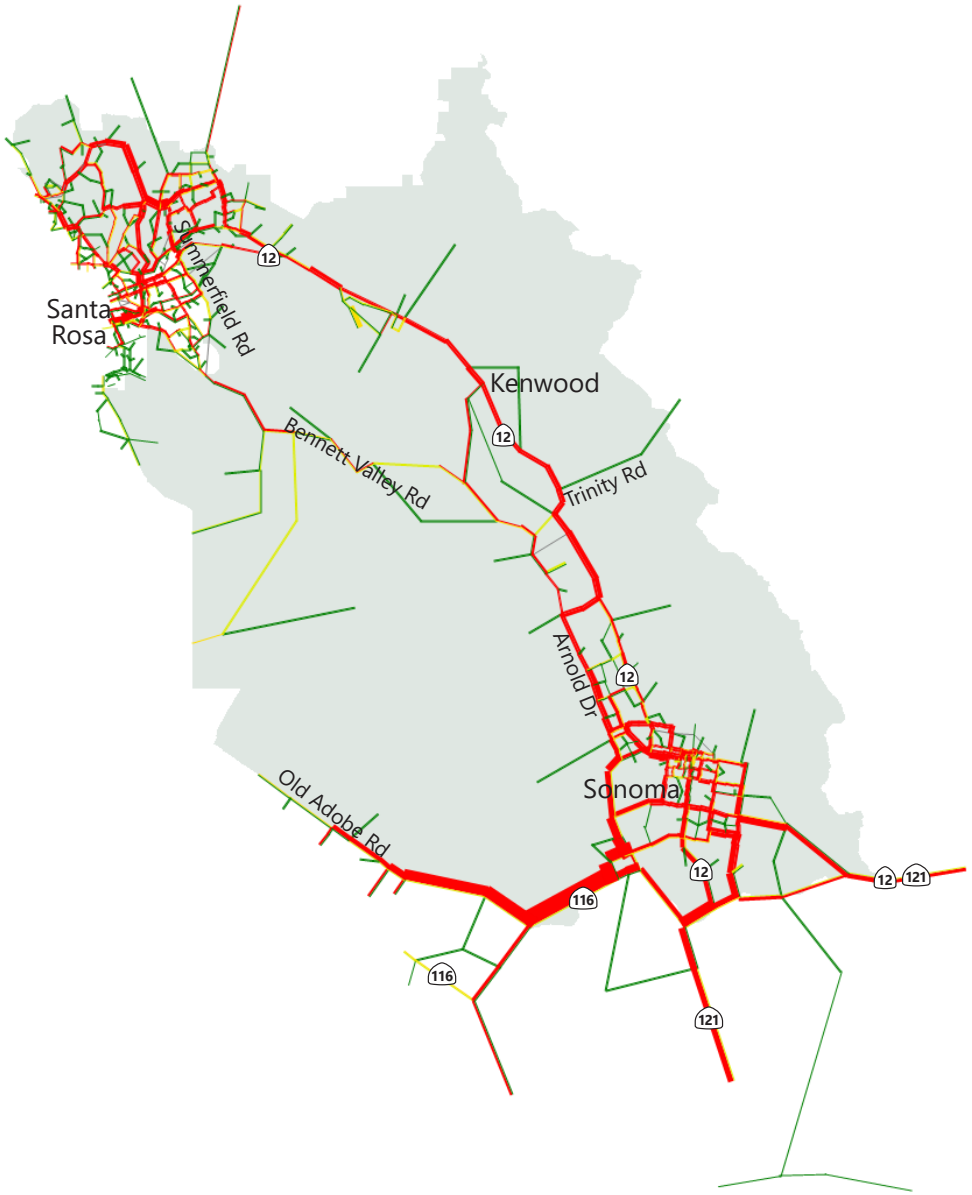


Figure 6.12

Scenario 3 Base Year Model Run - 5:15 PM

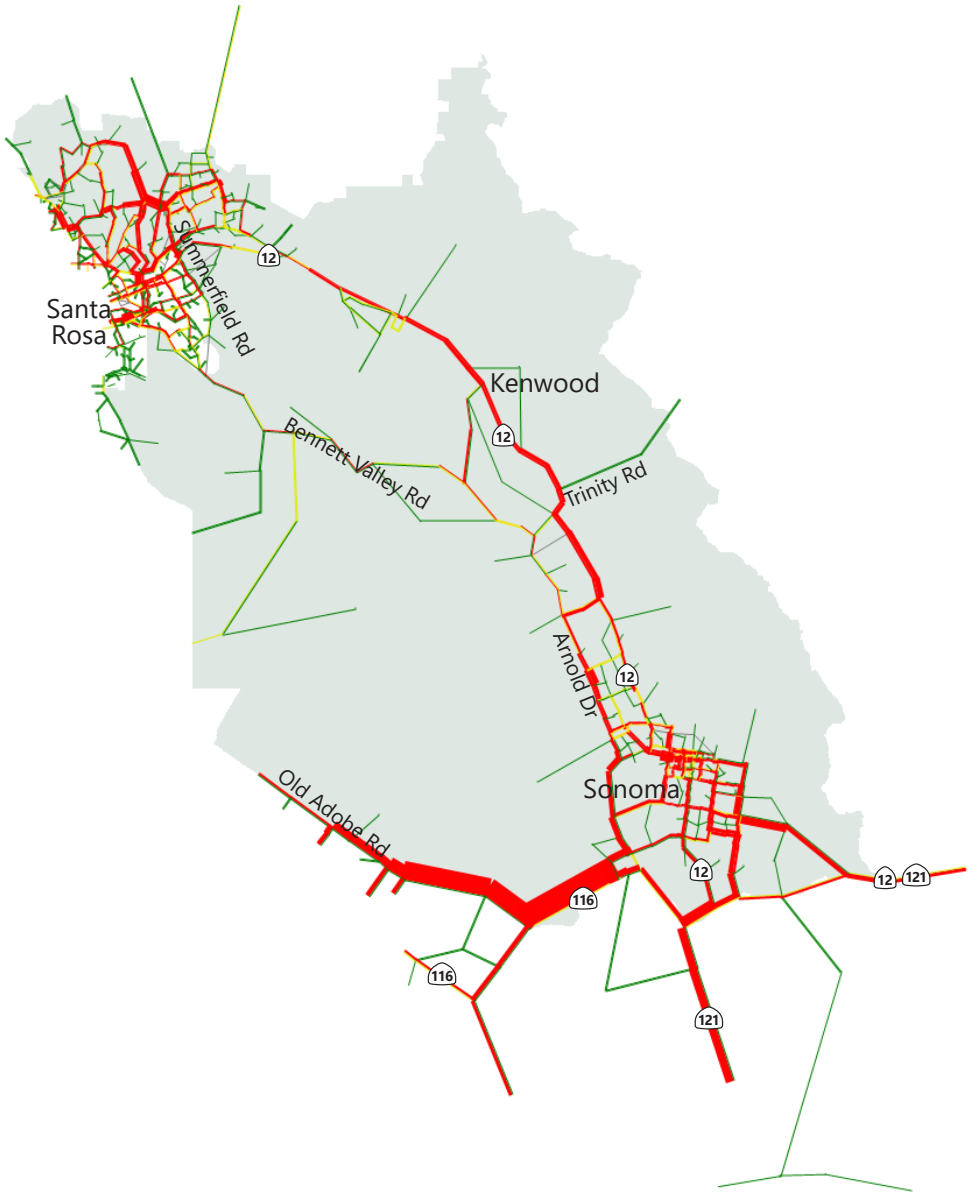
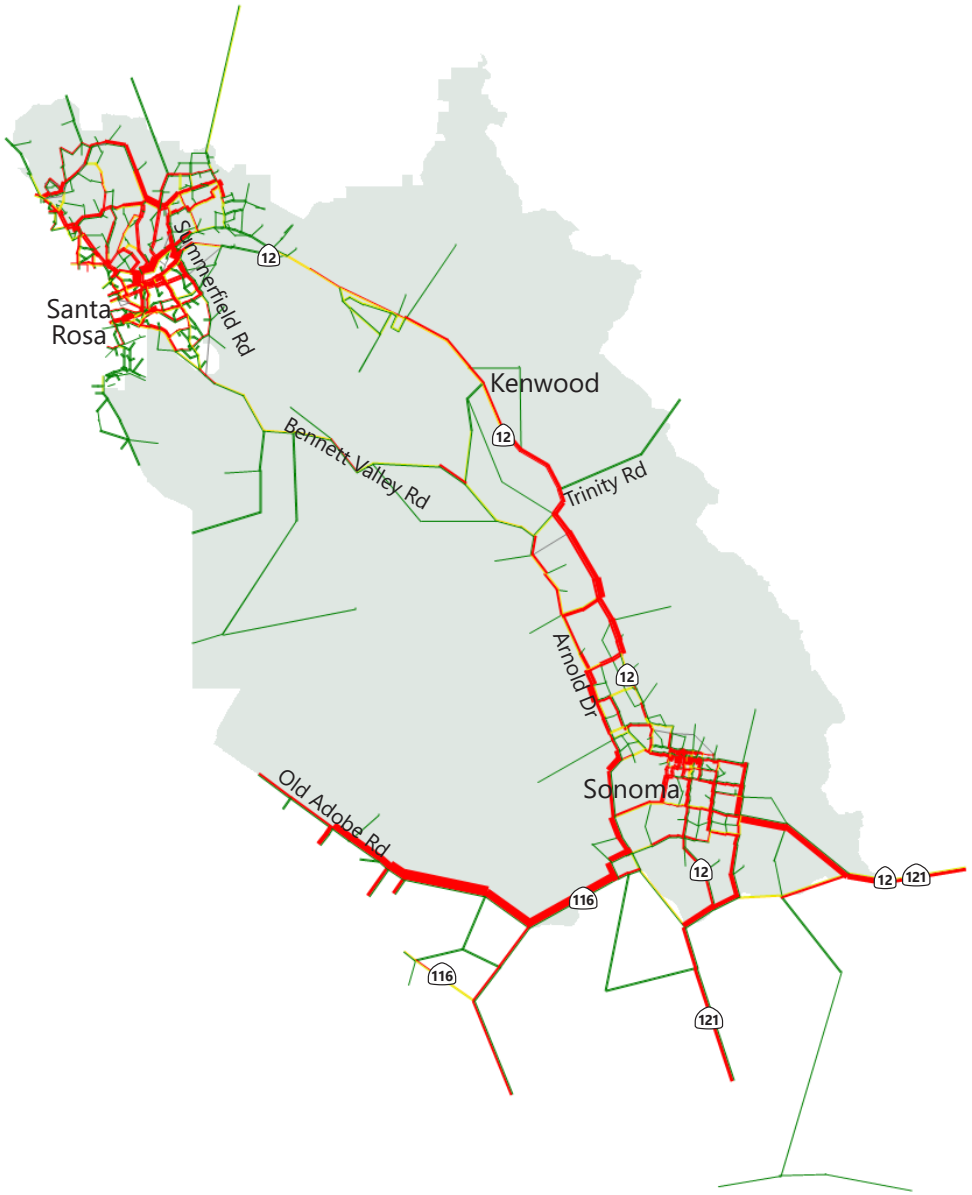


Figure 6.13

Scenario 3 Base Year Model Run - 5:30 PM



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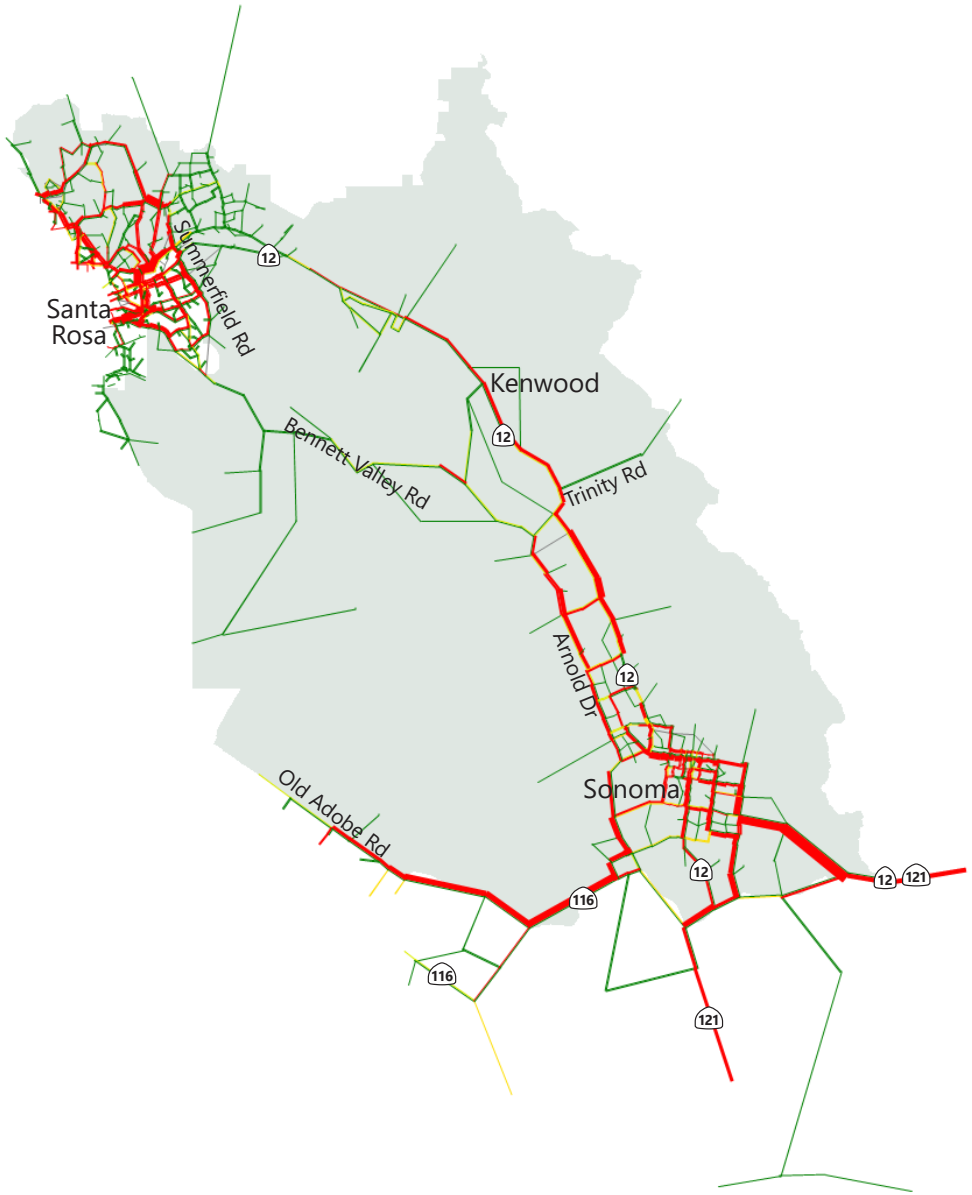

Figure 6.15

Scenario 3 Base Year Model Run - 6:00 PM

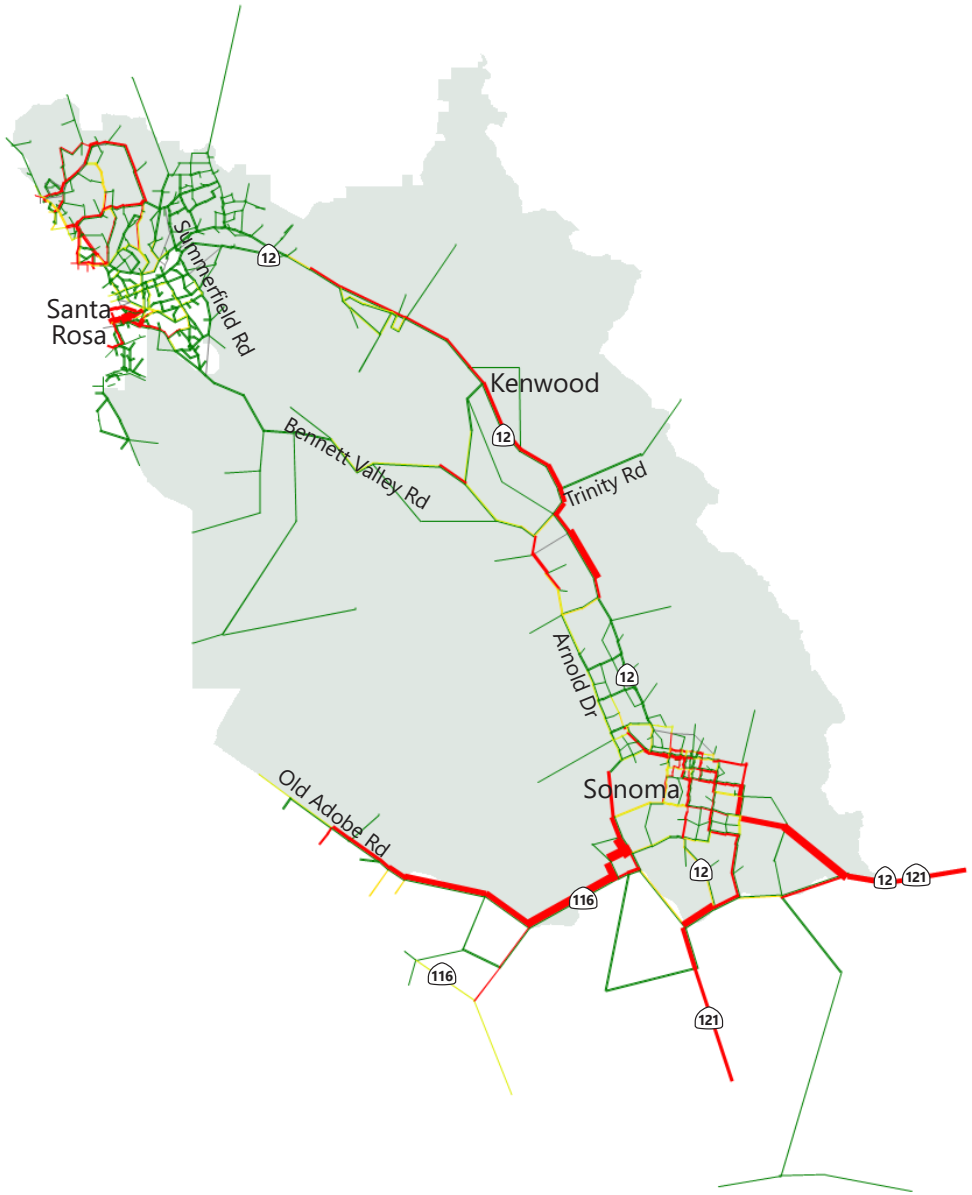

Figure 6.16

Scenario 3 Base Year Model Run - 6:15 PM

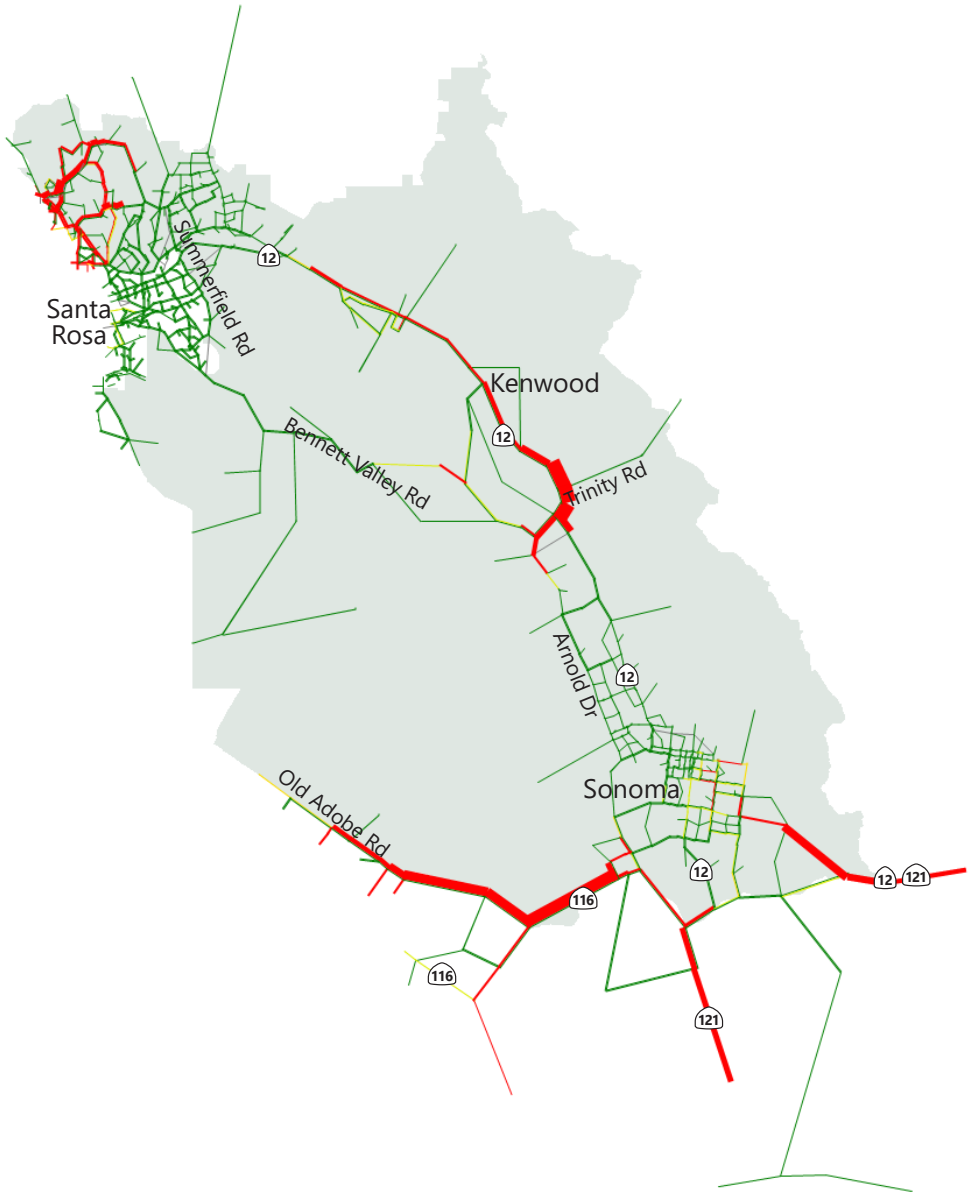

Figure 6.17

Scenario 3 Base Year Model Run - 6:30 PM

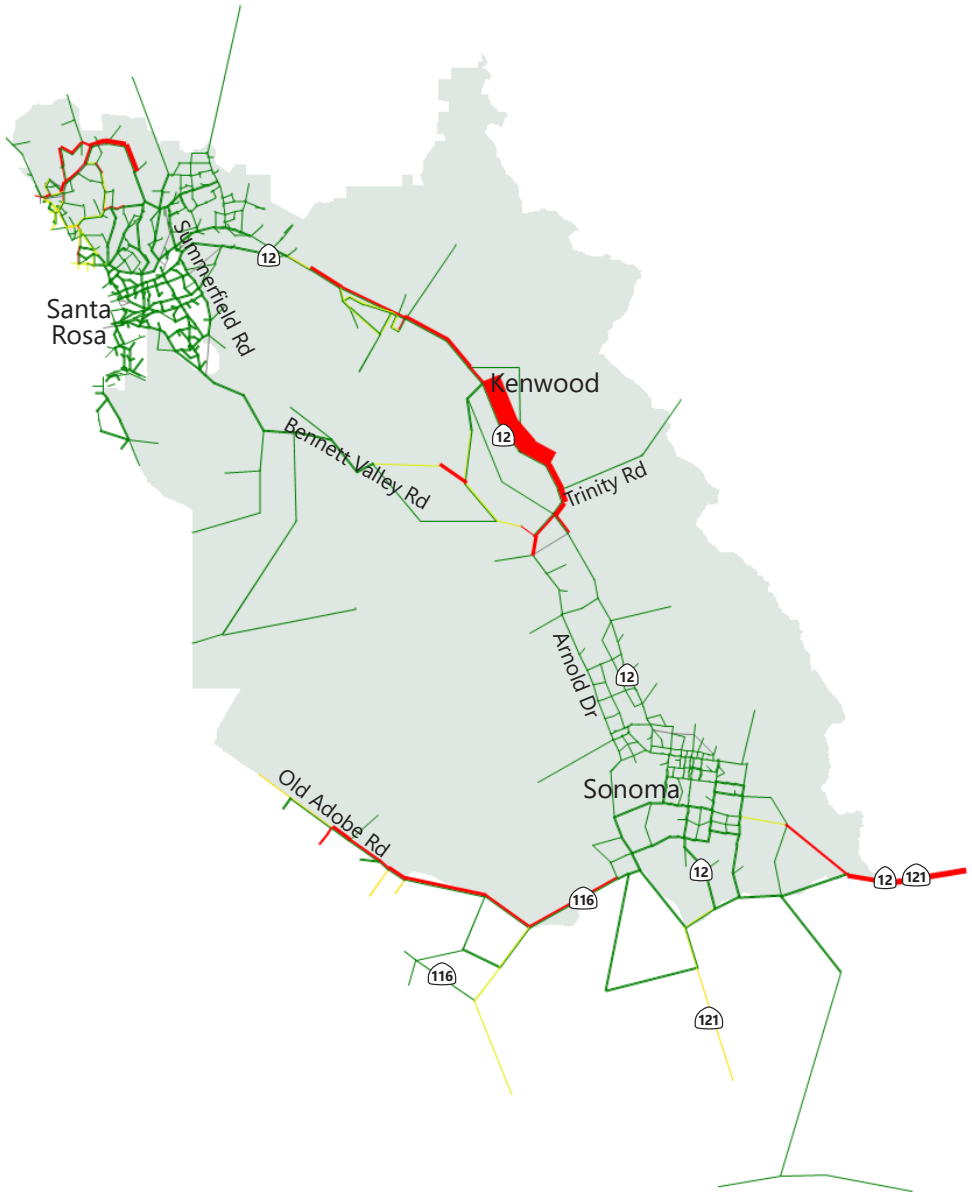

Figure 6.18

Scenario 3 Base Year Model Run - 6:45 PM

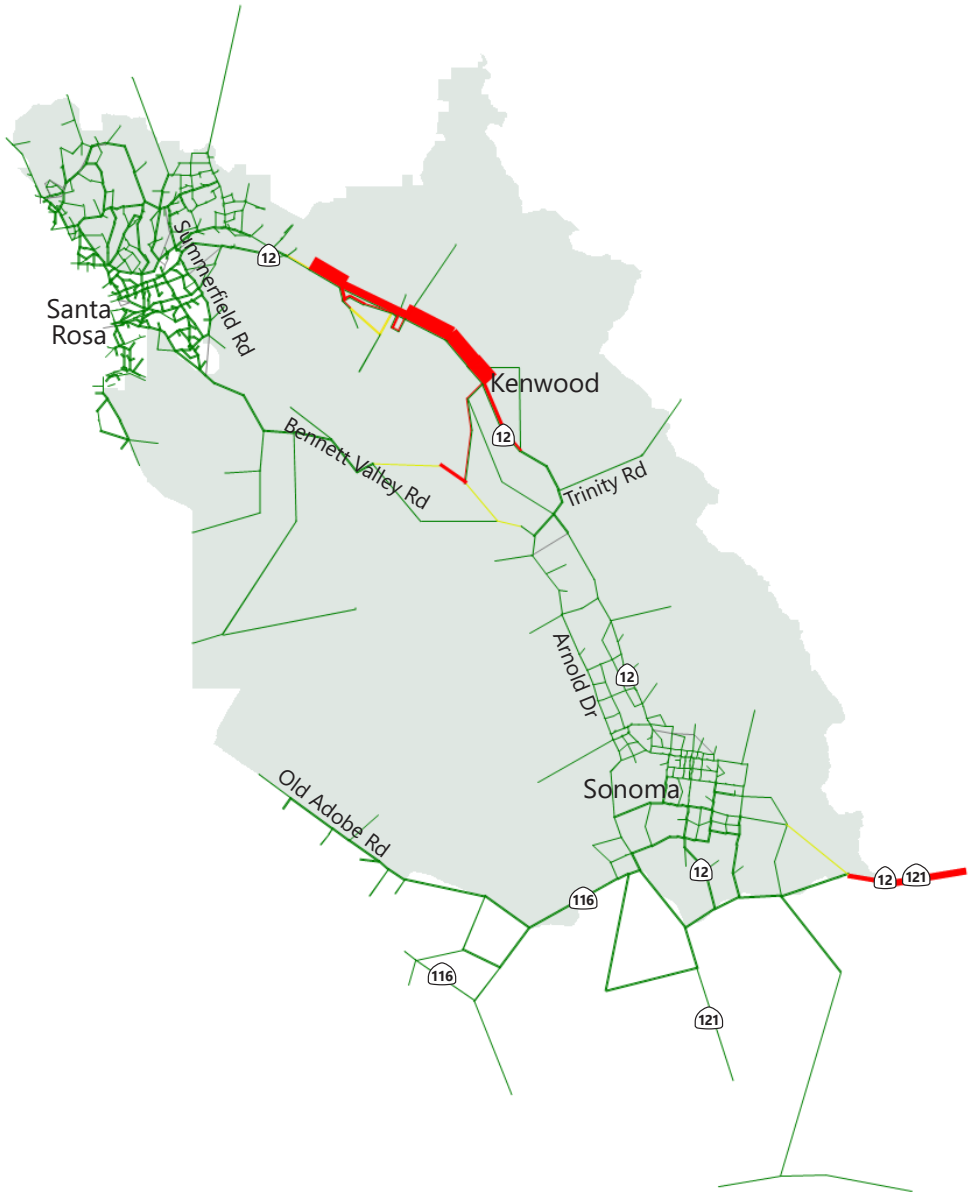

Figure 6.19

Scenario 3 Base Year Model Run - 7:00 PM

Figure 6.20

Scenario 3 Base Year Model Run - 7:15 PM

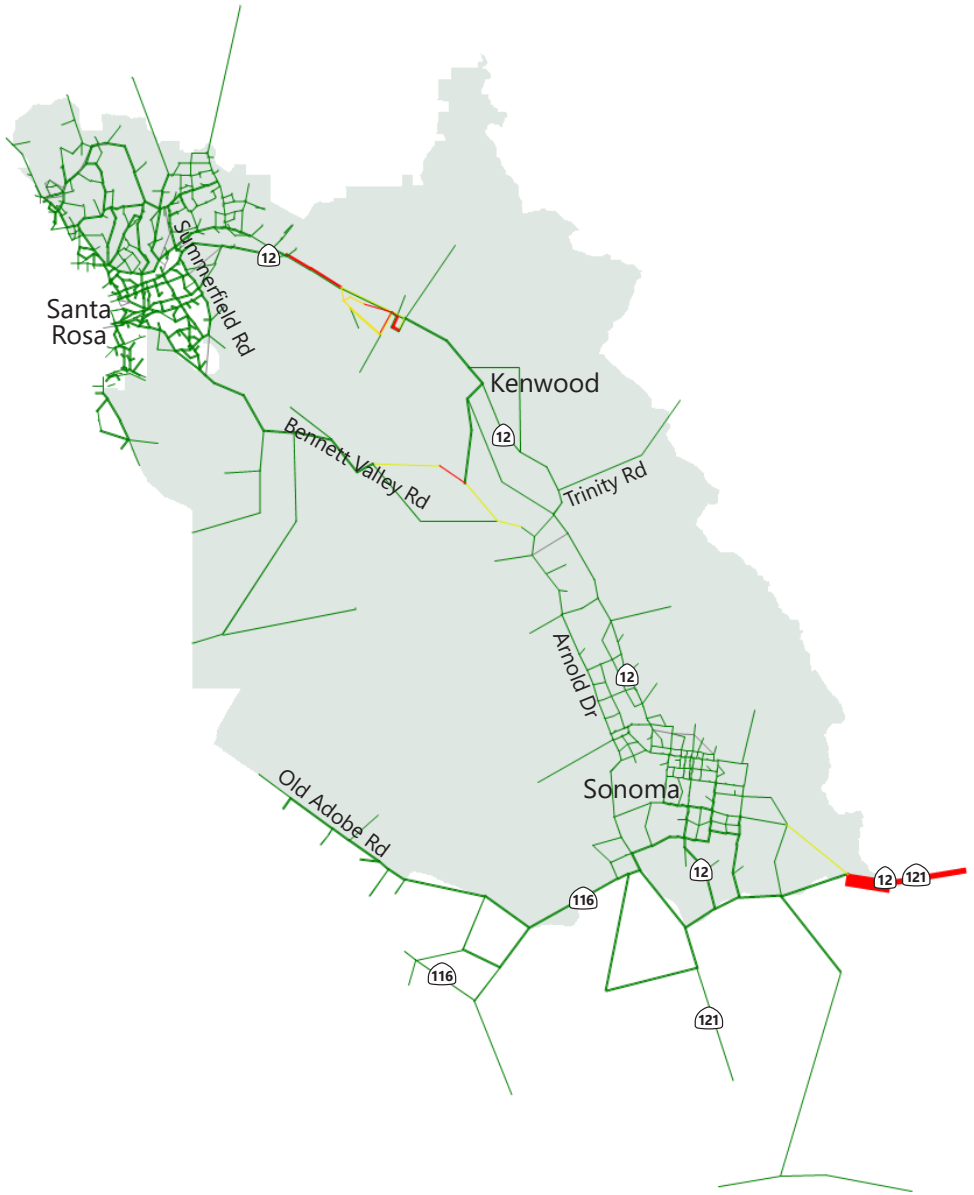

Figure 6.21

Scenario 3 Base Year Model Run - 7:30 PM

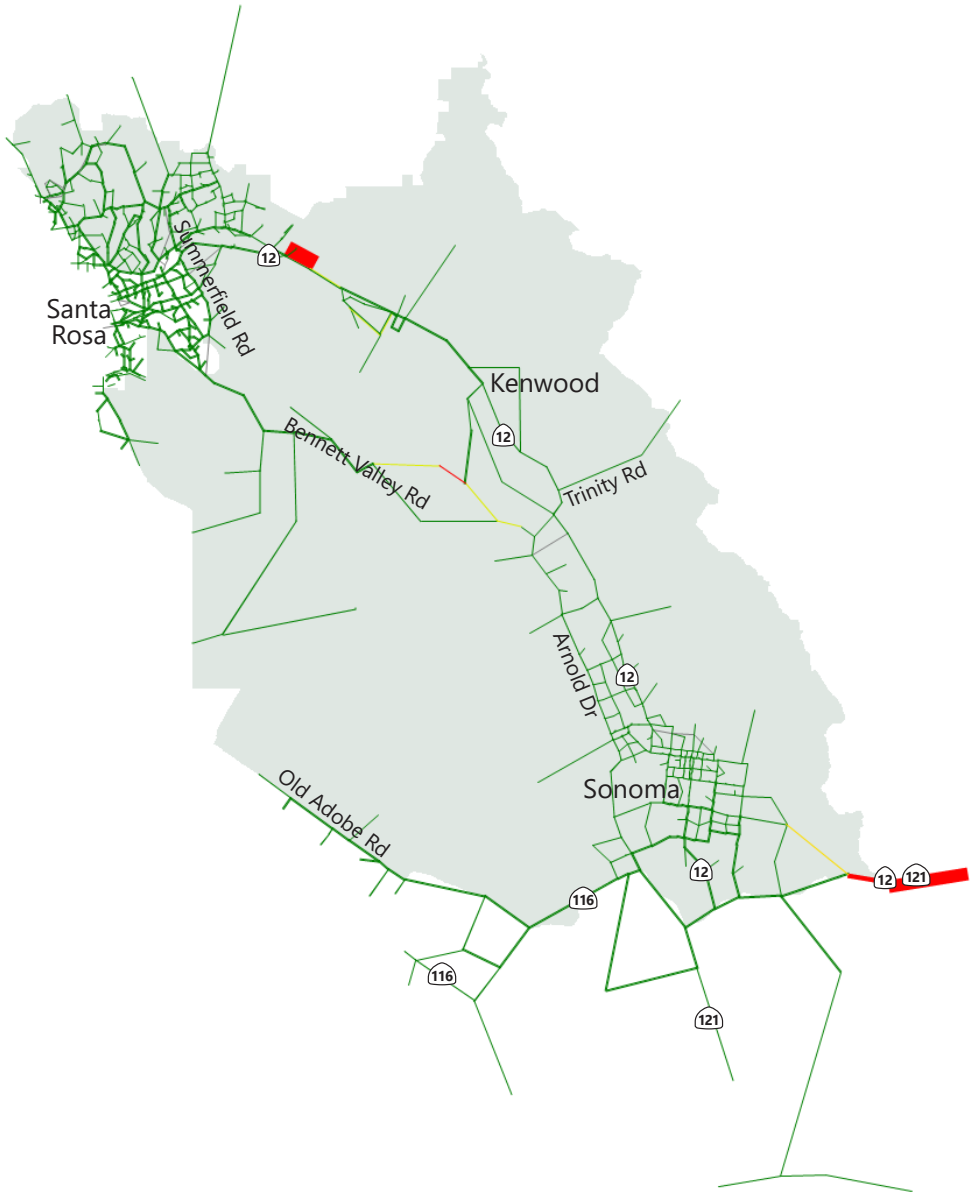

Figure 6.22

Scenario 3 Base Year Model Run - 7:45 PM

Figure 6.23

Scenario 3 Base Year Model Run - 8:00 PM

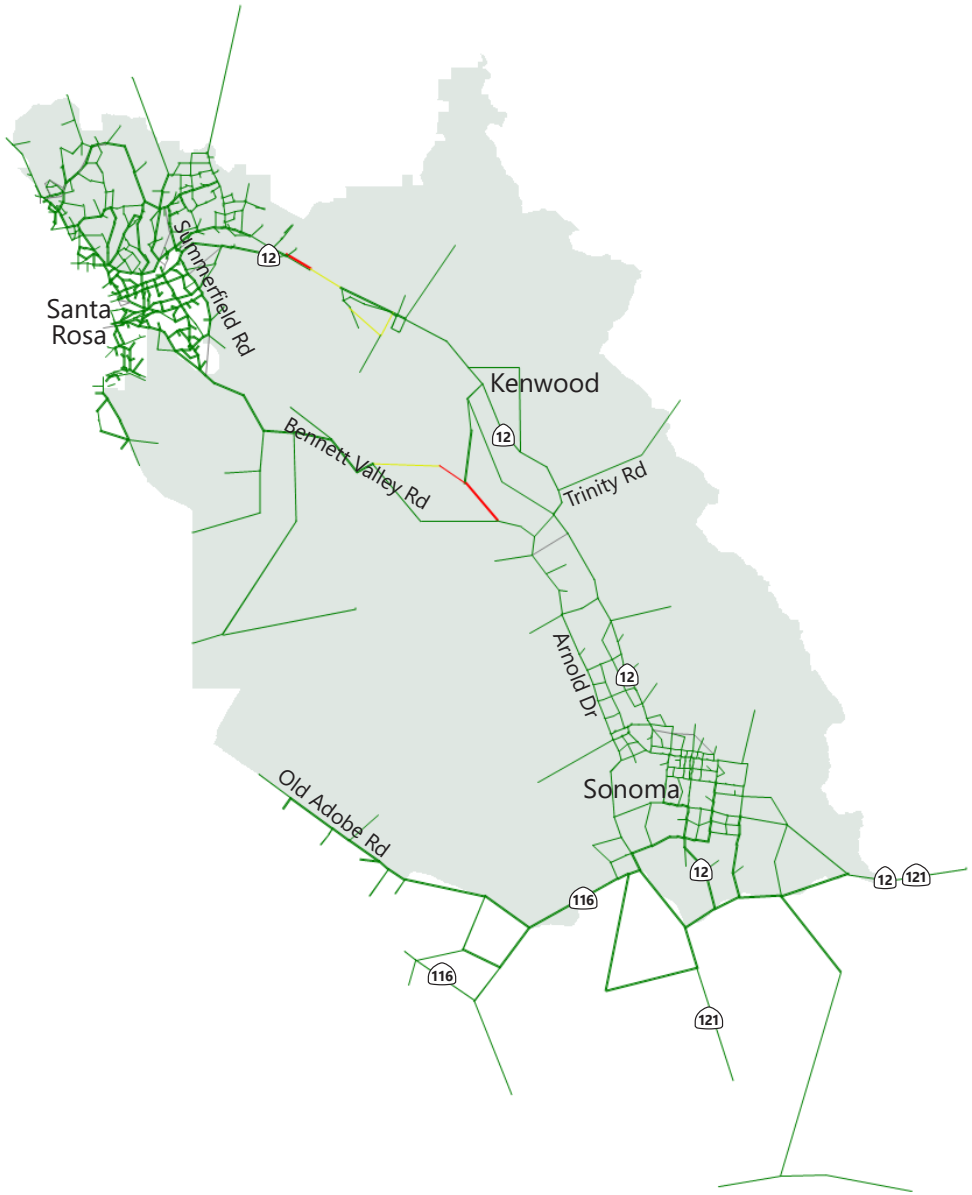

Figure 6.24

Scenario 3 Base Year Model Run - 8:15 PM

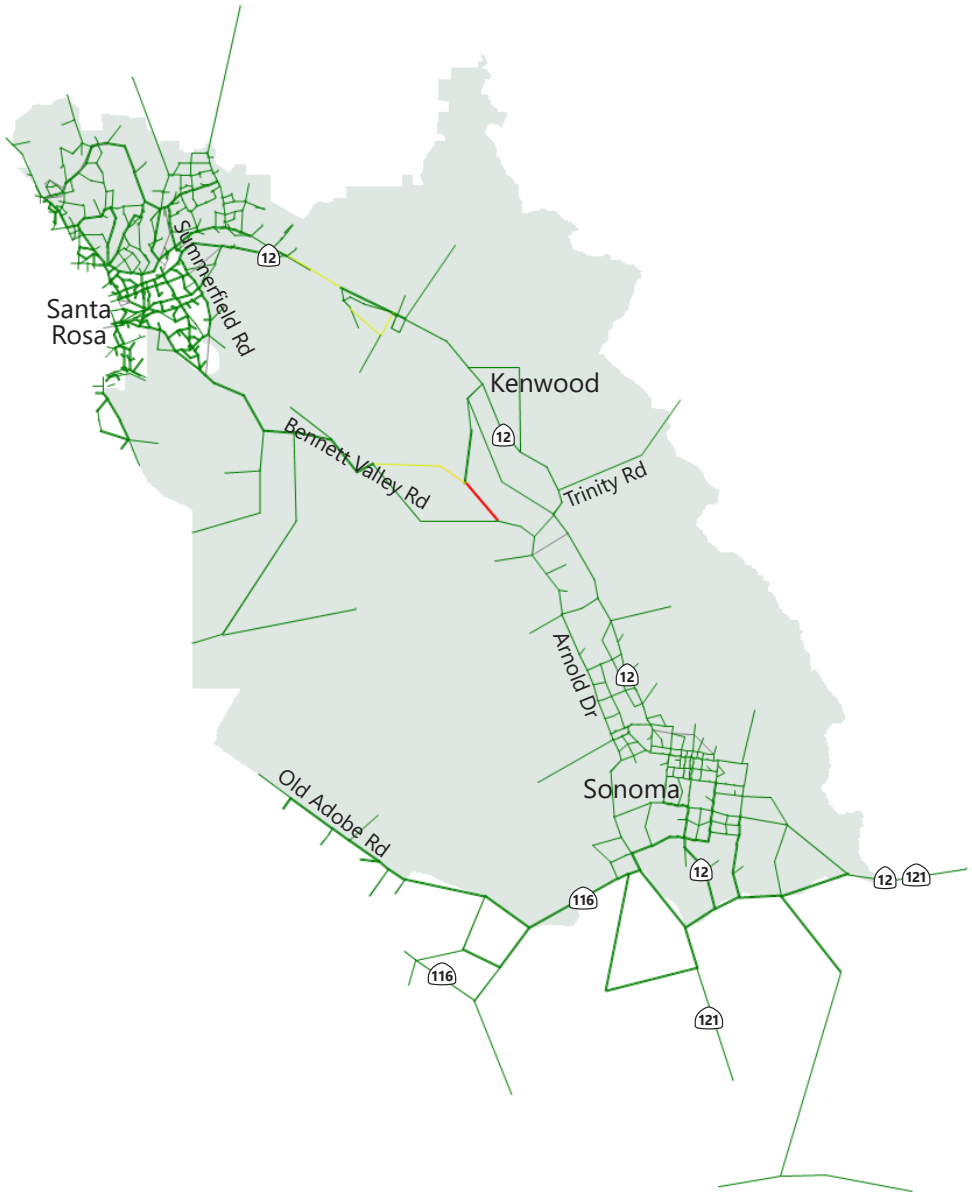

Figure 6.25

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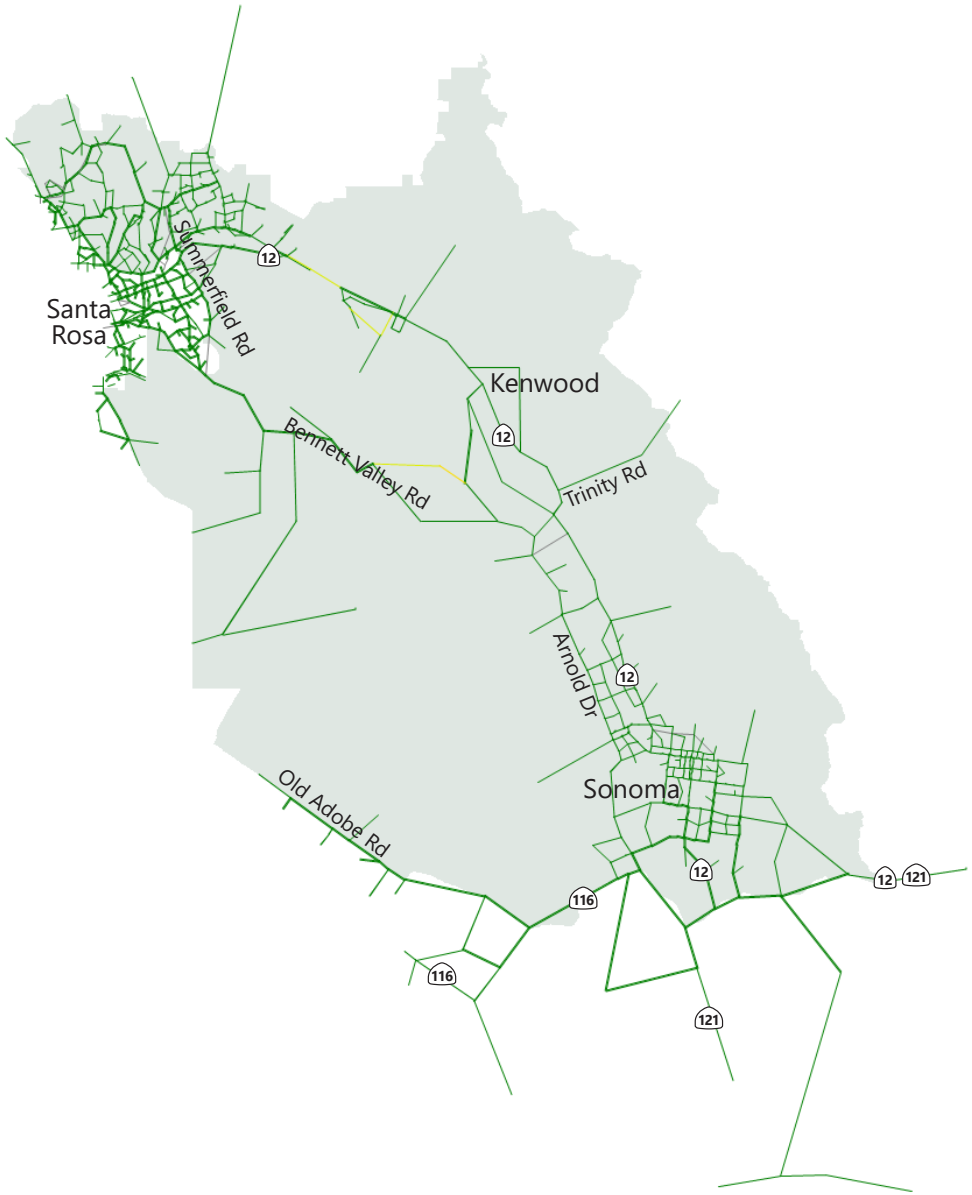

Figure 6.26

Scenario 3 Base Year Model Run - 8:45 PM

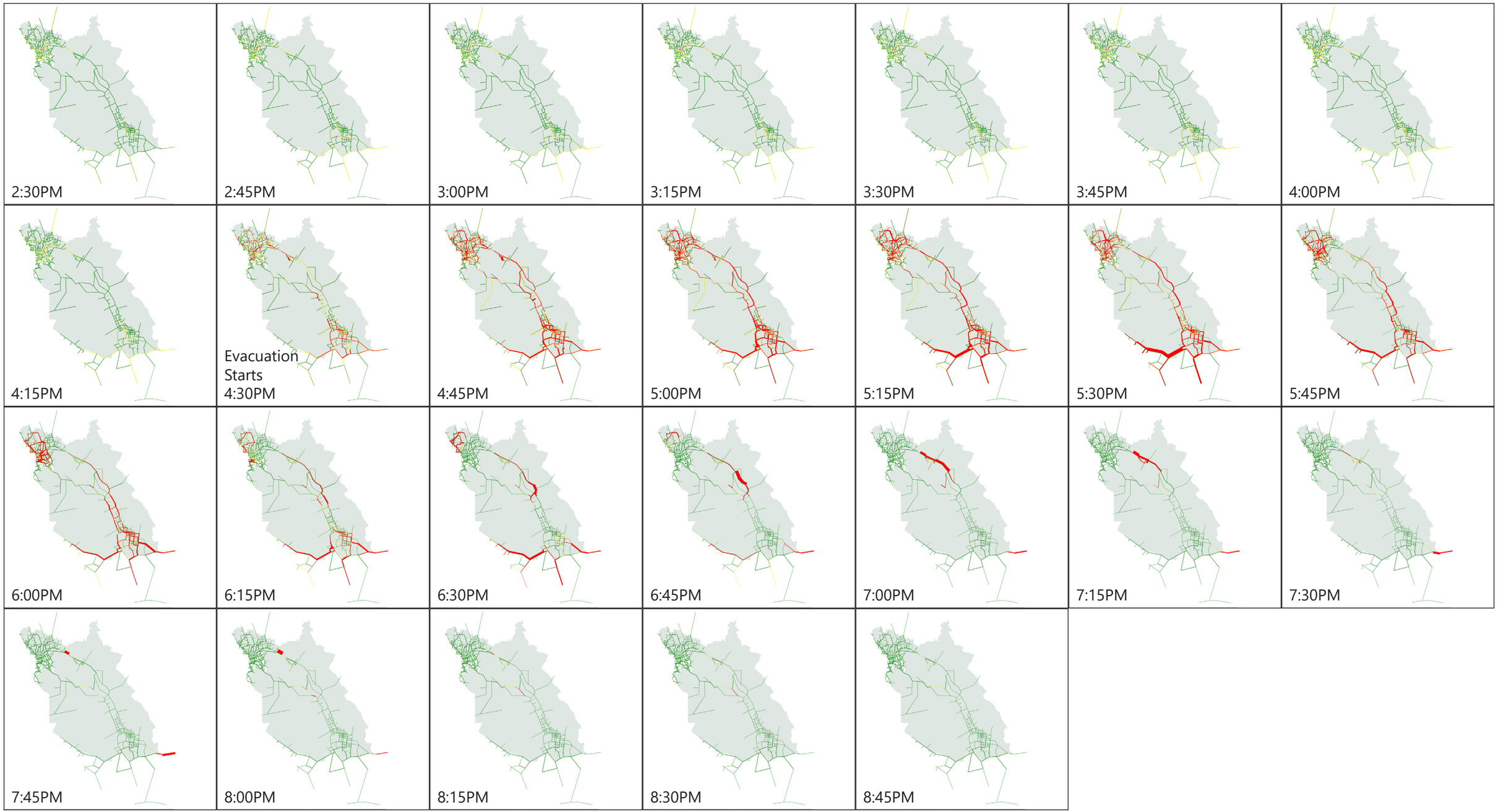

Figure 6.27

Scenario 3 Base Year Model Run Results

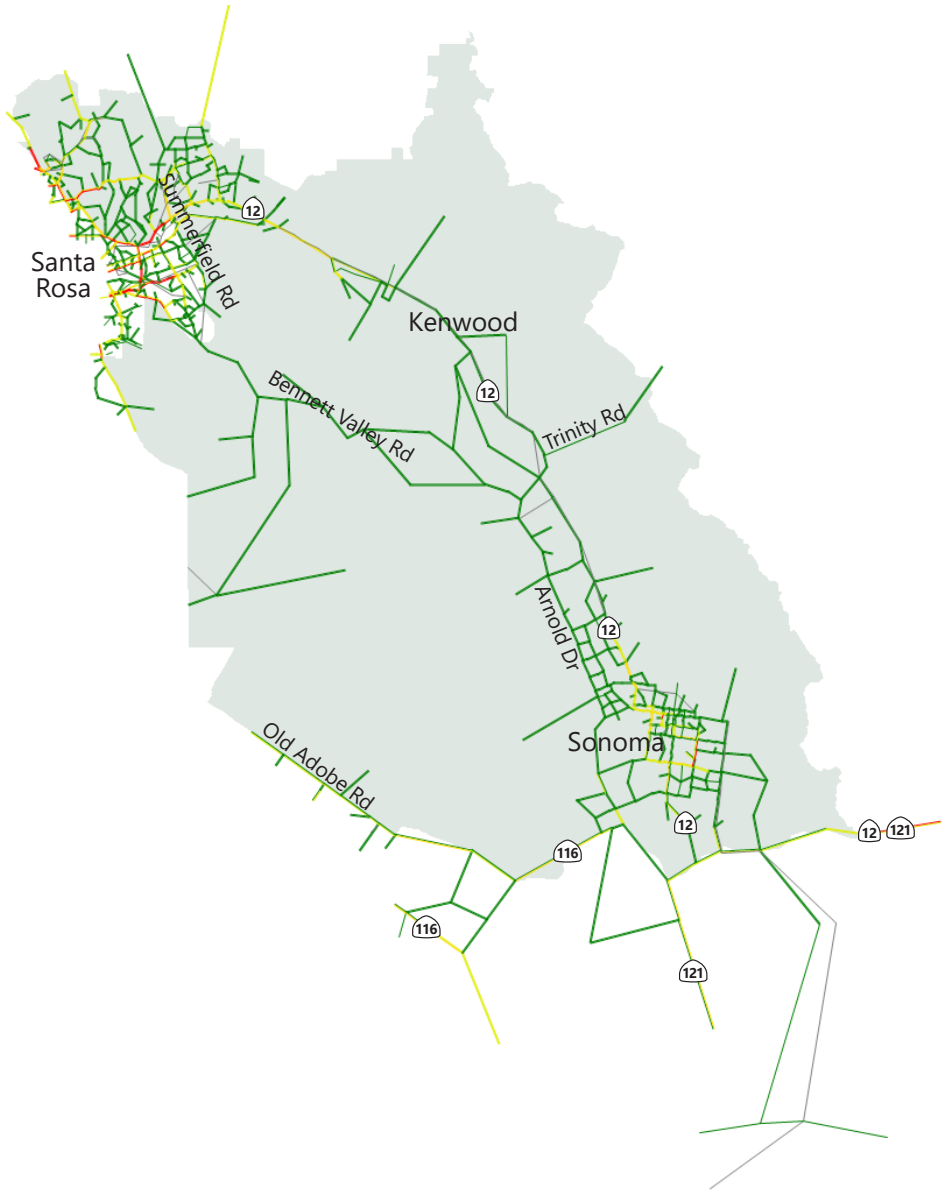

Figure 7.1

Scenario 3 Future Year Model Run - 2:30 PM

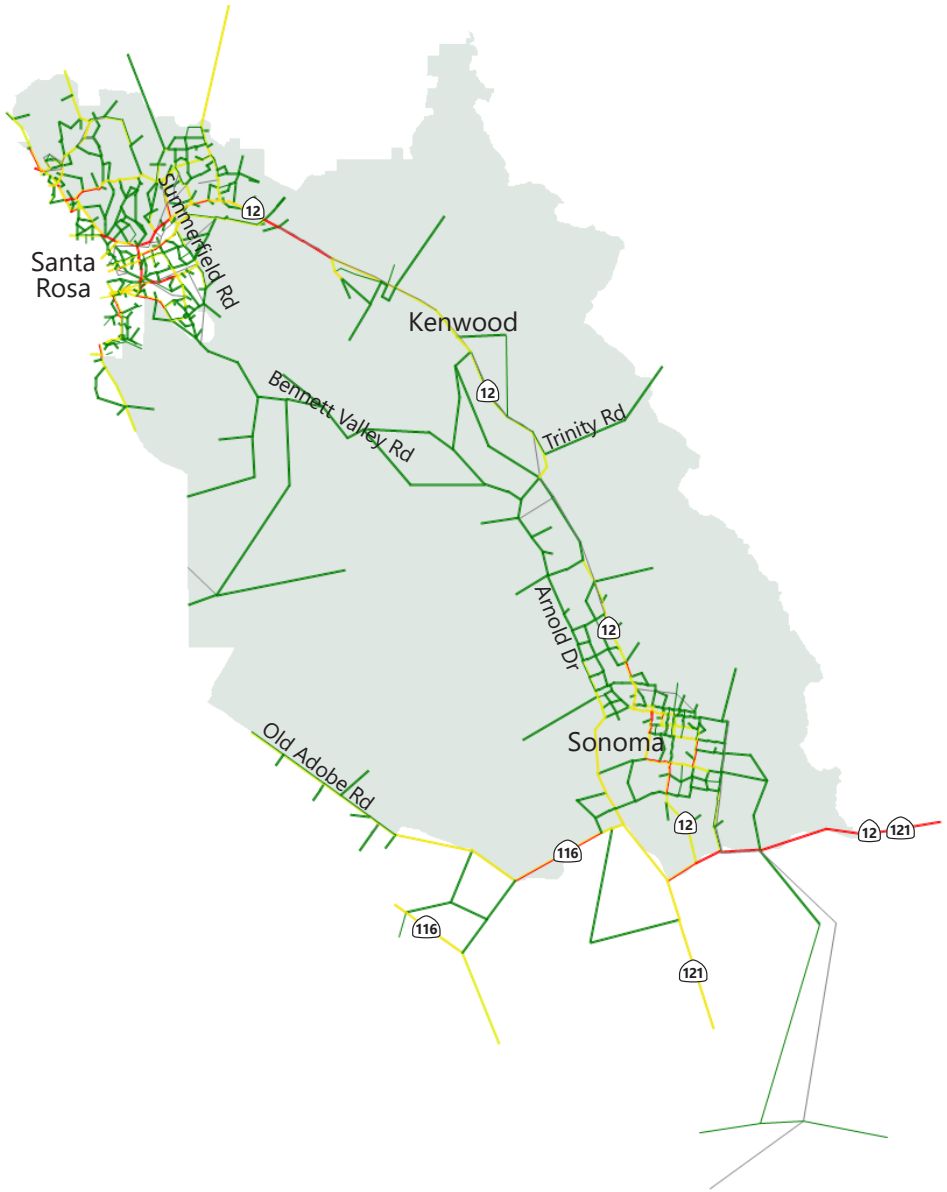

Figure 7.2

Scenario 3 Future Year Model Run - 2:45 PM

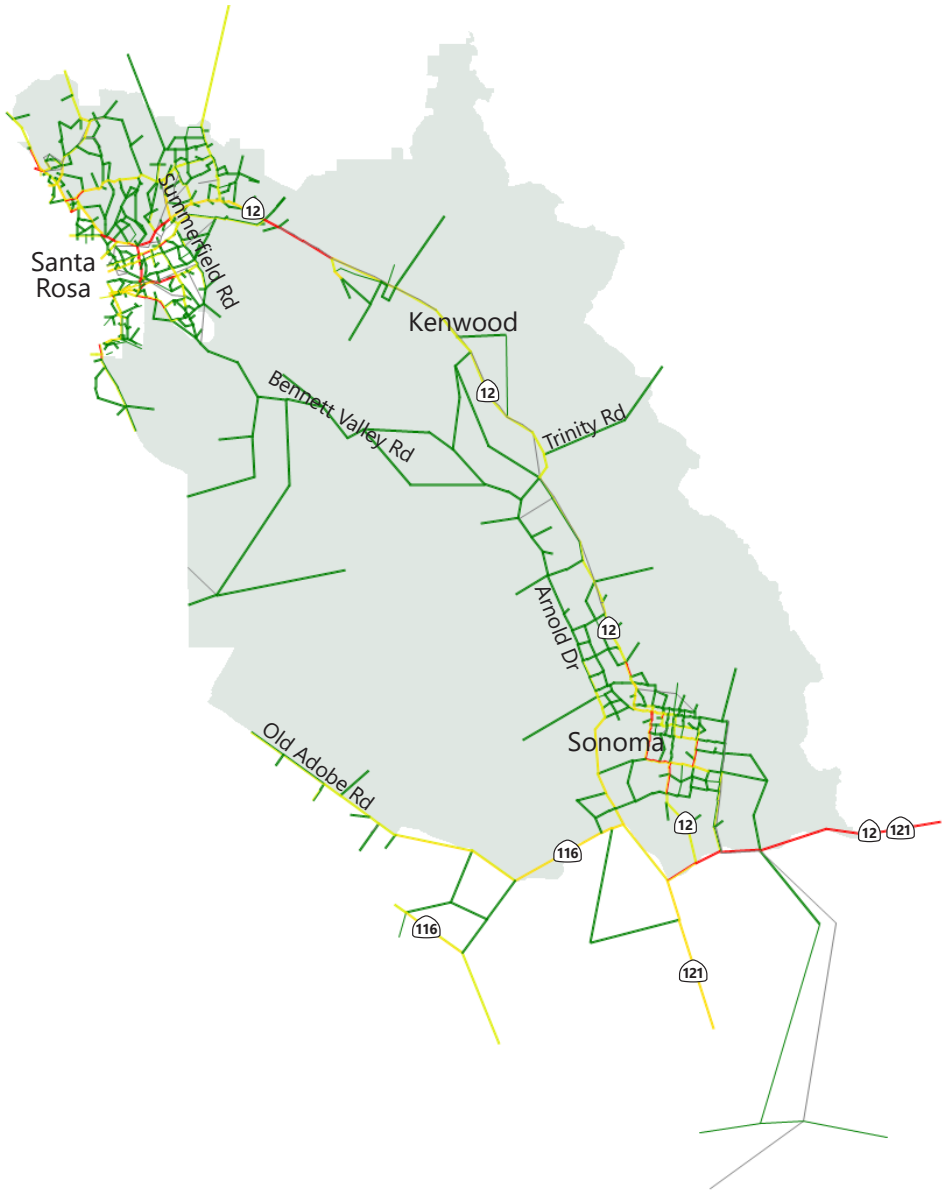

Figure 7.3

Scenario 3 Future Year Model Run - 3:00 PM

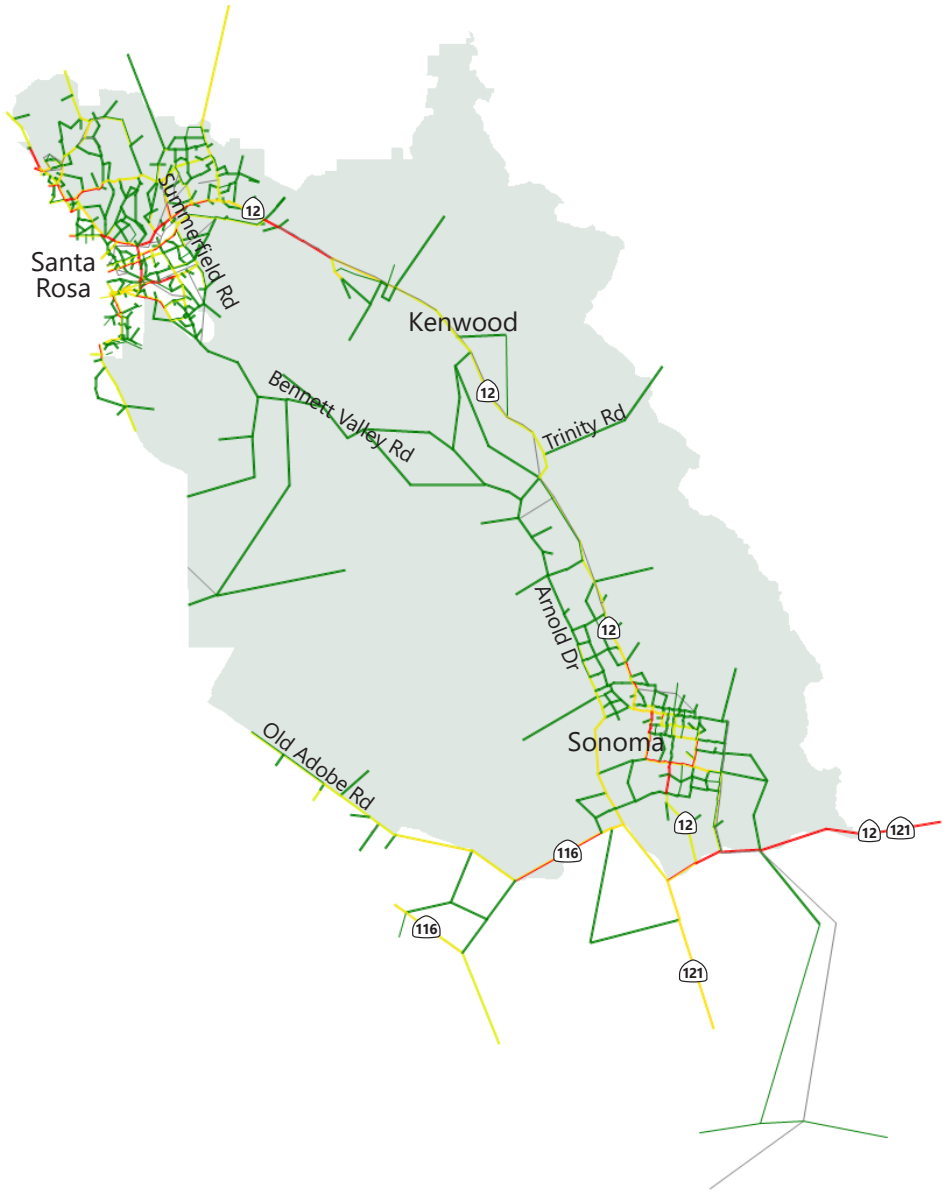

Figure 7.4

Scenario 3 Future Year Model Run - 3:15 PM

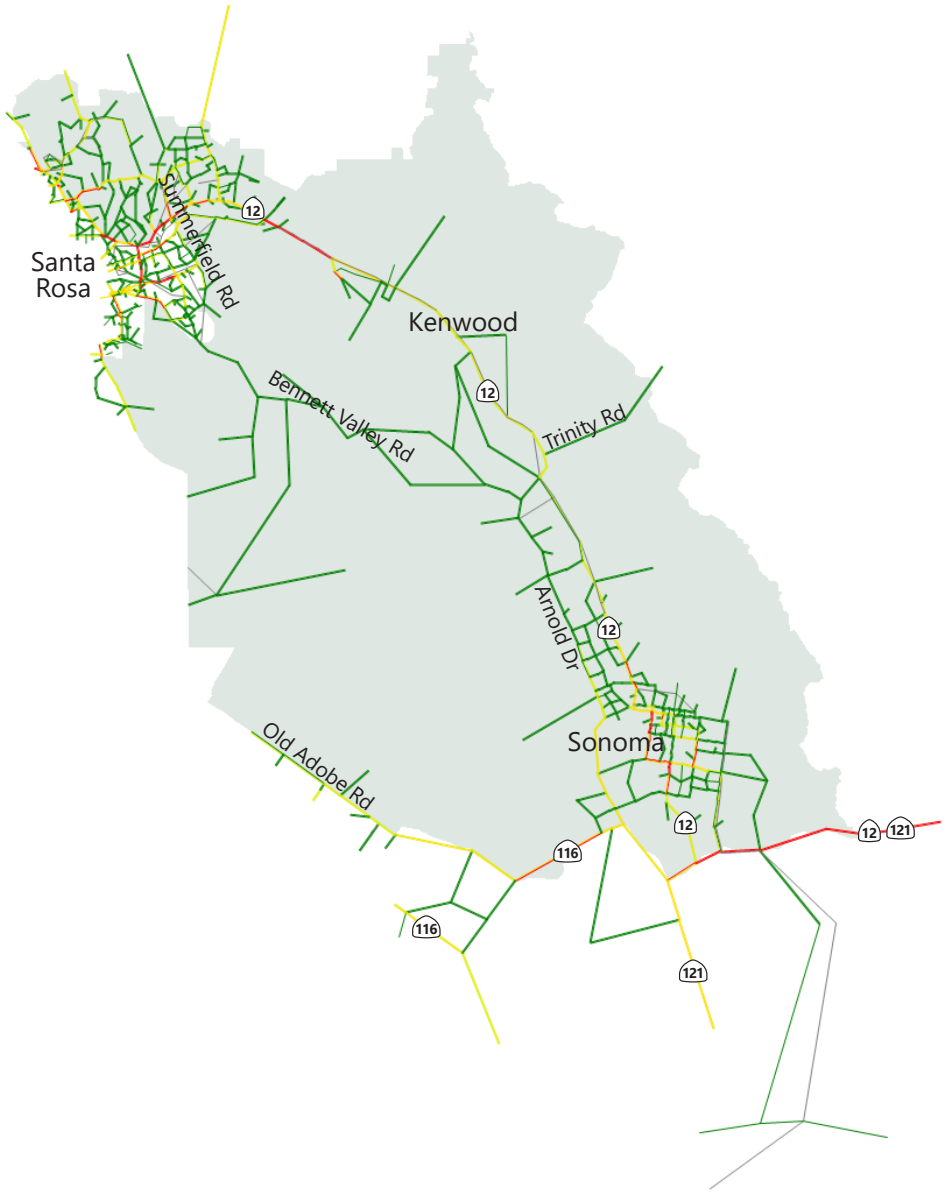

Figure 7.5

Scenario 3 Future Year Model Run - 3:30 PM

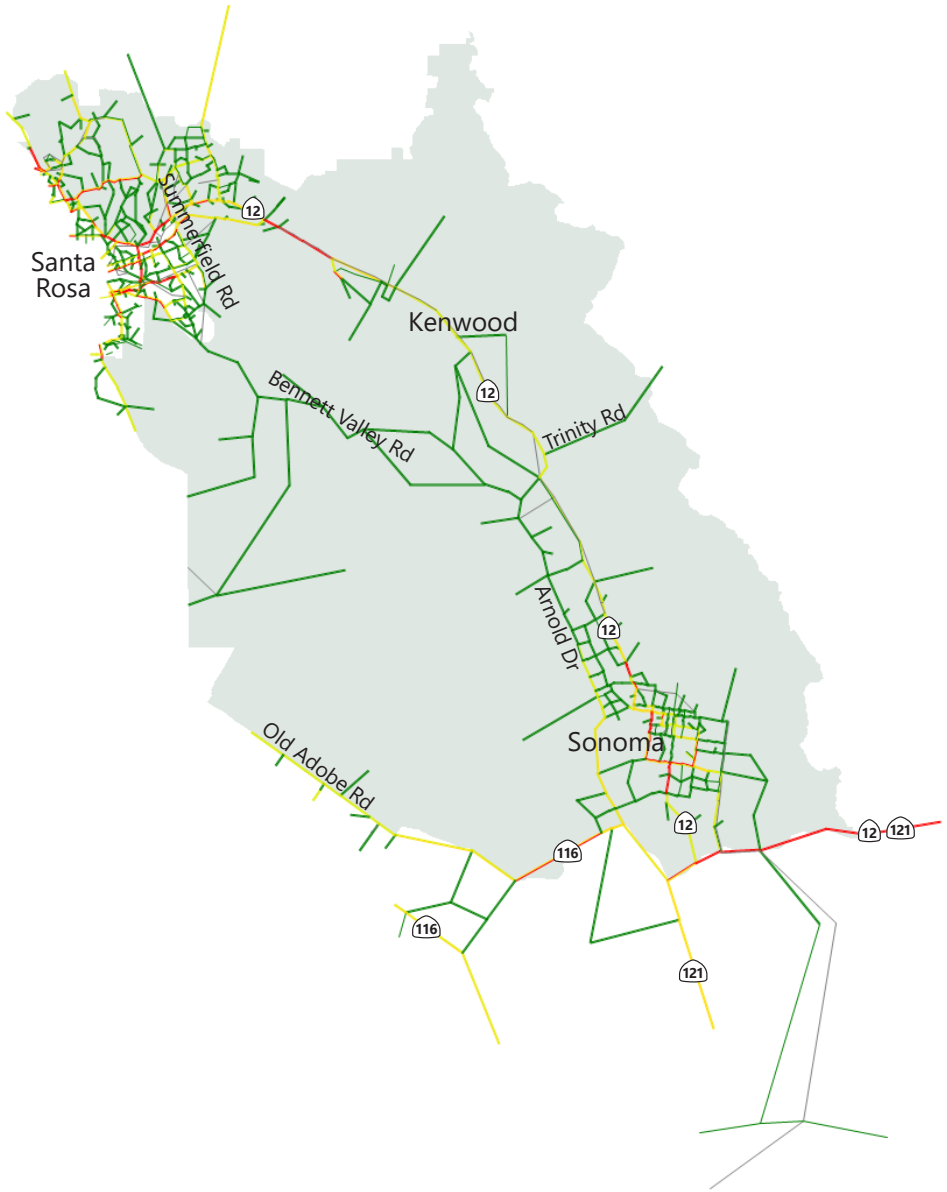

Figure 7.6

Scenario 3 Future Year Model Run - 3:45 PM

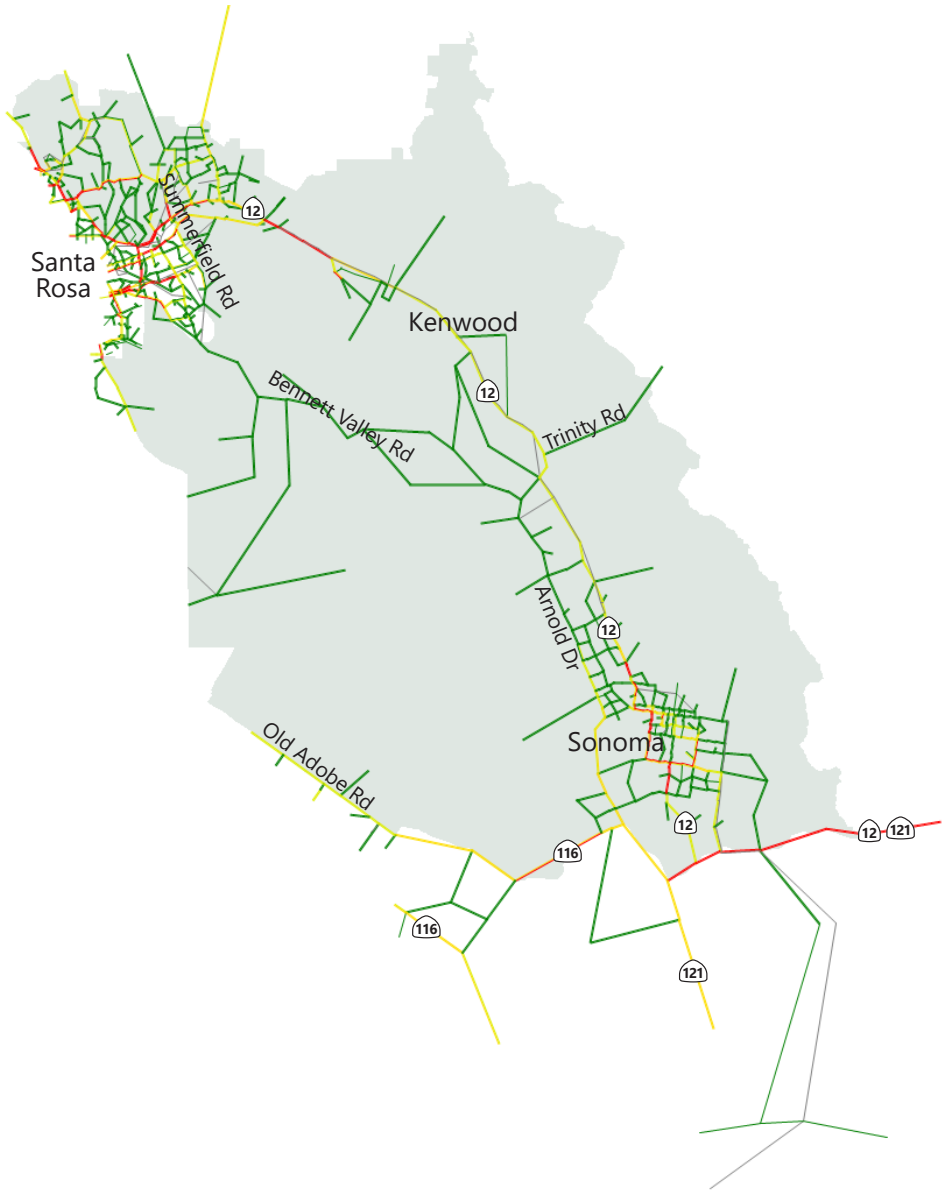

Figure 7.7

Scenario 3 Future Year Model Run - 4:00 PM

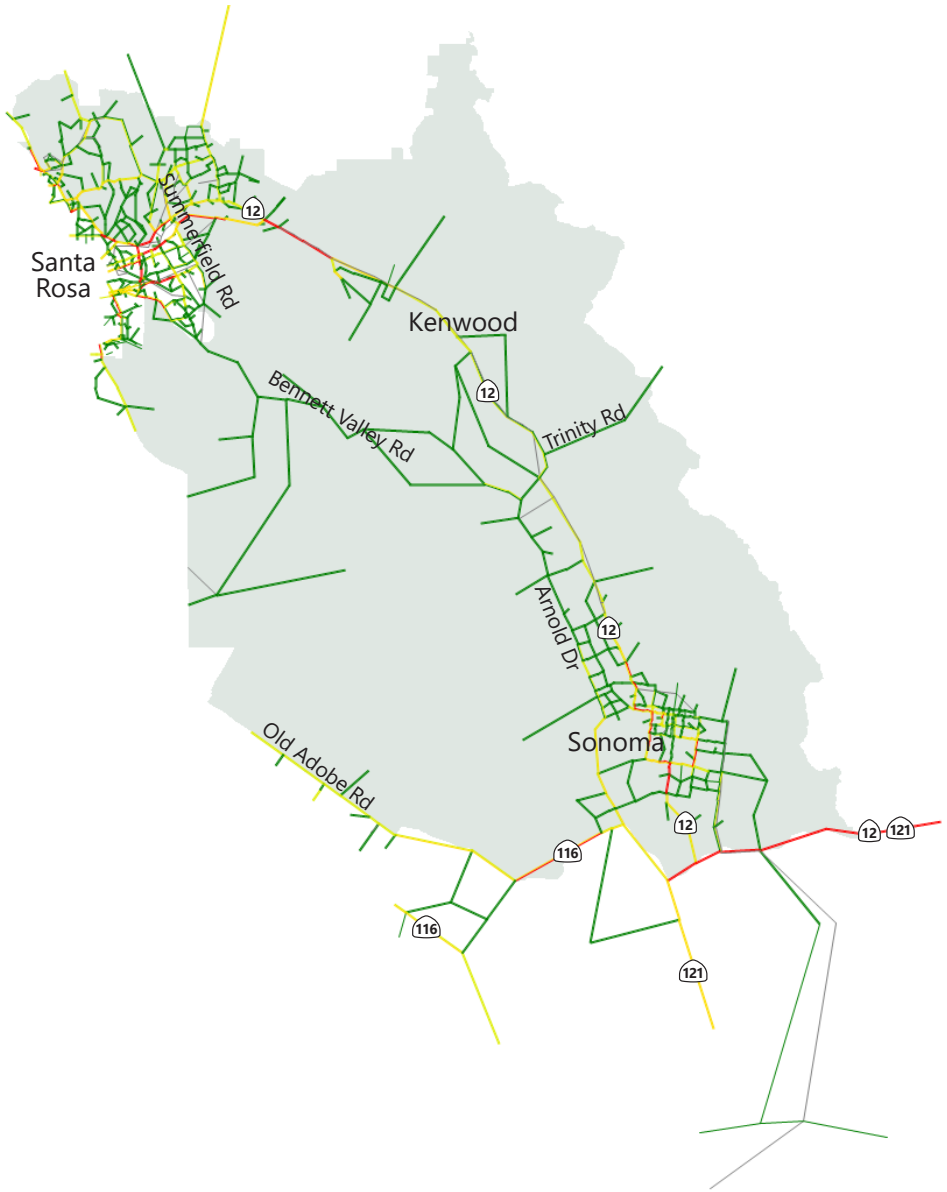

Figure 7.8

Scenario 3 Future Year Model Run - 4:15 PM

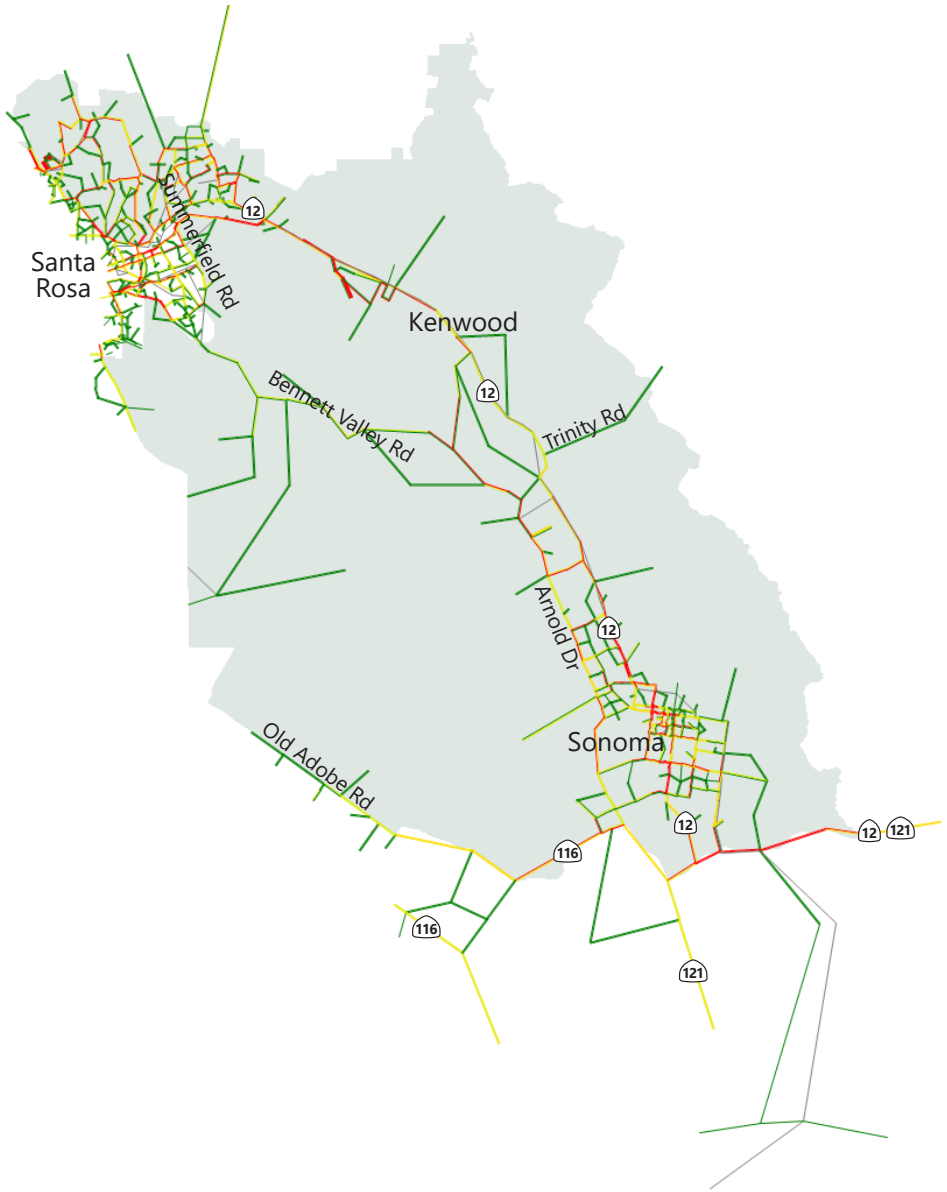

Figure 7.9

Scenario 3 Future Year Model Run - 4:30 PM (start of evacuation)

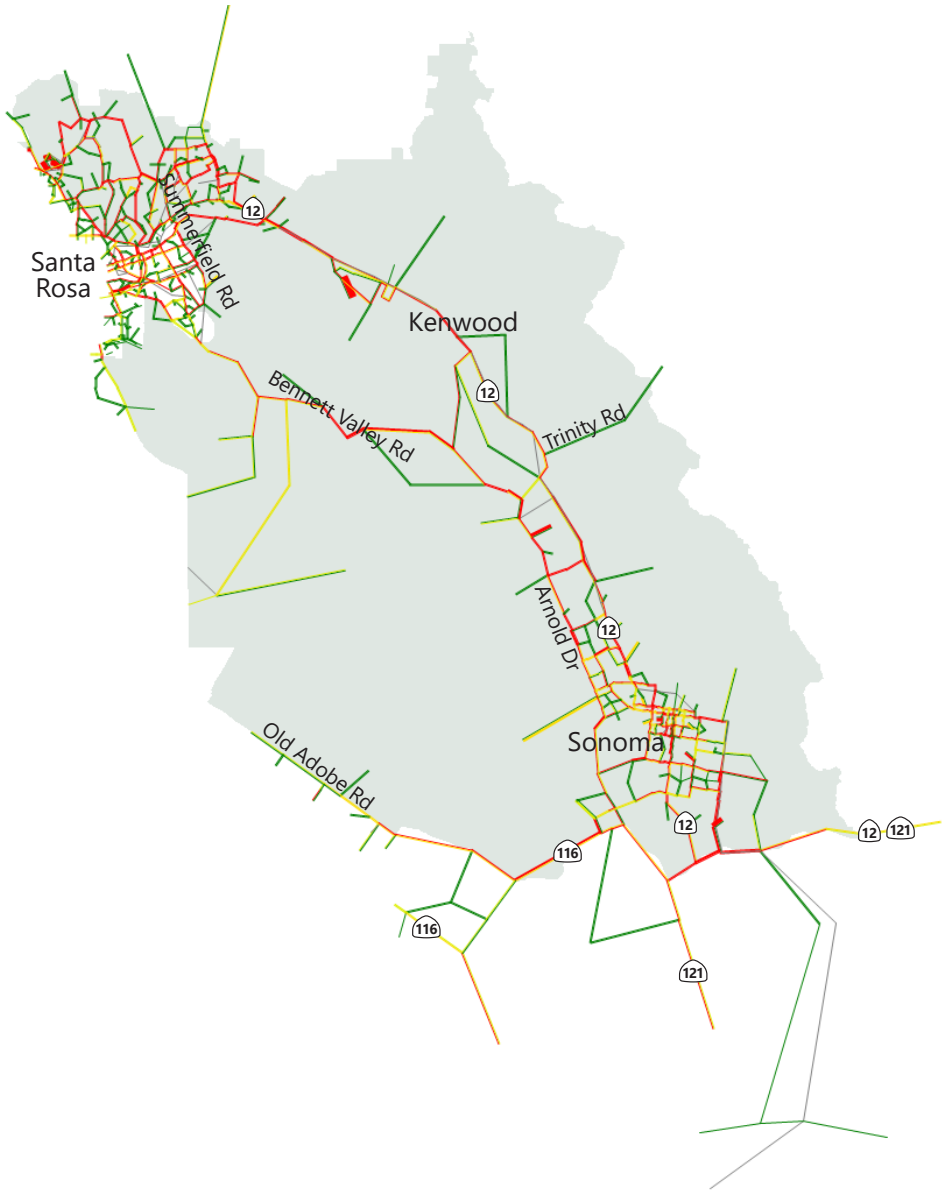

Figure 7.10

Scenario 3 Future Year Model Run - 4:45 PM

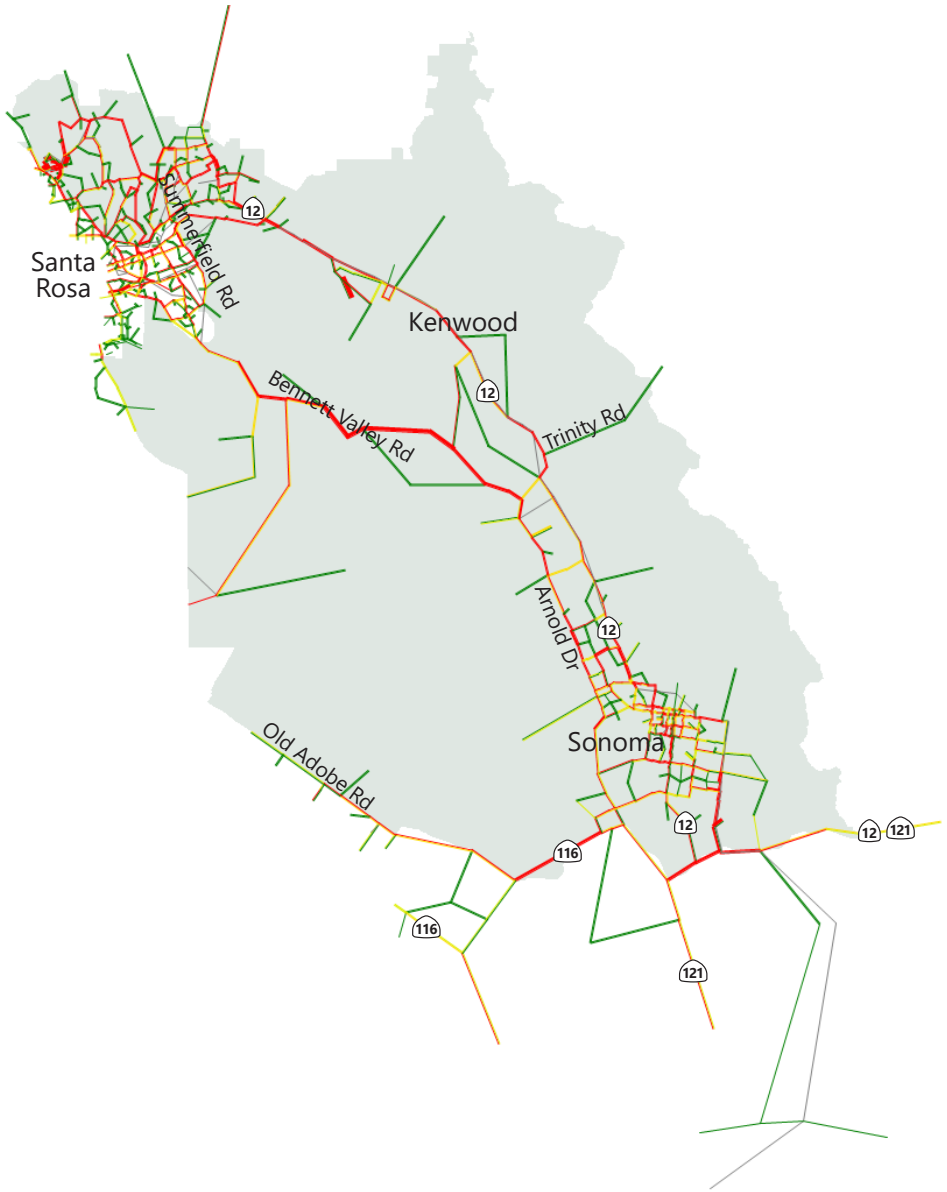

Figure 7.11

Scenario 3 Future Year Model Run - 5:00 PM

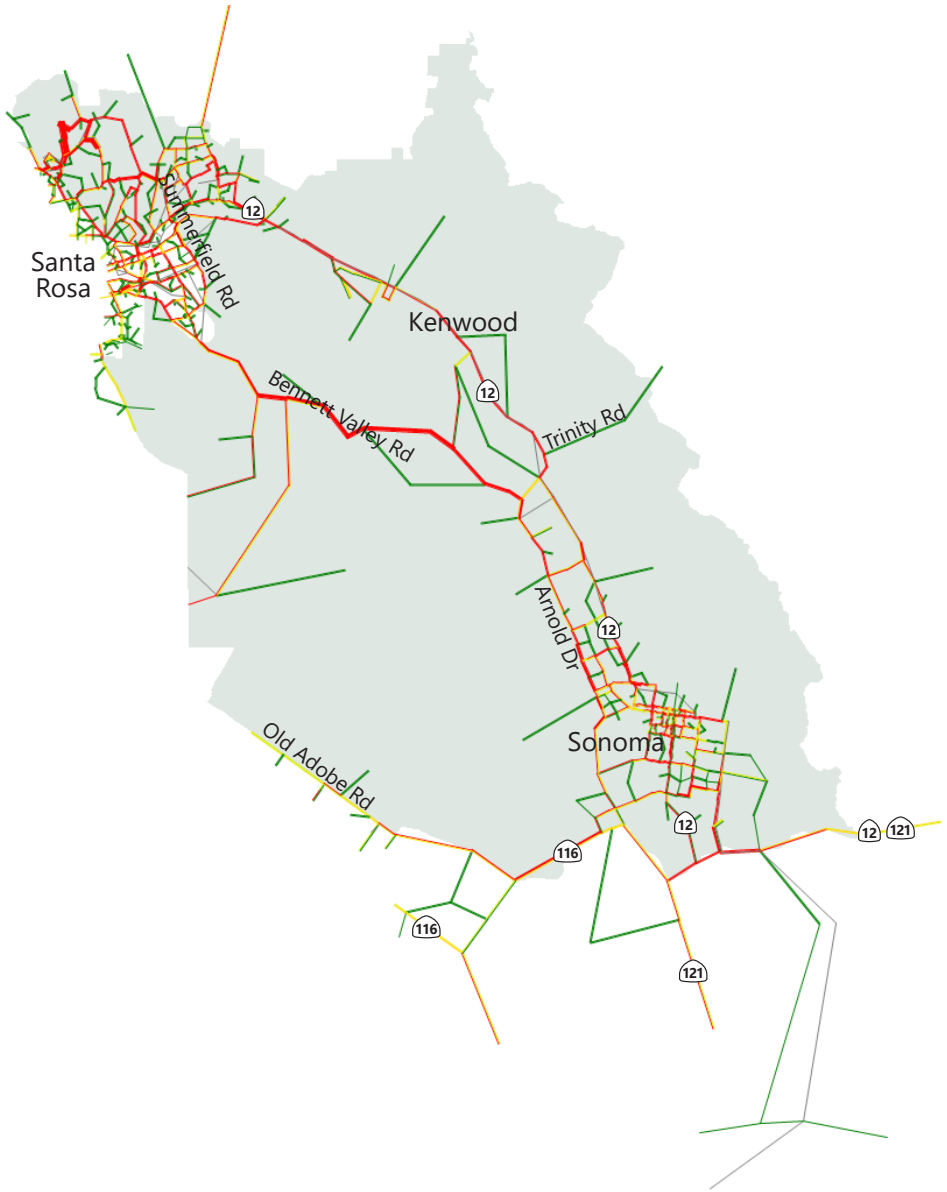

Figure 7.12

Scenario 3 Future Year Model Run - 5:15 PM

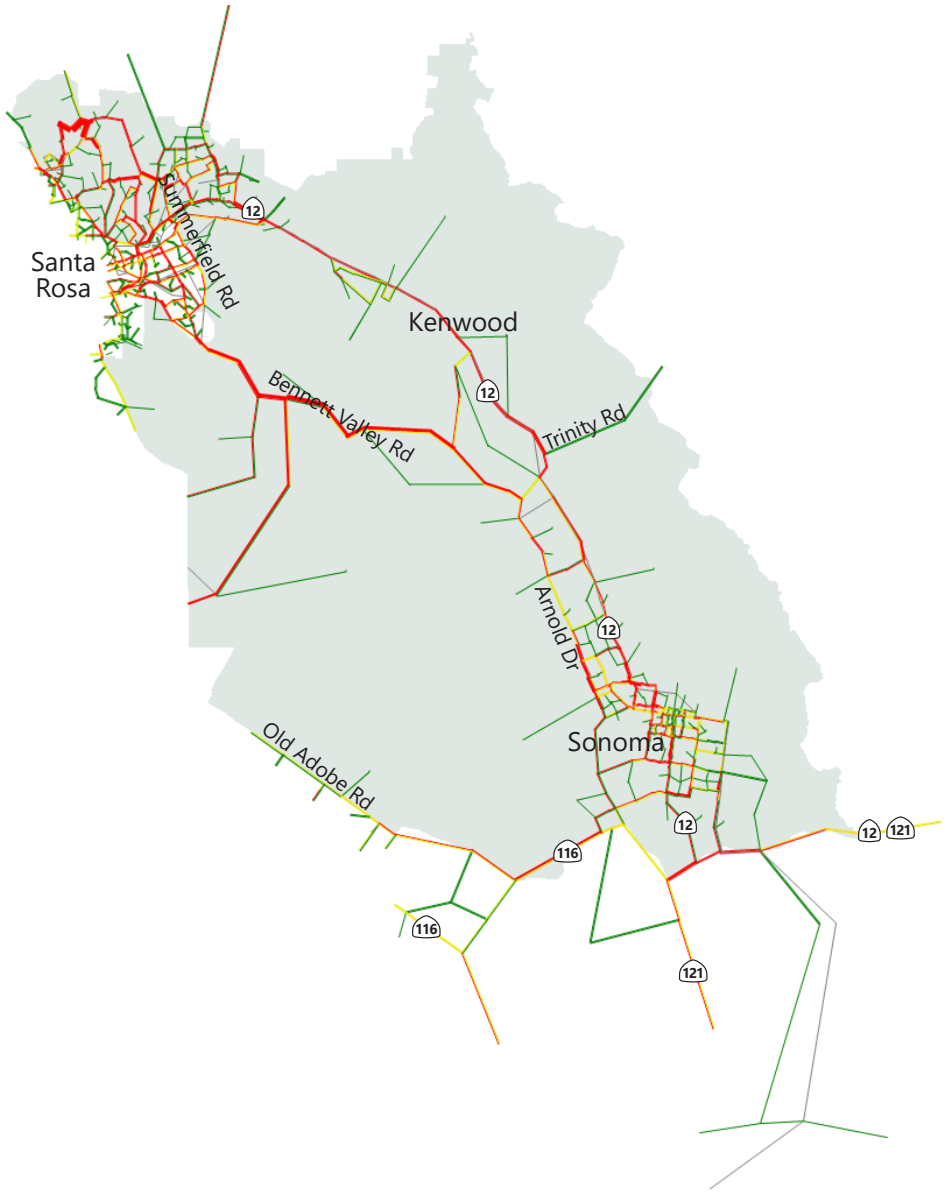

Figure 7.13

Scenario 3 Future Year Model Run - 5:30 PM

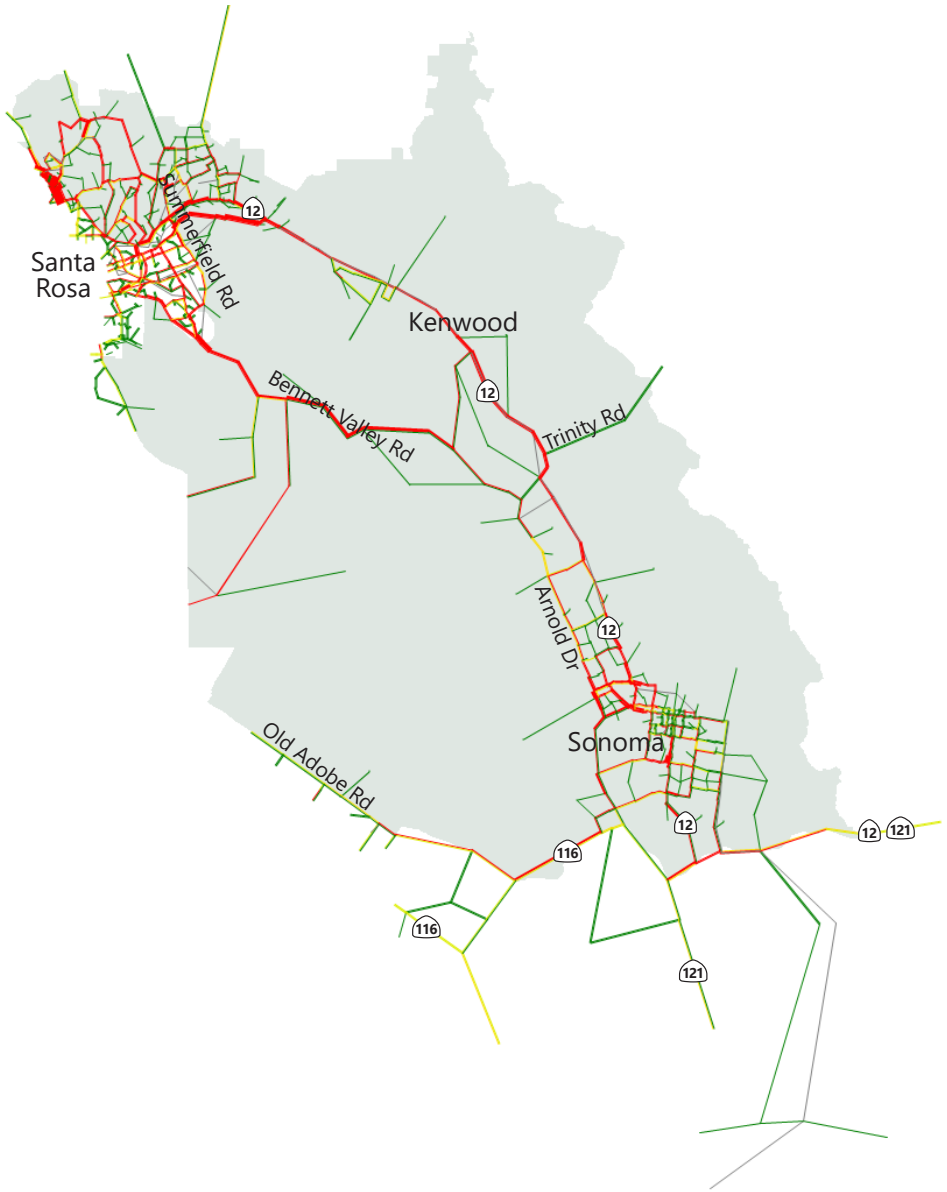

Figure 7.14

Scenario 3 Future Year Model Run - 5:45 PM

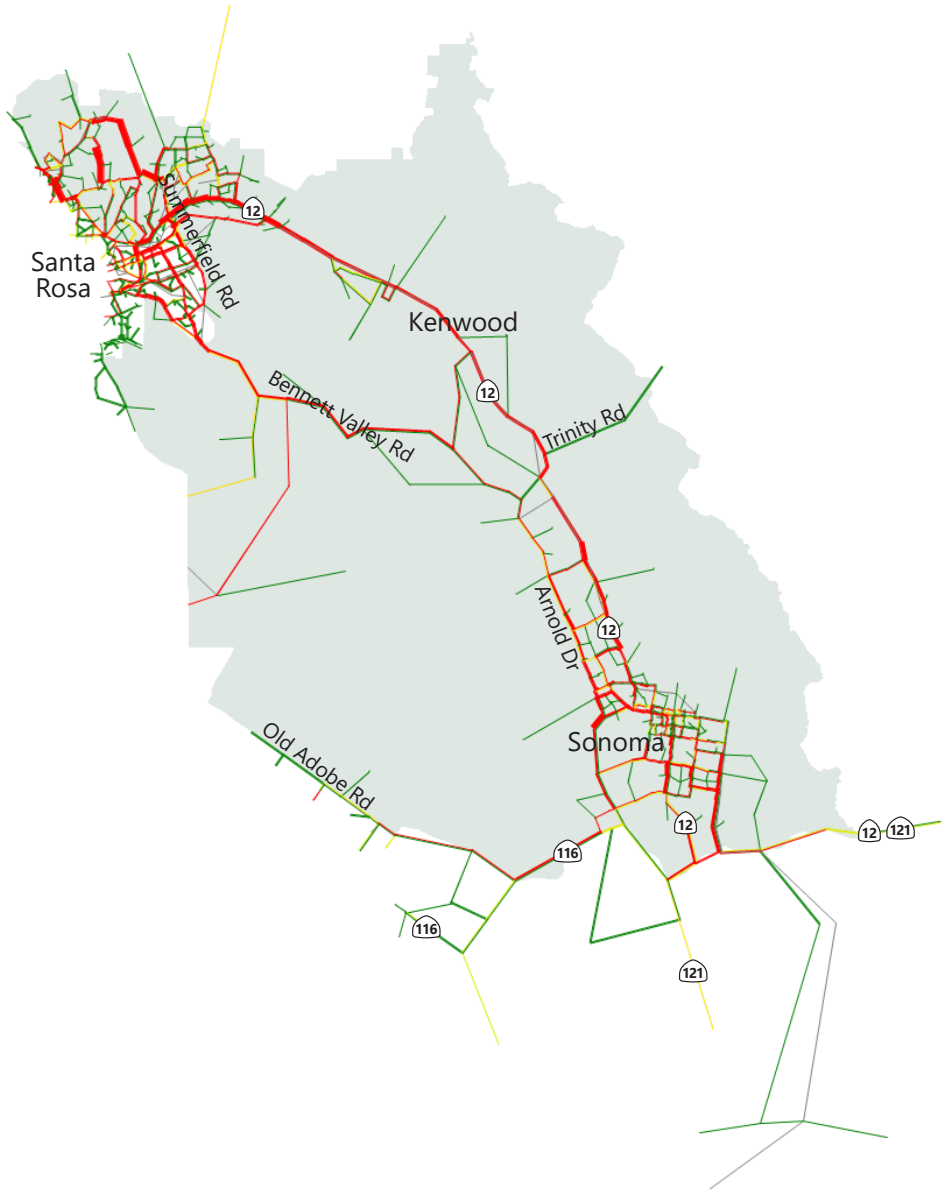

Figure 7.15

Scenario 3 Future Year Model Run - 6:00 PM

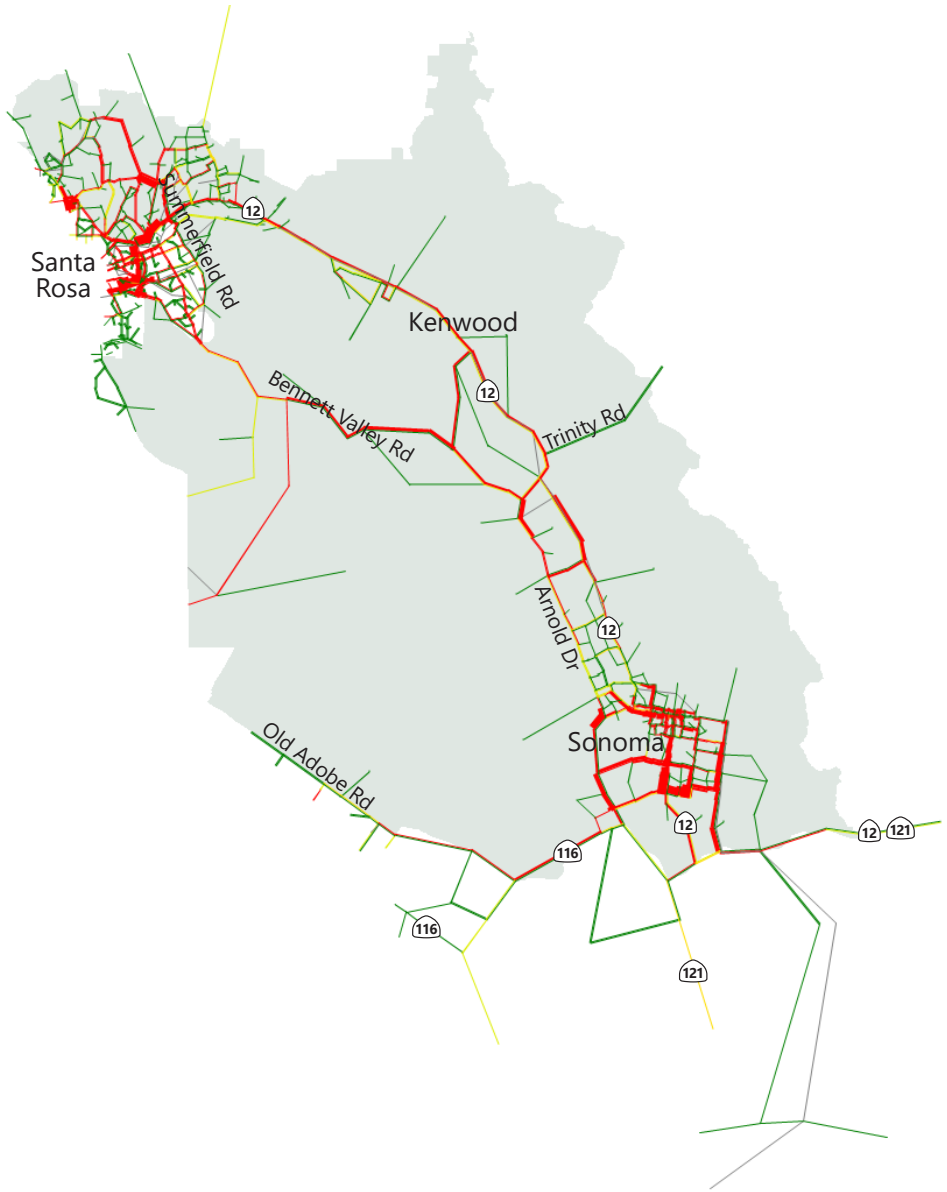

Figure 7.16

Scenario 3 Future Year Model Run - 6:15 PM

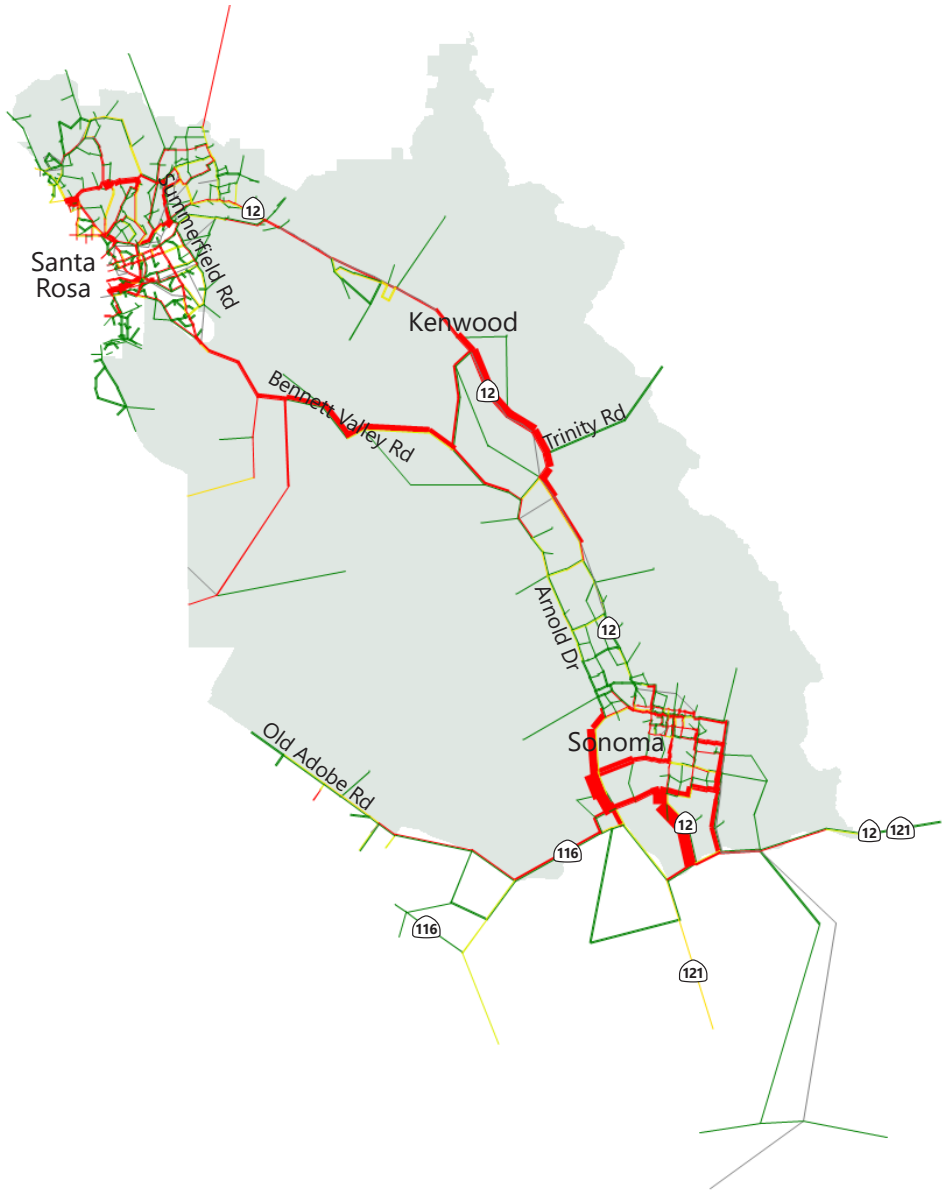

Figure 7.17

Scenario 3 Future Year Model Run - 6:30 PM

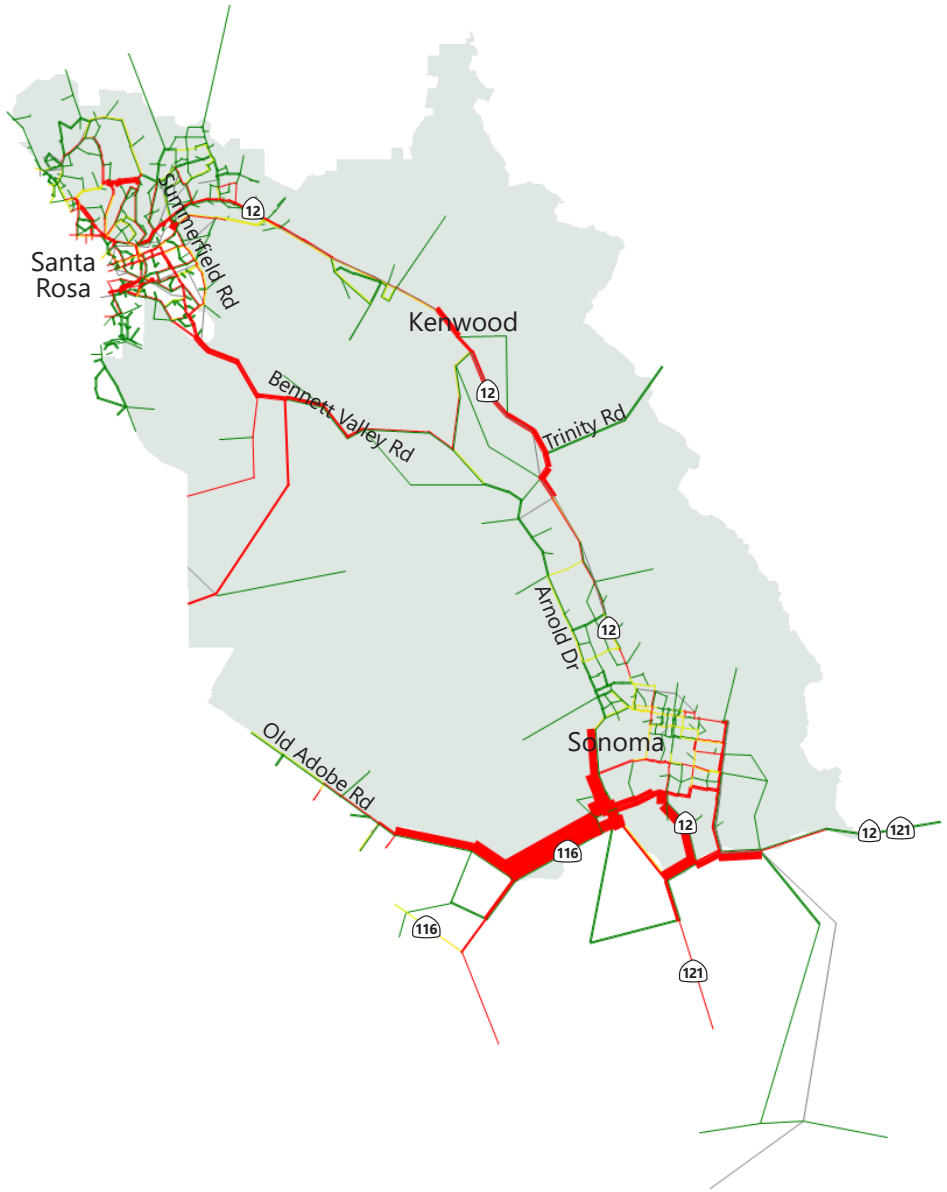

Figure 7.18

Scenario 3 Future Year Model Run - 6:45 PM

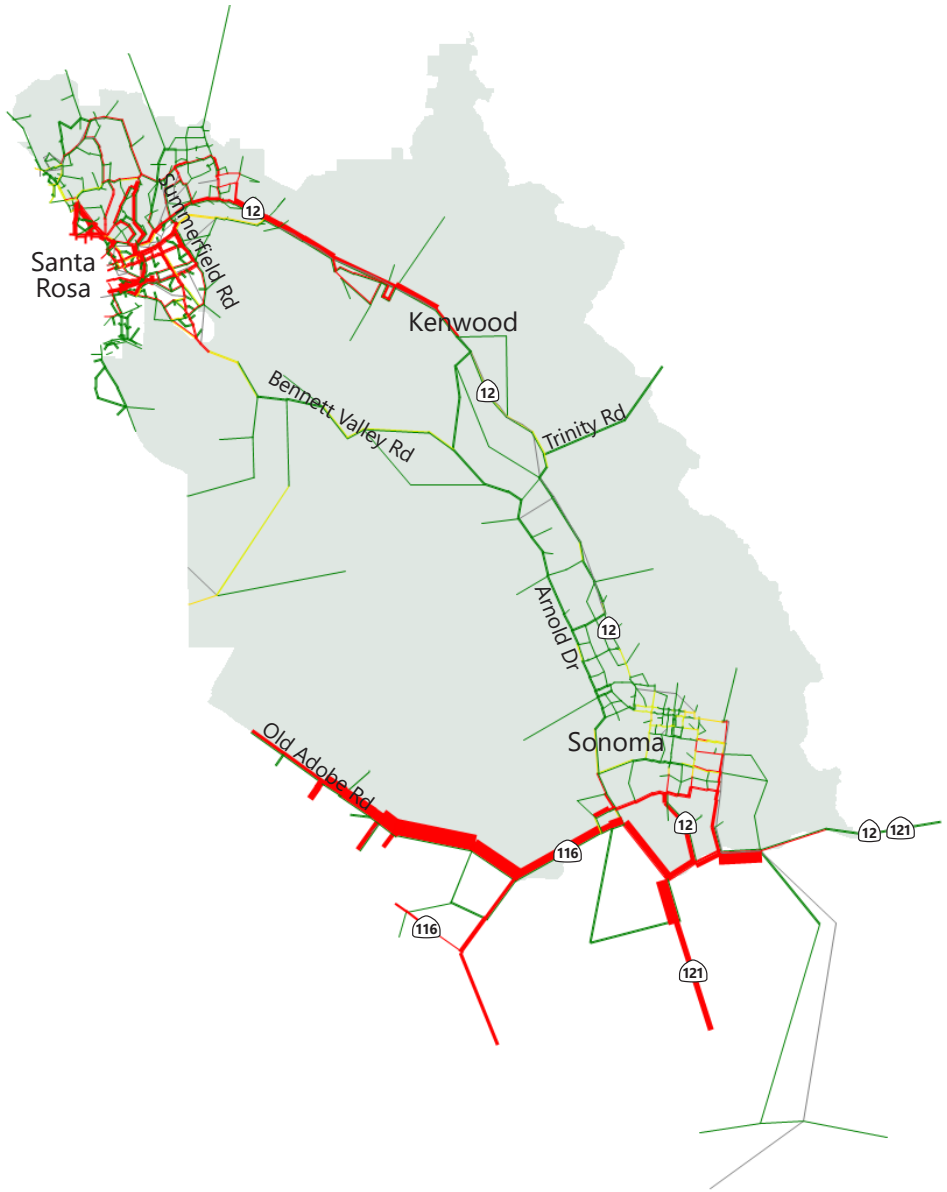

Figure 7.19

Scenario 3 Future Year Model Run - 7:00 PM

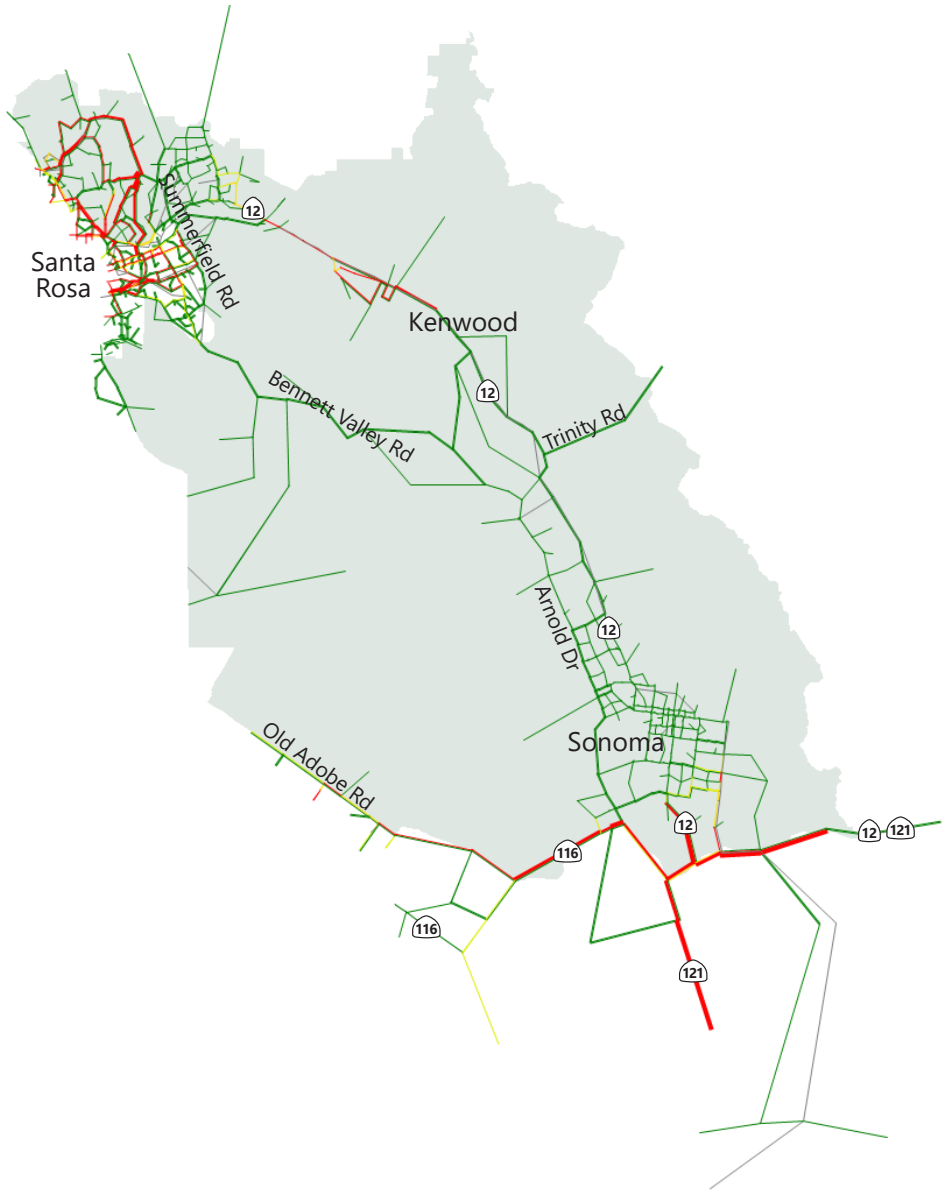

Figure 7.20

Scenario 3 Future Year Model Run - 7:15 PM

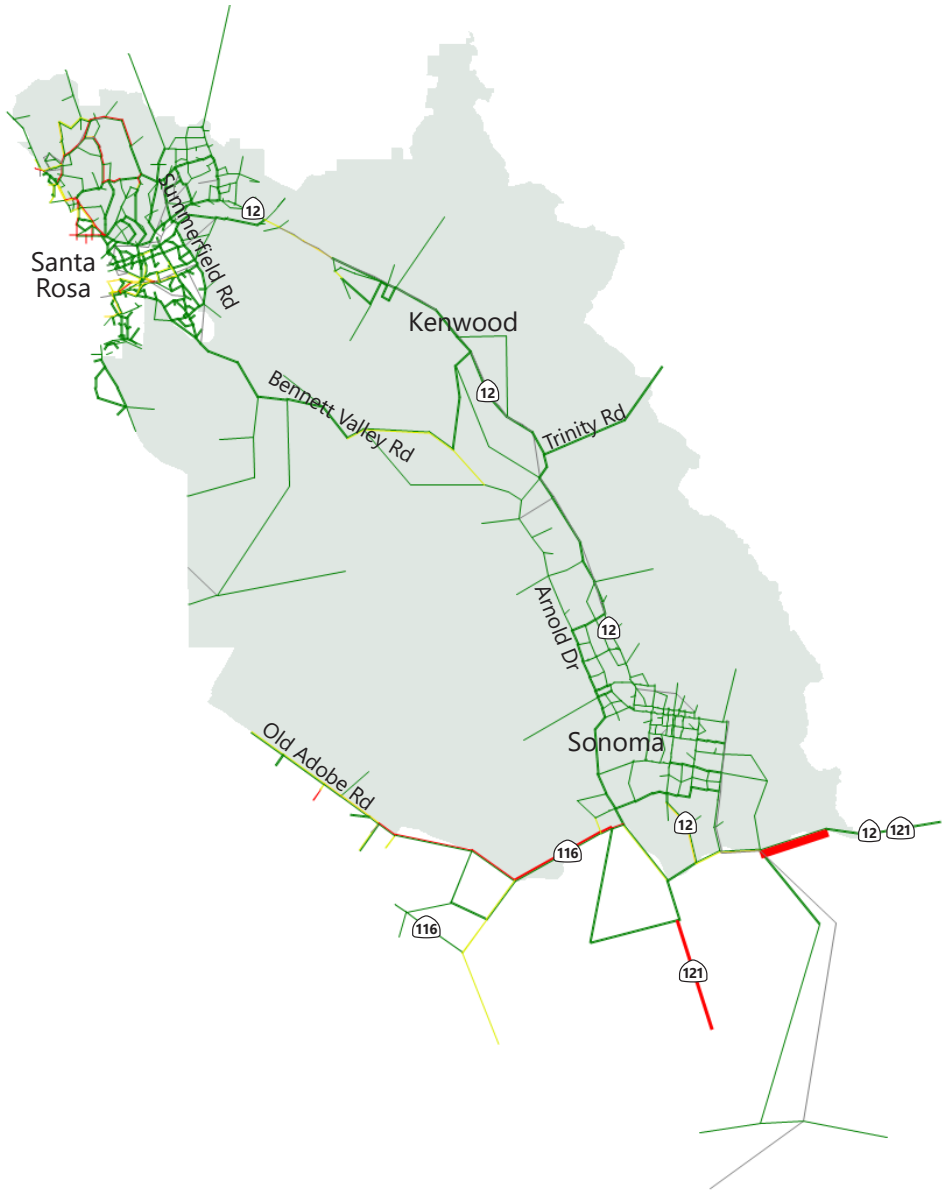

Figure 7.21

Scenario 3 Future Year Model Run - 7:30 PM

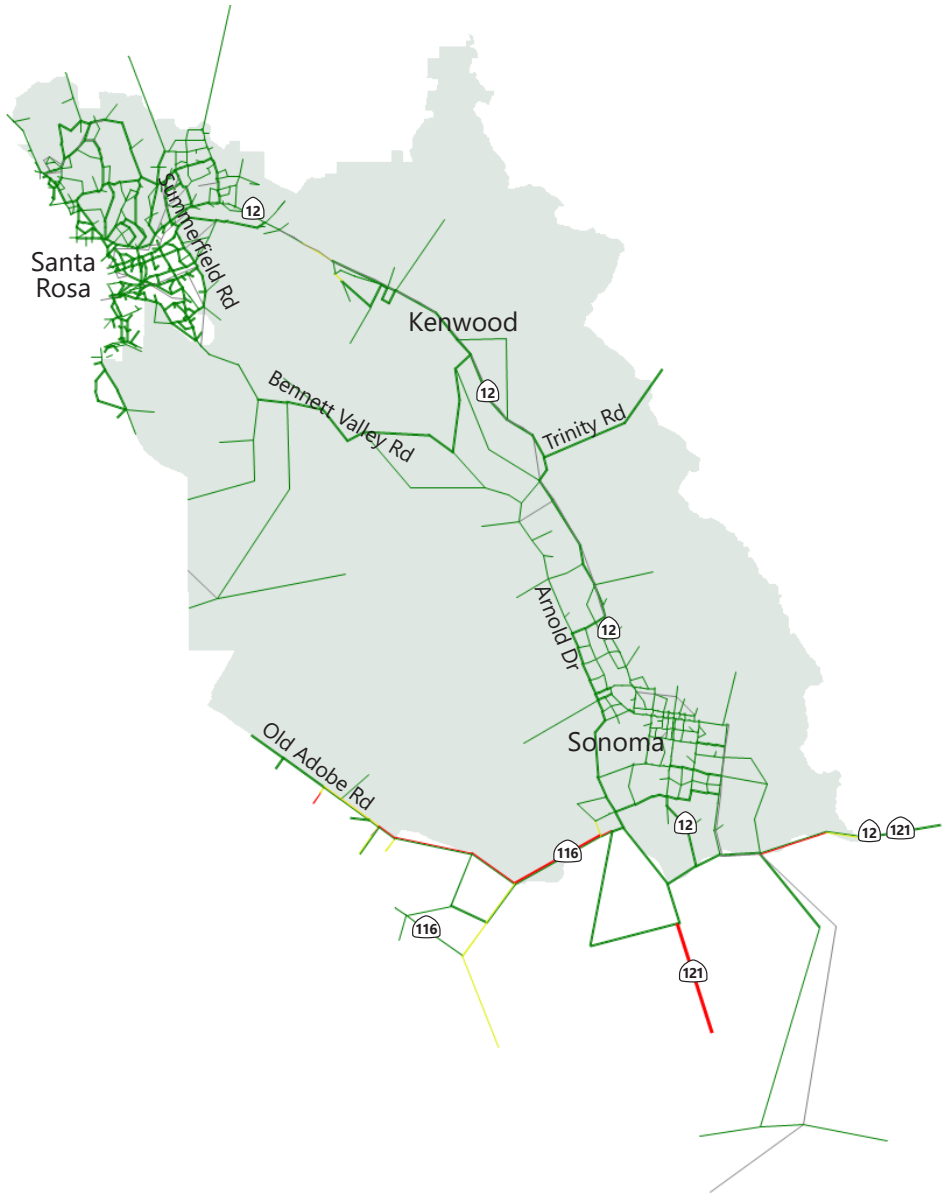

Figure 7.22

Scenario 3 Future Year Model Run - 7:45 PM

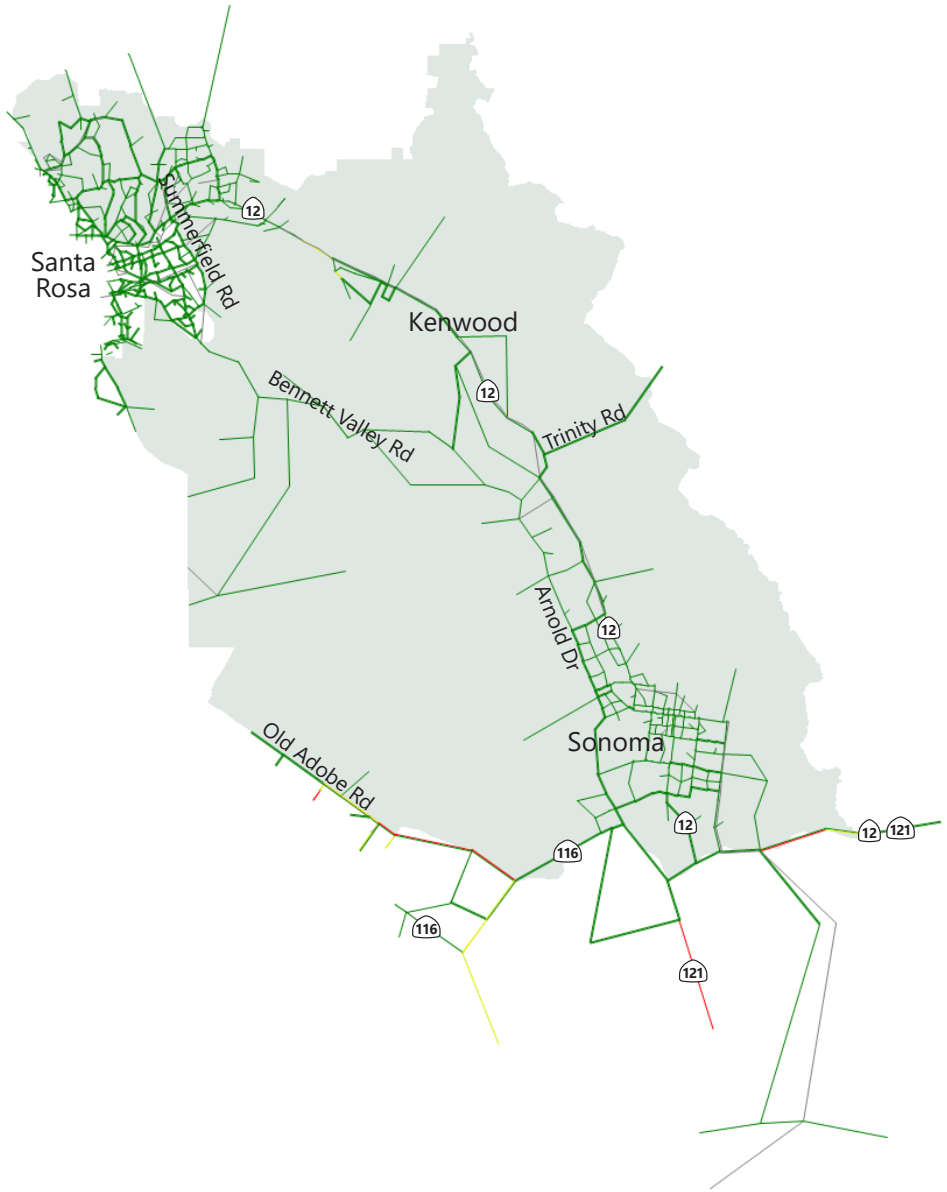

Figure 7.23

Scenario 3 Future Year Model Run - 8:00 PM

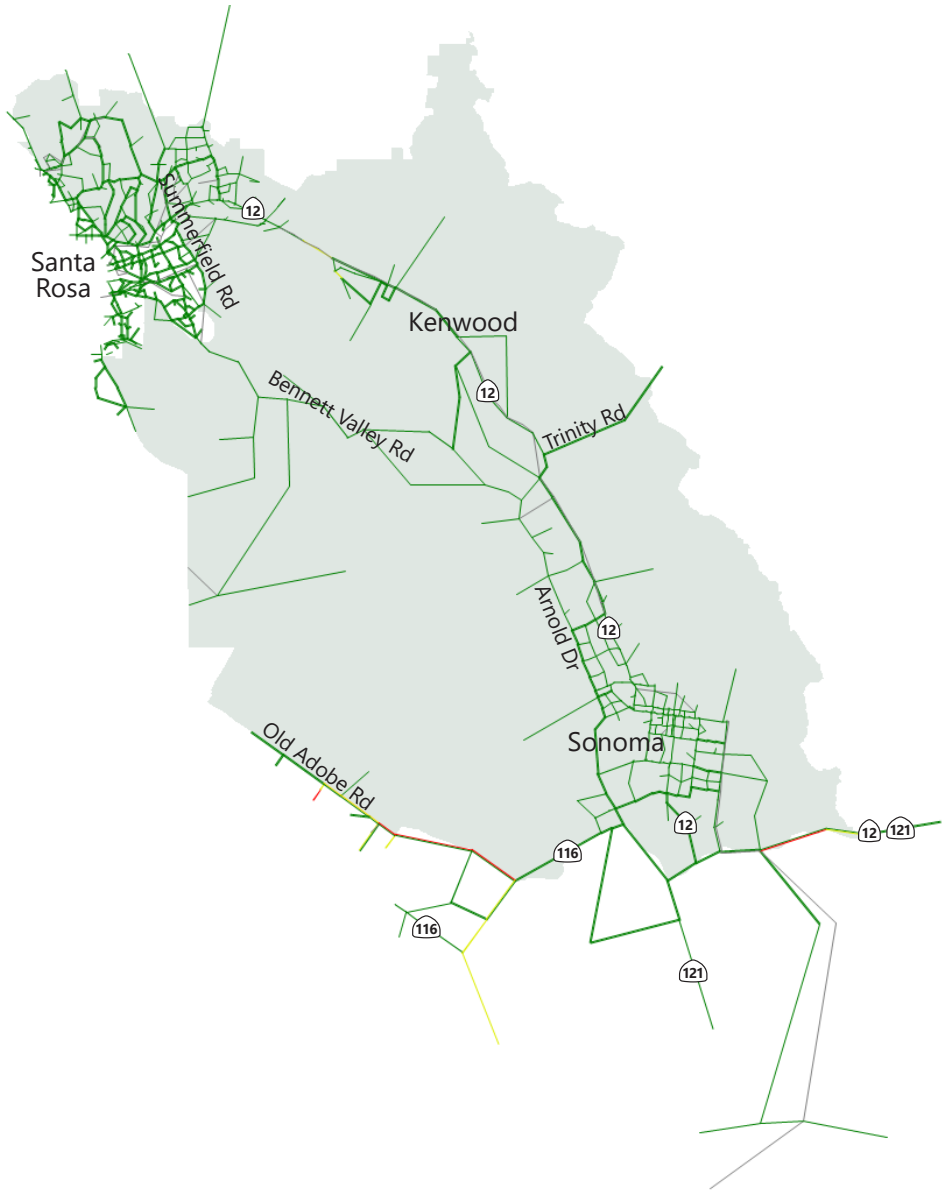

Figure 7.24

Scenario 3 Future Year Model Run - 8:15 PM

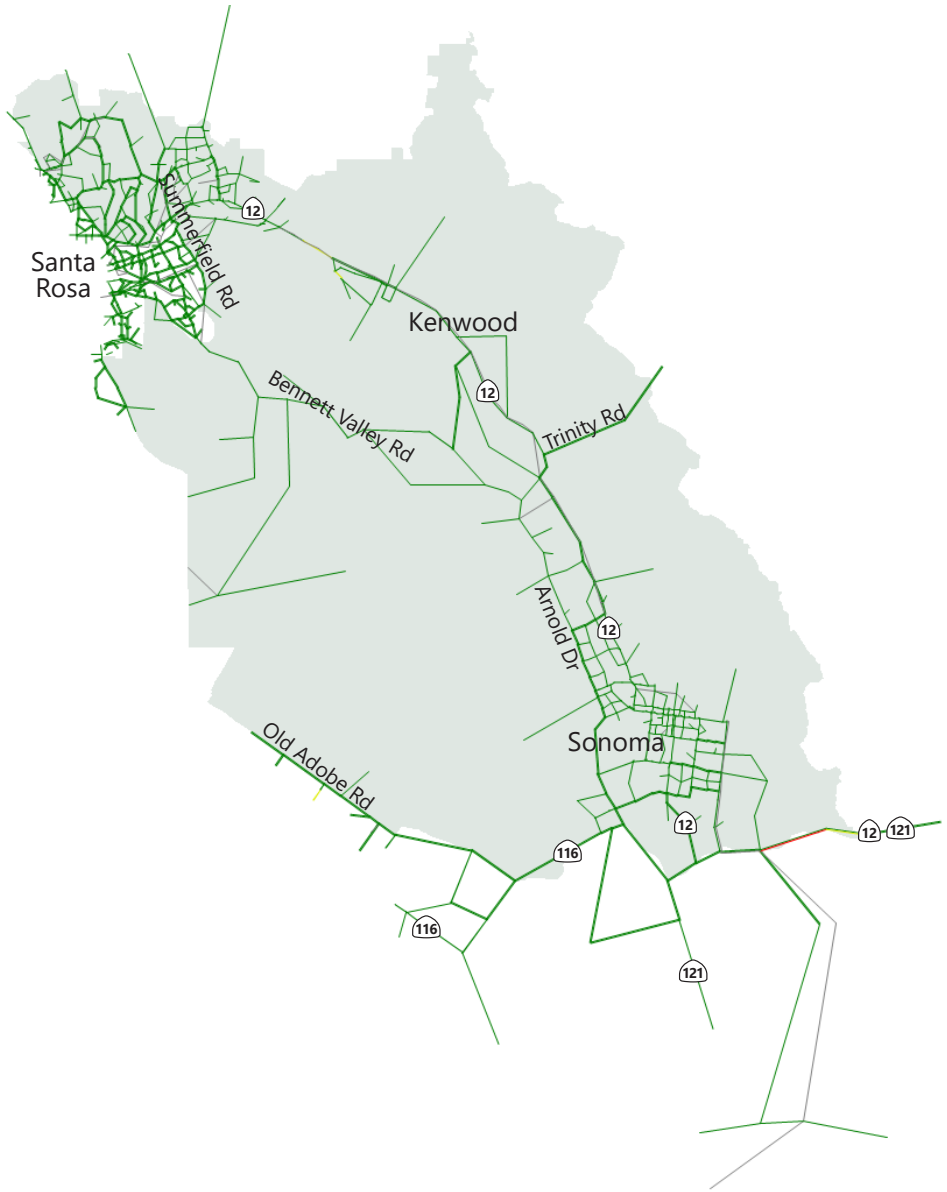

Figure 7.25

Scenario 3 Future Year Model Run - 8:30 PM

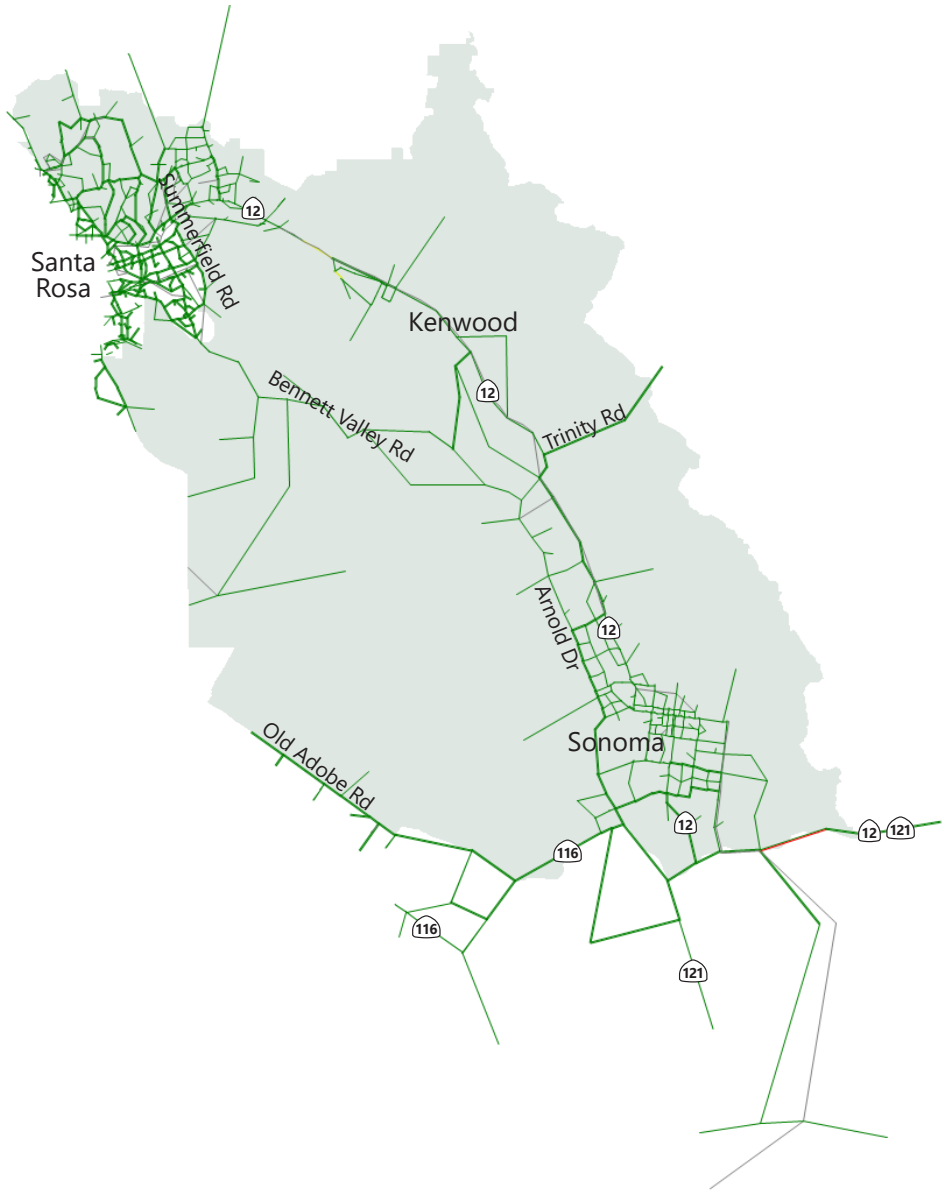

Figure 7.26

Scenario 3 Future Year Model Run - 8:45 PM

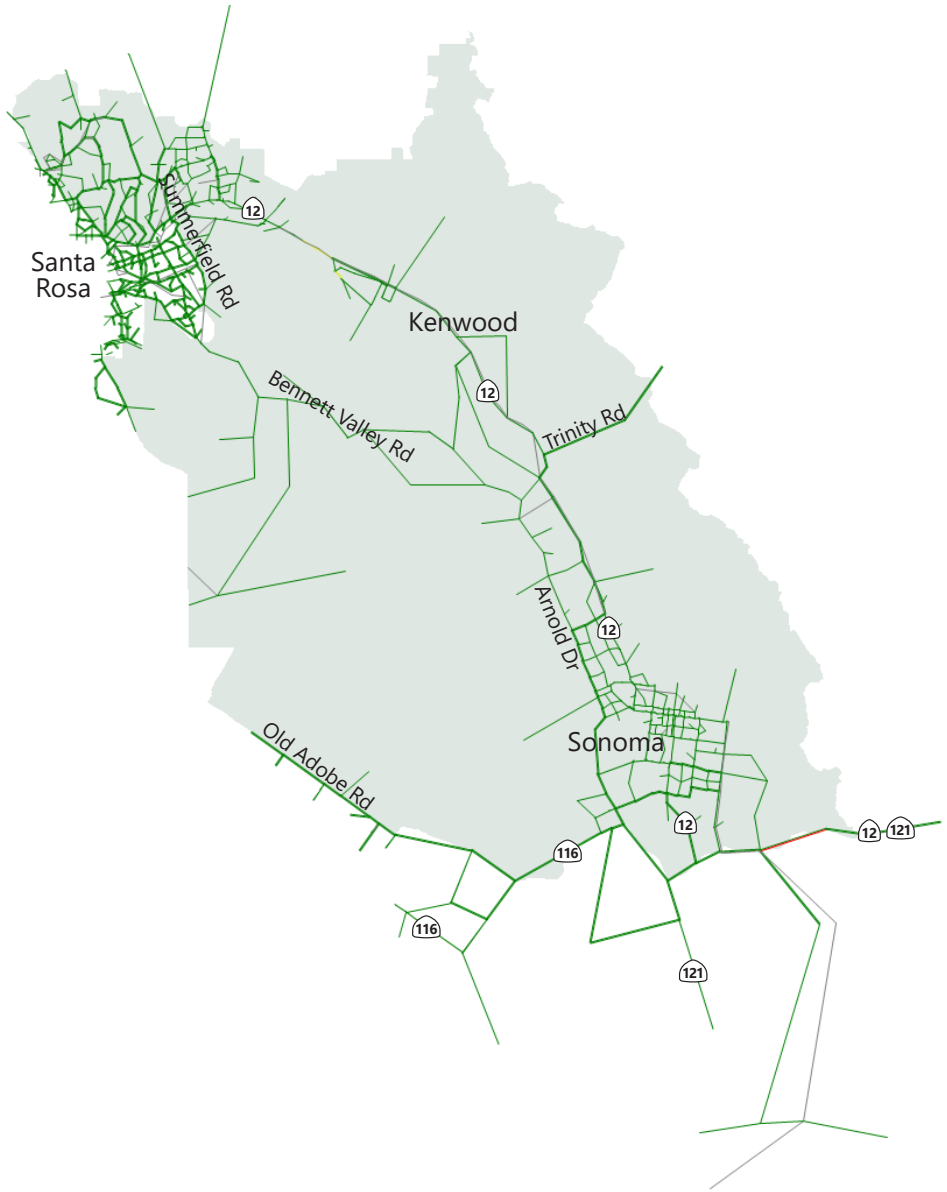

Figure 7.27

Scenario 3 Future Year Model Run - 9:00 PM

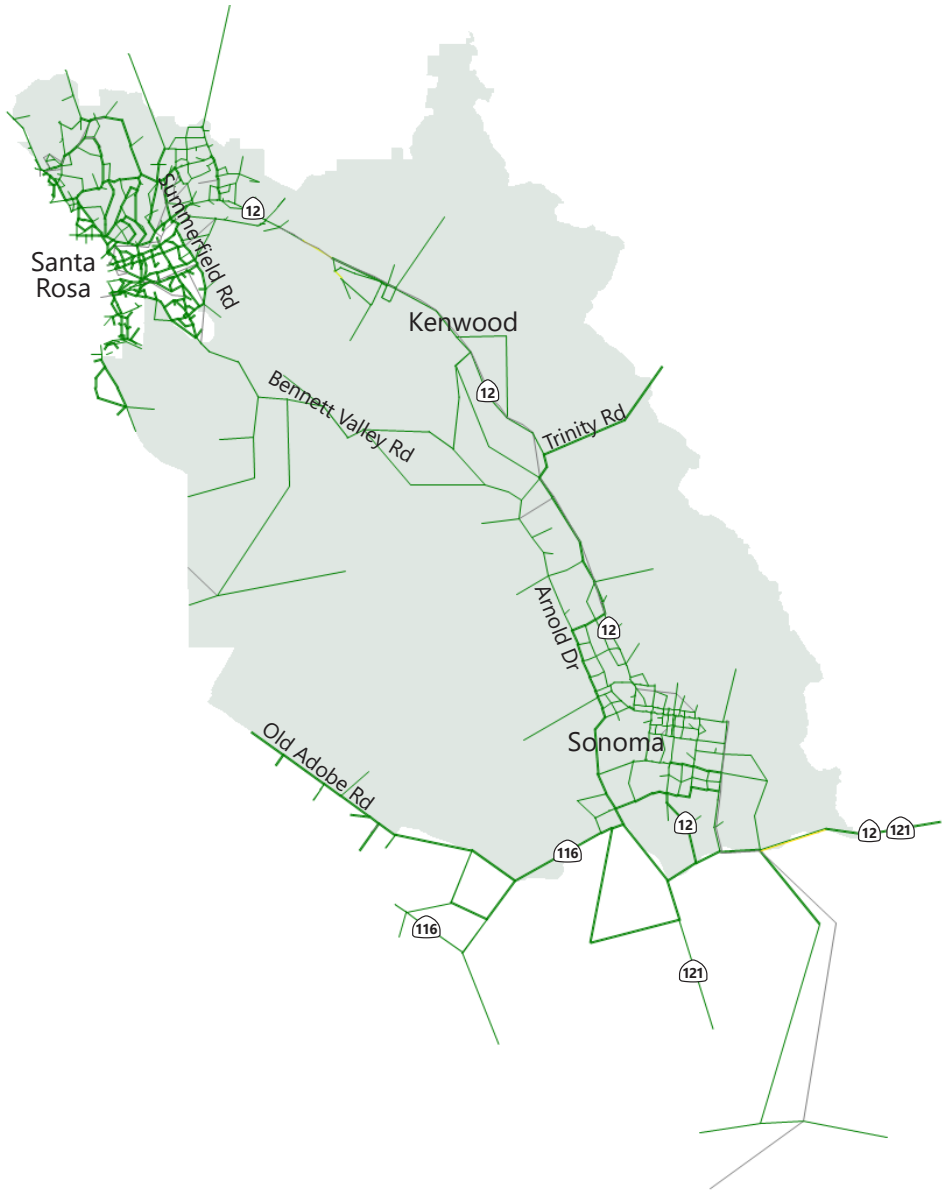

Figure 7.28

Scenario 3 Future Year Model Run - 9:15 PM

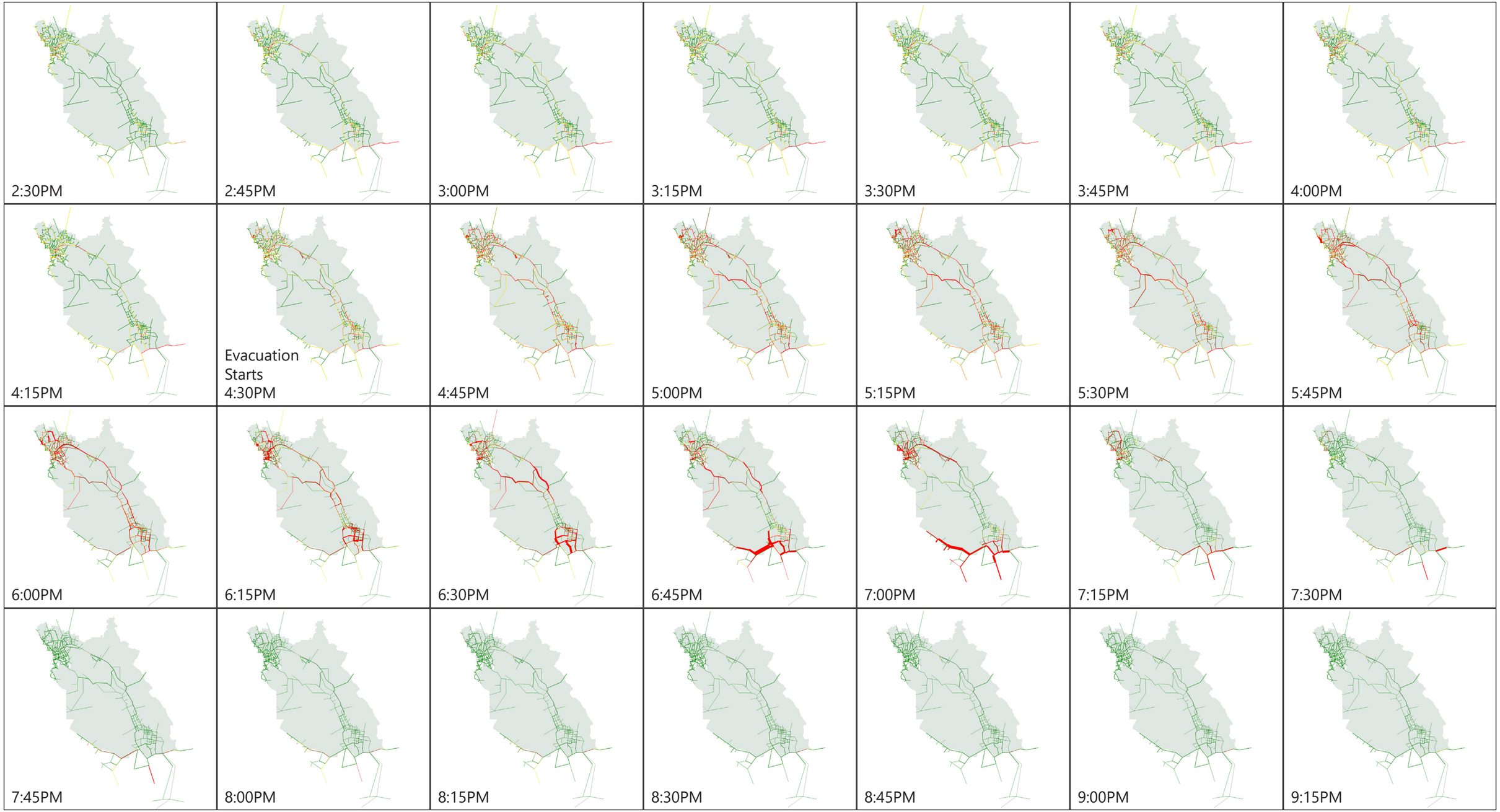

Figure 7.29

Scenario 3 Future Year Model Run Results

Appendix A: Estimated Evacuation Demand

Scenario	Population	Households	Employment	Household Vehicle Ownership					Estimated Evacuation Demand (Number of Vehicles)
				0	1	2	3	4+	
Scenario 1 Base (2019)	31,511	12,684	7,293	418	3,853	4,868	2,278	1,267	20,811
Scenario 1 Future (2040)	47,700	19,141	8,969	763	5,980	7,174	3,272	1,952	31,059
Scenario 2 Base (2019)	23,158	8,627	5,605	244	2,114	3,340	1,996	933	14,695
Scenario 2 Future (2040)	26,633	9,942	8,613	303	2,435	3,892	2,265	1,047	17,400
Scenario 3 Base (2019)	100,936	40,059	24,079	1,886	13,134	15,305	6,519	3,215	64,752
Scenario 3 Future (2040)	108,994	43244	37,142	2,023	14,209	16,511	7,013	3,488	69,878
Total (2019)	155,605	61,370	36,977	2,548	19,101	23,513	10,793	5,415	100,258
Total (2040)	183,327	72,327	54,724	3,089	22,624	27,577	12,550	6,487	118,337

Source: Sonoma County Transportation Authority (SCTA) Travel Demand Model, American Community Survey 2019-23.

Appendix C
Residential Egress Assessment (SB 99)

FEHR PEERS

Final Memorandum

Date: March 26, 2025

To: Reema Shakra and Lauren Collar, Rincon Consultants

From: Ian Barnes, PE, Terence Zhao, and Grace Chen, Fehr & Peers

Subject: Sonoma County Safety Element Update – SB 99 Assessment

WC23-3966

Fehr & Peers is conducting a general, programmatic assessment of emergency evacuation routes for the Safety Element Update of the Sonoma County General Plan. This assessment is consistent with Senate Bill 99 (SB 99) requirements.

This document describes the methodology for an assessment of roadway capacity and time needed to evacuate a designated study area under described evacuation scenarios. Please note that emergency evacuations can occur due to any number of events. Additionally, any emergency movement is unpredictable because it has an element of individual behavior related to personal risk assessment for each hazard event. As such, this assessment is intended to provide the jurisdiction with a broad understanding of the transportation system capacity during an evacuation scenario; it does not provide a guarantee that evacuations will follow the same modeling used for analysis purposes, nor does it guarantee that the findings are applicable to any or all situations.

Moreover, as emergency evacuation assessment is an emerging field, there is no established standard methodology. Fehr & Peers has adopted existing methodologies in transportation planning that, in our knowledge and experience, we believe are the most appropriate within the limits of the tools and data available and the budgetary and time constraints in the scope of work, and by current knowledge and state of the practice.

While this assessment should help the jurisdiction better prepare for hazard related events and associated evacuations, the jurisdiction should take care in planning and implementing any potential evacuation scenario. Fehr & Peers cannot and does not guarantee the efficacy of any of the information garnered from this assessment, as doing so would be beyond our professional duty and capability.

Legislative Requirements

SB 99 requires a review and update of the safety element to include information identifying residential developments in hazard areas identified in the safety element that do not have at least two emergency evacuation routes.

SB 99 Approach

The first part of this work consists of identifying residential areas with only a single access route. A threshold of 30 or more parcels was used as a threshold for this analysis. This approach is similar to CAL FIRE's Subdivision Review Program (required by Public Resources Code Section 4290.5), which requires CAL Fire to identify existing subdivisions with 30 dwelling units located in the State Responsibility Area or a Very High Fire Hazard Severity Zone in Local Responsibility Areas, without a secondary means of egress route that are at significant fire risk. While the SB 99 assessment required for safety elements is not required to incorporate CAL FIRE Subdivision Review Program findings, it is noted that the Subdivision Review Program is another source of information about egress in fire hazard areas and explains the differences in methodologies. We have also focused on locations where the single access roadway is at least a quarter mile long in order to exclude cul-de-sacs in urban and suburban areas with substantial street grids. With consideration for the variety of hazards faced throughout the County, it is noted that this analysis also considers single access route areas that are in flood hazard areas, not just fire hazard areas. Twelve such clusters of residential parcels were identified and numbered:

1. In Jenner, parcels along Balboa Avenue, a dead-end roadway
2. In Duncan's Mills, parcels along Freezeout Road, a dead-end roadway
3. In Duncan's Mills, parcels along Conifer Drive in Duncan's Mills
4. In Guernewood Park, parcels north and west of the northern intersection between Old Cazadero Road and Cherry Street, as well as those along Hidden Valley Road, all of which are dead-end roadways
5. In Rio Nido, parcels along Eagle Nest Lane and Canyon Two Road, both of which are dead-end roadways
6. The Odd Fellows Recreation Club and Summerhome Park – although their roadway networks are not contiguous, they are treated as a single cluster due to geographic contiguity; each only has one point of access, the former from the west and the latter from the east
7. In Mirabel Park, parcels along Vila Road west of its intersection with Champs De Elysees
8. In Alexander Valley, a cluster of parcels near Vineyard Lake and Gill Creek, where the sole paved access road is River Road from the south
9. The west side of Bodega Bay, whose only access is Bay Flat Road
10. The Bodega Harbour subdivision in Bodega Bay, whose only access is Harbour Way

11. Near Rohnert Park and Crane Canyon, the parcels along Inverness Avenue, a dead-end roadway
12. Parcels in Eastern Sonoma Mountain, where there are technically two routes of access, one via Grove Street from the south and another via Alta Sonoma Road from the north, but the latter is long, narrow, and winds through mountainous terrain with high fire risks, and is thus not likely to be a viable egress in emergency situations

Also as part of this work, evacuation access was assessed by reviewing the distance evacuees must travel during an evacuation event. This assessment is a proxy for accessibility and can assist in identifying potentially vulnerable communities during an evacuation event by identifying areas of the County that need to travel the furthest and thus are potentially the most vulnerable in an evacuation event. We approached this assessment by measuring distances from each point along the County roadway network to three evacuation locations within the County: the Petaluma Fairgrounds, the Santa Rosa Fairgrounds / Veterans Center, and Sonoma County Airport; as well as the following external gateways into and out of Sonoma County:

- SR 1 north at the Sonoma County line near Gualala
- SR 128 west at the Sonoma County line north of Cloverdale
- US 101 north at the Sonoma County line north of Cloverdale
- SR 128 east at the Sonoma County line near Kellogg
- Petrified Forest Road at the Sonoma County line west of Calistoga
- St. Helena Road at the Sonoma County line west of St. Helena
- Trinity Road at the Sonoma County line east of Glen Ellen
- SR 12 east at the Sonoma County line east of the City of Sonoma
- Ramal Road at the Sonoma County line east of the City of Sonoma
- SR 37 east at the Sonoma County line west of Vallejo
- SR 37 west at the Sonoma County line east of Novato
- US 101 south at the Sonoma County line south of Petaluma
- San Antonio Road at the Sonoma County line south of Petaluma
- D Street at the Sonoma County line south of Petaluma
- Point Reyes-Petaluma Road at the Sonoma County line south of Petaluma
- Chileno Valley Road at the Sonoma County line south of Petaluma
- Tomales Road at the Sonoma County line west of Two Rock
- Fallon Road at the Sonoma County line west of Two Rock
- SR 1 south at the Sonoma County line near Valley Ford

SB 99 Mapping Overview

Figure 1: SB 99 Parcels with One Access/Egress Route and Fire Hazard Severity Zones

Fire Hazard Severity Zones (FHSZs) are designated by the California Department of Forestry and Fire Protection (CAL FIRE) as moderate, high, and very high hazard. This figure shows high- and very high-severity fire hazard zones shown in relation to the twelve clusters identified previously. All clusters except 9 and 10 are located in or immediately adjacent to one of these zones.

Figure 2: SB 99 Parcels with One Access/Egress Route and Flood Hazard Zones

Flood hazard zones, identified by the Federal Emergency Management Agency (FEMA), are separated into two categories for Sonoma County. The 1% annual chance flood is referred to as the base flood or 100-year flood. The moderate flood hazard areas are identified as 0.2% annual chance (or 500-year) flood. This figure shows these flood hazard zones in relation to the twelve clusters identified previously. All clusters except 11 and 12 are located in or immediately adjacent to one of these zones.

Figure 3: Distance to Closest Evacuation Point

This figure maps the distance between each point along the County roadway network to the closest evacuation point listed previously, whether an in-county evacuation or external gateway.

Figure 4: SR 99 Inset Maps

These figure maps outline the SB 99 parcels at a zoomed-in level.

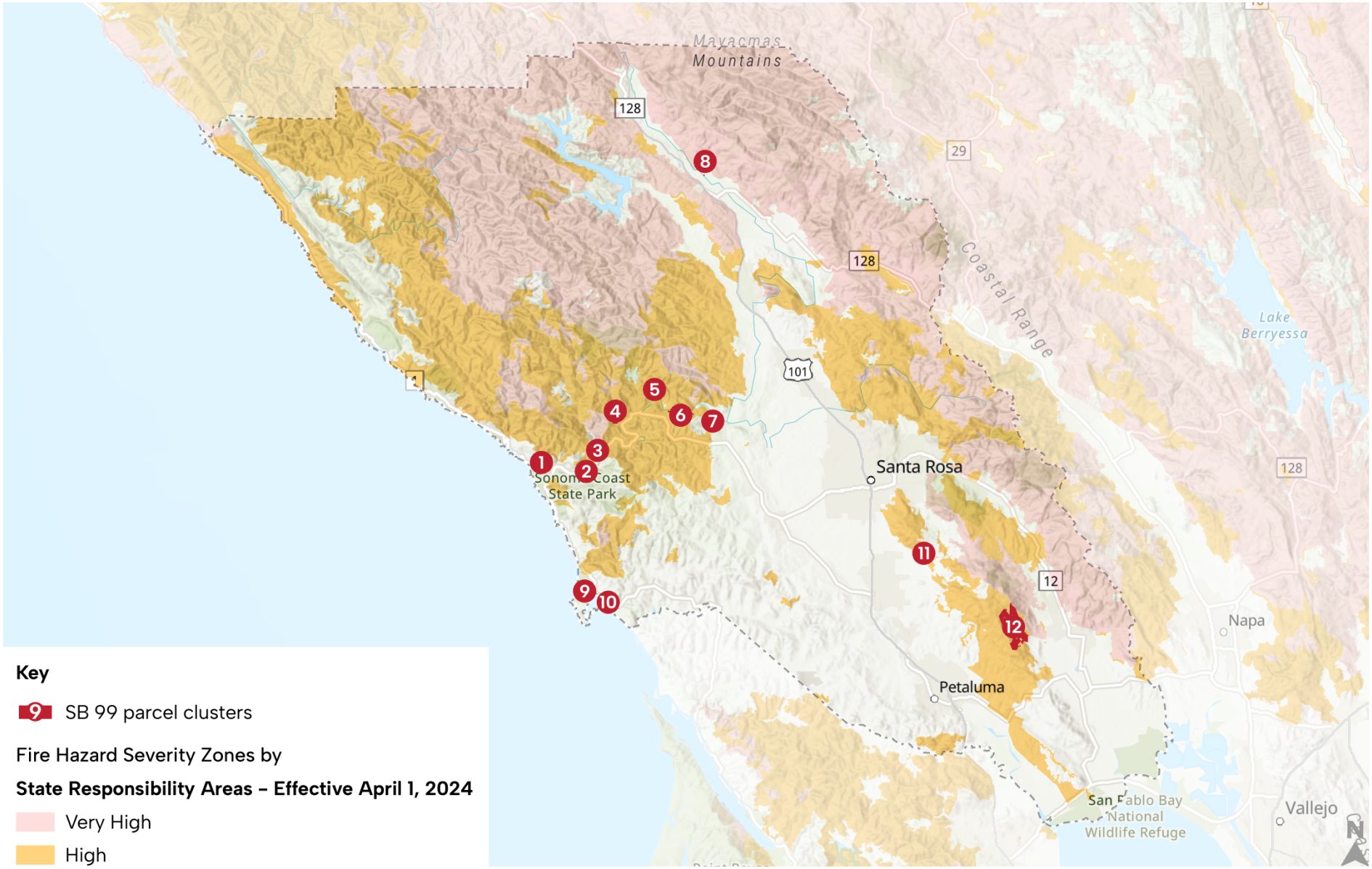

Figure 1

SB 99 Parcels with One Access/Egress Route and Fire Hazard Severity Zones

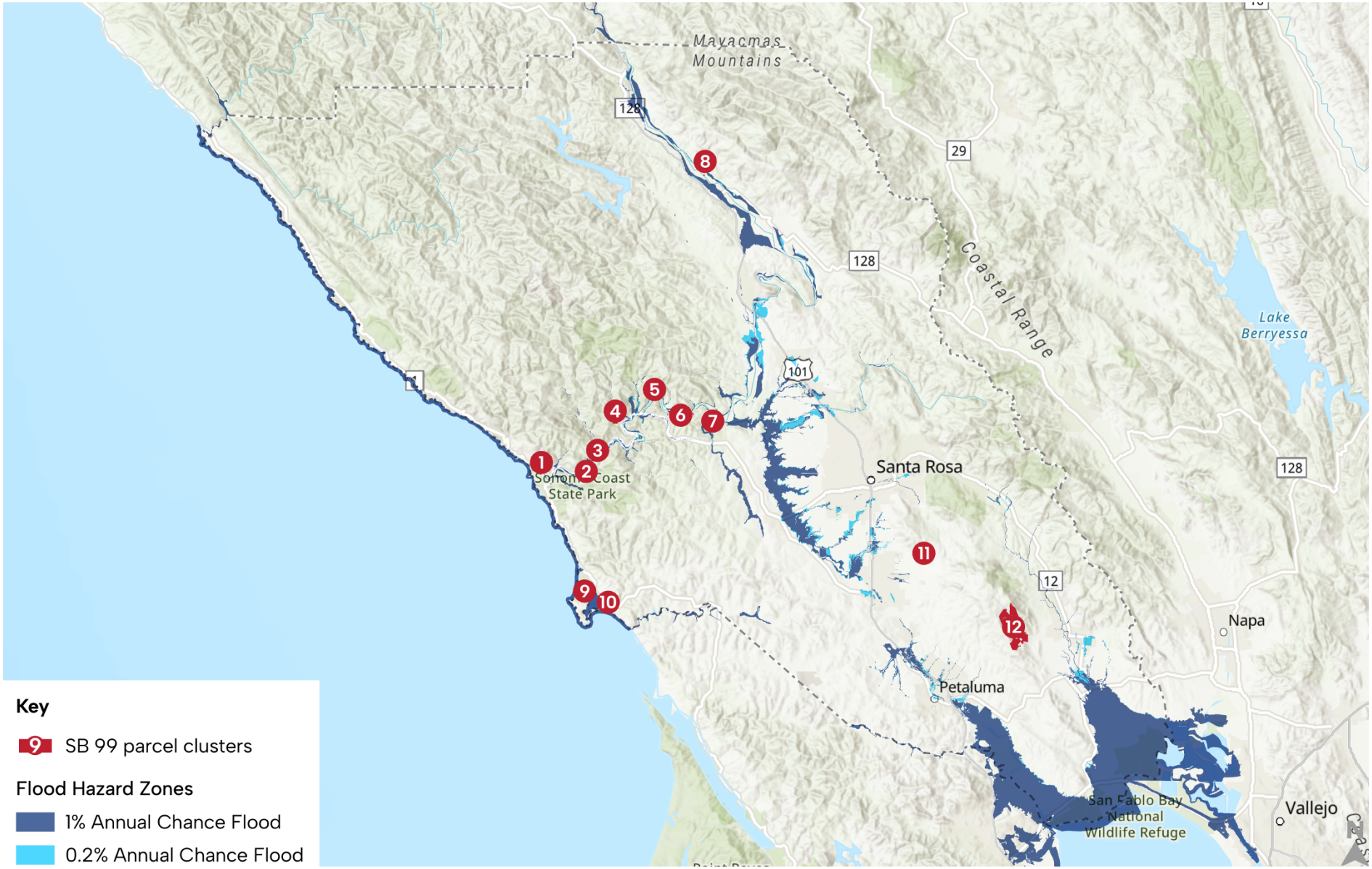

Figure 2

SB 99 Parcels with One Access/Egress Route and Flood Hazard Zones

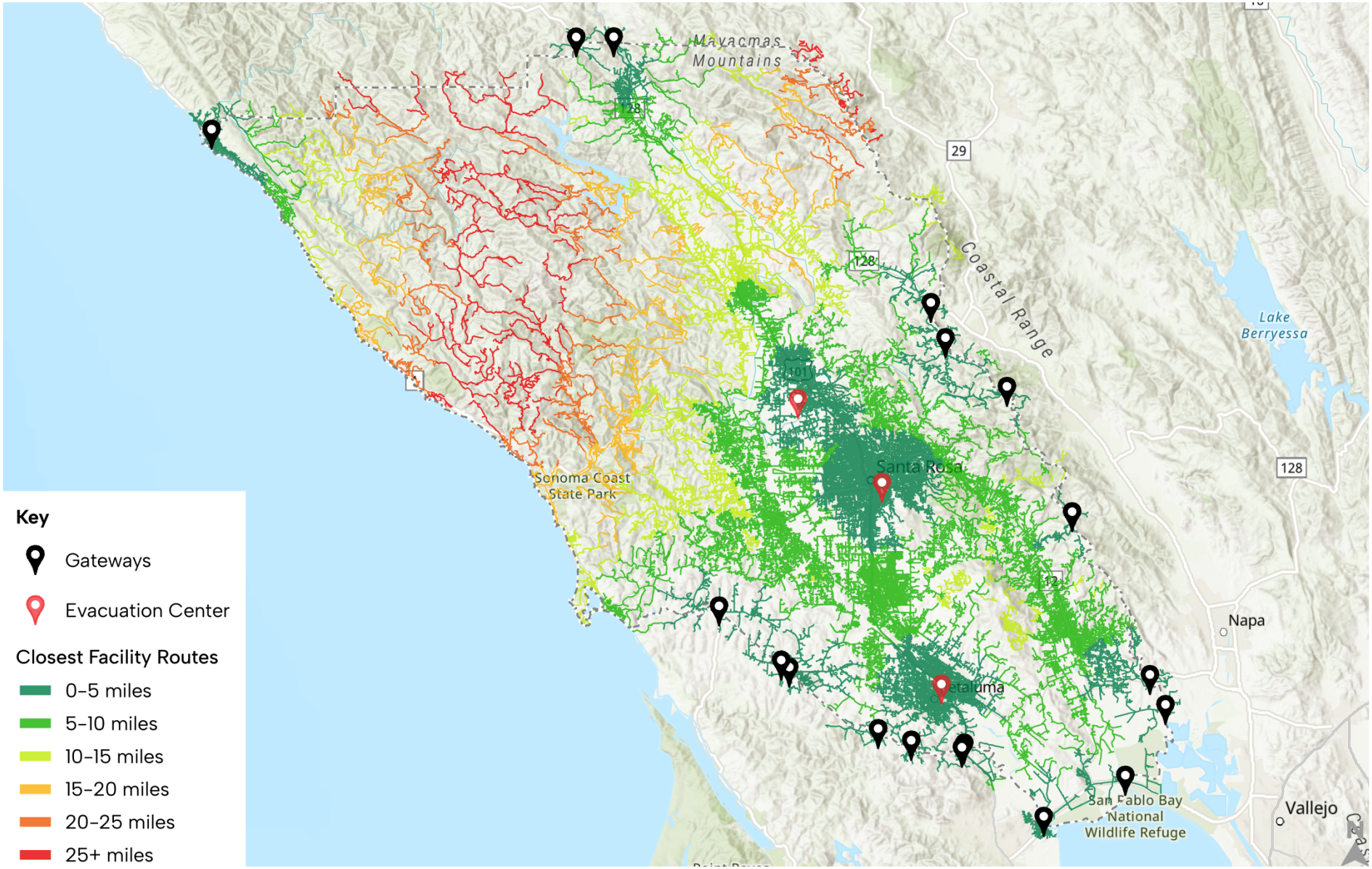

Figure 3

Distance to Evacuation Gateways

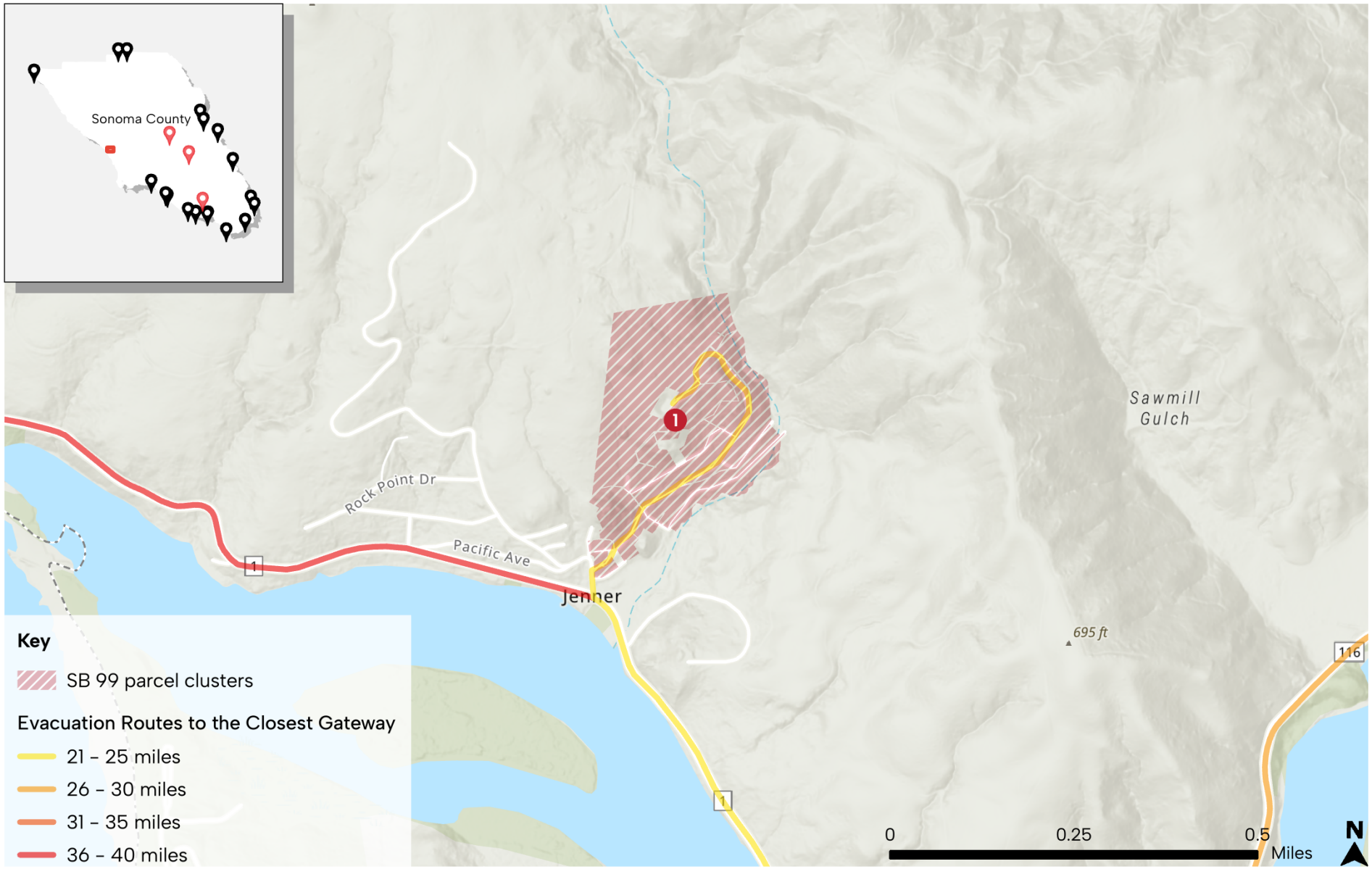

Figure 4-1

SB 99 Parcels with One Access/Egress Route
In Jenner, parcels along Balboa Avenue, a dead-end roadway

Figure 4-2

SB 99 Parcels with One Access/Egress Route
In Duncan's Mills, parcels along Freezeout Road, a dead-end roadway

Figure 4-3

SB 99 Parcels with One Access/Egress Route
In Duncan's Mills, parcels along Conifer Drive in Duncan's Mills

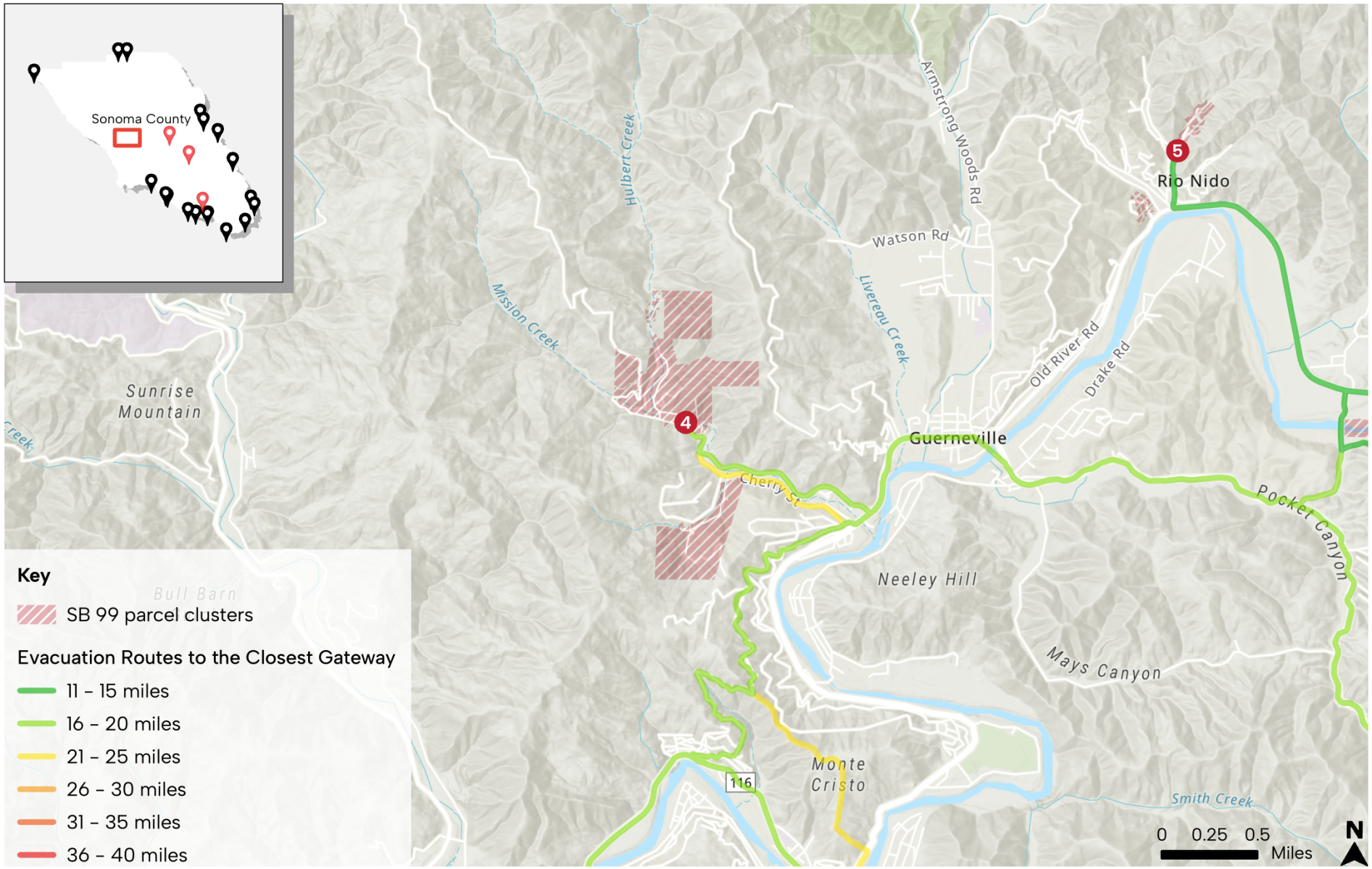

Figure 4-4

SB 99 Parcels with One Access/Egress Route
In Guernewood Park, parcels near Cherry Street and Old Cazadero Road/aking Hidden Valley Road

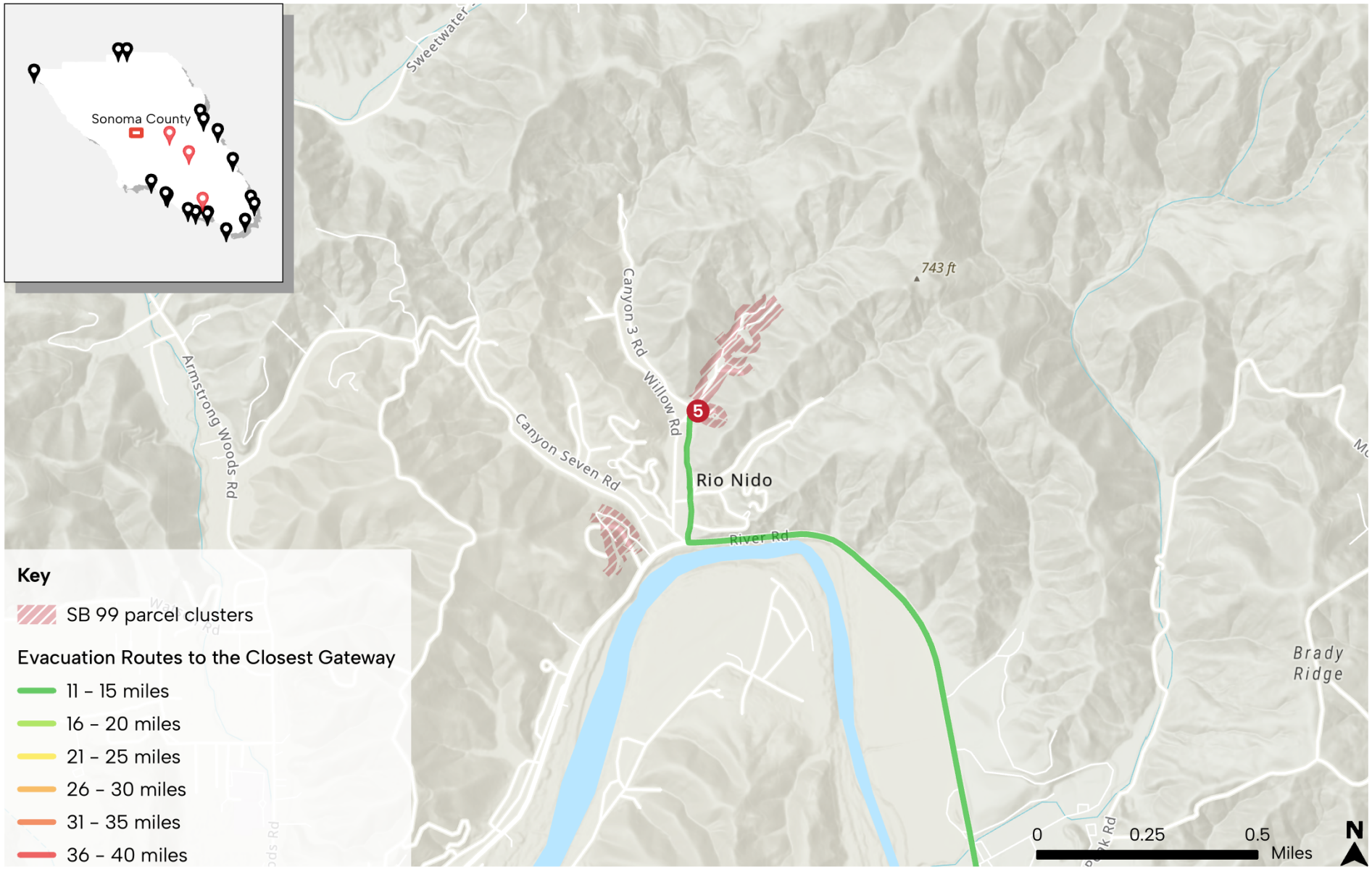

Figure 4-5

SB 99 Parcels with One Access/Egress Route
In Rio Nido, parcels along Eagle Nest Lane and Canyon Two Road

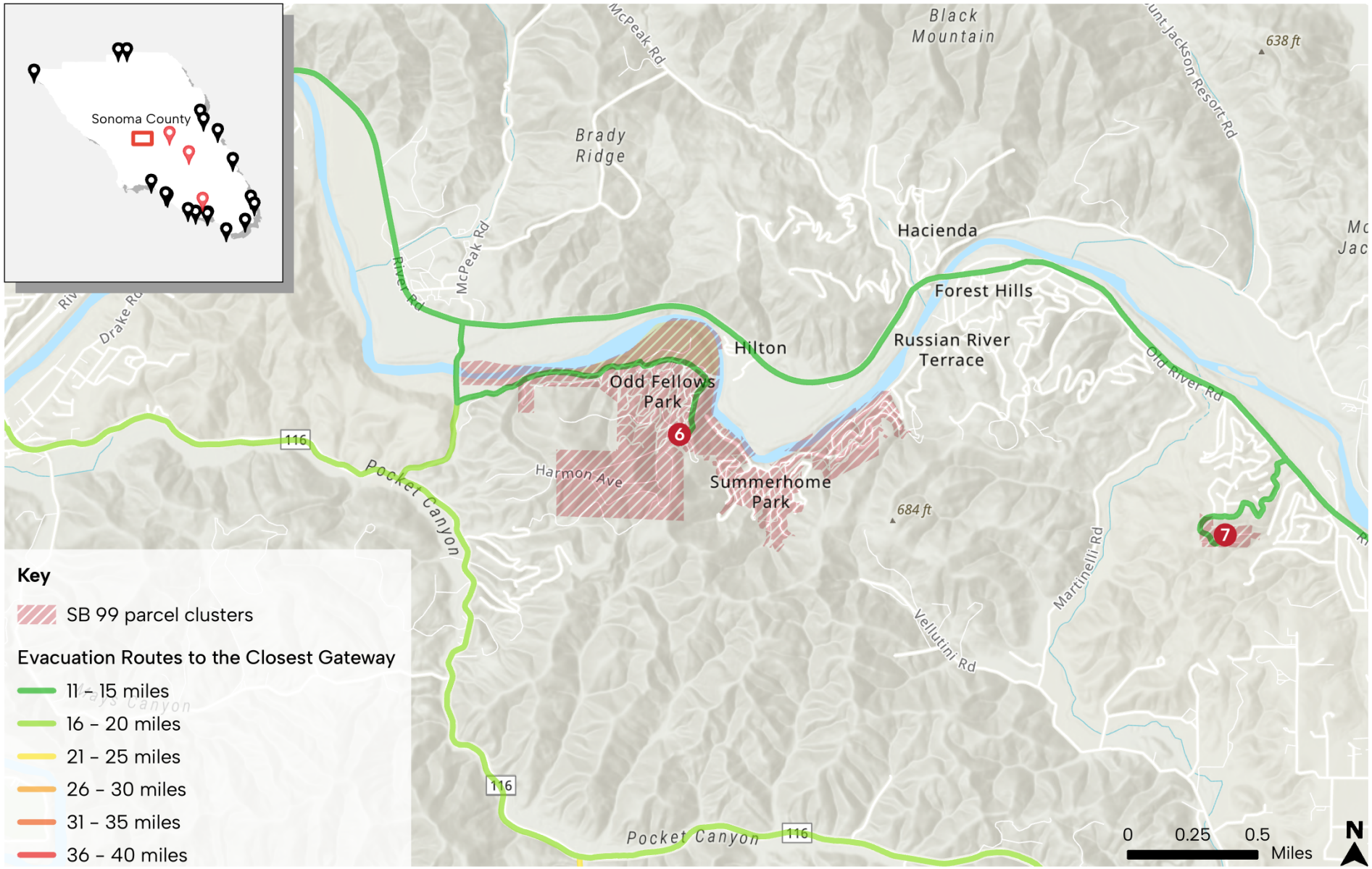

Figure 4-6

SB 99 Parcels with One Access/Egress Route
The Odd Fellows Recreation Club and Summerhome Park

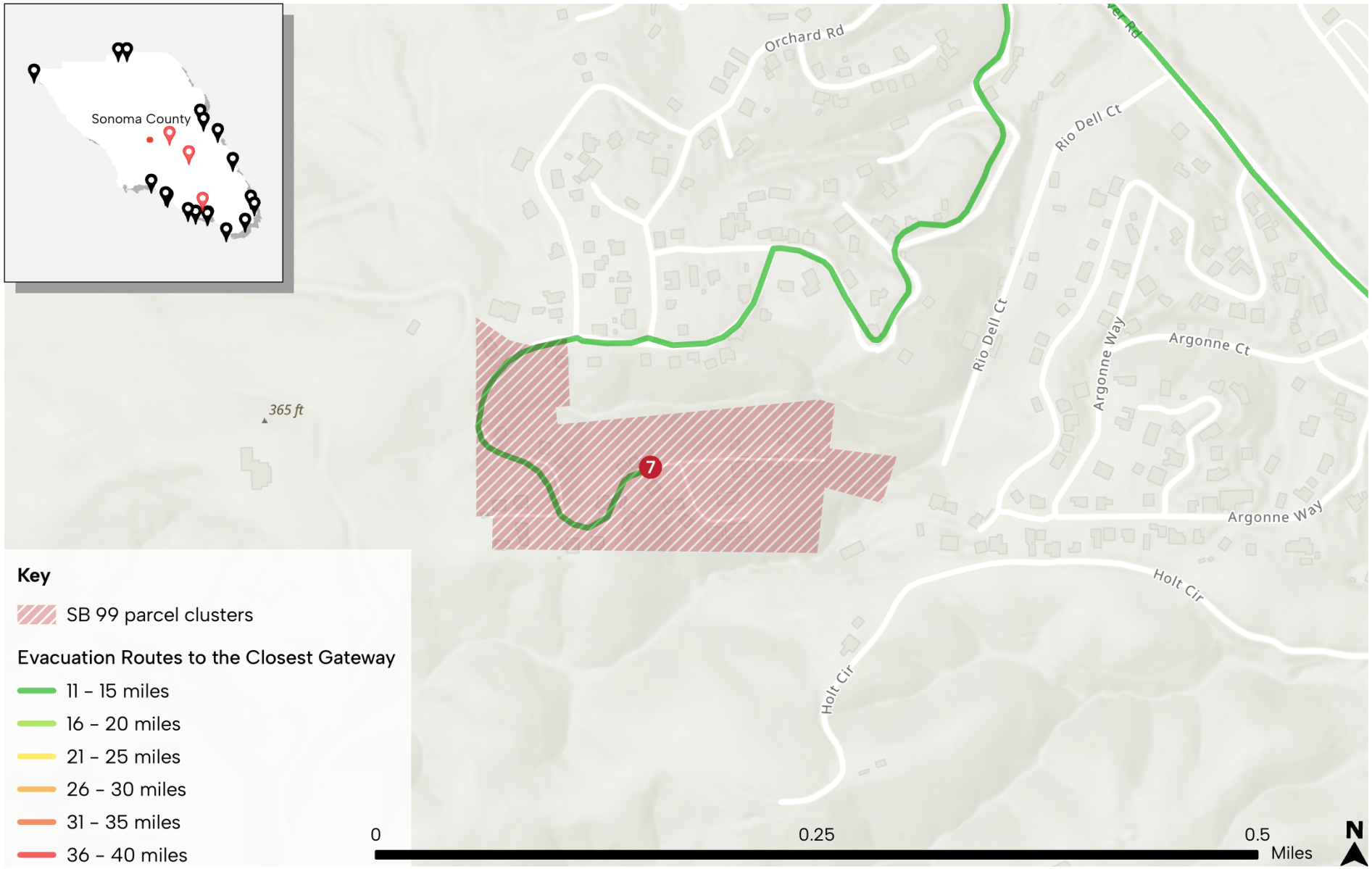

Figure 4-7

SB 99 Parcels with One Access/Egress Route
In Mirabel Park, parcels along Vila Road west of its intersection with Champs De Elysses

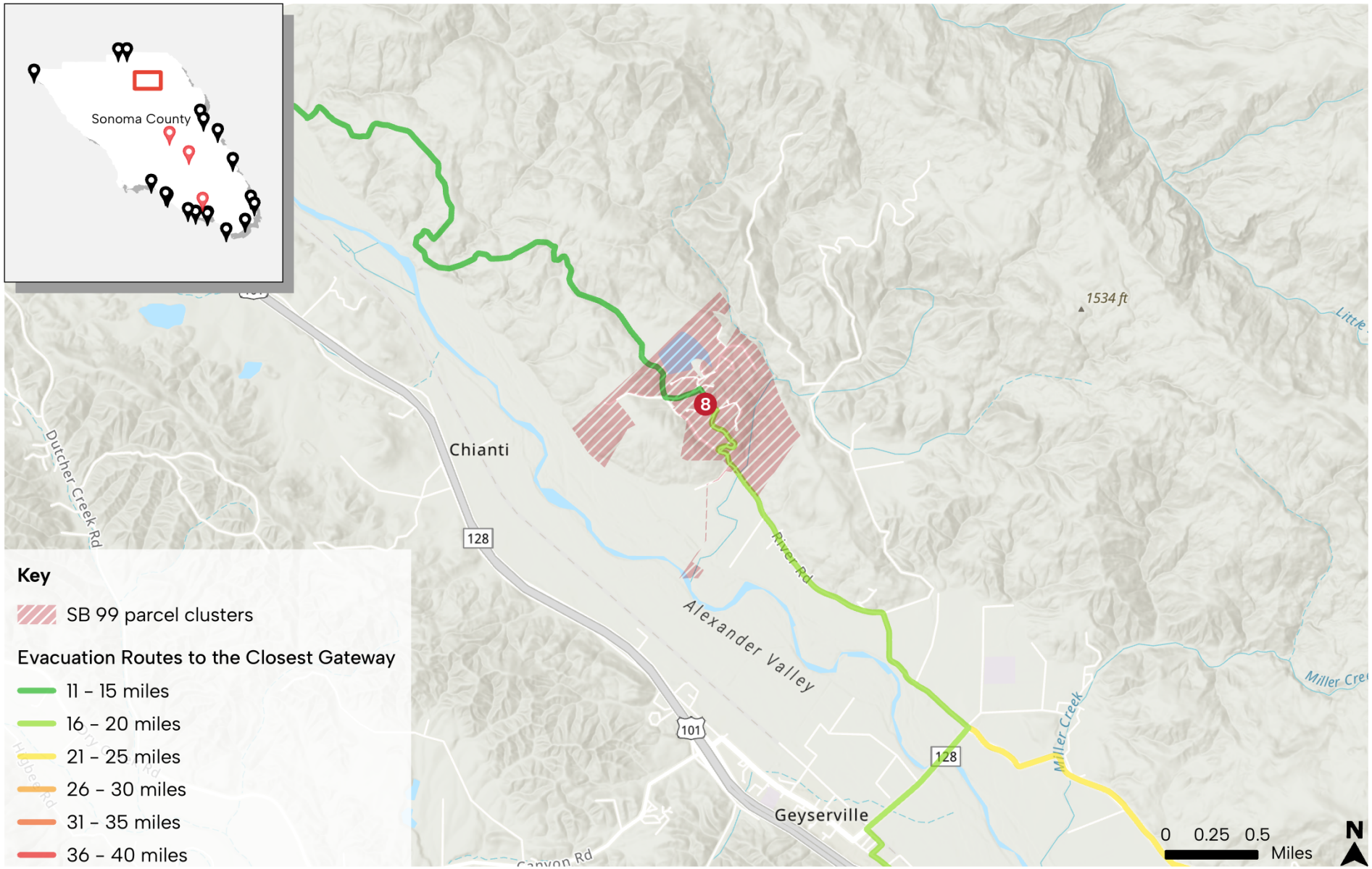

Figure 4-8

SB 99 Parcels with One Access/Egress Route
In Alexander Valley, a cluster of parcels near Vineyard Lake and Gill Creek

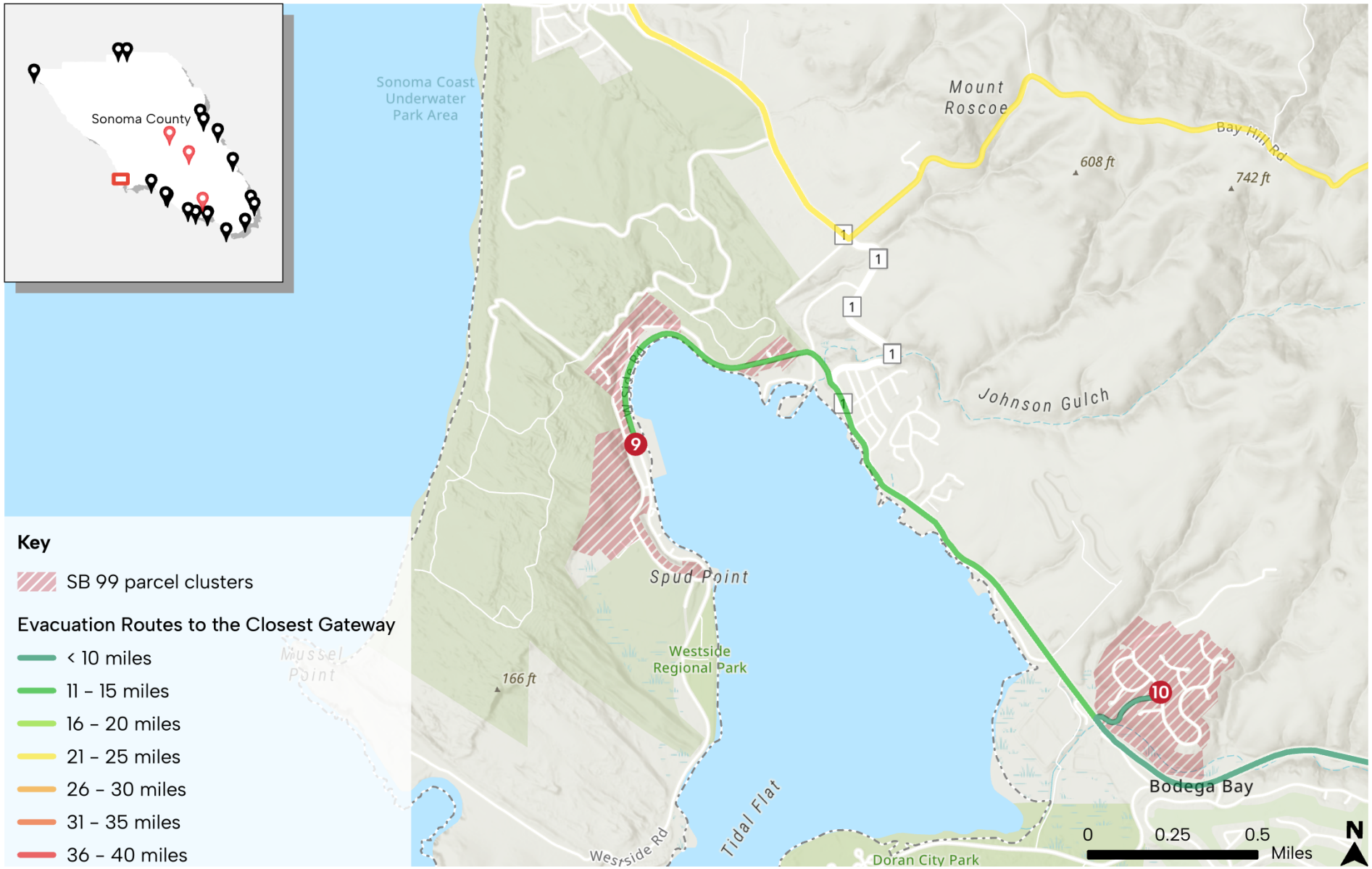

Figure 4-9

SB 99 Parcels with One Access/Egress Route
The west side of Bodega Bay

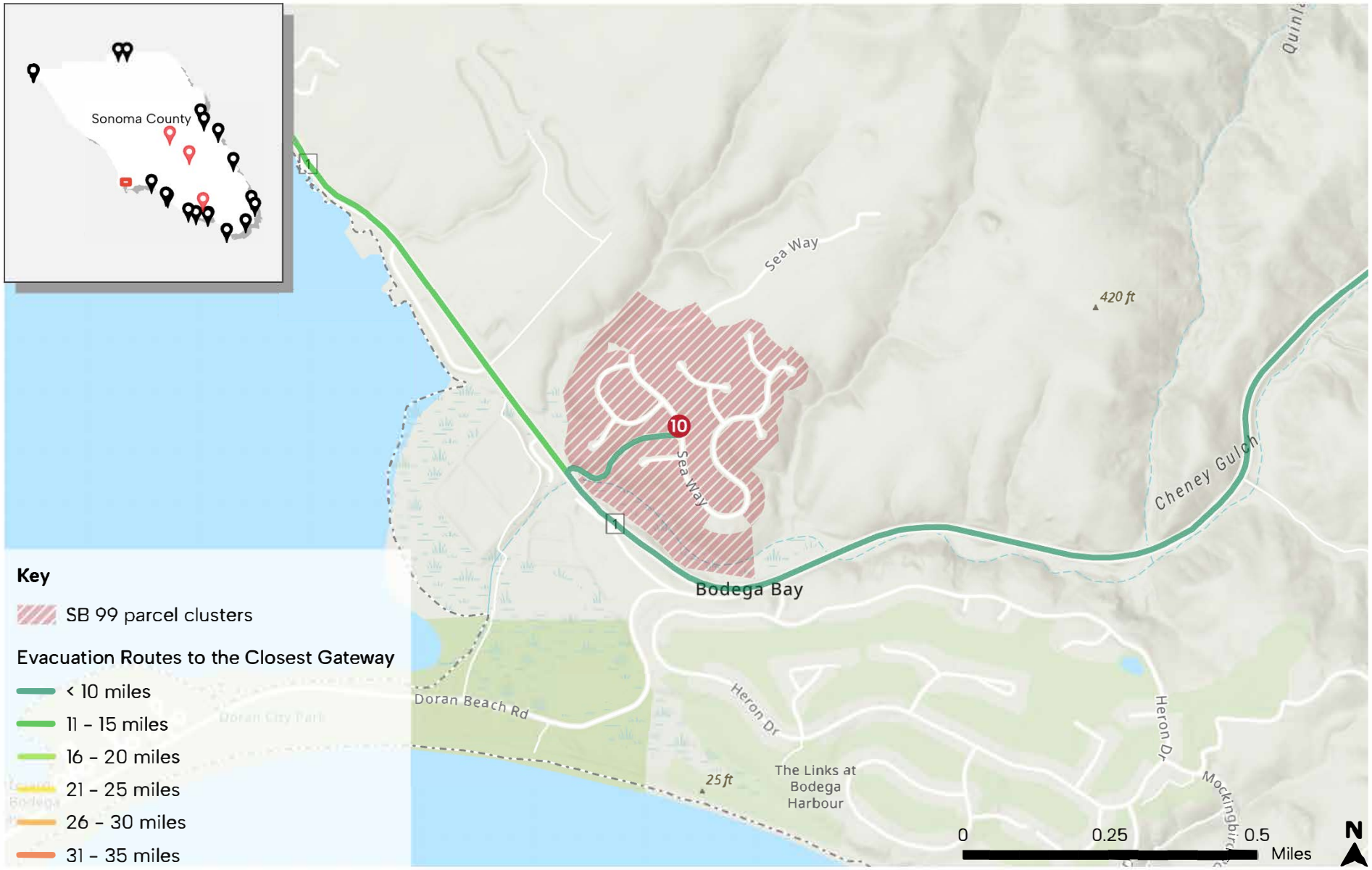

Figure 4-10

SB 99 Parcels with One Access/Egress Route The Bodega Harbour subdivision in Bodega Bay

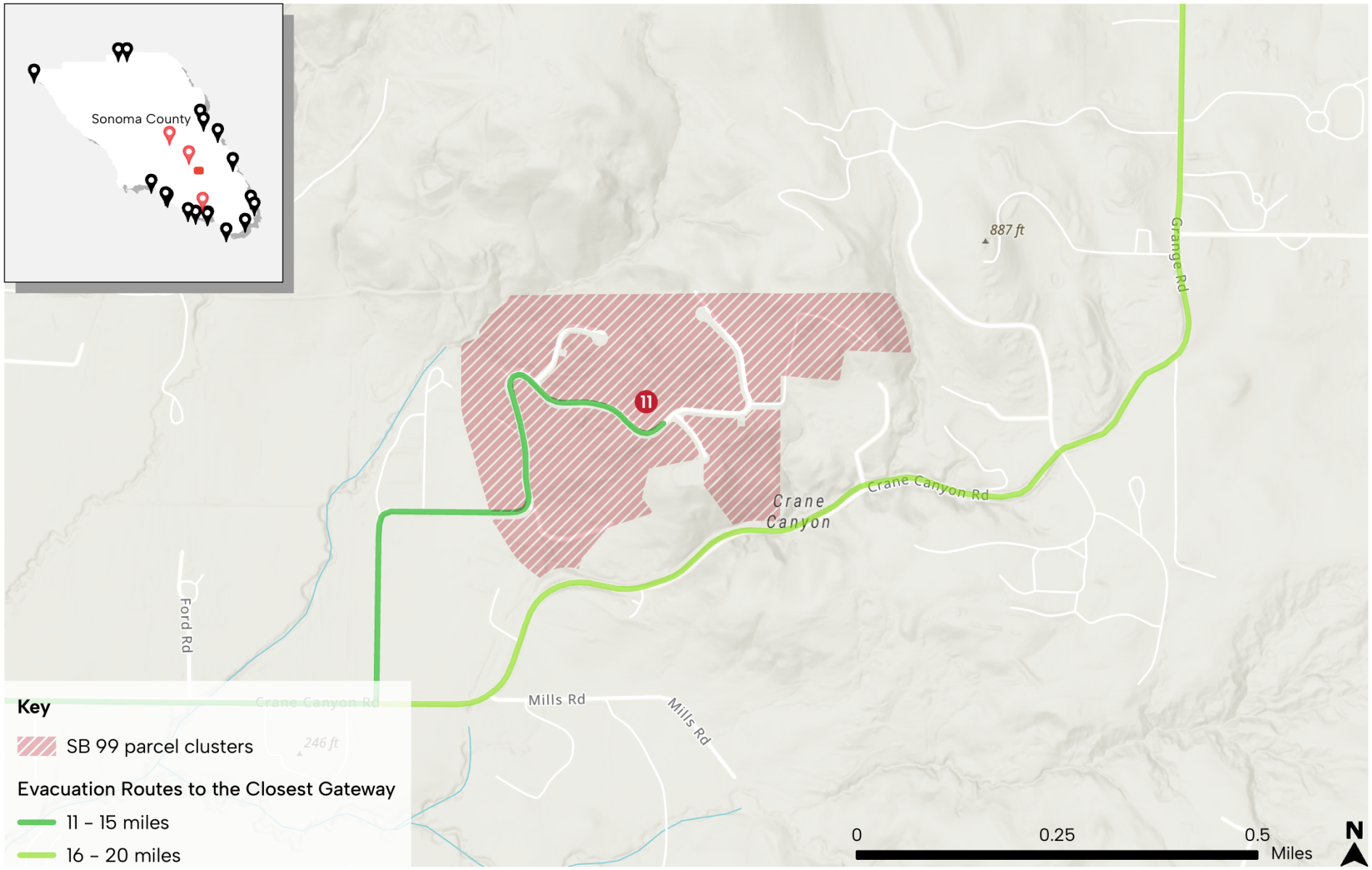

Figure 4-11

SB 99 Parcels with One Access/Egress Route
Near Rohnert Park and Crane Canyon, the parcels along Inverness Avenue

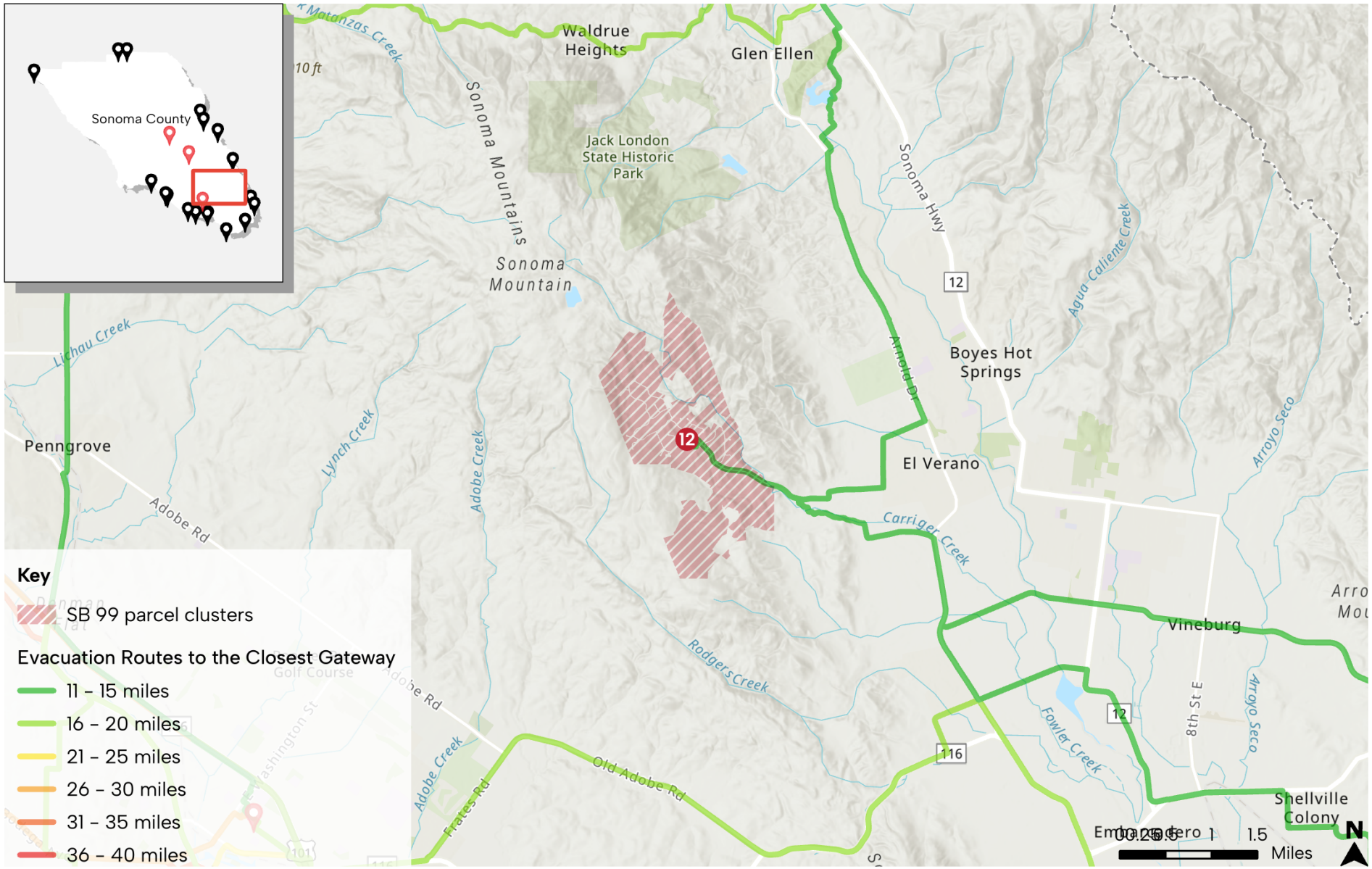

Figure 4-12

SB 99 Parcels with One Access/Egress Route
Parcels in Eastern Sonoma Mountain