VULNERABILITY ASSESSMENT

Marin Countywide Plan Safety Element Update

FINAL
JANUARY 2022

MARIN COUNTY
HOUSING & SAFETY ELEMENTS

ACKNOWLEDGMENTS

Thank you to the residents, community members, County staff and departments who gave their time and expertise to the development of this Vulnerability Assessment.

Marin County Board of Supervisors

Damon Connolly, District 1
Katie Rice, District 2
Stephanie Moulton-Peters, District 3
Dennis Rodoni, District 4
Judy Arnold, District 5

Marin County Community Development Agency

Jack Liebster, Advance Planning Manager
Leslie Lacko, Senior Planner

Marin County Staff Reviewers

Jeremy Tejirian
Julia Elkin
Veronica Pearson
Chris Choo
Hannah Lee

Prepared By

MIG

MIG Staff

Scott Davidson, Principal-in-Charge
Mark Hoffheimer, Project Manager
Barbara Beard, Safety Element Lead
Miranda Miller, Associate Planner
Lauren Scott, Associate Planner
Jose M. Rodriguez, GIS Mapping

This document contains blank pages to accommodate two-sided printing.

TABLE OF CONTENTS

Table of Contents i
List of Figures vi
List of Tables viii
Acronyms and Abbreviations ix
Executive Summary xi
Climate Change Hazards in Marin County xii
Populations and Asset Groups xv
Key Findings xv
Vulnerable Populations xvi
Vulnerable Infrastructure xvii
Vulnerable Key Services xviii
Vulnerable Buildings xix
Vulnerable Natural and Managed Resources xix
Vulnerable Economic Drivers xx
Next Steps xxi
1. Introduction 1
Purpose of the Vulnerability Assessment 1
Effects of Climate Change 2
Community Profile 2
Population 4
Economy 4
Infrastructure 4
2. Methodology 7
What Do These Terms Mean? 7
Step 1: Identify Exposure 8
Step 2: Analyze Sensitivity and Potential Impacts 9
Step 3: Evaluate Adaptive Capacity 10

Step 4: Conduct Vulnerability Scoring 12
Next Steps 12
Public Outreach and Engagement 12
Focus Groups 13
Community Workshops 13
Online Discussion Forum 13
Regulatory Setting 14
Guiding Documents 14
California Adaptation Planning Guide 14
California's Fourth Climate Assessment 15
Safeguarding California Plan 15
Marin County and Regional Planning Efforts 15
Data Sources 15
Scholarly Research 15
State and Federal Data 15
Local Data 16
3. Climate Change Exposures 17
Climate Scenarios 17
Climate Change Modeling Considerations 17
State of California Climate Change Hazard Resources 18
Climate Change in Marin 18
Drought 19
Hazard Profile 19
Disaster History 20
Probability of Future Events 23
Vulnerability 23
Extreme Heat 24
Hazard Profile 24
Disaster History 26
Probability of Future Events 27
Vulnerability 28
Flooding 30
Hazard Profile 30

Disaster History....35
Probability of Future Events....36
Vulnerability....37
Landslides, Debris Flows, and Post-Fire Debris Flows....38
Hazard Profile....38
Disaster History....40
Probability of Future Events....43
Vulnerability....43
Sea Level Rise....46
Hazard Profile....46
Sea Level Rise Modeling....46
Extent of Sea Level Rise....49
Disaster History....56
Vulnerability....61
Severe Weather....66
Hazard Profile....66
Disaster History....66
Probability of Future Events....67
Vulnerability....68
Subsidence....69
Hazard Profile....69
Disaster History....69
Probability of Future Events....69
Vulnerability....70
Wildfire....71
Hazard Profile....71
Disaster History....79
Probability of Future Events....79
Vulnerability....83
4. Selected Populations and Assets....89
Overlapping Assets....90
Data Limitations....90
Non-Climate Stressors....90

Selected Populations 91
Financially Constrained Households 91
Physically or Socially Isolated Communities 92
Persons with High Outdoor or Hazard Exposure 93
Low-Resourced Racial or Ethnic Minorities 93
Persons with Limited Mobility, Chronic Health Conditions, or Who May Be Dependent on Individuals or Services 94
Population Impacts 95
Selected Assets 101
Roads and Road Infrastructure 101
Airports 102
Transit Routes 102
Railroads 103
Energy Infrastructure 107
Water and Wastewater Infrastructure 107
Flood Control Infrastructure 108
Solid Waste Infrastructure 108
Key Services 110
Buildings 112
Natural and Managed Resources 113
Economic Drivers 124
Asset Impacts 125
5. Adaptive Capacity 149
Existing Resiliency Planning Efforts 149
Marin Countywide Plan (updated 2007) 149
Marin County Multi-Jurisdictional Local Hazard Mitigation Plan (2018, update anticipated 2023) 149
Climate Action Plan (updated 2020) 149
Marin Community Wildfire Protection Plan (2020) 150
Marin County Local Coastal Program Amendments (updated 2021) 150
Marin Ocean Coast Sea Level Rise Vulnerability Assessment (2016) 150
Marin Ocean Coast Sea Level Rise Adaptation Report (2018) 151
Marin Shoreline Sea Level Rise Vulnerability Assessment (2017) 151

Marin Operational Area Emergency Operations Plan (2014, update in process) 151
Marin Municipal Water District Local Hazard Mitigation Plan (draft released 2021) 152
Other Resiliency Planning Efforts 152
Summary of Adaptive Capacity Based on Current Planning Efforts 152
Adaptive Capacity Summary 153
6. Vulnerability Scoring 169
Vulnerable Populations 169
Vulnerable Infrastructure 170
Vulnerable Key Services 171
Vulnerable Buildings 172
Vulnerable Natural and Managed Resources 172
Vulnerable Economic Drivers 173
References 175
Glossary of Terms 179

Appendix A: Natural and Managed Resources Memo
Appendix B: Vulnerability Assessment Scoring Matrices

LIST OF FIGURES

Figure ES-1: California Adaptation Guide Vulnerability Assessment Method xi
Figure ES-2: Highly and Severely Vulnerable Populations xvii
Figure ES-3: Highly and Severely Vulnerable Infrastructure xviii
Figure ES-4: Highly and Severely Vulnerable Key Services xix
Figure ES-5: Highly and Severely Vulnerable Buildings xix
Figure ES-6: Highly and Severely Vulnerable Managed Resources xx
Figure ES-7: Highly and Severely Vulnerable Economic Drivers xx
Figure 1-1: Guiding Laws 1
Figure 1-2: Map of Marin County 3
Figure 2-1: California Adaptation Guide Vulnerability Assessment Method 8
Figure 3-1: Projected Annual Precipitation in Marin County 20
Figure 3-2: Projected Annual Average Maximum Temperature in Marin County 26
Figure 3-3: Projected Extreme Heat Days in Marin County 28
Figure 3-4: Marin County Flood Control & Water Conservation District Zones 33
Figure 3-5: FEMA Flood Zones 34
Figure 3-6: Landslide Hazard Areas 45
Figure 3-7: Southern Marin Coast 2030 Sea Level Rise and Storm Surge Expectations (Scenarios 1 & 2) 50
Figure 3-8: Northern Marin Coast 2030 Sea Level Rise and Storm Surge Expectations (Scenarios 1 & 2) 51
Figure 3-9: Southern Marin Coast 2050 Sea Level Rise and Storm Surge Expectations 52
Figure 3-10: Marin Coast 2050 Sea Level Rise and Storm Surge Expectations 53
Figure 3-11: Southern Marin Coast Long-term Sea Level Rise & Storm Surge Expectations 54
Figure 3-12: Northern Marin Coast Long-term Sea Level Rise & Storm Surge Expectations 55
Figure 3-13: Northern Study Area Sea Level Rise Scenarios 57
Figure 3-14: Southern Study Area Sea Level Rise Scenarios 58
Figure 3-15: Northern Study Area Sea Level Rise and 100-year Storm Surge Scenarios 59
Figure 3-16: Southern Study Area Sea Level Rise and 100-year Storm Surge Scenarios 60
Figure 3-17: Vegetation Map 74
Figure 3-18: Fuel Model Map 75
Figure 3-19: Wildland Urban Interface 77
Figure 3-20: Fire Hazard Severity Zones 80
Figure 3-21: FRA, SRA, and LRA 81
Figure 3-22: Fire Service Agency Jurisdictions 82
Figure 3-23: Historic Fire Perimeters from 1828 to 2020 84
Figure 3-24: Modeling Results for Average Fire Season Scenario 85
Figure 3-25: Modeling Results for Peak Fire Season Scenario 86
Figure 4-1: Population and Asset Categories 89
Figure 4-2: Transportation Facilities and Infrastructure 104
Figure 4-3: FireClear Evacuation Map for Inverness 105
Figure 4-4: Utilities Infrastructure and Facilities 109
Figure 4-5: Public Facilities 111
Figure 4-6: Schools 115
Figure 4-7: Protected Open Space 116
Figure 4-8: Watersheds 119

Figure 4-9: Streams 120
Figure 4-10: Historic Resources 122
Figure 6-2: Highly and Severely Vulnerable Populations 170
Figure 6-3: Highly and Severely Vulnerable Infrastructure 171
Figure 6-4: Highly and Severely Vulnerable Key Services 172
Figure 6-5: Highly and Severely Vulnerable Buildings 172
Figure 6-6: Highly and Severely Vulnerable Managed Resources 173
Figure 6-7: Highly and Severely Vulnerable Economic Drivers 173

LIST OF TABLES

Table 2-1: Impact Scoring 10
Table 2-2: Adaptive Capacity Scoring 11
Table 2-3: Vulnerability Scoring Matrix 12
Table 3-1: California Drought Incidents That Included Marin County, 1972-2021 21
Table 3-2: Marin County Flood Control & Water Conservation District “Flood Zones” 35
Table 3-3: Mass Movement Events in and near the MMWD Planning Area 41
Table 3-4: Sea Level Rise Projections for San Francisco, CA Region (NRC 2012) 47
Table 3-5: C-SMART Sea Level Rise & Storms Scenarios from CoSMoS 48
Table 3-6 BayWAVE Sea Level Rise Scenarios from CoSMoS 48
Table 3-7: Exposed Acres by Scenario (Bayside) 56
Table 4-1: Additional Population Characteristics for Low Resourced Ethnic Minorities 94
Table 4-2: Impacts to Selected Populations 96
Table 4-3: Miles of Trails in Marin County by Managing Agency 118
Table 4-4: National and State Parks in Marin County 123
Table 4-5: National Park Land Visitor Numbers 125
Table 4-6: Impacts to Infrastructure 126
Table 4-7: Impacts to Key Services 134
Table 4-8: Impacts to Buildings 138
Table 4-9: Impacts to Natural and Managed Resources 143
Table 4-10: Impacts to Economic Drivers 146
Table 5-1: Adaptive Capacity in Existing Plans and Reports 154
Table 5-2: Adaptive Capacity of Populations 155
Table 5-3: Adaptive Capacity of Infrastructure 157
Table 5-4: Adaptive Capacity of Key Services 159
Table 5-5: Adaptive Capacity of Buildings 161
Table 5-6: Adaptive Capacity of Natural and Managed Resources 164
Table 5-7: Adaptive Capacity of Economic Drivers 166
Table 6-1: Vulnerability Scoring Matrix 169

ACRONYMS AND ABBREVIATIONS

ACS: American Community Survey, U.S. Census Bureau
APG: Adaptation Planning Guide
ART: Bay Area Adapting to Rising Tides
CAP: Climate Action Plan
CalOES: California Office of Emergency Services
CEC: California Energy Commission
CalFire: California Department of Forestry and Fire Protection
CNRA: California Natural Resources Agency,
CWP: Countywide Plan (Marin's General Plan)
FEMA: Federal Emergency Management Agency
FIRM: Flood Insurance Rate Maps (FEMA)
GHG: Greenhouse Gas
ICS: California Incident Command System
IPCC: Intergovernmental Panel on Climate Change
LCP: Local Coastal Plan
MCEP: Marin Climate and Energy Partnership
MCM LHMP: Marin County Multijurisdictional Local Hazard Mitigation Plan
MCSTOPPP: Marin County Stormwater Pollution Prevention Program
MMWD: Marin Municipal Water District
NCDC: National Climatic Data Center
NIMS: National Incident Management System
NWS: National Weather Service
NFIP: National Flood Insurance Program
NWS: National Weather Service
NMWD: North Marin Water District
NOAA: National Oceanic & Atmospheric Administration
OPR: California Office of Planning and Research
RHNA: Regional Housing Needs Assessment
RPCs: Representative Concentration Pathways
SB: Senate Bill
SCWA: Sonoma County Water Agency
SEMS: California Standardized Emergency Management System
SFHA: Special Flood Hazard Areas (FEMA)

This page intentionally left blank.

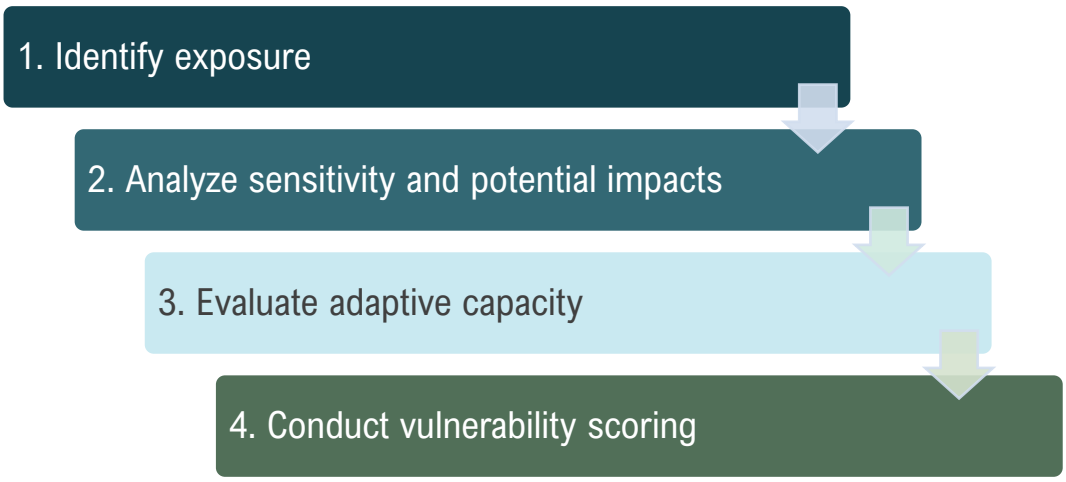
EXECUTIVE SUMMARY

This vulnerability assessment evaluates how the effects of climate change could be harmful to the people, infrastructure, buildings, key services, natural and managed resources, and economic drivers in the unincorporated areas of Marin County. It identifies the natural hazards in Marin County that climate change may affect, the damage that these hazards may cause to people and community assets, and the ability of people and assets to effectively anticipate and recover from these hazards.

Marin County is currently in the process of updating its Housing and Safety Elements, key parts of Marin County's General Plan, called the Countywide Plan (CWP). New state law (California Government Code § 65302(g)) requires Safety Elements to address climate adaptation and resiliency planning by January 1, 2022, as well as incorporate new information relating to flooding, sea level rise, wildfire hazards and resiliency planning. This Vulnerability Assessment is the first step in updating the Safety Element to include climate adaptation and resiliency planning. The Vulnerability Assessment focuses on environmental hazards worsened by climate change (drought, flooding, sea level rise, landslides, etc.). It does not address the other types of environmental hazards discussed in a Safety Element that would not be impacted by climate change such as seismic and geologic hazards and tsunamis.

The Vulnerability Assessment will be used to support analysis of climate change hazards in the Countywide Plan Safety Element and follows the recommended process in the 2020 California Adaptation Planning Guide 2.0 (APG) prepared by the California Governor's Office of Emergency Services (Cal OES).

FIGURE ES-1: CALIFORNIA ADAPTATION GUIDE VULNERABILITY ASSESSMENT METHOD



The APG suggests vulnerability assessments follow a four-step process, including the following steps:

1. **Identify Exposure.** This step identified environmental hazards that can be worsened by the effects of climate change and how these hazards are predicted to change under climate change conditions in Marin County. The hazards are identified and described, based on existing data sources such as California's Cal-Adapt database, and the local hazard mitigation plan and sea level rise planning documents. Marin County identified eight **climate change hazards** for this assessment, listed here and discussed in detail in Chapter 3. These hazards were selected because they are required components of a General Plan Safety Element and they are worsened by climate change impacts.

    - Drought
    - Extreme Heat
    - Flooding
    - Landslides, Debris Flows, and Post-Fire Debris Flows
    - Sea Level Rise
    - Severe Weather
    - Subsidence
    - Wildfire

2. **Analyze Sensitivity and Potential Impacts.** Following the guidance in the APG, the County identified **population groups and community assets that are sensitive to localized climate change effects**. This process identified 19 population groups and 43 assets. Sensitivity is the degree to which an entity would be affected by changing climate conditions based on the entity's exposure and sensitivity to a specific hazard. Impacts of applicable climate hazards to populations and assets are discussed in Chapter 4.
3. **Evaluate Adaptive Capacity.** Adaptive capacity is the ability to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. **The goal of this step is to characterize the identified populations and asset's ability to cope with climate impacts.** The current adaptive capacity of the County's populations and assets is discussed in Chapter 5.
4. **Conduct Vulnerability Scoring.** Climate vulnerability describes the degree to which natural, built (i.e., infrastructure, buildings), and human (i.e., population groups) systems are at risk of exposure to climate change impacts. Differences in exposure, sensitivity, and/or adaptive capacity affect an individual's or community's vulnerability to climate change. Vulnerability can increase or decrease because of physical (built and environmental), social, political, and/or economic factor(s). **This step uses the identified impact and adaptive capacity (scores) for community assets and population groups, to determine vulnerability, which is summarized in Chapter 6.**

Climate Change Hazards in Marin County

Existing reports and datasets for climate change-related hazards were reviewed to assess which exposures apply to Marin County. Full discussion of each hazard is included in Chapter 3, with key findings and facts summarized below.

Drought

- Projected annual rainfall is expected to increase from 34.3 inches to 36.1 inches by mid-century
- Precipitation will continue to exhibit high year-to-year variability - “booms and busts” - with very wet and very dry years
- 75% of Marin Municipal Water District water comes from rainfall in Mt. Tamalpais watershed
- Attempts to adapt to drought conditions were seen during the drought of 2021, where ranchers in Marin reduced their herd size and imported water by truck to keep the remaining animals alive
- Scientists expect climate change will cause more droughts that last longer and are more intense, compared to historical norms

Extreme Heat

- Average temperatures and the number of extreme heat events have increased in Marin County in recent years
- There were 0.2 heat waves in an average year in Marin County from 1950 to 2005
- By the end of the century, most of the region will average six heat waves a year, with extreme heat events extending seasonally into spring and fall
- Extreme heat creates a serious public health threat especially to vulnerable populations, including people with disabilities or chronic health conditions, seniors and children, and outdoor workers
- Heat can also impact energy services, both due to the demand from users and stress on the infrastructure
- Northern Marin County is likely to see greater increases in annual average maximum temperatures due to climate change at a faster rate than southern portions of the County

Flooding

- Flood disasters have occurred every few years since the middle of last century
- All of Marin’s watersheds are small and largely prone to flash flooding
- Flash floods often affect populated areas of Marin’s cities and towns and strike with little warning and are accompanied by high velocity flow
- When flooding occurs in Marin County, depths can commonly reach up to 2 feet in streets and sidewalks.
- Flooding can cause bank erosion and landslides, impacting homes, businesses, infrastructure, and natural ecosystems
- The likelihood of flood events occurring in the future is high with the projected increase in extreme precipitation events, and sea level rise, exacerbated by poor drainage conditions

Landslides, Debris Flows, & Post-Fire Debris Flows

- Landslides are a part of natural geologic processes and have impacted both private and public property in various areas throughout Marin County since development began
- The susceptibility of hillside and mountainous areas to non-earthquake induced landslides depends on variations in geology, topography, vegetation, and weather
- Wildfire can significantly alter the hydrologic response of a watershed to the extent that even modest rainstorms can produce dangerous flash floods and debris flows
- In Marin County, renewed and potentially widespread landslide activity will most likely occur during or after future periods of prolonged or intense rainfall

Sea Level Rise

- The California coast has already seen a rise in sea level of four to eight inches over the 20th century due to climate change
- Sea-level rise poses the greatest risk during coastal storms which increase tidal elevations.
- Rising sea levels submerge low-lying areas, creating direct impacts from inundation and facilitating the reach of high tides and storm surge further inland, impacting even more of the County's natural and built resources
- Sea level rise will affect Marin's coastal communities, infrastructure, and ecosystems
- The Marin Ocean Coast Sea Level Rise Vulnerability Assessment and Marin Shoreline Sea Level Rise Vulnerability Assessment estimate that by 2100 around 7,000 acres, 9,000 parcels, 10,000 buildings and 120 miles of roads throughout Marin County will be exposed to sea level rise and 100-year storm events

Severe Weather

- Severe weather includes strong winds, hail, and lightning, usually caused by intense storm systems, although types of strong winds can occur without a storm
- Severe winter storms occur every year, but those leading to federally declared disasters seem to occur about every 10 years – often in clusters and associated with high tides and/or atmospheric rivers
- Climate change increases the variance of weather patterns which means the occurrence of events at the edges of the observed range increases
- The entire county is susceptible to storms and damage from heavy wind and rain. The coastal and mountainous areas are particularly susceptible to wind, although wind has caused damages throughout the county
- Coastal areas are susceptible to storm surge and high tides. Flash flood primarily affects interior valleys, although there are some flashy coastal streams

Subsidence

- Land subsidence is a gradual settling or sudden sinking of the Earth's surface due to removal or displacement of subsurface earth materials
- Many shoreline properties in Marin County are built on fill and mud. As underlying soils become more saturated under sea level rise conditions, they consequently become more vulnerable to increasing rates of subsidence
- Subsidence is an ongoing issue in the low-lying exposed areas of many communities. Roadways throughout the County along the shoreline, notably US Highway 101, and roads in lower Paradise Cay, already experience subsidence. Subsidence will exacerbate the depths of sea level rise flooding.
- Subsidence can severely impact public facilities and infrastructure as well as private development in areas where it occurs through the damage or compete failure of underground utilities, damaged building or utility infrastructure foundations, damaged roadways

Wildfire

- Approximately 60,000 acres—18% of the County's land area—falls within the wildland urban interface (WUI) where residences are adjacent to or intermixed with open space and wildland vegetation
- A countywide assessment revealed that nearly 313,000 acres (approximately 82% of the total land area of the county) are ranked as having moderate to very high fire hazard severity zone ratings
- Many of the access roads within the WUI are narrow and winding and are often on hillsides with overgrown vegetation, making it even more difficult and costly to reduce fire hazards, fight wildfires, and protect homes and lives in these areas
- A warmer climate will bring drier winters, higher spring temperatures, and early snowmelt. Combined with drought conditions, this leads to drier soils in early summer, drier vegetation, and an increase in the number of days in the year with flammable fuels, all which further raise the likelihood of fires

Populations and Asset Groups

The County selected the populations and assets listed below to analyze in this Vulnerability Assessment based on guidance from the APG and Marin's demographics and the built infrastructure. Chapter 4 identifies, defines, and summarizes climate hazard impacts to 19 populations and 43 assets. The adaptive capacity of the populations and assets is discussed in Chapter 5.

Overall Population Categories	Overall Asset Categories
• Financially Constrained Households • Isolated and Rural Communities • Persons with High Outdoor or Hazard Exposure • Persons with Limited Resources • Persons with Limited Mobility, Chronic Health Conditions, or Who May Be Dependent on Individuals or Services	• Roads and Road Infrastructure • Airports • Transit Routes • Railroads • Energy Infrastructure • Water and Wastewater Infrastructure • Flood Control Infrastructure • Key Services • Buildings • Natural and Managed Resources • Economic Drivers

Key Findings

The significant vulnerabilities within each of the six main categories (populations, infrastructure, key services, buildings, natural and managed resources, and economic drivers) in Marin County were evaluated and the findings are summarized below.

Populations and assets that were ranked as highly (V4) or severely (V5) vulnerable to climate change hazards are shown for each of the six categories. All communities and assets in Marin County are vulnerable to climate change impacts to some extent. A minimal (V1) or low (V2) vulnerability score is not intended to imply a community or asset in question is not vulnerable to a climate change exposure, but that the population or asset in question is less vulnerable to the exposure relative to other populations and assets in the County due to underlying socioeconomic factors, the influence of geography, adaptive capacity, and other factors. It should also be noted that the vulnerability scoring system offers just one possible way to rank vulnerability to climate change impacts.

- V1: Minimal vulnerability
- V2: Low vulnerability
- V3: Moderate vulnerability
- V4: High vulnerability
- V5: Severe vulnerability

Grey squares in the tables mean that a climate hazard exposure is not applicable to the population or asset, and blank squares indicate that the hazard is applicable, but the score is

less than V4 (highly vulnerable). While many populations and assets have identified a high impact from certain hazards, in certain cases solutions are available or have been identified and funding is secured, which increases the adaptive capacity score therefore resulting in a lower vulnerability score. For instance, Marin County has identified bike infrastructure impacted by sea level rise, such as the Bothin-crossing bike path, and is pursuing funded adaptation solutions to protect that infrastructure resulting in a high impact score but high adaptive capacity score.

Additionally, populations and assets were viewed at a county-wide level understanding that there are regional differences in impact, adaptive capacity, and vulnerability.

The full impact, adaptive capacity, and vulnerability scores for each population and asset are included in Appendix B.

Vulnerable Populations

Exposure to extreme heat, flooding, and wildfire leaves many populations highly or severely vulnerable due to the impacts of exposure and lower levels of adaptive capacity. Adaptation to these hazards may not be possible or financially feasible for some populations.

People who have limited financial resources or who do not own their home are more limited in their emergency response capacity and therefore vulnerable to climate hazards. Households in poverty (11,256 households) have a higher vulnerability to climate hazards than low-income households (64,171 households) because of the differences in financial resources between the two household categories (low-income households having more assets than households in poverty).

Language barriers and lower levels of social capital, or the network of relationships an individual or population has, can increase vulnerability. Many communities in Marin may be unable to receive emergency notifications, may not be able to evacuate, or not able to evacuate quickly due to financial, social, or infrastructure limitations.

People with disabilities, the elderly, and others who are not as mobile face challenges in preparing for an event and evacuating and thus are considered highly vulnerable to climate hazards. Additionally, persons with disabilities, chronic illnesses, or seniors may rely on medical equipment that cannot be transported easily and would likely need assistance evacuating.

Marin’s outdoor workers and houseless populations are highly vulnerable to many different climate hazards due to their high outdoor exposure and lack of alternative options that would reduce impacts of climate hazards.

FIGURE ES-2: HIGHLY AND SEVERELY VULNERABLE POPULATIONS

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Populations								
Low-Income Households	_	V5	V5	V5	V5	V4		V4
Households in Poverty	_	V5	V5	V5	V5	V5	V4	V5
Cost-Burdened Households	_					V4		
Overcrowded Households	_				_			
Renters	_		V4	V4	_		_	
Persons Living on Single Access Roads			V4	V5				V5
Mobile Homes			V4			V4		V4
Persons Without Access to Transportation or Telecommunications	_	V4	V5	V5		V5		V5
Linguistically Isolated Communities	_		V4		_		_	
Low-Resourced Racial or Ethnic Minorities	_	V4	V4		_	V4	_	
Outdoor Workers	V5	V5	V4	V4		V5	_	V5
Healthcare Workers, First Responders, and Protective Service Occupations	_	V4	V4			V4	_	V4
Houseless Population	_	V5	V5	V4		V5	_	V5
Children	_	V5			_		_	V5
Persons with Disabilities	_	V4	V4	V4			_	V5
Persons with Chronic Health Problems	_	V4					_	V5
Senior Citizens	_	V4						V5
Persons Living Alone	_				_			V4

Note: Grey squares in the tables mean that a climate hazard exposure is not applicable to the population or asset, and blank squares indicate that the hazard is applicable, but the score is less than V4 (highly vulnerable).

Vulnerable Infrastructure

Many of the infrastructure networks (roads, water systems, wastewater systems, electricity grid) in Marin County are vulnerable to climate change hazards due to their expensive and complex nature, high exposure to hazards, and lack of alternative options.

Key infrastructure, including roads, electrical lines, and communication facilities, traverse through areas at risk for hazards, increasing the chance of disruption or impact. Major roadways throughout the county are vulnerable to landslides, wildfires, inland flooding, and sea level rise which can cause them to close or become impassable, isolating residents and business owners. Because these roads are critical for access to various communities and neighborhoods, any damage or closure can effectively isolate these communities, potentially creating severe health and safety risks. Single access roadways are severely vulnerable to wildfire and flooding, which can block or inundate single access roads, making them impassable. The railroad line in Marin is highly vulnerable to sea level rise impacts.

FIGURE ES-3: HIGHLY AND SEVERELY VULNERABLE INFRASTRUCTURE

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Infrastructure								
Airports	_	_	V5	_	V5			_
Bicycle Routes	_	_						
Bus Routes	_	_	V4	V5				
Major Roads and Highways	_	_	V4	V5	V4			V4
Single Access Roads	_	_	V4	V5		V4		V4
Evacuation Routes	_	_	V5	V5	V5	V4		V5
Railroads	_	_	V5	_	V5			_
Bridges and Tunnels	_	_		V4		_	_	
Electrical Substations	_	V4	V5	V4	V5	V4	_	V5
Electrical Transmission and Distribution Lines	_	V4	V4	V5	V5	V4		V5
Power Plants	_	_	V4	_	_		_	_
Oil and Gas Infrastructure	_	_		V4				V4
Water and Wastewater Infrastructure		_	V4	V5	V5			V4
Flood Control Infrastructure	_	_	V4		V4	V4	_	_
Solid Waste Infrastructure	_	_	V4	_			_	_

Grey squares in the tables mean that a climate hazard exposure is not applicable to the population or asset, and blank squares indicate that the hazard is applicable, but the score is less than V4 (highly vulnerable).

Vulnerable Key Services

Water and wastewater services are vulnerable key services. Water services are highly dependent on surface and groundwater supplies, whose amount or quality can be depleted by drought. The facilities that support this service can be damaged or destroyed by flooding, landslides, sea level rise, severe weather, and wildfires. Electricity service is also highly vulnerable because it is highly dependent on electrical transmission lines and substations functioning properly. Few feasible alternatives exist to adapt key services to climate hazards due to their complexity (integration within the system) and the coordination and cost necessary to redesign or relocate the infrastructure.

Emergency and communication services are key services but because the physical infrastructure investment is less than for other services, and emergency services are based on personnel and staffing rather than physical infrastructure, these services are considered more adaptable than the water, wastewater, and electricity services.

Climate-smart emergency management activities will likely require an increased commitment of staff time and expertise, materials and equipment, and other resources. Multi-jurisdictional emergency management efforts can allow for communities to effectively share resources but ensure that there is also a sufficient supply if all participating communities are simultaneously affected by a major disaster.

FIGURE ES-4: HIGHLY AND SEVERELY VULNERABLE KEY SERVICES

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Key Services								
Emergency Services	_	V4	V4			V4		V4
Communication	_			V4	V4		_	V4
Energy Delivery	_	V4		V4	V4	V4		V4
Water and Wastewater Service	V5	_	V4	V4	V5			V5

Grey squares in the tables mean that a climate hazard exposure is not applicable to the population or asset, and blank squares indicate that the hazard is applicable, but the score is less than V4 (highly vulnerable).

Vulnerable Buildings

Structures can be retrofitted, upgraded, or elevated to prevent damage from climate hazards, but these solutions can be expensive or infeasible for property owners to complete. A building's location may also mean increased hazard exposure as climate events become more frequent. Areas of concentrated residential development are highly or severely vulnerable to several hazards. However, some homeowners, especially low-income or cost-burdened households, may not have the appropriate disaster insurance or the ability to pay to fix structure damage. Chronic climate change hazards could cause buildings to become permanently uninhabitable.

FIGURE ES-5: HIGHLY AND SEVERELY VULNERABLE BUILDINGS

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Buildings								
Areas of Concentrated Residential Development	_	_	V5	V5	V5			V5
Community Centers	_	_	V4	V4	V4		_	V5
Evacuation and Homeless Shelters	_	V4	V4		_		_	V4
Government Buildings and Sites	_	_		V4			_	V4
Hazardous Materials Facilities	_	_				_	_	
Historic Buildings and Facilities	_	_	V4	V5	V4	V4		V5
Key Employment or Commercial Centers	_	_	V4	_				V4
Medical Care Facilities	_	_		_			_	V4
Public Safety Buildings	_	_		V5		_	_	V4
Schools	_	V4		V5			_	V5

Blank squares in the tables mean that a climate hazard exposure is not applicable to the population or asset, and gray squares indicate that the hazard is applicable, but the score is less than V4 (highly vulnerable).

Vulnerable Natural and Managed Resources

Aquatic ecosystems are highly susceptible to damage from drought and extreme heat in the inland areas of the county and sea level rise in the coastal areas. Drought can lower water levels and water quality, and stress plants and animals. In coastal areas, sea level rise can cause salt water to infiltrate freshwater systems further inland and can damage tidal wetlands. Higher temperatures and lack of water from drought or decreases in fog can stress Marin's forests and make them more susceptible to damage from pest infestations and wildfires. Farms, orchards, and vineyards are vulnerable to drought, extreme heat, and wildfire which can interrupt or completely cease operations depending on severity.

Marin's managed natural resources, such as hiking and biking trails, state and national lands, and historic and cultural resource areas are also vulnerable. The draw of these managed assets is dependent on the aesthetics and quality of the County's natural resources which are highly exposed to hazards.

FIGURE ES-6: HIGHLY AND SEVERELY VULNERABLE MANAGED RESOURCES

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Natural and Managed Resources								
Ecosystems	V5				V4		_	V4
Beaches and Coastal Dunes	_	_	V5		V5	V4	_	_
Endangered, Threatened, and Sensitive Species	V5	V4			V4	_	_	V4
Marshes, Wetlands, and Streams	V5		V4		V4		_	
Farms, Orchards, and Vineyards	V5	V5			_		_	V5
Hiking and Biking Trails	_	_		V4			_	V4
Scenic Views or Ridgelines	_	_	_		_	V4	_	V5
Historic and Cultural Resource Areas	_	_	V5		V4	V4	_	V5
State and National Parks, Forests, Wilderness Areas, and Other Protected Locations	V4			V4		V4	_	V5

Blank squares in the tables mean that a climate hazard exposure is not applicable to the population or asset, and gray squares indicate that the hazard is applicable, but the score is less than V4 (highly vulnerable).

Vulnerable Economic Drivers

Of the economic drivers discussed in this Vulnerability Assessment, farms, orchards, vineyards, outdoor recreation, and state and national protected lands have a high level of vulnerability to a number of different exposures. Marin County's natural resources, open space, and parks draw in many day visitors each year. In 2018 Marin County averaged between 12 to 14 million annual visits and the traveler spending exceeded $743 million while agriculture in Marin contributes over $100 million annually to the local economy.

While specific protective actions can be taken to reduce the risk of climate hazard impacts, these economic drivers are heavily reliant on natural resources which face high hazard impacts and have low adaptive capacities. The natural beauty of outdoor recreation areas and state and national protected lands can be diminished by climate hazards. While they may have the ability to recover from individual climate hazards, if climate change hazards become chronic, some may lose their current value to the public and management agencies may be unable to continue operations due to a lack of alternatives.

FIGURE ES-7: HIGHLY AND SEVERELY VULNERABLE ECONOMIC DRIVERS

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Economic Drivers								
Farms, Orchards, and Vineyards	V5	V5			_	V4		V5
Major Employers	_				_	_	_	
Outdoor Recreation	V4	V4			V4	V4		V5
State and National Protected Lands	V4	V4			V4	V4		V5

Blank squares in the tables mean that a climate hazard exposure is not applicable to the population or asset, and gray squares indicate that the hazard is applicable, but the score is less than V4 (highly vulnerable).

Next Steps

The County and regional partners and agencies have established plans, policies, and programs that address climate change impacts. However, the County does not have to comprehensively identify identified strategies that address the full scope and magnitude of potential climate change impacts. Additionally, existing County policies do not necessarily meet all the new mandated Safety Element requirements.

Upon completion of the vulnerability assessment, Marin County will begin preparing the Safety Element update with a focus on filling in any identified gaps in existing resiliency planning policy and identifying implementation programs to carry out the policy. The Safety Element will be developed with climate adaptation and resiliency strategies that are based on the outcome of this vulnerability assessment.

This page intentionally left blank.

1. INTRODUCTION

Purpose of the Vulnerability Assessment

Marin County is updating its Housing and Safety Elements, key parts of Marin County's General Plan, called the Countywide Plan (CWP). New state law (California Government Code § 65302(g)) requires Safety Elements to address climate adaptation and resiliency planning, as well as new information relating to flood and fire hazards. This Vulnerability Assessment is the first step in updating the Safety Element to include climate adaptation and resiliency planning. The Vulnerability Assessment focuses on environmental hazards worsened by climate change (drought, flooding, sea level rise, landslides, etc.). It does not address the other types of environmental hazards discussed in a Safety Element that would not be impacted by climate change such as seismic and geologic hazards and tsunamis.

A vulnerability assessment is a detailed analysis of how changing climate conditions can harm people, physical structures, and other community assets throughout the county. The assessment looks at the increasing severity of climate change hazards to the county's people and assets and identifies which ones face the greatest risks. The County will use these results to prepare an update of the County's General Plan Safety Element to comply with the requirements of state law and increase resiliency throughout the unincorporated county.

The Vulnerability Assessment will help Marin County comply with state laws, including Senate Bill (SB) 379, SB 1035, and SB 99, Assembly Bill (AB) 747.

FIGURE 1-1: GUIDING LAWS

SB 379	SB 1035	SB 99	AB 747
SB 379 is the foundation for adaptation and resiliency in general plan safety elements—it requires local governments to conduct vulnerability assessments as part of their long-range public safety planning efforts and prepare policies that will protect against harm caused by climate change.	SB 1035 builds on earlier legislation and requires local governments to review and update their safety elements if needed during an update to their housing element or local hazard mitigation plan, or at least once every eight years. Any revisions should include updated information related to flood hazards, fire hazards, and climate adaptation and resilience.	SB 99 requires jurisdictions to review and update the safety element to include information identifying residential developments in hazard areas that do not have at least two emergency evacuation routes.	Assembly Bill 747, which will go into effect at the beginning of 2022, focuses on evacuation routes and will require local governments to identify evacuation route capacity, safety, and viability in the safety element or local hazard mitigation plan.

In 2018, California Senate Bill (SB) 1035 revised California Government Code § 65302(g) to require General Plan Safety Elements to address climate adaptation and resiliency. After 2022, the Safety Element is to be updated upon each revision of the housing element or local hazard mitigation plan (LHMP), but no less than once every eight years to address new information or changing conditions.

This Vulnerability Assessment covers only unincorporated Marin County. The eleven incorporated communities (Belvedere, Corte Madera, Fairfax, Larkspur, Mill Valley, Novato, Ross, San Anselmo, San Rafael, Sausalito, and Tiburon) are not included in this assessment although some findings may apply to these communities. Although state and federal lands are not covered by the Marin Countywide Plan, they are presented on maps in this vulnerability assessment because so much of unincorporated Marin is composed of state and federal lands.

KEY COMPONENTS OF THE VULNERABILITY ASSESSMENT

Chapter 1: Introduction provides an overview of the document and describes the purpose of the Vulnerability Assessment.

Chapter 2: Methodology describes the methodology behind each step of the vulnerability assessment, and also describes the regulatory setting, guiding documents, and data sources.

Chapter 3: Climate Change Exposures identifies applicable climate change hazards in the County, describes them, maps them, and describes how they are expected to change.

Chapter 4: Selected Populations and Assets assesses the level to which the listed populations and assets would be affected by each applicable hazard and assigns an impact score.

Chapter 5: Adaptive Capacity looks at each population and asset and their current ability to cope with climate impacts.

Chapter 6: Vulnerability Scoring takes the impact and adaptive capacity scores to determine how susceptible a population or asset is to harm from a particular hazard.

Effects of Climate Change

The primary effects of climate change resulting from greenhouse gas emissions (GHG) include increased temperatures and changes in precipitation patterns. These factors, either individually or in combination, could contribute to an increase in the frequency and intensity of secondary climate effects such as drought, extreme heat events, extreme precipitation and flooding, landslides, wildfires, and sea-level rise. The level of impact from these climate change-related events will vary across the unincorporated county due to physical, social, and economic characteristics.

Community Profile

Marin County spans 828 square miles, of which 520 square miles is land and 308 square miles is water. Approximately 87 percent (527 square miles) of the County is unincorporated. Marin County is bordered by Sonoma County to the north and northeast; the Pacific Ocean to the northwest and southwest; The San Francisco Bay to the east and southeast; and the City and County of San Francisco to the south (Figure 1-2: Map of Marin County). It is one of the nine counties that comprise the San Francisco Bay Area and is linked to San Francisco by the Golden Gate Bridge and to the East Bay via the Richmond-San Rafael Bridge. Marin County is among the four smallest counties in the State.

Figure 1-2: Map of Marin County

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Marin County is largely defined by its natural resources and open spaces, which include six nationally protected areas, six state parks, and four marine protected areas. Much of the county is undeveloped and mountainous. A variety of factors have strictly limited development in the County including large swaths of permanently protected federal and state parkland, large acreage of farm and ranch lands permanently protected through conservation easements, and Countywide Plan policies and development codes which restrain growth in sensitive habitat areas and/or flood hazard areas.

Population

The entire County is home to an estimated 262,321 residents, although only 66,888 residents live in the unincorporated areas. Based on US Census Bureau ACS 5-year Data (2015-2019) the median age of the population is 47 years old, and seniors comprise 22% of the population living in unincorporated Marin County. Twenty seven percent of the residents are singles living alone. Families make up 66% of the population. Approximately 72% of the households in the County own their homes while 28% of the households are renters. Marin County has an estimated 74,983 individuals or 28.8 percent of the County's population that identify as a member of a racial and/or ethnic minority. At the time of data collection, approximately 172 people in unincorporated Marin were unhoused.

According to the California Department of Housing and Community Development 2021 income limits, a low-income wage for a single person is $102,450 while a low-income wage for a family of four is identified as being $146,350.

Economy

Marin County has a strong economic base which has changed significantly over the last century from an economy dominated by agriculture to the current economy which has seen increasing job growth in technology-related fields such as biotechnology, computer software, and multimedia. With natural attractions including beaches and parks in Marin, tourism is important to Marin County's economy. Services, retail trade, government, and manufacturing account for the majority of employers in Marin.[1]

Infrastructure

Transportation: Marin County has five primary Highways passing through, terminating, or located wholly in Marin: Interstate 580, U.S. Route 101, State Route 1, State Route 37, and State Route 131. Marin is connected to surrounding communities by bridges. The Golden Gate Bridge is to the south; the Richmond/San Rafael Bridge is to the east. One of the major problems Marin County faces during an emergency is the possibility of being isolated from the surrounding communities and any resources or help. Light rail service recently began supplementing existing transportation options along U.S. Route 101 between Marin and Sonoma Counties.[2]

Utilities: Municipal utilities in Marin County include water and wastewater (drinking water, stormwater, sanitary sewerage), power (electricity and natural gas), telecommunications, and solid waste. Several water management utilities supply treated water for domestic and fire suppression purposes. These distribution systems rely largely on the County's topography for

[1] Marin County Multi-Jurisdiction Local Hazard Mitigation Plan (MCM LHMP). Marin County, 2018.

[2] Ibid.

collecting surface water, storing it in reservoirs, and distributing it with gravity-fed systems. As such, the water management utilities are separated by both functional area and geography, but they are working more and more to coordinate within watersheds.

Marin Municipal Water District (MMWD) is the largest water district in Marin, serving central and southern portions of the county east of Mount Tamalpais and Bolinas Ridge. North Marin Water District (NMWD) serves Novato and communities along Tomales Bay including Olema, Point Reyes Station, Inverness, and Dillon Beach. Bolinas and Stinson Beach, two communities in West Marin, have separate water and sanitary districts.

There are 23 agencies providing wastewater services in Marin County, including special districts, municipalities, Joint Power Authorities, and the Federal and State government.

Stormwater infrastructure such as open channels, catch basins and storm drains are managed by the cities, towns, and the county in unincorporated areas and are coordinated through the Marin County Stormwater Pollution Prevention Program (MCSTOPPP). Additionally, the Marin County Flood Control and Water Conservation District maintains some larger drainage infrastructure where zones have been designated. The district and some cities/towns such as San Rafael, Corte Madera, and Novato operate stormwater pump stations.

Natural gas and electricity distribution occurs through infrastructure owned and maintained by PG&E, a private utility corporation. Natural gas is piped into Marin from the central valley around the North Bay through Solano, Napa, and Sonoma Counties. The main transmission pipelines are underground along Highway 101 and flow south, branching into local distribution lines and private laterals. PG&E also brings power into Marin around the North Bay on overhead transmission lines that emanate from the Ignacio substation in Novato. Additional substations are located along Hwy 101 in Las Gallinas, San Rafael, Greenbrae, and Mill Valley to the South and in Novato, Stafford, Tocaloma, Olema, Bolinas and Woodacre to the North and East.

Telecommunications include telephone service, cable television and wireless services. AT&T maintains infrastructure for providing landlines, while Comcast provides cable television. A variety of cellular and wireless service companies operate in Marin and provide access points in the form of cellular towers, wireless antennas, and equipment.

This page intentionally left blank.

2. METHODOLOGY

This report coalesces the information contained in numerous existing documents prepared by Marin County and others describing various climate change hazards and identifying the vulnerability of populations or physical assets. The geographic scope of this report is the unincorporated areas where the County has the authority to implement goals and policies. At times, regional climate change projection and countywide trends (inclusive of incorporated cities) are referenced because the effects and impacts of climate change cross jurisdictional boundaries.

This vulnerability assessment generally follows the recommended process in the California Adaptation Planning Guide 2.0 (APG) (2020). The APG, published by the California Natural Resources Agency (CNRA) and California Office of Emergency Services (Cal OES), guides regional and local governments in identifying and reducing the harmful effects of climate change. The APG recommends that vulnerability assessments follow a four-step process, with outreach and engagement conducted throughout, as shown and described further below.

What Do These Terms Mean?

Exposure is the presence of people, infrastructure, natural systems, and economic, cultural, and social resources in areas that are subject to harm.

Sensitivity is the degree to which a species, natural system, or community, government, and other associated systems would be affected by changing climate conditions.

Impact is a specific negative result of a climate change effect, generally on a particular population or asset. Impact is often determined by the combination of exposure and sensitivity.

Adaptive capacity is the "combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts [or] moderate harm or [to] exploit beneficial opportunities. Simply stated, it is the ability to adjust to potential damage, to take advantage of opportunities, or to respond to consequences."

WHAT IS VULNERABILITY?

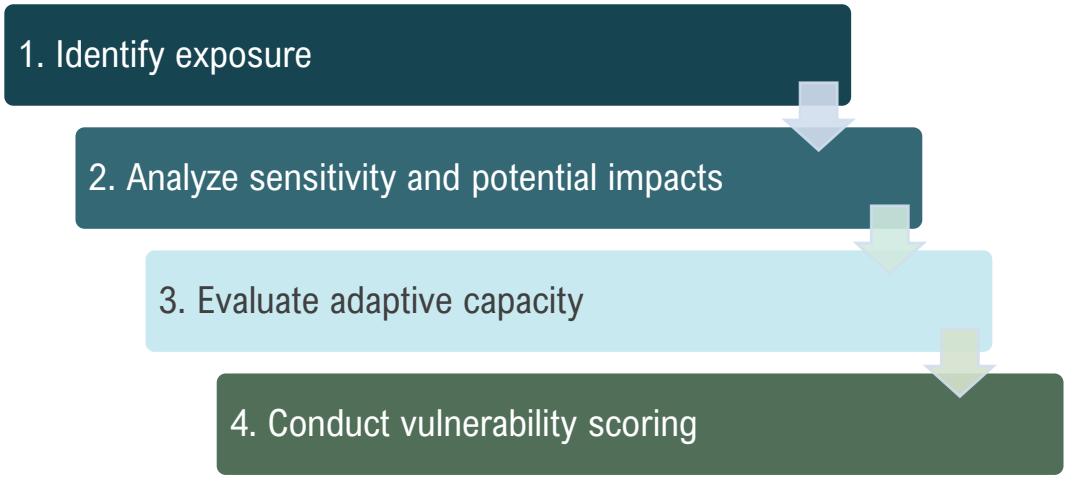
Vulnerability is the exposure of human life and property to damage from natural and human-made hazards. Climate vulnerability describes the degree to which natural, built, and human systems are at risk of exposure to climate change impacts.

Differences in exposure, sensitivity, and capacity to adapt affect an individual's or community's vulnerability to climate change. Vulnerability can increase because of physical (built and environmental), social, political, and/or economic factor(s).

Vulnerability is considered a function of exposure, sensitivity, and adaptive capacity.

Source: 2020 APG 2.0

FIGURE 2-1: CALIFORNIA ADAPTATION GUIDE VULNERABILITY ASSESSMENT METHOD



Step 1: Identify Exposure

The purpose of this step is to understand existing hazards within the unincorporated county, and how these hazards will change. Existing hazards that can be worsened by the effects of climate change are identified and climate projection data was used to develop projections for how existing hazards are expected to change by mid- and late- century.

Exposure is the presence of people, infrastructure, natural systems, and economic, cultural, and social resources in areas that are subject to harm.

Source: 2020 APG 2.0

Marin County identified eight **climate change hazards** for this assessment, listed here and discussed in detail in Chapter 3. These hazards were selected because they are required components of a General Plan Safety Element and they are worsened by climate change impacts.

- Drought
- Extreme Heat
- Flooding
- Landslides
- Sea Level Rise
- Severe Weather
- Subsidence
- Wildfire

Step 2: Analyze Sensitivity and Potential Impacts

Following the guidance in the APG, the County has compiled a list of **population groups and community assets that are sensitive to localized climate change effects**. This list includes 19 population groups and 43 assets.

The County identified which hazards are likely to affect specific populations and assets both directly and indirectly. Direct impacts affect buildings and infrastructure, populations, or immediate operations of economic activities or community services. Indirect impacts affect the broader system or community, including populations or asset types in a different category. For example, severe weather can directly damage electrical transmission lines (direct impact) causing power outages, which can indirectly impact persons with chronic illnesses (indirect impact) who depend on the electricity for life support systems. Therefore, both electrical transmission lines and persons with chronic illnesses were identified as being affected by severe wind and were evaluated in the assessment.

Sensitivity is the degree to which a species, natural system, or community, government, and other associated systems would be affected by changing climate conditions.

Impact is a specific negative result of a climate change effect, generally on a particular population or asset. Impact is often determined by the combination of exposure and sensitivity. For example, if the effect of climate change is that droughts are likely to become more frequent and severe, a potential impact to farmers is that less water could be available for irrigation.

Source: 2020 APG 2.0

To identify how great the impacts of each relevant exposure are on the sensitive populations and assets, the 2020 APG 2.0 recommends the following questions to help ensure the assessment broadly covers the range of potential harm:

- What types of impacts may occur?
- Could they cause physical injury or damage?
- Is there a risk of behavioral or mental harm, loss of economic activity, or other nonphysical effects?
- How many people or community assets could be affected by both direct and indirect harm?
- How long would the impacts persist?
- Is there a substantial chance of death or widespread destruction?

Based on the results of the impact assessments, impacts to each population and asset were ranked on a three-point scale from low to high for each relevant exposure (see Appendix B for rankings). As impact is a negative quality, a lower impact score is better (i.e. a lower score means less impact experienced from exposure to a specific climate hazard). This step is summarized in a series of tables identifying the exposure and impact of hazards to populations and assets.

TABLE 2-1: IMPACT SCORING

Impact Score	*Impact Meaning to Population or Ecosystem*	*Impact Meaning to Assets*
Low Impact	Impact is unlikely based on projected exposure; would result in minor consequences to public health, safety, and/or other metrics of concern. Some may not experience or notice any change.	There are minor interruptions in service, damage or negative effects on the economy. Effects may be small or intermittent enough to go mostly unnoticed.
Medium Impact	Impact is somewhat likely based on projected exposure; would result in some consequences to public health, safety, and/or other metrics of concern.	Damage, service interruptions, and other impacts are clearly evident. Impacts may be chronic and occasionally substantial.
High Impact	Impact is highly likely based on projected exposure; would result in substantial consequences to public health, safety, and/or other metrics of concern. This includes widespread injury or death to people or significant or total ecosystem loss.	Impacts are chronic. Buildings, infrastructure, and services may be often or always unable to meet community demand and cannot function as intended or needed. Large sections of the economy experience major hardships.

Step 3: Evaluate Adaptive Capacity

The goal of this step is to characterize the County's current ability to cope with climate impacts. The County, partner agencies, and countywide organizations have already taken steps to build resilience and protect sensitive populations and assets from hazards. The ability of the County to adapt to each of the identified climate impacts is determined through a review of existing plans, policies, and programs, and through stakeholder engagement.

Adaptive capacity is the "combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts [or] moderate harm or [to] exploit beneficial opportunities. Simply stated, it is the ability to adjust to potential damage, to take advantage of opportunities, or to respond to consequences."

Source: 2020 APG 2.0

Following a similar process as used to analyze impacts, the 2020 APG 2.0 recommends various questions to help make sure that the adaptive capacity assessment covers the full potential of a sensitivity to resist and recover from harm. Questions include:

- Are there existing programs and policies to provide assistance?
- Can affected community members take advantage of these programs?
- Are there barriers that limit response or recovery?
- Are these barriers financial limitations, political challenges, lack of access to technology or other resources, or others?
- For community assets, do alternatives exist in or near Marin County that community members can use?

In the context of this vulnerability assessment, the term "resources" can include financial, social, technological, and/or organizational means that a population or asset has access to. Access to resources can increase or decrease adaptive capacity.

Based on the results of the adaptive capacity assessment, Marin County ranked each sensitivity on a three-point scale from low to high. Adaptive capacity is a positive quality, so a higher adaptive capacity score is better. The outcome of this step is an assessment summarized in tables describing Marin County's capacity to adapt to each of the climate impacts based on existing polices, plans, and programs and the adaptive capacity scoring tables in Appendix B. The results of this step then feed into the final phase of vulnerability scoring.

TABLE 2-2: ADAPTIVE CAPACITY SCORING

Adaptive Capacity Score	*Meaning (all Populations and Assets)*
Low Capacity	Adaptive solutions are available, but they are expensive, technologically difficult, and/or politically unpopular. Alternatives may not exist that can provide similar services.
Some Capacity	Some adaptation methods are available, but not always feasible. Adapting may create significant challenges for some sensitivities. Some alternatives exist within the jurisdiction area that can provide similar services.
High Capacity	Adaptation solutions are feasible for most or all sensitivities. There may be occasional or small-scale challenges to implementing adaptation methods. Many alternatives exist in the area that can provide similar services.

Step 4: Conduct Vulnerability Scoring

Lastly, this step determines the County's greatest climate vulnerabilities through a vulnerability scoring process. Vulnerability is based on several factors including:

- How severe projected climate exposures will be,
- How sensitive population groups and assets are to the anticipated climate effects,
- Whether sufficient adaptive capacity exists to manage the potential impact.

The outcome of this step is a summary of vulnerabilities in a matrix showing the vulnerability score of the populations and assets for each applicable climate hazard. Vulnerability is assessed on a scale of 1 to 5:

- V1: Minimal vulnerability
- V2: Low vulnerability
- V3: Moderate vulnerability
- V4: High vulnerability
- V5: Severe vulnerability

The matrix below shows how different impact and adaptive capacity scores translate to a vulnerability score.

TABLE 2-3: VULNERABILITY SCORING MATRIX

		Impact Score		
		Low Impact	*Medium Impact*	*High Impact*
Adaptive Capacity Score	*Low Capacity*	V3	V4	V5
	Some Capacity	V2	V3	V4
	High Capacity	V1	V2	V3

The vulnerability scoring assessment helps the County understand which populations and assets are most sensitive to climate change, have the greatest adaptive capacity, and are most urgent and should be prioritized for developing adaptation strategies in the Safety Element.

Next Steps

Upon completion of the vulnerability assessment, Marin County will begin preparing the Safety Element update with a focus on filling in any identified gaps in existing resiliency planning policy and identifying implementation programs to carry out the policy. The Safety Element will be developed with climate adaptation and resiliency strategies that are based on the outcomes of this vulnerability assessment.

Public Outreach and Engagement

The project team conducted focus groups, public workshops, and an on-line discussion forum called Consider-It to ensure the Vulnerability Assessment reflected the experiences of community members in Marin County. This engagement expanded the analysis to include and

respond to the local experience, knowledge, and expertise of residents. Engaging community partners during preparation of the Vulnerability Assessment improved the analysis and supported the identification of community successes and lessons learned from community members and business owners. Outreach activities included community workshops, core team meetings, adaptive capacity meetings, Equity Advisory and Outreach Committee meetings, and stakeholder interviews. Each outreach activity is summarized below.

Focus Groups

In the Fall of 2021, the County conducted four focus group sessions with groups composed of low-income residents, lower-income homeowners, community-based organizations, and seniors and people with disabilities. The format allowed participants to share their perceptions of risks and preparedness in the event of natural disasters or hazards due to extreme weather.

Some participants expressed that they don't feel prepared and are concerned about not receiving information, maintaining communications, and limited cell service. Some lower income renters expressed that their homes did not provide them the level of comfort and perceived safety, especially during extreme heat and during period of poor air quality. People were generally limited by their mobility and access to transportation. Those with lower incomes would not have funds during an emergency to go to find other lodging.

Community Workshops

The project team hosted two community workshops. The first one was held on September 22, 2021. The first community workshop raised awareness about the Safety Element update and the preparation of the Vulnerability Assessment. It also provided participants an opportunity to share their issues and concerns and ideas for solutions. Translation was provided in Spanish and Vietnamese. One hundred and seventy-six (176) people registered for the event and eighty-two (82) people participated.

The second workshop, held on November 15, 2021, focused on providing an in-depth overview of the Vulnerability Assessment findings and solicited feedback from the community about impacts from hazards and the adaptive capacity of residents and businesses in the county. The project team provided short presentations with on-line polling workshops, followed by small group and large group discussions. Translation was provided in Spanish and Vietnamese. One hundred (100) people registered for the event and thirty-one (31) people attended.

Online Discussion Forum

In mid-October 2021, the County launched an on-line discussion forum named Consider-it which allowed people to share their responses to a series of questions or statements and provide an explanation of their choices. The platform allowed for on-going dialogue so that those with a high level of interest could be as active as they liked. Comments were linked to the registered participants and the platform provides data on which explanations are the most prominent or influential.

Participants shared the level of impact different threats would have on them. They could also weigh in on ideas related to policies and homeowner responsibilities. Respondents also identified varying levels of readiness in the event of an emergency or if evacuation was required.

Regulatory Setting

As outlined in Figure 1-1, Senate Bill 379 requires general plan safety elements to address climate change vulnerability, adaptation strategies, and emergency response strategies. SB 379 states:

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

As specified in Government Code section 65302(g)(4)(A) vulnerability assessments must identify the risks that climate change poses to the local jurisdiction and the geographic areas at risk from climate change impacts, utilizing federal, state, regional, and local climate vulnerability documentation such as APG 2.0 and the Cal-Adapt climate tool created by the California Energy Commission (CEC) and University of California, Berkeley Geospatial Innovation Facility. Other sources of information include data from local agencies regarding their adaptive capacity and historical data on natural events and hazards.

Per Government Code section 65302(g)(4)(B), adaptation policies, goals, and objectives are to be developed based on findings from the vulnerability assessment. Additionally, Government Code section 65302(g)(4)(C) requires jurisdictions to create a set of feasible implementation measures to reduce climate change impacts on new or proposed land uses. This Vulnerability Assessment has been prepared to meet those requirements.

SB 1035 builds on earlier legislation and requires local governments to review and update their safety elements if needed during an update to their housing element or local hazard mitigation plan, or at least once every eight years. Any revisions should include updated information related to flood hazards, fire hazards, and climate adaptation and resilience.

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

Assembly Bill 747, which will go into effect at the beginning of 2022, focuses on evacuation routes and will require local governments to identify evacuation route capacity, safety, and viability in the safety element or local hazard mitigation plan.

Guiding Documents

California Adaptation Planning Guide

The California Office of Emergency Services (CalOES) published the 2020 Adaptation Planning Guide 2.0 (APG) to provide vulnerability assessment and adaptation planning guidance for communities. CalOES released APG 2.0 (dated June 2020), which includes guidance with an increased focus on equity and outreach, and best practices. APG 2.0 provides a framework for

communities to identify potential climate change effects and important physical, social, and natural assets, create adaptation strategies to address climate change impacts, and develop a monitoring and implementation framework for climate change adaptation (CalOES 2020). This vulnerability assessment was prepared according to the guidance provided in APG 2.0.

California's Fourth Climate Assessment

CNRA, OPR, and CEC prepared California's Fourth Climate Assessment (Climate Assessment) in 2018. The Climate Assessment was designed to address critical information gaps that decision-makers at the state, regional, and local levels need to close to protect and build the resilience of people, infrastructure, natural systems, working lands, and waterways. The Vulnerability Assessment relies upon California's Fourth Climate Assessment to provide background information and evidence of regional climate change impacts.

Safeguarding California Plan

Alongside the update to the Climate Assessment, CNRA released the Safeguarding California Plan in 2018 which provides a roadmap for State government action to build climate resilience. The Safeguarding California Plan identifies actions the State government will take to protect communities, infrastructure, services, and the natural environment from climate change impacts and includes strategies for use as local examples for climate adaptation. The Vulnerability Assessment relied upon the Safeguarding California Plan to provide guidance on assessing the County's vulnerability to climate change.

Marin County and Regional Planning Efforts

In addition to State adaptation efforts, the County and supporting agencies have developed planning documents focused on local and regional adaptation to climate change hazards. These planning documents analyze existing hazards and include strategies or guidelines to mitigate their severity. The County's Multijurisdictional Local Hazard Mitigation Plan, Community Wildfire Protection Plan, Sea Level Rise Vulnerability Assessments, Sea Level Rise Adaptation Report, Climate Action Plan, Emergency Operations Plan, Local Coastal Plan, and Countywide Plan (General Plan) were considered in the development of this vulnerability assessment.

Data Sources

The vulnerability assessment is based on the best available science and information contained in the available supporting documents. It uses data from a variety of credible sources including scholarly research, state and federal data, and locally provided data.

Scholarly Research

Much of the background information on the causes and worsening impacts of climate change came from an extensive body of scientific research that discusses how climate change may affect people and community assets. In most cases, this research was not conducted in Marin County, but the results are applicable and relevant as background information.

State and Federal Data

Marin County relied on data from state and federal agencies, including published reports and datasets. The state APG provided extensive information about climate-related exposures and vulnerabilities, as did federal reports such as the National Climate Assessment.

Cal-Adapt, a web-based tool developed by the California Energy Commission, provided highly specific information about historic climate conditions and future climate projections. The data available on this website offers a view of how climate change will likely affect Marin County at the local level.

Documents from the California Natural Resources Agency, such as the Safeguarding California and California Climate Adaptation Strategy reports, provided additional information about state climate vulnerabilities and adaptation strategies. Marin County also relied on information from several agencies including the California Department of Forestry and Fire Protection (Cal Fire) and the California Energy Commission. Marin County also relied on demographic data from the US Census Bureau.

Local Data

In addition to the County documents listed under guiding documents, this Vulnerability Assessment also relied on spatial data maintained by Marin County. This data shows the location of various buildings and infrastructure, different land uses, boundaries, areas at risk of different hazards, and other items of importance to the vulnerability assessment. The documents described under guiding documents and used as sources of local data include:

1. Marin County Multijurisdictional Local Hazard Mitigation Plan update (2018)
2. Marin County Community Wildfire Protection Plan (CWPP) (2020)
3. Marin Shoreline (BayWAVE) Sea Level Rise Vulnerability Assessment (June 2017)
4. Bay Waterfront Adaptation & Vulnerability Evaluation (June 2017)
5. Marin Ocean Coast Sea Level Rise Vulnerability Assessment (September 2015)
6. Marin Ocean Coast Sea Level Rise Adaptation Report (May 2017)
7. Marin Geohub Map Data (https://gisopendata.marincounty.org)
8. Marin Adaptation and Land Use Planning: A Guidance for Marin County Local Governments (December 2019
9. Richardson Bay Shoreline Study (2015)
10. Marin Operational Area Emergency Operations Plan (2014)
11. Marin Municipal Water District Local Hazard Mitigation Plan

3. CLIMATE CHANGE EXPOSURES

Climate Scenarios

Climate change is a long-term change in the average meteorological conditions in an area.[3] Currently, the global climate is changing due to an increase in greenhouse gas (GHG) emissions that trap heat near the Earth's surface. While some levels of these gases are necessary to maintain a comfortable temperature on Earth, an increased concentration of these gases due to human activity traps additional heat, changing Earth's climate system in several ways ranging from extended periods of drought, extreme periods of heat, to increased frequency and intensity of storms. This can create intensified or new hazardous conditions that can increase the risk of damage to critical infrastructure, injury to populations, particularly sensitive populations, and disruption of essential services.

Climate Change Modeling Considerations

The Intergovernmental Panel on Climate Change (IPCC), an organization that represents the global scientific consensus about climate change, has identified four climate scenarios, also called Representative Concentration Pathways (RCPs), that can be used to project future conditions.[4] RCPs are labeled with different numbers (e.g., RCP 2.6, RCP 6) that refer to the increase in the amount of energy that reaches each square meter of Earth's surface under that scenario. The four RCPs are:

- RCP 2.6: Under this scenario, global GHG emissions peak around 2020 and then decline quickly.
- RCP 4.5: Under this scenario, global GHG emissions peak around 2040 and then decline.
- RCP 6: Global emissions continue to rise until the middle of the century.
- RCP 8.5: Global emissions continue to increase at least until the end of the century.

Projections of climate hazards from Cal-Adapt, the Bay Area Adapting to Rising Tides (ART) project, and other sources rely on climate models, which are computer simulations that forecast future climate conditions under these different RCP scenarios. It is important that the County account for all reasonably plausible future conditions, including the most severe of plausible conditions, which will help ensure greater resiliency to climate change. **Therefore, the projections in the Vulnerability Assessment use the RCP 8.5 scenario, following State of California guidance from the California Adaptation Planning Guide.** No model can project future conditions perfectly, but current models are heavily reviewed by climate scientists and can accurately reproduce observed climate conditions.

[3] City of San Carlos. 2021. City of San Carlos Climate Mitigation and Adaptation Plan. Public Review Draft. June 2021.

[4] County of Placer. 2018. Placer County Sustainability Plan Vulnerability Assessment Report. Administrative Draft. October 2018.

The vulnerability assessment also relies on the understanding that "weather" and "climate" are two different phenomena.[5] "Weather" describes the conditions at a particular time and place, and "climate" describes the long-term average of conditions. Because there are large variations in the weather, it is difficult to accurately project weather conditions more than a few days in advance. However, because climate is a long-term average, it can be projected out for years or decades with a higher degree of accuracy. It is important to remember that, because climate is an average, climate projections do not say whether an event will or will not occur, only how likely it is. For example, extreme heat is likely to become more frequent in California, but a year with few heat waves does not mean that this projection is wrong, because the projection only says that extreme heat days are expected to occur, on average, more often than in the past.

State of California Climate Change Hazard Resources

The State of California has developed a comprehensive set of reports and tools that local jurisdictions can use to assess climate change hazards and how to prepare for these hazards. The State-provided reports and tools that support resiliency planning and the preparation of vulnerability assessments include:

- Cal-Adapt.org
- California 4th Climate Change Assessments (statewide and regional reports)
- California Adaptation Clearinghouse
- California Adaptation Planning Guide
- California Building Resilience Against Climate Effects
- Planning and Investing for a Resilient California
- Safeguarding California

Climate Change in Marin

Marin County has developed a comprehensive set of reports that can be used to assess climate change hazards and how to prepare for these hazards. These documents are listed in Chapter 2 Local Data and are discussed in more detail in Chapter 5, Adaptive Capacity.

In Marin County, climate change is expected to intensify existing hazards, such as sea level rise, wildfire, and drought, or create new hazards, such as extreme heat events, which are described below. The Vulnerability Assessment evaluates how hazards are expected to occur, including frequency and severity, and how these hazards will affect community populations and assets. Each discussion on climate change exposures contains a list of populations in Marin County that would be most vulnerable to the hazard. The populations listed are the V4 (High vulnerability) and V5 (Severe vulnerability) populations identified in Chapter 6, Vulnerability Scoring.

[5] County of Placer. 2018. Placer County Sustainability Plan Vulnerability Assessment Report. Administrative Draft. October 2018.

Drought

Hazard Profile

Drought occurs when conditions are drier than normal for an extended period, making less water available for people and ecosystems. Droughts are a regular occurrence in California; however, scientists expect that climate change will lead to more frequent and more intense droughts statewide. Overall, precipitation levels are expected to remain similar, with more years of extreme precipitation events and droughts that last longer and are more intense. Drought conditions mean less water available for human use (especially if the local water supply depends on surface water) and natural ecological systems. According to the California Fourth Climate Change Assessment, San Francisco Bay Area Region Report, precipitation in the San Francisco Bay Area will continue to be highly variable year to year, with very wet and very dry years.[6]

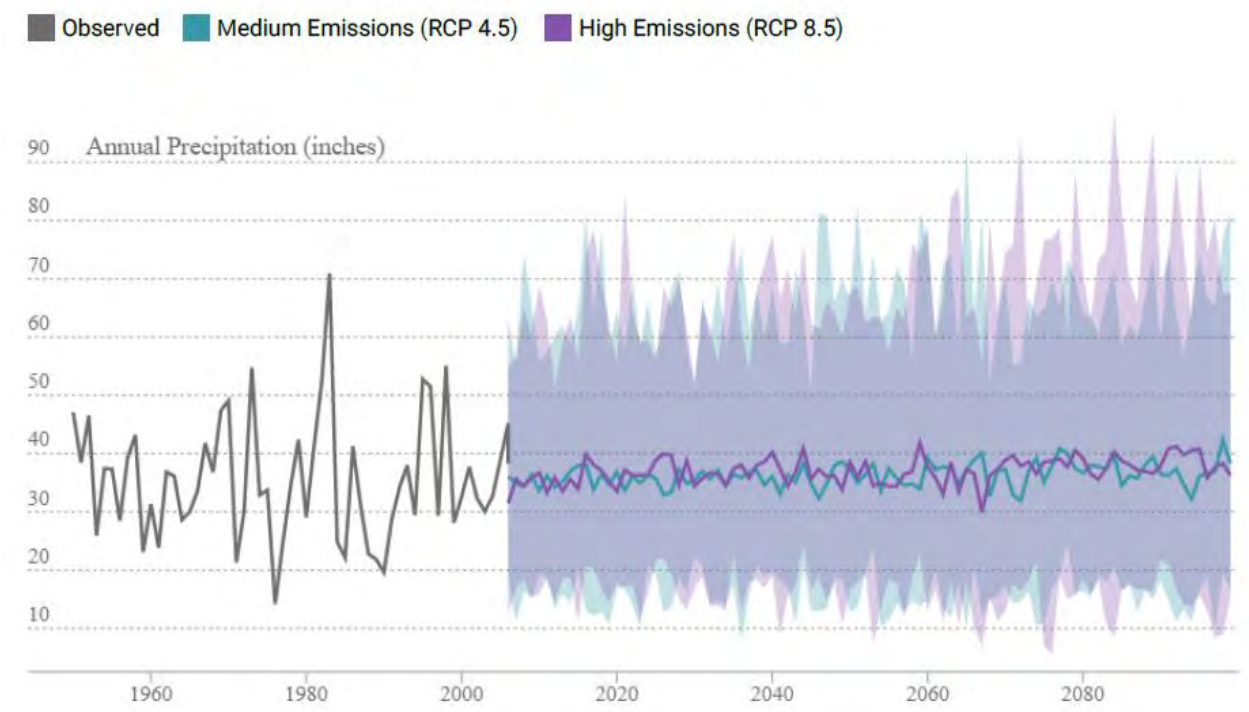
Marin County's water supplies include surface water, groundwater, recycled water, and imported water. Surface water is the main source of potable water in urban areas in the eastern portion of the County while groundwater and surface water are the primary sources for rural areas. Approximately 75 percent of MMWD water originates from rainfall in the Mt. Tamalpais watershed while the remaining supply comes from Sonoma County's Russian River water system.

The figure presented below shows average annual precipitation under two different GHG emission scenarios; a medium emissions scenario (RCP 4.5) in which emissions peak around 2040, then decline and a high emissions scenario (RCP 8.5) in which emissions continue to rise strongly through 2050 and plateau around 2100. Figure 3-1 shows the total precipitation projected for a year with temperatures of 94.4 °F in Marin under the medium and high emissions scenarios. The average annual precipitation for the historical baseline years of 1961 to 1990 was 34.3 inches. Under the medium emissions scenario, projected annual rainfall in Marin would increase to 36.1 inches by mid-century (2035 to 2064) and 37 inches by the end of century (2070 to 2099). Under the high emissions scenario, projected annual rainfall increases to 36.7 inches by mid-century and 38.4 inches.[7] The bold teal and purple lines in Figure 3-1 represent the most likely outcome and the less saturated teal and purple shading shows the range of future projections of annual precipitation.

[6] Ackerly, David, Andrew Jones, Mark Stacey, Bruce Riordan. (University of California, Berkeley). 2018. San Francisco Bay Area Summary Report. California's Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005. https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-005_SanFranciscoBayArea_ADA.pdf

[7] Cal-Adapt. Maps of Projected Change. https://cal-adapt.org/tools/maps-of-projected-change/

FIGURE 3-1: PROJECTED ANNUAL PRECIPITATION IN MARIN COUNTY



Source: Cal Adapt, Local Climate Change Snapshot for Marin County (2021)

Disaster History

Drought has affected virtually every county in California at one time or another. Droughts exceeding three years are relatively rare in Northern California. The 1929-1934 drought, which affected the entire state, established the criteria commonly used in designing storage capacity and yield for large Northern California reservoirs. Within the past 50 years in California, significant droughts occurred in the following years: 1975-1977, 1987-1992, 2007-2009, and 2012-2017.[8] Drought years that included Marin County are summarized in Table 3-2 below.

[8] California Governor's Office of Emergency Services. 2018. 2018 State of California Multi-Hazard Mitigation Plan. https://www.caloes.ca.gov/cal-oes-divisions/hazard-mitigation/hazard-mitigation-planning/state-hazard-mitigation-plan.

TABLE 3-1: CALIFORNIA DROUGHT INCIDENTS THAT INCLUDED MARIN COUNTY, 1972-2021

Year	Counties Affected	Statewide Crop Damage
1976-1977	Alpine, Calaveras, Colusa, Fresno, Glenn, Madera, Merced, San Diego, San Joaquin, Solano, Stanislaus, Sutter, Tuolumne, Alameda, Butte, Contra Costa, Kings, Los Angeles, Riverside, San Luis Obispo, Tulare, Yolo, Amador, Monterey, Napa, Nevada, San Benito, San Bernardino, Tehama, San Mateo, Marin	$2.67 billion
1991-1992	Alameda, Alpine, Colusa, Fresno, City of Orange Cove, Glenn, Kern, Kings, Lake, Madera, Marin, Mendocino, Monterey, Placer, Santa Barbara, City of Santa Barbara, Shasta, Siskiyou, Solano, Sonoma, Sutter, Tehama, Tulare, Tuolumne, and Yuba	U.S. Department of Agriculture - nationwide: $995 million for 1990- 1991 crop loss. Additional $775 million in emergency funds for 1990-1992 crop losses.
2012-2016	All counties	$3.8 billion
2020-present	All counties	Unknown

Sources: 1. 2018 State of California Multi-Hazard Mitigation Plan (California Governor's Office of Emergency Services 2018). 2. Drought.gov: National Integrated Drought Information System (https://www.drought.gov/states/california, accessed September 20, 2021).

The average annual precipitation in Marin County in the last thirty years was 37.77 inches.[9] Marin's cumulative rainfall figures are at record lows, with rainfall levels in the last 18 months (January 2020 to July 2021) the lowest recorded in more than 140 years. Marin Water's reservoir storage levels are the lowest they have been in more than 40 years since capacity was expanded. According to Marin Water, rainfall measurements taken at Lake Lagunitas from July 2019 to July 2020 totaled about 34 inches, well below the reservoir's historical annual average total of 52 inches.[10]

[9] National Oceanic and Atmospheric Administration (NOAA) Environmental Centers for Environmental Information. Climate at a Glance. Accessed September 20, 2021 at: https://www.ncdc.noaa.gov/cag/county/time-series/CA-041/pcp/1/2/1895-2021

[10] Measurements taken by the Marin County Flood Control and Water Conservation District at various locations around the county show that Marin has, as of July 2021, received less than half the rainfall than it did the previous year (County of Marin - News Releases - Drought Update. Marin Added to State's Drought Emergency Counties. July 9, 2021).

The MMWD and the NMWD operate and maintain eight major dams for municipal water supplies within their jurisdictions. MMWD dams include Alpine Dam, Bon Tempe Dam, Lagunitas Dam, Phoenix Dam, Peters Dam (Kent Lake), Nicasio Dam, and Soulajule Dam.[11] NMWD maintains and operates one dam at Stafford Lake on Novato Creek for its smaller service area. As of September 16, 2021, the MMWD dams were at 35.65% of their capacity at 28,363-acre-feet, down from 68.26% at 54,308-acre-feet from the same date last year. The average storage for this date is 71.83% and 57,149-acre-feet.[12]

In July 2021, the State of California added Marin County to its list of counties falling under its state of emergency regarding deepening drought conditions and record-breaking high temperatures statewide. After hearing details about local dry conditions and water supplies, the Marin County Board of Supervisors voted unanimously on May 18, 2021 to declare a local emergency and acknowledge the imminent threat of disaster. The declaration acknowledged the extent and impacts of the drought in Marin, which is severely affecting dairies and ranchers in West Marin. It also made the County eligible for California Disaster Assistance and other forms of state funding and resources. The local declaration cleared the way for state authorities to aid response and recovery efforts available to the County, water suppliers, farmers, impacted businesses and residents.[13] As of August 2021, with reservoir levels at historic lows, both MMWD and NMWD have declared a water shortage emergency and adopted mandatory water use restrictions, with respective reduction goals of 40 percent and 20 percent.[14] In October 2021, the Governor of California signed a proclamation extending the drought emergency statewide.

Ranchers have been importing water by truck to keep their animals alive and reducing their herds. With far less vegetation for grazing because of the drought, animals are eating imported feed shipped from other states at high costs to the ranchers. Marin crop producers have fallowed approximately 150 acres, or about 50% of the 300 crop acres in the county. The Board of Supervisors recently approved $150,000 in drought relief funds for the agricultural industry and another $250,000 for general drought relief needs to augment other state and federal aid.[15]

In the fall of 2021 MMWD was investigating the potential to run a $90 million duct across the Richmond-San Rafael Bridge as an emergency backup plan if the drought worsens. The MMWD could deplete its reservoir supplies next summer if the area experiences a third consecutive dry winter.[16]

---

[11] Marin County Multi-Jurisdiction Local Hazard Mitigation Plan (MCM LHMP). Marin County, 2018.

[12] Marin Water: Water Watch. Accessed September 20, 2021 at: https://www.marinwater.org/water-watch

[13] County of Marin - News Releases - Drought Update. Marin Added to State's Drought Emergency Counties. July 9, 2021.

[14] Ibid.

[15] County of Marin - News Releases - Drought Update. Marin Added to State's Drought Emergency Counties. July 9, 2021.

[16] Marin Independent Journal. Drought: Marin pipeline could face water capacity shortfall. October 6, 2021.

Probability of Future Events

Scientists expect that climate change will lead to more frequent and more intense droughts statewide. Overall, precipitation levels are expected to stay similar, and may even increase in some places. However, the state's current data say that there will be more years with extreme levels of precipitation, both high and low, as a result of climate change.[17] This is expected to cause more droughts that last longer and are more intense, compared to historical norms. Higher air temperatures are expected to increase evaporation, causing more water loss from lakes and reservoirs and decreasing soil moisture to greater depths.

Vulnerability

Regardless of whether total amounts of precipitation increase in the future due to climate change, future increases in temperature will likely cause longer and deeper droughts in California and in Marin County.

Infrastructure

During drought, declines in surface water flows can be detrimental to water supplies for agriculture and cities, hydropower production, navigation, recreation, and natural ecosystems, particularly habitat for aquatic and riparian species.[18] Communities in Marin County may experience water shortages during drought conditions which lead to mandatory water use restrictions and possibly the importation of water. Droughts affect the County's agricultural productivity.

---

[17] Ackerly, David, Andrew Jones, Mark Stacey, Bruce Riordan. (University of California, Berkeley). 2018. San Francisco Bay Area Summary Report. California's Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005. https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-005_SanFranciscoBayArea_ADA.pdf

[18] United States Geological Survey (USGS) California Water Science Center: Drought. Accessed September 20, 2021 at: https://ca.water.usgs.gov/california-drought/what-is-drought.html

Droughts also impact the health and productivity of natural ecosystems. During drought events, the flow of water in creeks and streams is reduced, creating more slow-moving or standing water. This can concentrate sediment and toxins in the low water levels, causing harm to plants and animals. Many fish species also prefer specific water temperatures and stream flow speeds, especially for spawning and egg incubation, and changes to stream velocity as a result of drought conditions can affect reproduction. Droughts can also indirectly lead to more wildfires, and the stress caused by water shortages can weaken plants, making them more susceptible to pests and diseases. As drought persists, longer-term impacts can emerge, such as land subsidence, seawater intrusion, and damage to ecosystems.[19]

Populations

During prolonged or severe drought, County residents would be impacted by water use restrictions and changes to water supply. Marin County populations most vulnerable to the effects of drought include:

- Outdoor workers.

Extreme Heat

Hazard Profile

Extreme heat is any time period when the temperature is well above the usual level. Extreme heat affects both coastal and inland zones of the Bay Area, including Marin County, with extreme heat days, heat waves, and heat emergencies.

Although extreme heat usually does not cause substantial physical damage to the built environment, extreme heat creates a serious public health threat especially to vulnerable populations, including people with disabilities, the elderly, and children, and outdoor workers. Extreme heat events are dangerous because people exposed to extreme heat can suffer a number of heat related illnesses, including heat cramps, heat exhaustion, and (most severely) heat stroke. Extreme heat events often result in increased nighttime temperatures, which prevents overnight cooling and, as a result, reduces the relief from heat typically provided by nighttime temperatures. Very high temperatures can harm plants and animals that are not well adapted to them in wild ecosystems as well as farm crops and livestock. Indirectly, extreme heat puts more stress on power lines, causing them to run less efficiently. The heat also causes more demand for electricity (usually to run air conditioning units), and in combination with the stress on the power lines, may lead to brownouts and blackouts. A study by the California Energy Commission

WHAT IS EXTREME HEAT?

There is no universal definition of extreme heat. California guidance documents define Extreme heat is temperatures that are hotter than 98 percent of the historical high temperatures for the area, as measured between April and October of 1961 to 1990. Days that reach this level are called extreme heat days.

WHAT IS A HEAT WAVE?

An event with five extreme heat days in a row is called a heat wave.

Source: 2020 APG (2.0)

[19] United States Geological Survey (USGS) California Water Science Center: Drought. Accessed September 20, 2021 at: https://ca.water.usgs.gov/california-drought/what-is-drought.html

states that heat waves have claimed more lives in California than all other disaster events combined. Extreme heat emergencies typically build over time with cumulative effects.[20]

The frequency, intensity, and duration of extreme heat events and heat waves are expected to rise as a result of climate change, with an increased number of extreme heat days and nights, increased temperatures over extreme heat days and greater duration of extreme heat events. By the end of the century, most of the region will average six heat waves a year, with the average longest heat wave lasting ten days. Extreme heat events will also extend seasonally into spring and fall.[21]

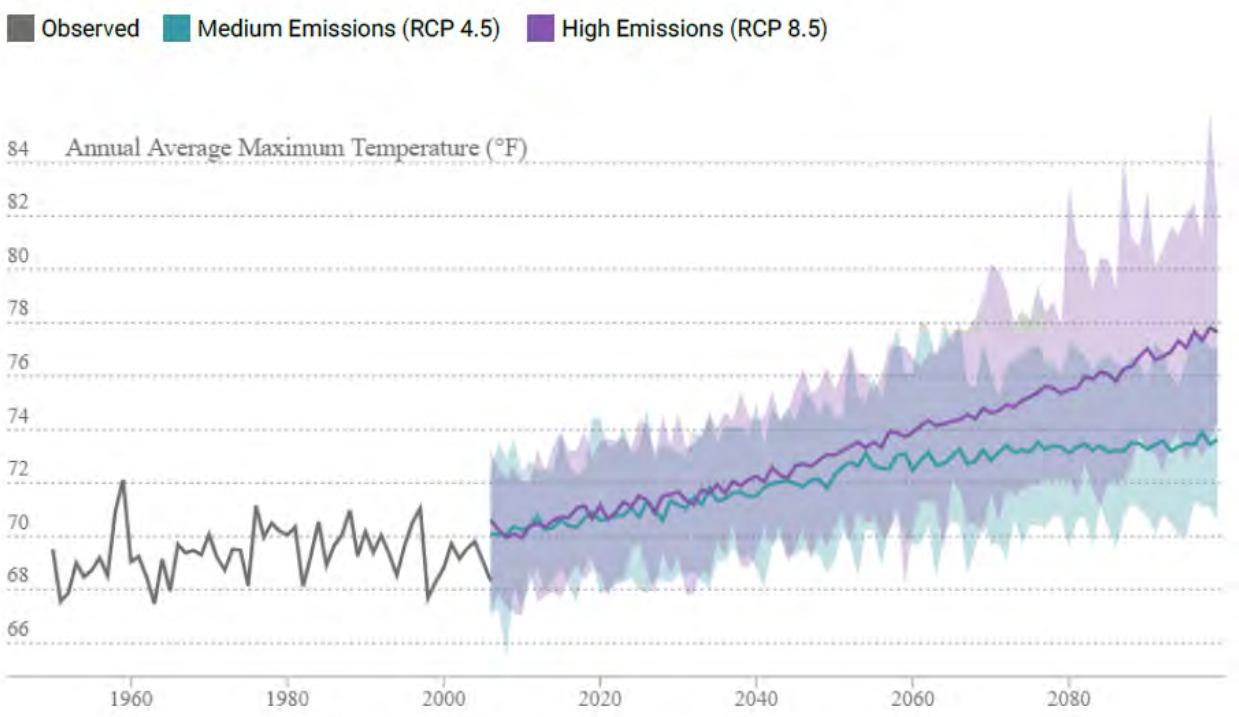
Figure 3-2 below shows the projected average of all the hottest daily temperatures in a year in Marin under medium (RCP 4.5) and high (RCP 8.5) emissions scenarios. The historical baseline (1961-1990) for annual average maximum temperature in Marin was 69.5 °F. Under the medium emissions scenario, the annual average maximum temperature would reach 72.3 °F by mid-century (2035-2064) and 73.3 °F by end of century (2070-2099).[22] Under the high emissions scenario, the annual average maximum temperature would reach 73 °F by mid-century and 76.1 °F by end of century. The bold teal and purple lines in Figure 3-2 represent the most likely outcome and the less saturated teal and purple shading shows the range of future projections of annual average maximum temperature. While Figure 3-2 shows temperatures in Marin County increasing, even the High Emissions scenario (RCP 8.5) does not show annual average maximum temperature into the 80's until 2070 – 2080.

[20] Association of Bay Area Governments: Extreme Heat. Accessed September 29, 2021 at: https://abag.ca.gov/our-work/resilience/data-research/extreme-heat

[21] Ibid.

[22] Cal-Adapt. Maps of Projected Change. https://cal-adapt.org/tools/maps-of-projected-change/; Annual Averages, Marin County, https://cal-adapt.org/tools/annual-averages/

FIGURE 3-2: PROJECTED ANNUAL AVERAGE MAXIMUM TEMPERATURE IN MARIN COUNTY



Source: Cal-Adapt, Local Climate Change Snapshot for Marin County (2021)

Disaster History

For purposes of the Cal-Adapt tool, a heat wave is defined as a period of 4 consecutive extreme heat days or warm nights when the daily maximum/minimum temperature is above the extreme heat threshold.[23] The extreme heat threshold for Marin County is 94.4 °F. Each 4 day/night period is counted, so that if extreme temperatures persist for 10 consecutive days/nights, it counts as 2 heat waves. There were 0.2 heat waves in an average year in Marin County from 1950 to 2005.[24] Marin County had an average of 4 extreme heat days and 5 warm nights in Marin County between 1950 and 2005, lasting an average of 2.1 days. All extreme heat days and warm nights in this time period occurred between June and September.[25]

[23] There is no universal definition for "extreme heat wave." The 2020 California Adaptation Planning Guide defines an extreme heat wave as five extreme heat days in a row. Cal-Adapt defines an extreme heat wave as four consecutive extreme heat days/warm nights. For the purpose of projecting the number of extreme heat days Marin County will experience each year due to climate change, the Cal-Adapt definition of extreme heat wave was used.

[24] Ibid.

[25] Cal-Adapt: Extreme Heat Days and Warm Nights, Marin County. Accessed September 29 at: https://cal-adapt.org/tools/extreme-heat/

Average temperatures and the number of extreme heat events has increased in Marin County in recent years. The Cal-Adapt tool shows the projected annual average number of extreme heat days to be nine and warm nights to be 10 from 2006 to 2020, lasting an average of 3.4 days. The average annual number of heat waves was projected to be 0.6 from 2006 to 2020.[26] Actual data on annual temperature and frequent heat warnings over that time period are consistent with the projections. For example, the average temperature in Marin County was 54.8°F from the years 1901 to 2000 but was 57.2°F over the past five years (August 2016 to July 2021).[27]

Probability of Future Events

Under a scenario in which emissions peak around 2040, then decline, the average annual number of extreme heat days and warm nights in Marin County is projected to increase to 19 and 27 by 2050, and 18 and 28 by 2099. The timing of extreme heat days and warm nights is projected to expand from June to September (historical) to May to October. The average duration of extreme heat days is projected to be six days by 2050 and four days by 2099 under this scenario. The average annual heat wave frequency is projected to be 2.0 by 2050 and 1.0 by 2099.[28]

Under a scenario in which emissions continue to rise strongly through 2050 and plateau around 2100, the average annual number of extreme heat days and warm nights in Marin County is projected to increase to 19 and 20 by 2050, and 37 and 88 by 2099. The timing of extreme heat days and warm nights is projected to expand from June to September (historical) to May to October. The average duration of extreme heat days is projected to be 5.8 days by 2050 and 7.3 days by 2099 under this scenario. The average annual heat wave frequency is projected to be 1.5 by 2050 and 3.5 by 2099.[29] Figure 3-3 shows the projected number of extreme heat days (i.e., the number of days in a year when daily maximum temperature is above a threshold temperature) in Marin under medium and high emissions scenarios. The temperature threshold for Marin is 94.4 °F, which is the 98th historical percentile of daily maximum/minimum temperatures based on observed historical data from 1961 to 1990 between April and October. The bold teal and purple lines in Figure 3-3 represent the most likely outcome and the less saturated teal and purple shading shows the range of future projections of extreme heat days. Figure 3-3 shows extreme heat days reaching 80 degrees around 2080 and beyond.

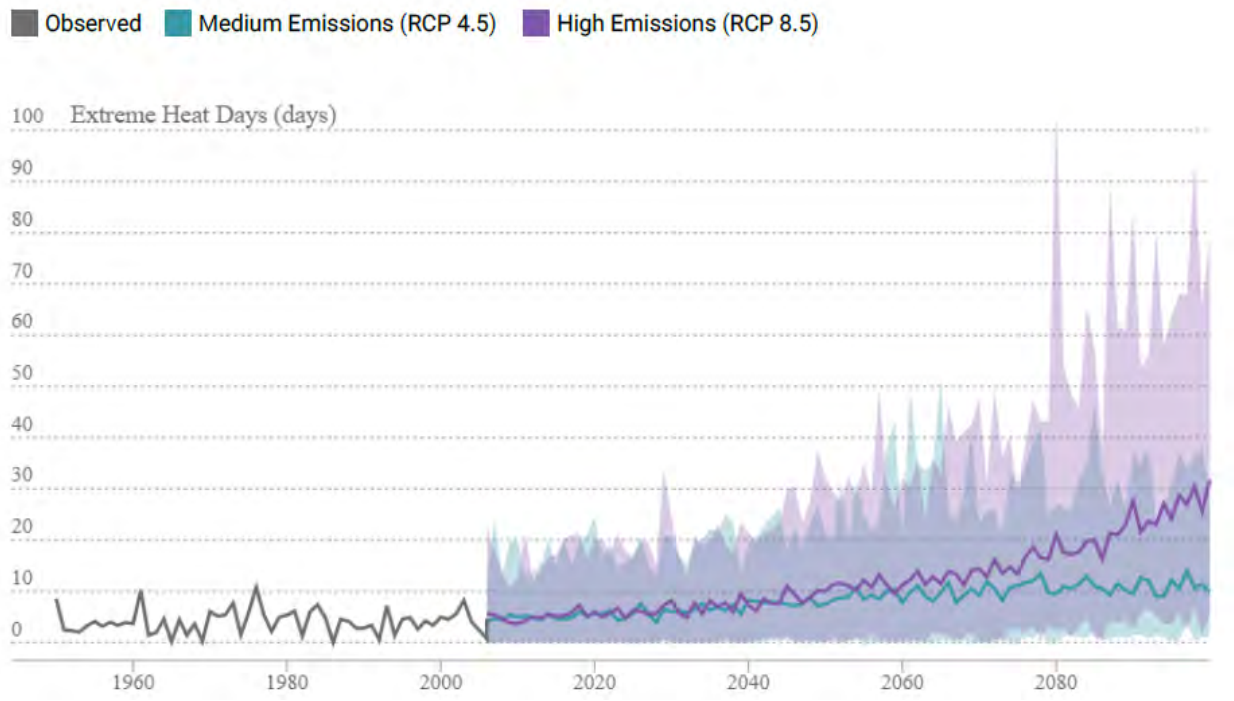
[26] Ibid.

[27] NOAA National Centers for Environmental Information: Climate at a Glance. Accessed September 29, 2021 at: https://www.ncdc.noaa.gov/cag/county/mapping/4/tavg/202108/60/value

[28] Cal-Adapt: Extreme Heat Days and Warm Nights, Marin County. Accessed September 29 at: https://cal-adapt.org/tools/extreme-heat/

[29] Ibid.

FIGURE 3-3: PROJECTED EXTREME HEAT DAYS IN MARIN COUNTY



Source: Cal-Adapt, Local Climate Change Snapshot for Marin County (2021)

Vulnerability

Infrastructure

Extreme heat can affect a range of key infrastructure from energy systems, water and wastewater treatment systems, the operation of government buildings, and public transit. While higher summer temperatures increase electricity demand for cooling, at the same time, it also can lower the ability of transmission lines to carry power, possibly leading to electricity reliability issues during heat waves. Increased temperatures also impact the efficiency of solar power infrastructure by increasing the surface temperature of solar panels, which reduces the voltage that panels can generate and thereby lowers efficiency. Although warmer winters will reduce the need for heating, modeling suggests that total U.S. energy use will increase in a warmer future.[30]

Extreme heat can also increase the risk of other types of disasters and exacerbate the urban heat island effect. Heat can exacerbate drought, and hot dry conditions can in turn create wildfire conditions. In cities, buildings roads and infrastructure can be heated to 50 to 90 degrees hotter than the air while natural surfaces remain closer to air temperatures. The heat island effect is most intense during the day, but the slow release of heat from the infrastructure overnight (or an atmospheric heat island) can keep cities much hotter than surrounding areas.[31]

[30] Ibid.

[31] Ibid.

Animals, including livestock, poultry, and domestic pets are susceptible to extreme heat. For example, dogs and cats are in danger of heat stroke in temperatures of 110°F. The heat wave of 2006 resulted more than 25,000 cattle, 700,000 fowl, and 15 reported heat-related pet deaths in California. Heat wave impacts on livestock and poultry can lead to financial losses in agriculture.[32]

Populations

Northern Marin County (roughly north of Point Reyes, Nicasio, and Lucas Valley to the northern County line) is likely to see greater increases in annual average maximum temperatures due to climate change at a faster rate than southern portions of the County.[33] While climate change-induced extreme heat events will impact County residents in the future, extreme heat effects will be less severe in the County relative to other areas of the state, including the Central Valley, that already experience higher temperatures and more extreme heat events. In terms of overall level of impact to County residents and infrastructure, extreme heat due to climate change will be less of a concern compared to flooding, sea level rise, wildfire, and landslides, debris flows, and post-fire debris flows in most cases. However, extreme heat will have a relatively greater impact on certain populations. Marin County populations most vulnerable to the effects of extreme heat include:

- Low-income households,
- Households in poverty,
- Persons without access to transportation or telecommunications,
- Low-resources racial or ethnic minorities,
- Outdoor workers,
- Healthcare workers, first responders, and protective service occupations,
- Houseless population,
- Children,
- Persons with disabilities,
- Persons with chronic health problems, and
- Senior citizens.

In extreme temperatures, air quality is also affected. Hot and sunny days can increase ozone levels, which in turn affects NO_X levels. In addition, greater use of heating and cooling of indoor spaces requires more electricity and, depending on the electricity source, can emit more of other types of pollution, including particulates. These increases in ozone and particulate matter can pose serious risks to people, particularly the same vulnerable groups directly impacted by heat mentioned above.[34]

---

[32] Ibid.

[33] Ackerly, David, Andrew Jones, Mark Stacey, Bruce Riordan. (University of California, Berkeley). 2018. San Francisco Bay Area Summary Report. California's Fourth Climate Change Assessment. Publication number: CCCA4-SUM-2018-005. https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-005_SanFranciscoBayArea_ADA.pdf

[34] Center for Climate and Energy Solutions: Heat Waves and Climate Change. Accessed September 29 at: https://www.c2es.org/content/heat-waves-and-climate-change/

Flooding

Hazard Profile

Both the Marin County Multi-Jurisdiction Local Hazard Mitigation Plan (MCM LHMP) and the Marin Municipal Water District (MMWD or Marin Water) Hazard Mitigation Plan document the extent and impacts of flooding in Marin. Information in these two documents provided the basis of this discussion, unless otherwise indicated.

A flood occurs when there is too much water on the ground to be held within local bodies of water, drain into soils, or to be carried away by rivers or urban drainage systems, causing the water to flow into normally dry areas. Two forms of flooding primarily occur in Marin: 1) tidal flooding and 2) river or watershed flooding. Coincident tidal and watershed flooding can also occur.[35]

Tidal flooding develops when high tides exceed either the top of bank elevation of tidal sloughs and channels, or the crest of bay levees.

Watershed flooding occurs because of severe or prolonged rainfall and the streams and drainages within the watershed cannot accommodate the amount of runoff. Major watershed floods are typically generated by rainstorms of 3-4 days duration that include periods of high intensity rainfall. Such rainstorms occur primarily during the wet winter season which normally extends from November through March. When watershed flooding occurs in conjunction with high bay tides, the extent and/or depth of overbank flooding or levee overtopping can increase due to the volume of stormwater being discharged into the bay.

[35] County of Marin. 2007. Marin Countywide Plan. November 6, 2007.

WHAT ARE KING TIDES?

An especially high tide event that occurs during alignment of the gravitational pull between the sun and the moon, causing tidal water levels to rise to higher-than-normal levels. King tides are normal, predictable events that occur semi-annually during winter months in the County.

Source: Marin County CDA

WHAT IS STORM SURGE?

The rise in seawater level caused solely by a storm.

Source: NOAA

In coastal areas, flooding may occur when strong winds or tides result in a surge of seawater into areas that are above the normal high tide line. This is commonly referred to as storm surge. The result can be waves that extend further inland, causing damage to development that would not normally be subject to wave action.

Flooding can be caused by short periods of heavy rainfall, long periods of moderate rainfall, or clogged storm drains during periods of rainfall. In rare instances, a break in a water pipe or water tank, or a dam failure can also cause flooding. Storm drainage systems throughout the developed parts of the county collect stormwater runoff and convey water to prevent flooding, although these systems are typically designed based on winter storms recorded in the past and may not be designed to accommodate more intense storms.

Floodwaters can be deep enough to drown people and move fast enough to sweep people and vehicles away, lift buildings off foundations, and carry debris that smashes into buildings and other property. Flood waters can cause significant erosion which can lead to slope instability, severely damage the transportation and utility infrastructure by undermining foundations or washing away pavement. If water levels rise high enough to get inside buildings, it can cause extensive damage to personal property and the structure itself. Flood events that develop very quickly, called flash floods, are especially dangerous because there may be little advance warning.

The key factors that contribute to urban flooding are rainfall intensity and rainfall duration. Topography, soil conditions, urbanization, and groundcover also play an important role.[36]

According to the 2018 MCM LHMP, what is currently considered a 100-year flood, or a flood that has a 1 percent chance of occurring annually, may occur more often due to climate change.

All of Marin's watersheds are small and largely prone to flash flooding. The National Weather Service (NWS) defines a flash flood as one in which the peak flow travels the length of a watershed within a 6-hour period. These floods arise when storms produce a high volume of rainfall in a short period over a watershed where runoff collects quickly. They often affect populated areas of Marin's cities and towns and strike with little warning and are accompanied by high velocity flow.

Several Marin communities, such as Tamalpais Valley, Santa Venetia, Corte Madera, Belvedere, and parts of Strawberry, Novato, and Ross Valley are protected by levees. No levee system provides full protection from all flooding events and some level of flood risk will exist in the levee protected areas. Except for one levee system in Novato-Hamilton, none of the County's levees are FEMA-accredited. Most were built many decades ago (non-engineered) by farmers or developers and material may have been added over the years. Levees can fail in the event of an earthquake, internal erosion, poor engineering/construction, or landslides, but levees most

[36] Marin Municipal Water District Hazard Mitigation Plan Public Review Draft. September 2021

commonly fail because of significant rainfall or very high tides. During a period of heavy rainfall, the water on the water-body side of the levee can build up and either flow over the top ("overtopping") or put pressure on the structure causing quickening seepage and subsequent erosion of the earth. The overflow of water washes away the top portion of the levee, creating deep grooves. Eventually the levee weakens, resulting in a breach or collapse of the levee wall and the release of uncontrollable amounts of water.

Flooding can cause secondary impacts. The most problematic secondary hazard for riverine flooding is bank erosion, which can be more harmful than actual flooding. Floodwaters may scour stream banks, edging properties closer to the floodplain or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, rivers, or storm sewers, or sanitary sewers overflow from stormwater infiltration.[37]

In many cases, where there is a significant history of flooding there is a Marin County Flood Control & Water Conservation District "Flood Zone" established. There are eight County Flood Zones, which are listed in Table 3-2 below and shown in Figure 3-4.

Many unincorporated communities in Marin contain FEMA Special Flood Hazard Areas (SFHA), meaning they have at least a 1% chance of flooding in a given year. They all participate in the National Flood Insurance Program and many of the structures in the SFHA carry FEMA flood insurance or private flood insurance. Marin County and its cities participate in the National Flood Insurance Program (NFIP). The NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in communities that adopt and enforce floodplain management ordinances to reduce future flood damage. SFHAs in unincorporated Marin are shown in Figure 3-5.

[37] ibid

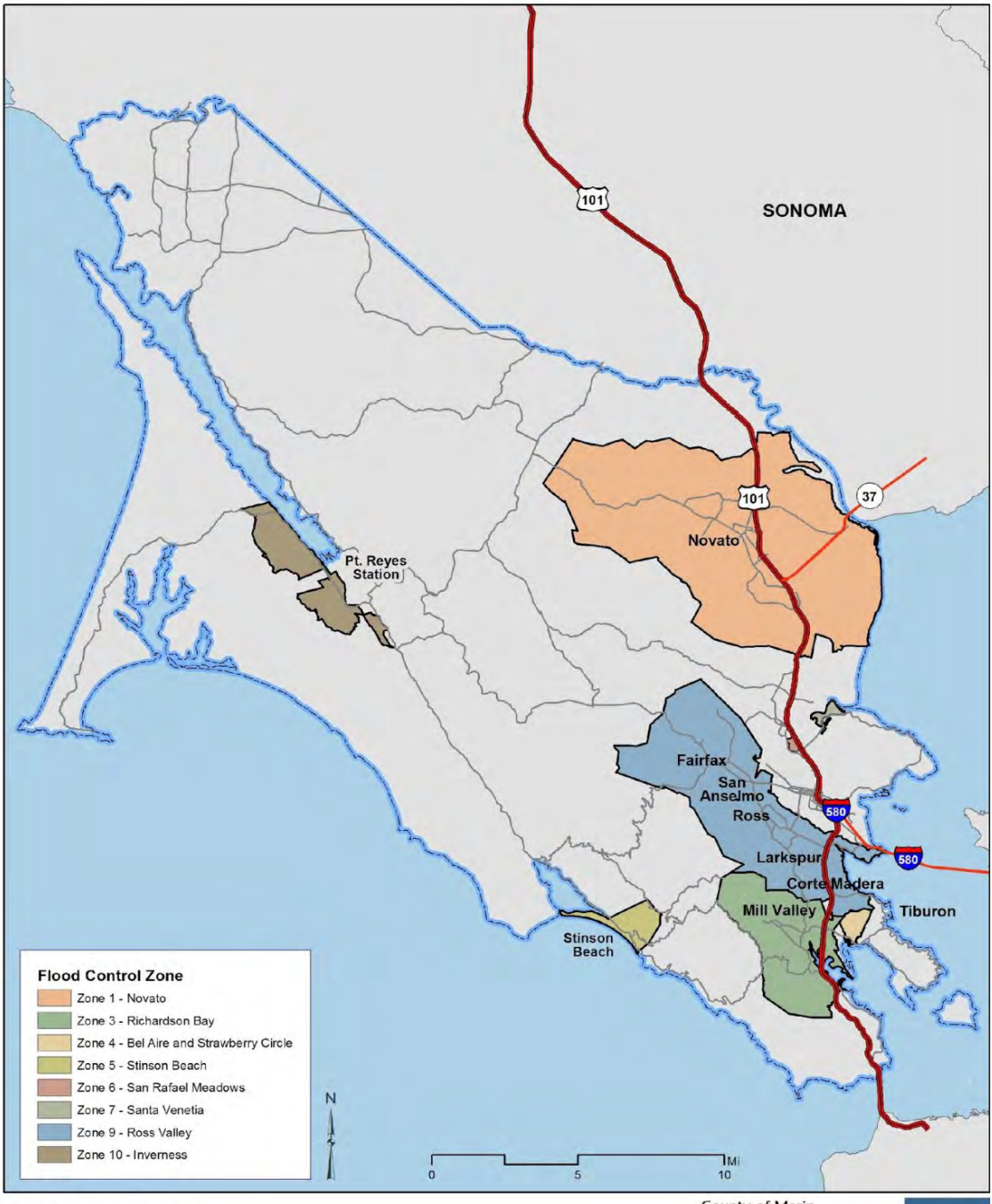


Figure 3-4: Marin County Flood Control & Water Conservation District Zones

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin County Multi-Jurisdiction Local Hazard Mitigation Plan

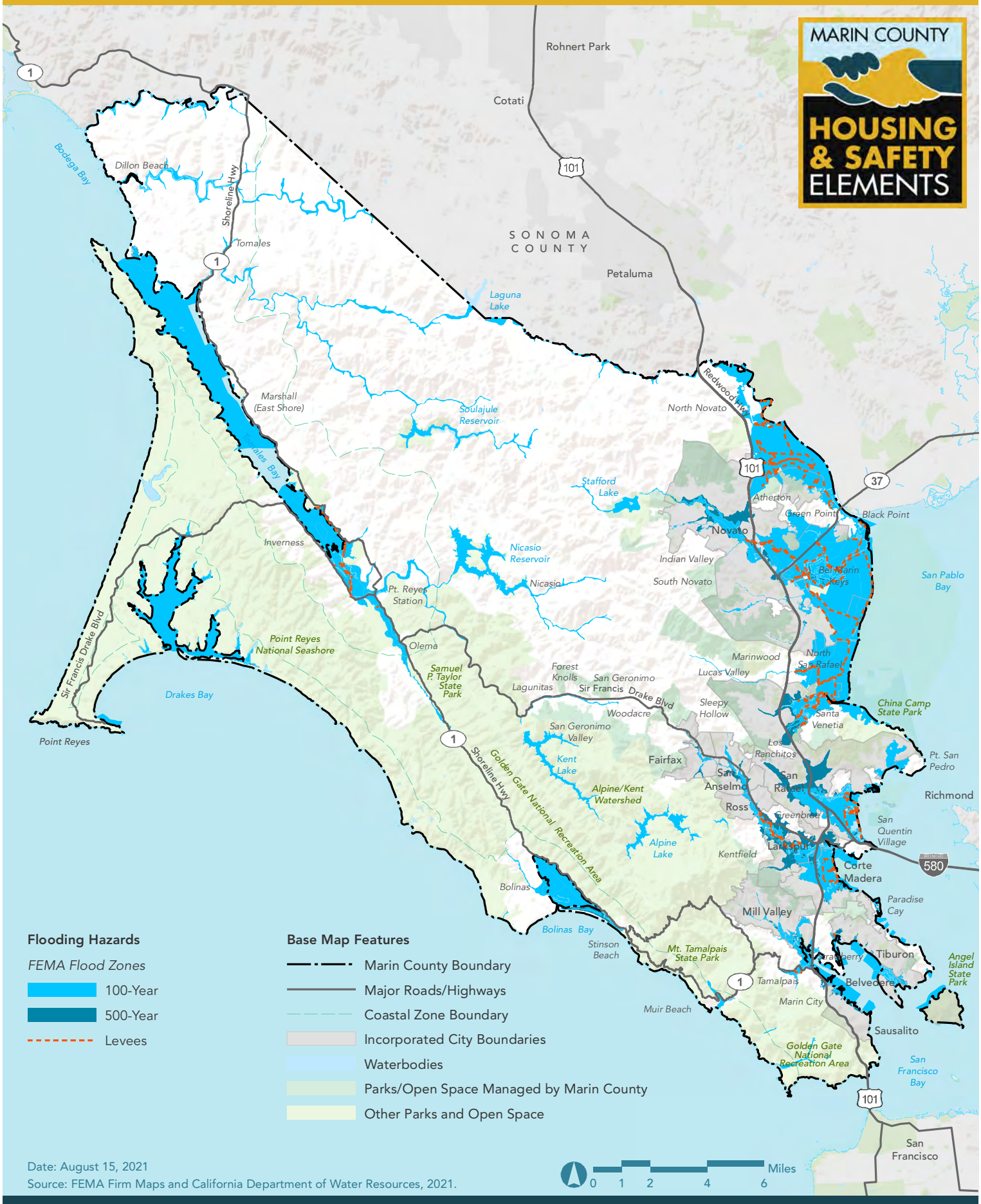


Figure 3-5: FEMA Flood Zones

SAFETY ELEMENT VULNERABILITY ASSESSMENT

TABLE 3-2: MARIN COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT "FLOOD ZONES"

Zone	Name	Location
1	Novato	Northern Marin: Most of City of Novato and some surrounding areas within the Novato Creek watershed.
3	Richardson Bay	Southern Marin: Marin City watershed, Coyote Creek watershed (includes Tamalpais Valley and Almonte); Arroyo Corte Madera del Presidio watershed and Ryan Creek watershed (both include much of the City of Mill Valley), a watershed including Sutton Manor/Alto/part of Strawberry.
4	Bel Aire	Southern Marin: East and West Creek watersheds which run through the Bel Aire neighborhood of the Town of Tiburon and part of (unincorporated) Strawberry.
5	Stinson Beach	West Marin: Part of the lower Easkoot Creek watershed at Stinson Beach
6	San Rafael Meadows	Central Marin: A part of the Las Gallinas Creek watershed in the City of San Rafael across from the County Civic Center.
7	Santa Venetia	Central Marin: The unincorporated community of Santa Venetia along Las Gallinas Creek.
9	Ross Valley	Central Marin: The Corte Madera Creek watershed, including the towns of Fairfax, San Anselmo, Ross, and Larkspur, as well as unincorporated parts of San Anselmo, Fairfax, Kentfield and Greenbrae.
10	Inverness	West Marin: Inverness, along the west shore of Tomales Bay and the East flank of Inverness Ridge.

Source: Marin County Multi-Jurisdiction Local Hazard Mitigation Plan (MCM LHMP) (2018)

Note: The source table is from the MCM LHMP; Table 3-6 of the MCM LHMP does not show information for a Zone 2 or a Zone 8.

Disaster History

Since the middle of the last century, the winter/spring storms of 1950, 1955*, 1958*, 1963, 1964*, 1969*, 1970*, 1973*, 1978, 1980, 1982*, 1983*, 1986*, 1995*, 1996, 1997*, 1998*, 2002, 2005/2006*, 2006*, 2008, 2014, and 2017* caused significant damage. The "*" denotes Major Federal Disasters declared for flood. When flooding occurs in Marin County, depths are commonly on the order of 0-2 feet in streets and sidewalks. This level occurs when storm drains are overwhelmed and/or during king tides.

Typically storms in which high tides coincide with peak stormwater flow are the most damaging. The New Year's Eve 2005-2006 flood was the last major riverine flooding event that caused

widespread damage in Marin. Localized flooding occurred in almost all areas of the County in the 2006 winter storm. San Anselmo, Ross, Fairfax, and Mill Valley were the most heavily impacted. At least $219 million in damage was reported in Marin due to this storm, including $94 million in the Ross Valley (Corte Madera Creek) Watershed alone. Over a thousand homes, apartments and businesses were damaged or destroyed. Prior to 2006, the last flood of similar magnitudes occurred in 1982 and 1983. Many improvements were made to flood facilities since then, particularly in Novato.

Novato Creek in the northern part of the county historically caused damage to large numbers of homes, particularly in the 1960's, until the Novato Flood Control Project was completed in 2006. Novato still experiences some damage during significant winter storms. For example, over a million dollars-worth of levee damage occurred in 2014 and 2017 and a heavy burden on stormwater pumping systems caused additional damage to pumping system components. Power outages are also a frequent problem for one of the major pump stations in the area.

Probability of Future Events

Marin County has experienced 16 flood events that triggered a federal disaster declaration since 1969, and averages one such flood event every 3.25 years. Records show that the County can expect to experience some degree of localized flooding annually. The likelihood of flood events occurring in the future is high with the projected increase in extreme precipitation events.[38] Projected changes in sea level are expected to directly exacerbate flooding and indirectly make existing poor drainage conditions worse throughout the County.

The County of Marin has several major 100-year and 500-year floodplains which are mapped by FEMA in the most recent Flood Insurance Rate Maps (FIRM), several of which were updated in 2016 and 2017. While they may look small relative to the size of the County as a whole, the bulk of the floodplains are located in some of the County's most heavily populated areas along the eastern shoreline, notably portions of Novato, San Rafael, and Mill Valley.

These floodplains vary in size, probability and severity of inundation, underlying causes of flooding (riverine, tidal, etc.), and potential impacts to the communities in them. The areas of most concern are located in designated FEMA 100-year flood zones or SFHA. Due to the increased probabilities of flooding (1% chance in any given year), these properties face high insurance premiums and major restrictions on further development.

For some of the developments along the San Francisco Bay, such as Santa Venetia and Tamalpais Valley, the main flooding issues concern poor drainage due to flat terrain and/or differential settlement, low elevation relative to the tides, and the reliance on a system of pumps and levees to keep floodwaters from inundating homes. Runoff collecting in this area can be especially difficult to remove during high tides.

[38] Marin Municipal Water District Hazard Mitigation Plan Public Review Draft. September 2021

Other more inland areas, such as areas along Corte Madera Creek and its tributaries, have higher elevations yet still contain properties located in 100-year flood zones. This is mainly due to threats caused by local creeks which have a tendency to overflow their banks when rainfall reaches critical levels. Properties along Novato Creek and its tributaries face similar threats. The main stems of these creeks and many of their tributaries are constrained by development on the banks.

Although the Corte Madera Creek Flood Control project has been implemented, flooding will still occur for storms greater than about a 5-year recurrence flood event. Potentially all nine southerly and some centrally located communities of Marin County on this creek are impacted by high tides and heavy rains in above average winter storms. The north-east part of the County, densely populated around the floodplain zones, is threatened every winter and still experiences some damage during winter storms despite the completed Novato Creek Flood Control project.

With sea level rise, it is projected that more land along Marin's coastline and bayside will be permanently inundated or subject to more regular flooding, while the frequency and intensity of storm events are anticipated to increase with climate change. Greater riparian flooding may also occur with sea level rise and future storm events, though modeling is necessary to better understand the extent of such hazards. For more discussion on sea level rise see discussion below.

Vulnerability

Infrastructure

Major County watersheds where significant numbers of structures are at risk from riverine flooding include Coyote Creek, Arroyo Corte Madera del Presidio, East and West Creek watersheds, Corte Madera Creek, Novato and Rush Creeks, Miller Creek, Easkoot Creek (Stinson Beach), Gallinas Creek. Additionally, many locations along Richardson Bay, Tomales Bay, lower Las Gallinas Creek, the San Rafael Canal, East San Rafael and Novato shores, and the outer Pacific coastline are vulnerable to coastal flooding.[39]

Thousands of residential and commercial structures, and hundreds of industrial structures are potentially impacted by 100-year floods. Transportation is also heavily impacted (even during smaller storms), with hundreds of miles of roadways and 19 miles of railroad potentially flooded during and after flood events. Because of this, access issues during and after major storms can be widespread. Critical water and wastewater facilities may also be affected by flooding, which can have devastating secondary effects on health of residents. Because of the diverse microclimates and small and varying watersheds of Marin, it is not common that all areas in designated FEMA 100-year floodplains would severely flood during the same storm system. However, given extensive historical development within the floodplain, impacts of a single powerful storm system to people and infrastructure can be extreme. Flooding is a relatively frequent occurrence in many populated areas of the County, making the county quite vulnerable to floods.

[39] County of Marin. 2018. Marin County Multi-Jurisdiction Local Hazard Mitigation Plan (MCM LHMP).

The Draft MMWD LHMP pointed out several planning issues that increase vulnerability to flood effects including:

- The currently effective flood hazard mapping does not accurately reflect the true flood risk in Marin County because FEMA mapping does not recognize flooding associated with urban drainage issues.
- Planning tools whose use depends on flood hazard mapping are less effective due to the deficiencies in the currently available mapping.
- A lack of concern regarding flood risk by property owners can translate to the lack of political will to make changes.
- The potential impact of climate change on flood conditions needs to be better understood.

Populations

Marin County populations that are most vulnerable to the effects of flooding include:

- Low-income households,
- Households in poverty,
- Renters,
- Persons living on single access roads,
- Mobile home owners,
- Person without access to transportation or telecommunications,
- Linguistically isolated communities,
- Low-resources racial or ethnic minorities,
- Outdoor workers,
- Healthcare workers, first responders, and protective service occupations,
- Houseless population, and
- Persons with disabilities.

Landslides, Debris Flows, and Post-Fire Debris Flows

Hazard Profile

Landslide is a general term for the dislodging and fall of a mass of soil or rocks along a sloped surface or the dislodged mass itself.[40] The term is used for varying phenomena, including mudflows, mudslides, debris flows, rock falls, rockslides, debris avalanches, debris slides, and slump-earth flows. A debris flow occurs when water begins to wash material from a slope or when water runs off a newly burned stretch of land, picking up speed and debris as it descends the slope.

[40] County of Marin. 2018. Marin County Multi-Jurisdictional Local Hazard Mitigation Plan.

Landslides can be earthquake-induced or non-earthquake induced.[41] The Vulnerability Assessment only looks at non-earthquake induced landslides. Non-earthquake induced landslides may involve a wide range of combinations of natural rock, soil, or artificial fill.[42] The susceptibility of hillside and mountainous areas to non-earthquake induced landslides depends on variations in geology, topography, vegetation, and weather. Steep slopes made up of loose or fractured material are more likely to slide. In some cases, the hillside can become so waterlogged that the sliding soil becomes mud, causing a mudslide. Landslides and mudslides can move fast enough to damage or destroy buildings or other structures in their path, block roads or railways, and injure or kill people caught in them.

Landslides are a part of natural geologic processes and have impacted both private and public property in various areas throughout Marin County since development began. When much of Marin County was developed in the early 20th century, many of the roads were benched or cut into steep hillsides without sufficient compaction of the roadbed. The use of earth retaining structures was not common in roadway construction and/or retaining structures were built using wood materials that have since deteriorated. Marin County is largely undeveloped and has a widespread natural environment where creeks and rivers adjoin both private and public infrastructure. During times of intense rainfall, creeks rise, and the resulting high flows can erode roadway supporting earthen embankments leading to landslides and sometimes property damage.

[41] Ibid.

[42] Ibid.

Another example of a non-earthquake-induced landslide is that which results from physical undermining and erosion of a slope. Most commonly this occurs because of high volume and/or high velocity water flows of a creek or flood waters which lead to scour at the toe of a sloped creek bank or hillside. Prolonged and/or heavy precipitation leads to increases in landslide events in Marin County more often than other natural phenomena referenced above.

Wildfire can significantly alter the hydrologic response of a watershed to the extent that even modest rainstorms can produce dangerous flash floods and debris flows. The USGS conducts post-fire debris-flow hazard assessments for select fires in the Western U.S.

Disaster History

Winter storms in 2006 and 2017 resulted in hundreds of locations in Marin County where damage occurred from landslides, rock fall, or other infrastructure damage related to slope instability.[43]

The bluff along the Bolinas Mesa in the unincorporated town of Bolinas has been associated with a variety of landslide activity. The major cause of earth movement in this area is the extensive presence of weak cohesion-less (sandy) soils combined with undermining wave action at the toe of the bluff. As wave action removes toe-supporting soils, the outer face of the bluff slumps or creeps downwards causing settlement and landslides at the top of the Mesa.

State Route 1 between Bolinas and Stinson is adjacent to hillsides of Franciscan complex friable soils that are highly erodible. As a result, the steep hillsides east of SR 1 have historically experienced many landslides. Landslides and debris flows are a concern because the potential to re-route sections of SR 1 in this area is limited by constriction of the lands against Bolinas Lagoon.

The California Geological Survey inventory shows extensive areas of prior landslides around the County particularly in developed areas. Smaller scale, and/or more isolated slides occur throughout the county where there are slopes.

[43] Ibid.

The MMWD has compiled in its LHMP a list of historical landslide/debris flow activity within the district planning area, which encompasses much of the developed and adjacent undeveloped area in southeast Marin. Table 3-3 below contains MMWD's list of recent landslide/debris flow events.

TABLE 3-3: MASS MOVEMENT EVENTS IN AND NEAR THE MMWD PLANNING AREA

Event Date	Event Type	FEMA Number	Description
01/16/2020	Debris Flow	N/A	Mud/dirt/rocks reported on US-101 S and Marin City on ramp. Mud and dirt falling from right hand side.
02/24/2019 – 03/01/2019	Severe Winter Storms, Flooding, Landslides, and Mudslides	DR-4434	An atmospheric river moved through the region near the end of the month with the bulk of the debris flows experienced in the North Bay.
02/13/2019 – 02/15/2019	Severe Winter Storms, Flooding, Landslides, and Mudslides	DR-4431	An atmospheric river with an associated cold front moved through the region from February 12th to the 15th bringing widespread flooding and debris flows.
01/16/2019	Debris Flow	N/A	Mud slide shutdown SB 101 Waldo Grade.
01/06/2019	Debris Flow	N/A	Mud slide covering lanes on Sir Francis Drake Blvd at Lagunitas Rd.
02/01/2017 – **02/23/2017**	Severe Winter Storms, Flooding, Mudslides	DR-4308	Potent atmospheric river brought copious amounts of rain to the region causing widespread flooding, debris flow, accidents, and over topping of reservoir spillways.
01/03/2017 – **01/12/2017**	Severe Winter Storms, Flooding, and Mudslides	DR-4301	State Highway 1 in Marin County was closed between Bolinas and Stinson Beach on due to mudslides. The District sustained over $2 million in damage.
01/16/2016	Debris Flow	N/A	Minor mud slide on SR1 at Steep Ravine Trail, blocked one lane.
12/11/2014	Debris Flow	N/A	A significant mudslide occurred along Tennessee Valley Road, causing $1 million in property damage.
12/11/2014	Debris Flow	N/A	A slide under sixty feet of Highway 1 near Muir Beach resulted in a full closure of the road, causing $1 million in damages.
02/28/2014	Debris Flow	N/A	Rock and mudslide blocking portions of Highway 1 at Panoramic.

Event Date	Event Type	FEMA Number	Description
03/29/2006 – 04/16/2006	Severe Storms, Flooding, Landslides, and Mudslides	DR-1646	Persistent heavy rainfall caused a massive number of landslides across the Sonoma and Marin County valleys area during the first half of April. About $20 million of damage was done to agriculture. In Marin County the hardest hit areas were Mill Valley, Fairfax, and San Rafael. In Mill Valley, a man was killed after he was buried in a mudslide in his backyard.
12/17/2005 – 01/03/2006	Severe Storms, Flooding, Mudslides, and Landslides	DR-1628	Declaration of Emergency for Marin County declared due to severe winter storms. These caused flashfloods, mudslides, and damage to roads and other infrastructure.
01/03/1995 – **02/10/1995**	Severe Winter Storms, Flooding, Landslides, Mud Flows	DR-1044	A series of winter storms caused several mudslides in Marin County, blocking roads and damaging residential and public property.
01/21/1983 – **03/30/1983**	Coastal Storms, Floods, Slides, Tornadoes	DR-677	A series of winter storms along the California coast caused widespread property damage. As of January 29, 11 deaths were reported, along with damages to over 2,600 homes and 30 public roads.
12/19/1981 – 01/08/1983	Severe Storms, Flood, Mudslides, High Tide	DR-651	Heavy rainfall in the San Francisco Bay region on January 3–5 triggered thousands of debris flows from Santa Cruz Country to Contra Costa and Sonoma Counties, as well as flooding along the San Lorenzo River, Soquel Creek, and Aptos Creek in Santa Cruz County. Floods along creeks in Marin County plus added significant amounts of sediment to Tomales Bay. The landslides caused at least $66 million in damage. Landslides caused 25 of the 33 storm-caused deaths. Total estimated storm-related losses were $280 million.

The USGS has developed mass movement mapping for the Bay Area that designates historical landslide occurrence throughout the area in four ratings: flat land (little or no potential for slides), few landslides (few, if any, large historical landslides), mostly landslide (mapped historical slides and some areas surrounding them), and many landslides (mapped historical slides and more extensive surrounding areas than in the mostly landslide category).[44] Figure 3-6 shows the areas mapped as “mostly landslide” within the County.

There are no examples in recent history of post-fire debris flow in Marin County.[45]

[44] Marin Water (MMWD). 2021. Marin Municipal Water District Hazard Mitigation Plan Public Review Draft. September 2021.

[45] County of Marin. 2018. Marin County Multi-Jurisdictional Local Hazard Mitigation Plan.

Probability of Future Events[46]

While landslides occur in any given year, the frequency and number of landslides has been observed to be directly proportionate to the frequency and duration of rainfall events. Landslides are less likely to occur during the fall months (October-November) when the ground is sufficiently dry and can absorb the moderate rain events typically observed during this time of year. Landslides are more often observed between December and May when rain events are usually more intense and/or frequent. In Marin County, renewed and potentially widespread landslide activity will most likely occur during or after future periods of prolonged or intense rainfall. Climate change will likely increase the frequency and intensity of storm events in the County,[47] which in turn would increase the potential for rainfall-induced landslides and debris flows in the future.

Climate change is expected to cause an increase in the number of years that see intense levels of precipitation. During these years, heavy rainfall or snowfall could cause an increase in the number of landslides or make landslides larger than normal. Vegetation helps to hold the material of a hillside together, but vegetation can be stripped away by climate exposures such as increased wildfires, more frequent and intense droughts, or disease/pest infestations. Without vegetation to help stabilize the slope, hills may be more likely to slide. Combined with the increase in intense rainfall years, there may be a significant increase in landslides because of climate change.

There have been no major wildfires in the County since 2013, reducing the potential for post-fire debris flow. USGS analysis also does not show any existing significant post-fire debris flow threats in Marin. However, any summer or fall wildfires that occur could lead to post-fire debris flows originating from the burn areas during the following rainy season. Thus, the location of this hazard coincides with watershed locations with the greatest wildfire and flood threats. Without recently burned watersheds the extent and probability of future events can't be analyzed. However, precautions should always be taken after a burn to ensure that soil stability is maintained to the extent feasible.

The locations of past mass movements are often likely sites of future mass movements. Although most show no evidence of recent movement, a small portion may become active in any given year. Ancient dormant mass movements sites can be reactivated by earthquakes or by exceptionally wet weather. These dormant sites also are vulnerable to construction-triggered sliding. As development spreads into hillsides, unstable soil and erosion often contribute to landslides.[48]

Vulnerability[49]

Infrastructure

Marin County is hilly, and the distribution of the landslide hazard varies across the County, as shown in Figure 3-6. The combination of factors that cause landslides, including geology,

[46] Ibid.

[47] County of Marin. 2020. Marin County Unincorporated Area Climate Action Plan 2030. December 2020.

[48] Marin Municipal Water District. 2021. Hazard Mitigation Plan Public Review Draft. September 2021

[49] County of Marin. 2018. Marin County Multi-Jurisdictional Local Hazard Mitigation Plan.

vegetation, local drainage, and local grading make slope a poor proxy of landslide risk. However, parcels with an average slope above 20% are considered hillside lots and risks of slides are present slopes of 30 and above. Slopes as high as 60 or 65 are common on hillsides throughout the County.

Historic development in Marin tends to be concentrated in small areas, with many homes located along creeks and on steep hillsides potentially impacted by precipitation-induced landslides. Thousands of existing structures have the potential to be impacted by landslides, including over ten thousand single-family homes, in addition to multi-family, commercial structures, and structures on a few industrial parcels. Notably, hundreds of miles of roads are potentially impacted by landslides which can lead to their short-term closure during and after intense storm events and some power utility facilities could also be affected. Infrastructure, such as natural gas pipelines and water or wastewater infrastructure, can break or malfunction if the soil supporting them fails. This can lead to disruptions in energy delivery and water or wastewater services.

Landslides, mudslides, and debris flows can move fast enough to damage or destroy homes or other structures in their path, block roadways (including evacuation routes), and injure or kill people caught in them. The most vulnerable populations are those that may be unable to evacuate due to limited mobility, lack of access to a vehicle, or language barriers that may prevent awareness of emergency notifications. Those living on single-access roadways in the hilly areas of the County or those living in less resilient housing may lose access to their homes if roadways or the structures are damaged or destroyed by a landslide.

Populations

Landslides, mudslides, and debris flows can move fast enough to damage or destroy homes or other structures in their path, block roadways (including evacuation routes), and injure or kill people caught in them. Marin County populations that are most vulnerable to the effects of landslides, debris flows, and post-fire debris flows include:

- Low-income households,
- Households in poverty,
- Renters,
- Persons living on single access roads,
- Persons without access to transportation of telecommunications,
- Outdoor workers,
- Houseless population, and
- Persons with disabilities.

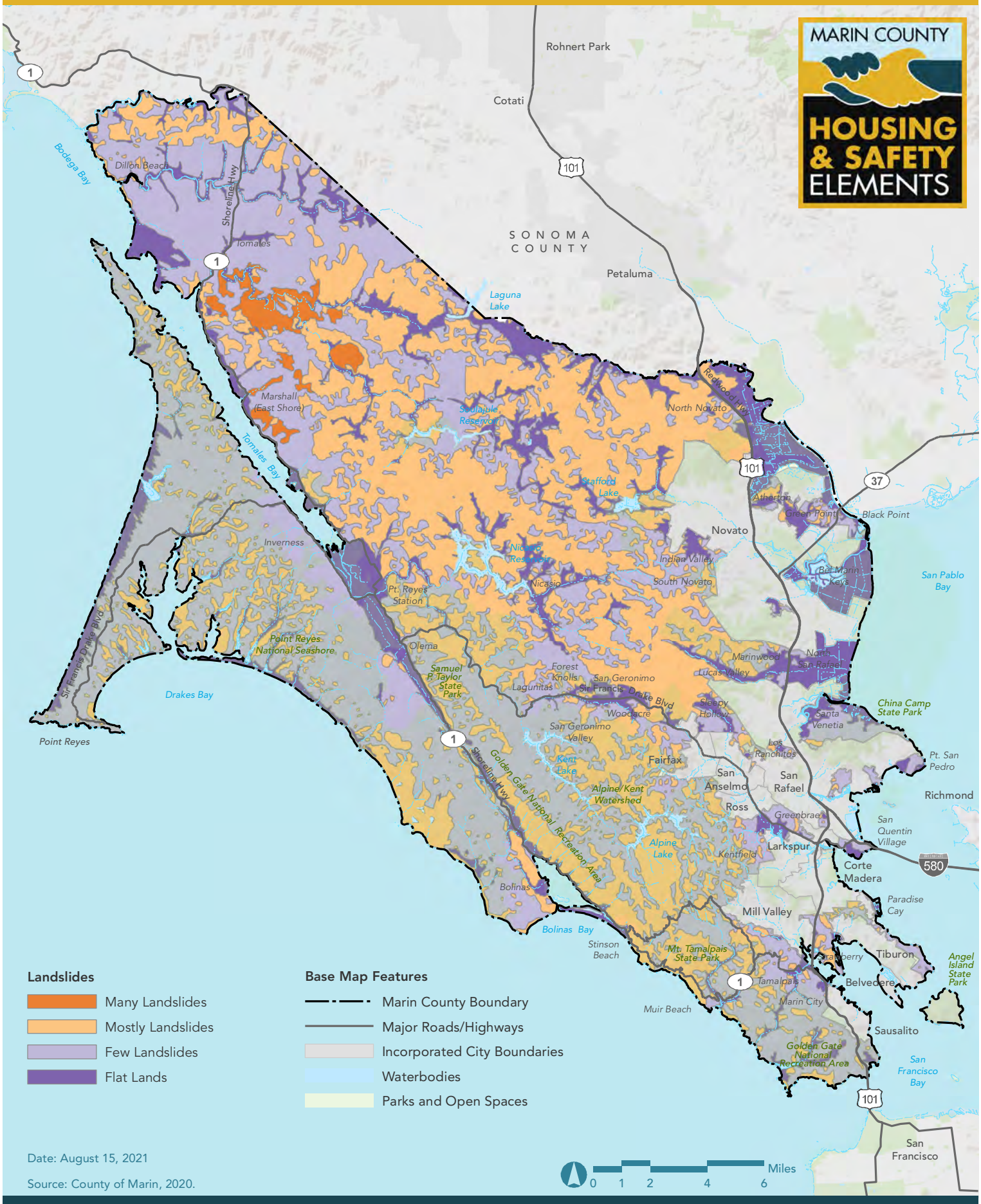


Figure 3-6: Landslide Hazard Areas

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Sea Level Rise

Marin County has prepared two Sea Level Rise (SLR) planning documents. The Marin Ocean Coast Sea Level Rise Vulnerability Assessment focuses on sea level rise conditions along the Pacific Ocean coastline. The Bay Waterfront Adaptation & Vulnerability Evaluation focuses on sea level rise conditions along the San Francisco Bay shoreline. Information in these two documents provided the basis of this discussion.

Hazard Profile

Rising sea levels are considered a secondary effect of climate change due to warming ocean temperatures and melting glacial ice sheets into the ocean. The California coast has already seen a rise in sea level of four to eight inches over the 20th century due to climate change. Sea level rise impacts can be exacerbated during coastal storms, which often bring increased tidal elevations called "storm surge." The large waves associated with such storm surges can cause flooding in low-lying areas, erosion of coastal wetlands, saltwater contamination of drinking water, disruption of septic system operations, impacts on roads and bridges, and increased stress on levees. In addition, rising sea levels results in coastal erosion as shoreline sediment is re-deposited back into the ocean. Evidence shows that winter storms have increased in frequency and intensity since 1948 in the North Pacific, increasing regional wave heights and water levels during storm events.

The Marin Ocean Coast Sea Level Rise Vulnerability Assessment and Marin Shoreline Sea Level Rise Vulnerability Assessment estimate that by 2100 around 7,000 acres, 9,000 parcels, 10,000 buildings and 120 miles of roads throughout Marin County will be exposed to sea level rise and 100-year storm events.[50]

Sea Level Rise Modeling

Sea-Level Marin Adaptation Response Team (C-SMART), an initiative of the Marin County Community Development Agency (CDA), developed the Marin Ocean Coast Sea Level Rise Vulnerability Assessment to assess the threat of sea level rise on Marin County communities and assets in West Marin.[51]

Given the uncertainty in the magnitude and timing of future sea level rise, C-SMART used a scenario-based approach to assess a range of potential sea level rise impacts in the Marin County Coastal Zone, which covers approximately 82,168 acres and includes lands under National Park Service, jurisdiction and County jurisdiction. The five scenarios selected were derived from the USGS Coastal Storm Modeling System (CoSMoS), which identified areas that may flood at 10 various sea levels (ranging from 0 to 500 centimeters above the current level) and four storm severities (no annual storm, 20-year storm, 100-year storm). CoSMoS scales down global and regional climate and wave models to produce local hazard projection. The scenarios include sea level rise, tides, storm surge, El Niño effects, wave setup, and wave runup.

Table 3-4 shows the range of sea level rise projections for California adopted by the National Research Council (NRC) in 2012. While these projections pre-date the CoSMoS modelling, they

[50] County of Marin. 2018. Marin County Multi-Jurisdictional Local Hazard Mitigation Plan.

[51] Marin County Community Development Agency. 2015. Marin Ocean Coast Sea Level Rise Vulnerability Assessment. September 2015.

offer a useful sense of projected sea level rise impacts and approximate time horizons for those impacts. As sea level rise science and understanding of ice melt dynamics have evolved, projected impacts for the mid and end of century time periods defined in the NRC dataset are trending toward more severe

TABLE 3-4: SEA LEVEL RISE PROJECTIONS FOR SAN FRANCISCO, CA REGION (NRC 2012)

Time Period	Projected Range
by 2030	1.6 – 11.8 inches
by 2050	4.7 – 24 inches
by 2100	16.6 – 65.8 inches

For sea level rise adaptation planning, C-SMART used five of the CoSMoS sea level rise scenarios (Table 3-5). Scenarios 1 and 2 represent the near-term and correspond to the 2030 National Research Council (NRC) projected sea level range. Scenario 3 is considered medium-term and is within the 2050 NRC range. Scenarios 4 and 5 represent the long-term. Scenario 4 corresponds to the 2100 NRC range. Scenario 5 represents levels based on additional research theorizing the worst case: that by 2100 sea level rise is nearing 70 inches globally. The CoSMoS option that most closely reflects that is a rise of 200 centimeters, or 77 inches, and is referenced as 80 inches in the Marin Ocean Coast Sea Level Rise Vulnerability Assessment.

On May 1, 2020, the California Coastal Commission adopted, "Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action," an effort to guide unified, effective sea level rise resilience efforts undertaken across the state.[52] The Principles for Aligned State Action include six Principles that call for use of the best available SLR science, building resilience partnerships, improving resilience communications, supporting local leadership, strengthening alignment around resilience, and learning from past coastal resilience projects. Principle 1. Develop and Utilize Best Available Science guides coastal resilience planners to use SLR targets based on the best available science and **a minimum of 3.5 feet of SLR by 2050**. As shown in Table 3-5 below, Scenario 3, which is the medium-term (i.e., 2050 NRC range) CoSMoS scenario, SLR projections of 20 inches + 20-year storm falls short of the 3.5 feet SLR minimum from the Principals for Aligned State Action, and Scenario 4 (i.e., long-term, 2100 NRC range) most closely matches the new SLR minimum.

[52] California Coastal Commission. 2020. Sea Level Rise Principles, Exhibit 1 – "Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action." May 1, 2020. https://documents.coastal.ca.gov/reports/2020/5/w6g/w6g-5-2020-exhibits.pdf

TABLE 3-5: C-SMART SEA LEVEL RISE & STORMS SCENARIOS FROM COSMOS

Sea Level Rise Scenario		Term
1	10 inches + annual storm	Near
2	10 inches + 20-year storm	Near
3	20 inches + 20-year storm	Medium
4	40 inches + 100-year storm	Long
5	80 inches + 100-year storm	Long

The Bay Waterfront Adaptation & Vulnerability Evaluation (BayWAVE), a program of the Marin County Department of Public Works and CDA, produced the Marin Shoreline Sea Level Rise Vulnerability Assessment to identify the risks and exposure from sea level rise along the Marin bay shoreline, which includes eight municipalities and 17 unincorporated jurisdictions, including Almonte, Bayside Acres, Bel Marin Keys, Black Point, California Park, Country Club, Greenbrae, Kentfield, Marin City, North Novato, Paradise Cay, Point San Pedro, San Quentin, Santa Venetia, St. Vincent's, Strawberry, Tamalpais Valley, Unincorporated Tiburon, and Waldo Point Harbor. The Marin Shoreline Sea Level Rise Vulnerability Assessment uses the same modeling system (CoSMoS) and projections as the Marin Ocean Coast Sea Level Rise Vulnerability Assessment, but developed six, instead of five, SLR scenarios specific the bay shoreline, which are shown in Table 3-6 below. These scenarios include sea level rise alone (i.e., no storm) as well as sea level rise plus the 100-year storm.

TABLE 3-6 BAYWAVE SEA LEVEL RISE SCENARIOS FROM COSMOS

Scenario	Description
Scenario 1	10 inches
Scenario 2	10 inches+100-year storm surge
Scenario 3	20 inches
Scenario 4	20 inches+100-year storm surge
Scenario 5	60 inches
Scenario 6	60 inches+100-year storm surge

Extent of Sea Level Rise

Along the Marin coastline, SLR would cover different amounts of land in the Coastal Zone under each scenario. Scenario 1 would cover 1,681 acres, and scenarios 2 through 5 cover an additional 373, 381, 1,091, and 1,165 acres respectively.[53] SLR extent in each of the five Coastal Zone scenarios is mapped in Figures 3-7 through 3-12.

[53] Marin County Community Development Agency. 2015. Marin Ocean Coast Sea Level Rise Vulnerability Assessment. September 2015.

NEAR-TERM

Scenario 1: 10 in. Sea Level Rise +Annual Storm Surge
Scenario 2: 10 in. Sea Level Rise +20-year Storm Surge

By 2030, higher high tides could adversely impact shoreline natural resources, all overwater development, and shoreline development in the Calles and Patios neighborhoods of Stinson Beach and downtown Bolinas. A 20-year storm is enough to impact nearly all housing west of State Route 1 in Stinson Beach, and will reach further inland in Bolinas. Ten inches of sea level rise combined with an annual storm surge could reach 450 parcels, 235 buildings, 2 miles of road. Bluff erosion could compromise another 42 buildings in Bolinas and Muir Beach at ten inches of sea level rise. A more severe storm surge, such as a 20-year storm surge could reach 665 parcels, 455 buildings, and more than 2.5 miles of road. Shoreline Highway, between Stinson Beach and Bolinas, could face some tidal and storm closures. Similarly, flooding on Olema-Bolinas Road would prevent travel to lower Wharf Road and the Mesa. Recreational facilities and access points to the Pacific Ocean, including Muir, Stinson and Upton Beaches and Duxbury Reef, could become severely eroded and unavailable more often.

Sea Level Rise & Storm Scenarios 1 & 2
- 10"+annual storm surge
- 10"+20-year storm surge

Vulnerable Buildings
- @ 10"+annual storm surge (flooding)
- @ 10" + 20-year storm surge (flooding)
- @ 10" sea level rise only (erosion)

Vulnerable Roads
- @ 10" + Annual storm
- @ 10" + 20-year storm

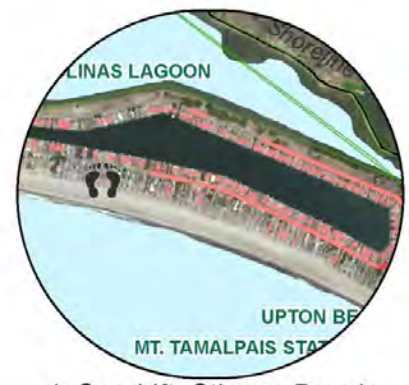
Other Vulnerable Assets
- Park
- Access Point
- Port
- Agriculture
- Emergency
- Historic
- Recreation

Location Indicators
- Communities
- Water

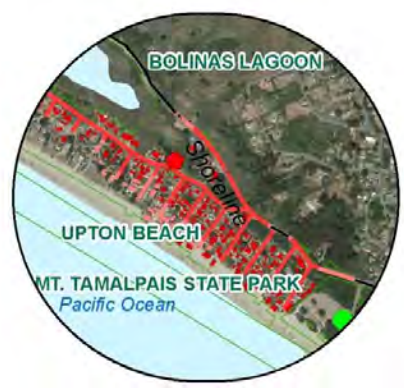
1: Bolinas Bluffs

2: Downtown Bolinas

3: Bolinas Wye

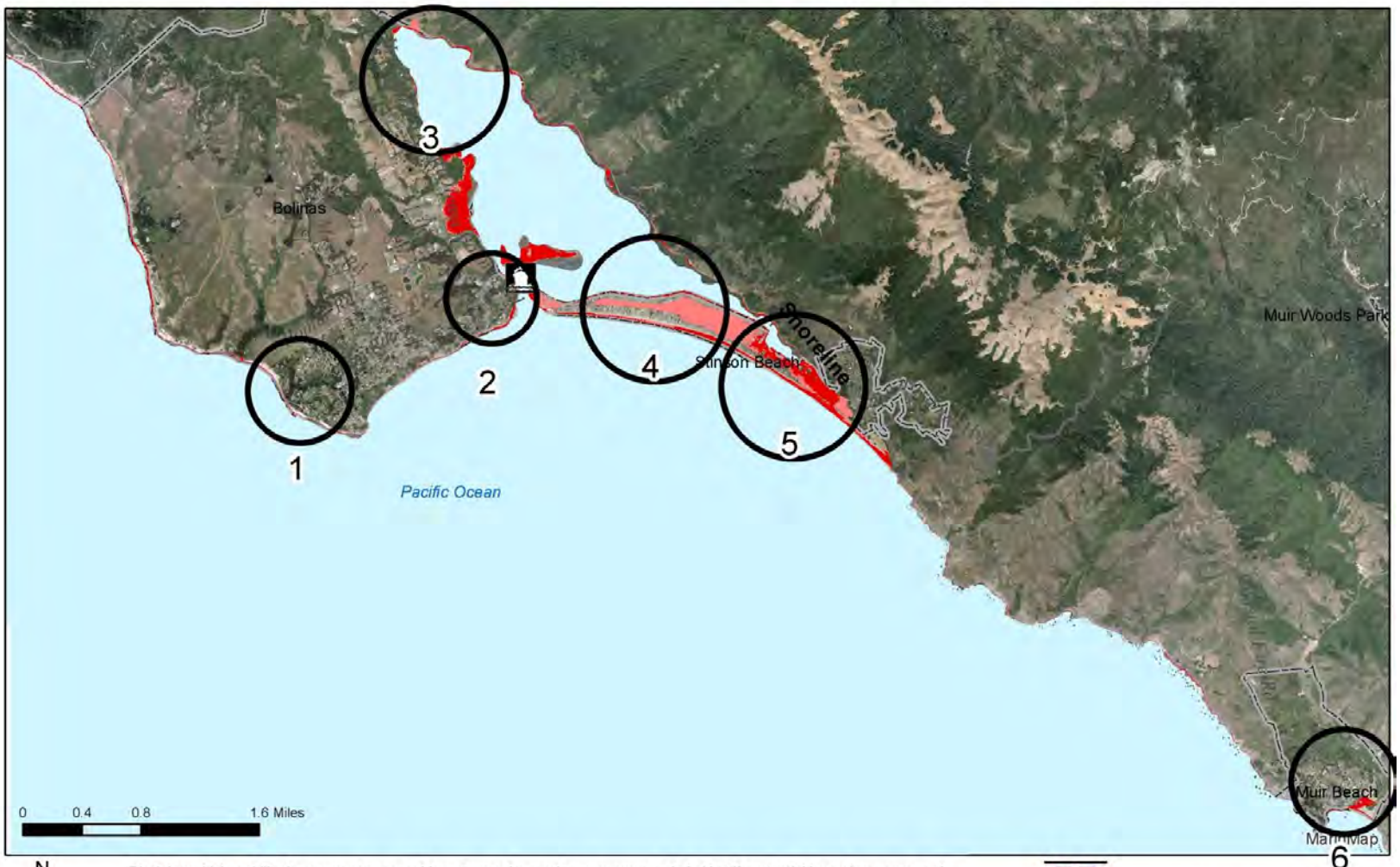


4: Seadrift, Stinson Beach



5: The Calles, Stinson Beach

6: Muir Beach



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

EVB CONSULTING

Date: 2/6/2018

OCOF CoSMoS

Figure 3-7: Southern Marin Coast 2030 SLR and Storm Surge Expectations

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin Ocean Coast Sea Level Rise Vulnerability Assessment

NEAR-TERM|

Scenario 1: 10 in. Sea Level Rise + Annual Storm Surge
Scenario 2: 10 in. Sea Level Rise +20-year Storm Surge

By 2030, high tides could adversely impact low-lying areas west of Shoreline Highway and east of Sir Francis Drake Boulevard. Ten inches of sea level rise combined with an annual storm surge could reach 290 parcels, 125 buildings, 0.14 miles of road. Bluff erosion could compromise another 42 buildings in Bolinas and Muir Beach at ten inches of sea level rise. A 20-year storm would marginally increase these numbers, though may have more severe consequences than the annual storm. Overwater and nearshore development in Inverness, Point Reyes Station, and East Shore would be at risk of tidal and storm surge flooding. Eight buildings in Dillon Beach would be vulnerable to bluff erosion. Sir Francis Drake Boulevard, Shoreline Highway and roads to Lawson's Landing would be subject to regular flooding at high tides and hazardous flooding during storms, especially near creeks. Recreational facilities and access points to the bay would close during high tide. Storm damage could require repairs.

1: Dillon Beach/ Lawsons's Landing

2: Shoreline Highway

3: Marshall

4: Inverness

5: Inverness Park

6: Shoreline Highway, Pt. Reyes Station

Sea Level Rise & Storm Scenarios 1 & 2
- 10"+annual storm surge
- 10"+20-year storm surge

Vulnerable Buildings
- @ 10"+annual storm surge (flooding)
- @ 10" + 20-year storm surge (flooding)
- @ 10" sea level rise only (erosion)

Vulnerable Roads
- @ 10" + annual storm
- @ 10" + 20-year storm

Other Vulnerable Assets
- Park
- Access Point
- Marina

- Historic

Location Indicators
- Communities
- Water

EVB CONSULTING

Date: 2/6/2018

OCOF CoSMoS

Figure 3-8: Northern Marin Coast 2030 SLR and Storm Surge Expectations

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin Ocean Coast Sea Level Rise Vulnerability Assessment

MEDIUM-TERM

Scenario 3:
20 in. Sea Level Rise
+20-year Storm Surge

By 2050, higher high tides could significantly alter the coastline with dramatic effect on all overwater and shoreline development. The Calles, Patios, and Seadrift neighborhoods of Stinson Beach, and downtown and flats areas of Bolinas, are at greater risk for more damage than before. Many assets that flooded only during storm conditions in the near-term could now flood at high tides. Twenty inches of sea level rise with a 20-year storm surge could flood 680 parcels, 40 buildings, and nearly 3 miles of road in West Marin's southern communities. Bluff erosion could compromise 100 buildings in Bolinas and Muir Beach. Shoreline Highway between Stinson Beach and Bolinas could face prolonged closures along this entire segment, as could local streets in lower Stinson Beach. High water levels in Bolinas could prevent access to the town center. Water and wastewater utilities could begin to fail or fall into disrepair more often with salt water exposure. Consistent water damage to buildings, roads, and utilities in these areas would make daily life difficult. Most access points to the Pacific Ocean could become severely eroded and only offer limited availability.

Sea Level Rise & Storm Scenario 3

- 20"+20-year storm surge

Vulnerable Buildings

- @ 20"+20-year storm surge (flooding)
- @ 20" sea level rise only (erosion)

Vulnerable Roads

- @ 20"+20-year storm surge

Other Vulnerable Assets

- Park
- Access Point
- Port
- Agriculture
- Emergency
- Historic
- Recreation

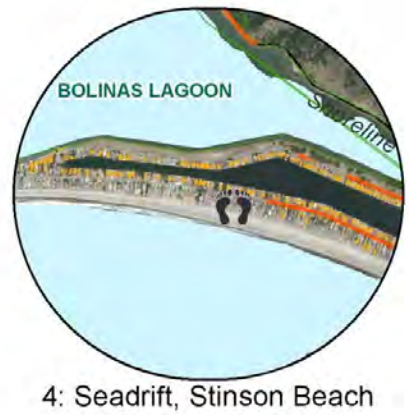
Location Indicators

- Communities
- Water

1: Bolinas Bluffs

2: Downtown Bolinas

3: Bolinas Wye



4: Seadrift, Stinson Beach

5: The Calles, Stinson Beach

6: Muir Beach

N

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

EVB CONSULTING

Date: 2/6/2018

OCOF CoSMoS

Figure 3-9: Southern Marin Coast 2050 SLR and Storm Surge Expectations

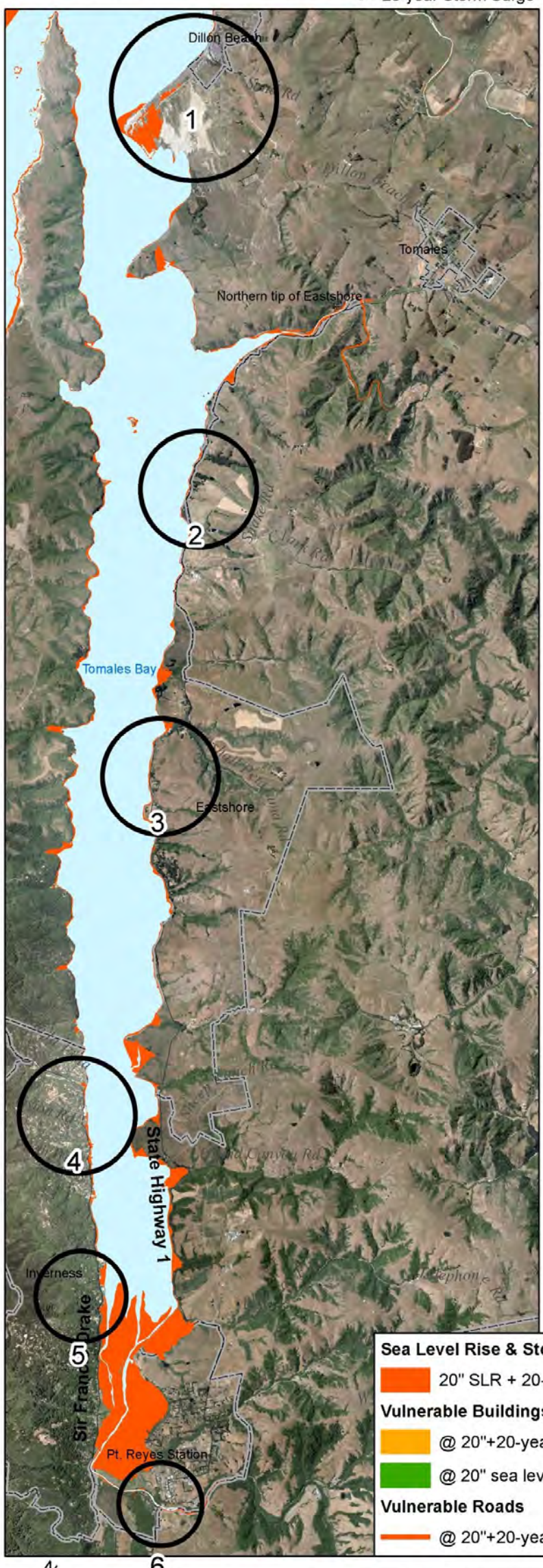
SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin Ocean Coast Vulnerability Assessment

MEDIUM-TERM

Scenario 3:
20 in. Sea Level Rise
+ 20-year Storm Surge

By 2050, high tides could adversely impact overwater and low-lying shoreline locations in Inverness and East Shore west of Shoreline Highway and east of Sir Francis Drake Boulevard on a regular basis. Twenty inches of sea level rise combined with a 20-year storm surge could reach 270 parcels, 156 buildings, and 4 miles of road. Bluff erosion could compromise another 22 buildings in Dillon Beach at twenty inches of sea level rise. Sir Francis Drake Boulevard, Shoreline Highway, and roads to Lawson's Landing would be subject to increased tidal flooding due to high tides and potentially hazardous flooding during storms, especially near creeks. Several recreational facilities and access points to the bay in all of West Marin's northern communities would face prolonged closures, and require repairs or relocation. Aquaculture operations would face significantly higher tides that could reduce the amount of usable habitat and require operational changes.



1: Dillon Beach/ Lawsons's Landing

2: Shoreline Highway

3: Marshall

4: Inverness

5: Inverness Park

6: Shoreline Highway, Pt. Reyes Station

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Figure 3-10: Northern Marin Coast 2050 SLR and Storm Surge Expectations

SAFETY ELEMENT VULNERABILITY ASSESSMENT

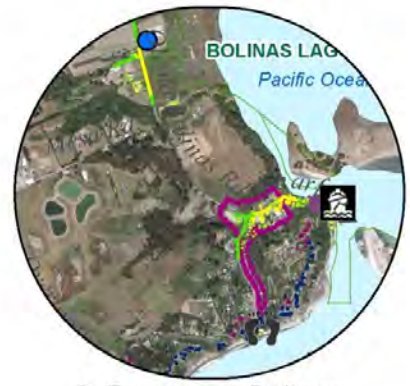
Source: Marin Ocean Coast Sea Level Rise Vulnerability Assessment

LONG-TERM

Scenario 4: 40 in. Sea Level Rise +100-year Storm Surge
Scenario 5: 80 in. Sea Level Rise +100-year Storm Surge

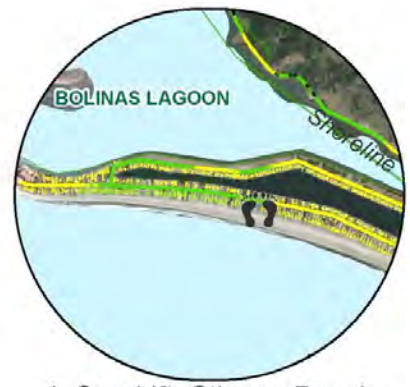
By 2100, the remaining properties in lower Stinson Beach could face tidal and/or storm surge flooding. Those that do not, may experience difficulties traveling to their home or business. Shoreline Highway, on the way to Bolinas, may not sustain continued flooding and erosion as is, preventing through traffic. In Bolinas, properties beyond Wharf Road up to Olema-Bolinas Road, Brighton Avenue, and north of Olema-Bolinas Road in the Gospel Flats area would face tidal and/or storm surge flooding, impeding access to the main activity centers. At the low end estimate for 2100, 40 inches of sea level rise plus a 100-year storm surge, could reach 700 parcels, 619 buildings, and almost 6 miles of road in West Marin's southern communities. Beach erosion in Stinson Beach could compromise 275 buildings. Bluff erosion in Bolinas and Muir Beach could compromise 330 buildings in. At the high end estimate for 2100, 80 inches of sea level rise plus a 100-year storm surge, flooding could reach 741 parcels, 758 buildings, and 10.5 miles of road in. Beach erosion in Stinson Beach could compromise 51 more buildings than at 40 inches of sea level rise. Bluff erosion in Bolinas and Muir Beach could threaten 276 more buildings than 40 inches of sea level rise. All roads vulnerable in previous scenarios, if accessible, would be regularly impassable. Existing recreation sites along the Pacific Ocean, including Stinson and Bolinas beaches, would not be usable. Muir beach would be compromised.

1: Bolinas Bluffs



2: Downtown Bolinas

3: Bolinas Wye



4: Seadrift, Stinson Beach

5: The Calles, Stinson Beach

6: Muir Beach

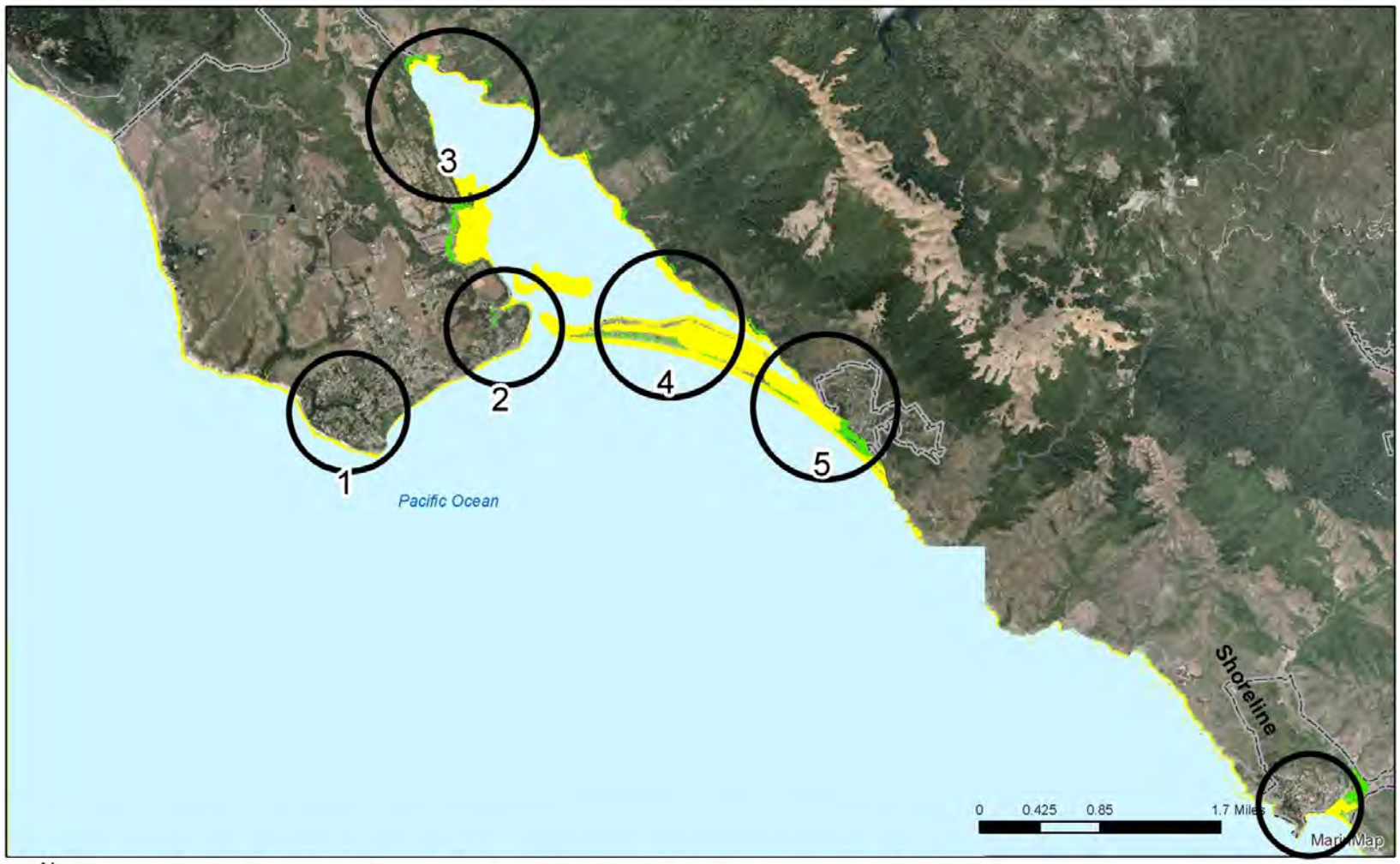
Sea Level Rise & Storm Scenarios 4 & 5
- 40"+100-year storm surge
- 80"+100-year storm surge

Vulnerable Buildings
- @ 40"+100-year storm surge (flooding)
- @ 80"+100-year storm surge (flooding)
- @ 40"sea level rise only (erosion)
- @ 80"sea level rise only (erosion)

Vulnerable Roads
- @ 40"+100-year storm surge
- @ 80"+100-year storm surge

Other Vulnerable Assets
- Park
- Historic District
- Access Point
- Port
- Agriculture
- Emergency
- Historic
- Recreation

Location Indicators
- Communities
- Water



N

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 2/7/2018

6

Figure 3-11: Southern Marin Coast Long-Term SLR and Storm Surge Expectations

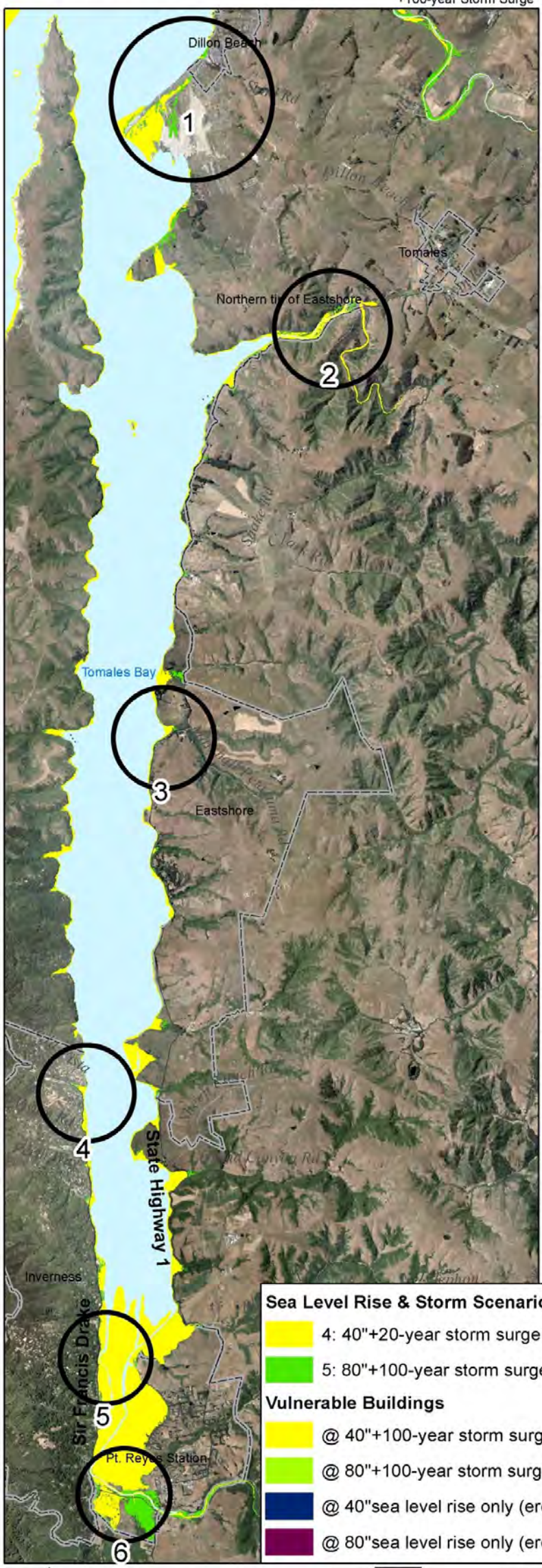
SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin Ocean Coast Sea Level Rise Vulnerability Assessment

LONG-TERM

Scenario 4: 40 in. Sea Level Rise +100-year Storm Surge
Scenario 5: 80 in. Sea Level Rise +100-year Storm Surge

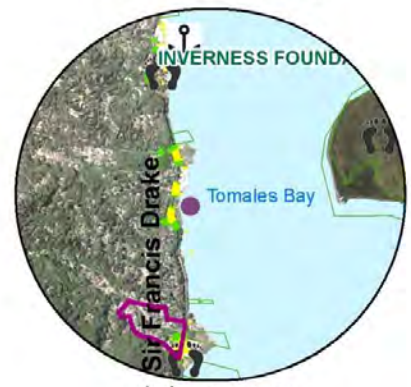
By 2100, south and north of Inverness Park and in Inverness, high tides could reach Sir Francis Drake Boulevard. At their current elevations, shoreline development would need to be elevated or relocated. Buildings along Sir Francis Drake Boulevard on the way to Point Reyes Station from Inverness may have already relocated, as would those currently over or along Tomales Bay in East Shore. Flooding would reach beyond State Route 1 in Marshall. In the northern portion of the study area, 40 inches of sea level rise plus a 100-year storm surge could reach 324 parcels, 197 buildings, and 1.3 miles of road, mostly Sir Francis Drake Boulevard. In Dillon Beach, bluff erosion could compromise 43 buildings. At the high end estimate for 2100, 80 inches of sea level rise and a 100-year storm surge, flooding could reach 364 parcels, 465 buildings, and 6 miles of road. Flooding would reach properties and roads west of Sir Francis Drake in Inverness and east of Shoreline Highway in East Shore about 3 miles outside of Point Reyes Station and north of Marshall. All overwater and nearshore development in its current state would be severely compromised, if not submerged at the floor level, during high tides and/or storm surges. In Dillon Beach, 100 buildings would be vulnerable to bluff erosion. Access to Lawson's Landing would also be subject to regular flooding and erosion. Existing bay access points and recreation sites would be flooded out. Aquaculture and ranch lands abutting creeks would face dramatically different conditions.



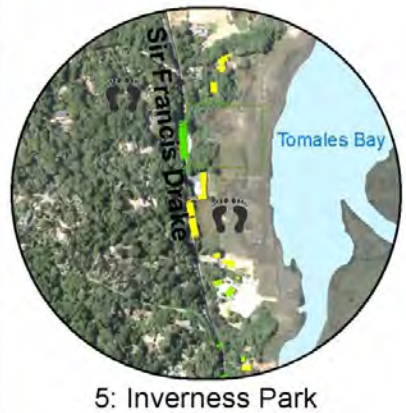
1: Dillon Beach/ Lawsons's Landing

2: Walker Creek @ Shoreline Highway

3: Marshall



4: Inverness



5: Inverness Park

6: Shoreline Highway, Pt. Reyes Station

Figure 3-12: Northern Marin Coast Long-Term SLR and Storm Surge Expectations

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin Ocean Coast Sea Level Rise Vulnerability Assessment

The extent of sea level rise on the San Francisco Bay shoreline under each of the six sea level rise scenarios used in BayWAVE and shown in Table 3-7.[54] Approximately 5,000 to 18,000 acres of bayside land would be impacted by sea level rise as shown below in Table 3-7 and mapped in Figures 3-13 through 3-16.

TABLE 3-7: EXPOSED ACRES BY SCENARIO (BAYSIDE)

Scenarios		Acres	
		#	Percent of study area
Near-Term	1	4,829	6
	2	8,072	9
Medium-Term	3	6,685	8
	4	13,544	16
Long-Term	5	16,332	20
	6	17,854	21

Disaster History

Sea levels have risen approximately eight inches in the San Francisco Bay Area in the past century.[55] Rising sea levels submerge low-lying areas, creating direct impacts from inundation and facilitating the reach of high tides and storm surge further inland, impacting even more of the County's natural and built resources.

King tides already flood large areas of roadway, parking, trails, and infrastructure even without storms along the San Francisco Bay shoreline. When king tides occur during floods or storm surges, water levels can rise higher and have the potential to cause great damage to the coastline and coastal property. With rising sea levels, future king tides have the potential to cause even more damage than at present.

[54] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

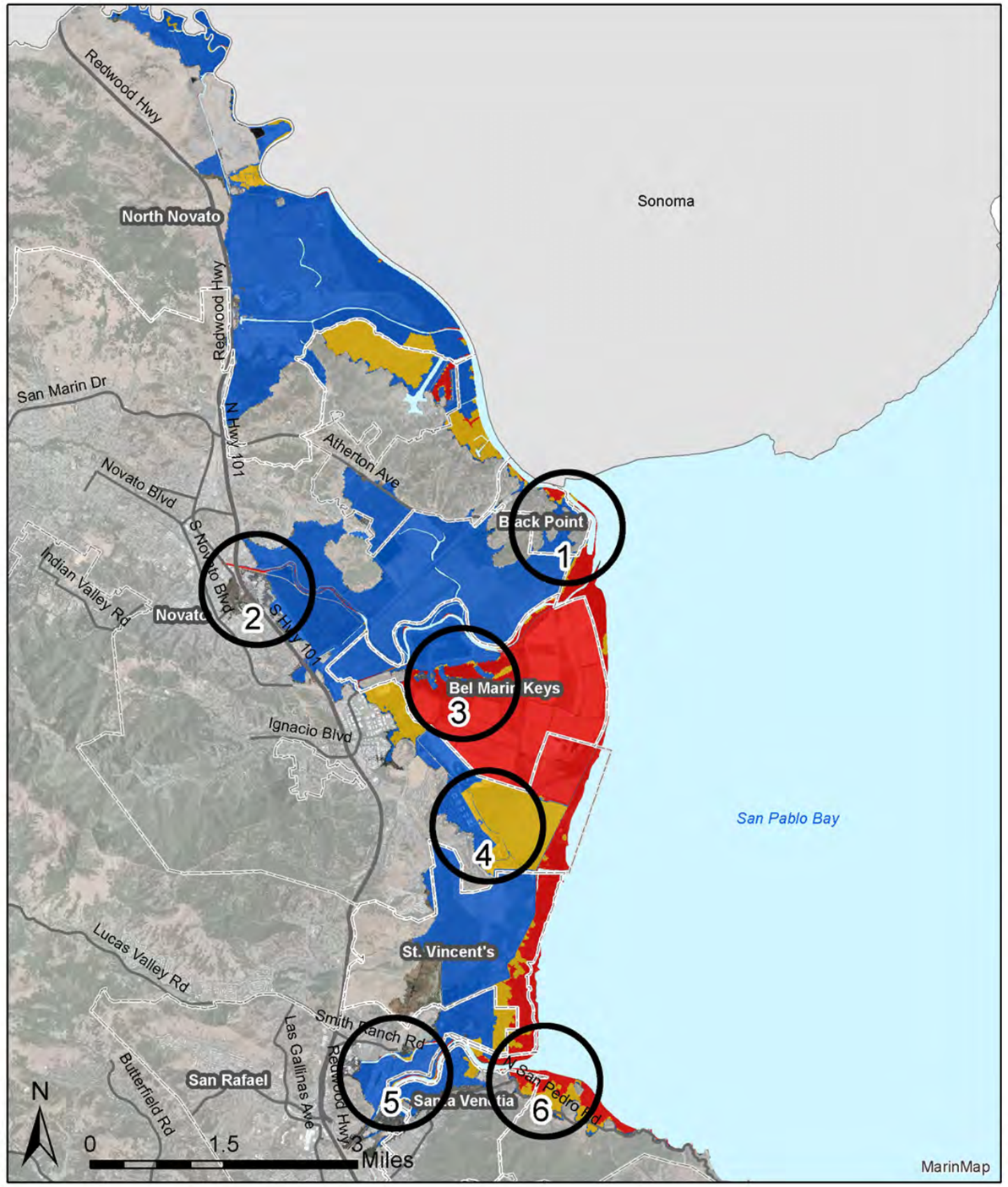
[55] County of Marin. 2018. Marin County Multi-Jurisdictional Local Hazard Mitigation Plan.

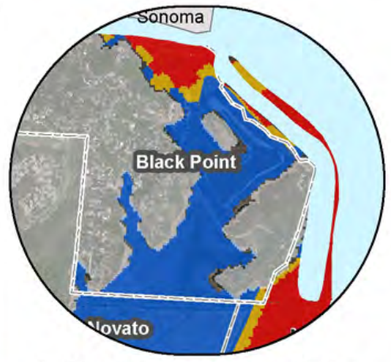
BayWAVE Sea Level Rise (SLR) Scenarios

- Scen 1: 10" SLR
- Scen 3: 20" SLR
- Scen 5: 60" SLR

Location Indicators

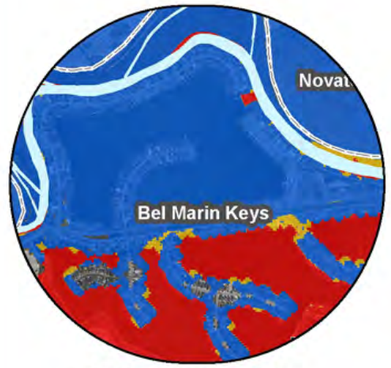
- Unincorporated
- Municipality
- Road
- Bay



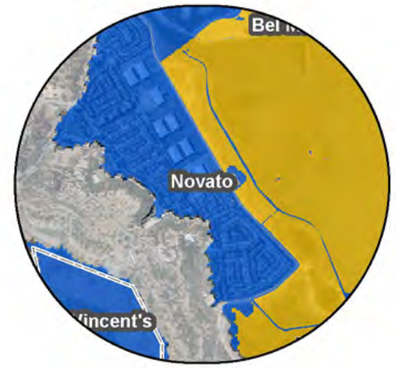


1: Black Point/Green Point

2: U.S. Hwy. 101 @ Rowland Blvd.

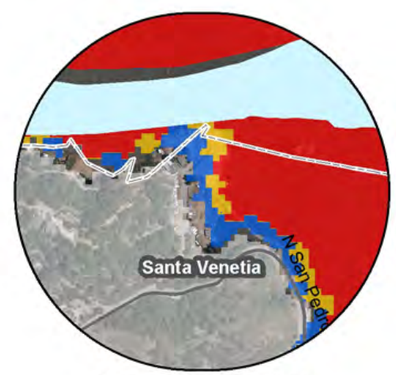


3: Bel Marin Keys



4: Hamilton

5: Santa Venetia/ Marin Lagoon



6: Buck's Landing

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

EVB CONSULTING

Date: 4/1/2017

OCOF OUR COAST OUR FUTURE CoSMoS

Figure 3-13: Northern Study Area SLR Scenarios

SAFETY ELEMENT VULNERABILITY ASSESSMENT

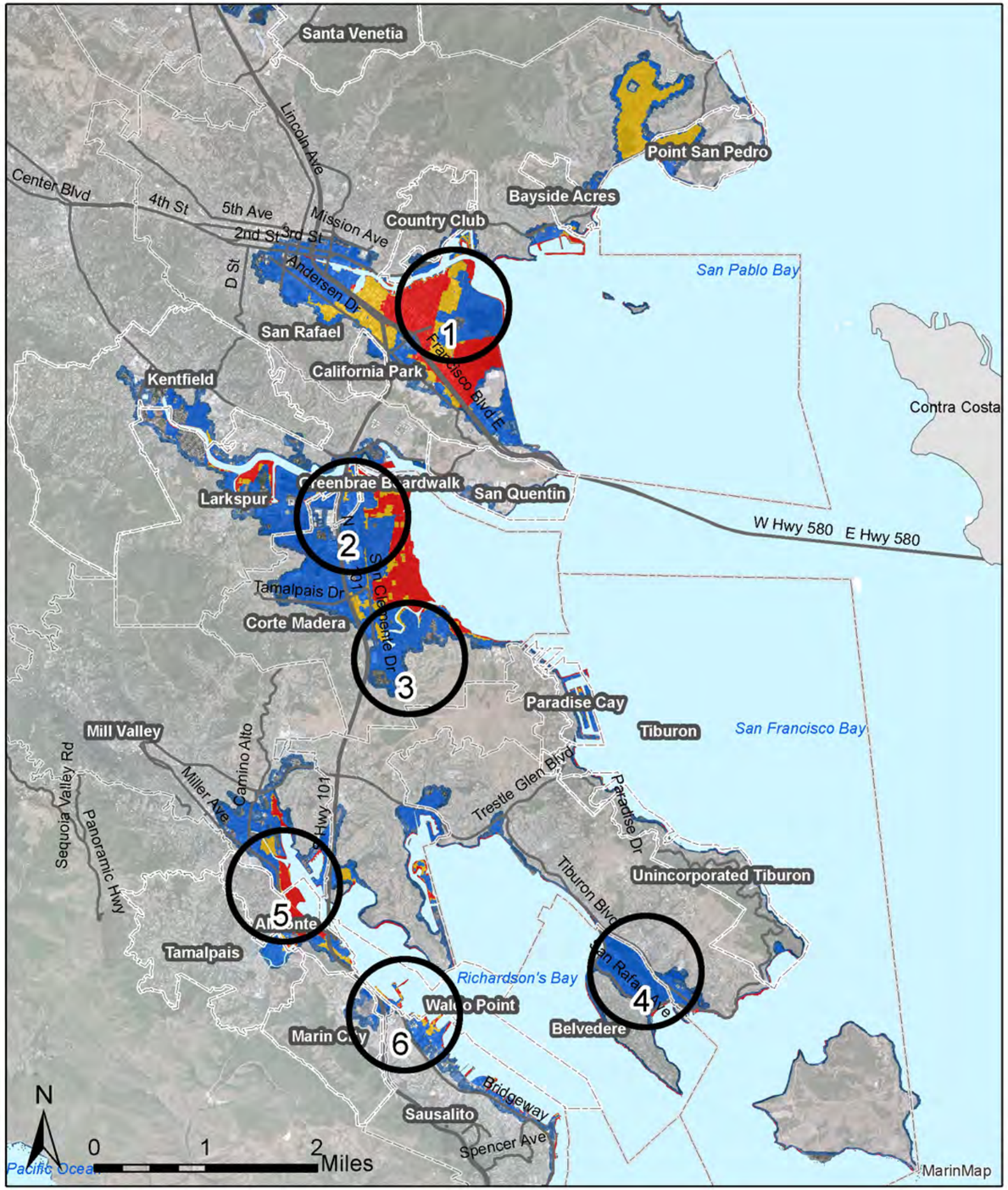
Source: Marin Shoreline Sea Level Rise Vulnerability Assessment

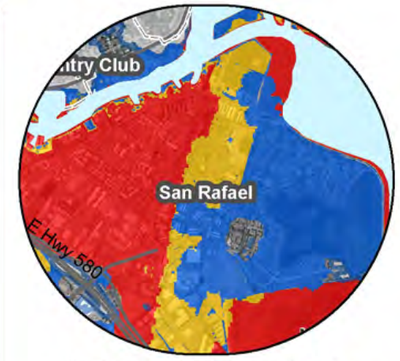
BayWAVE Sea Level Rise (SLR) Scenarios

- Scen 1: 10" SLR
- Scen 3: 20" SLR
- Scen 5: 60" SLR

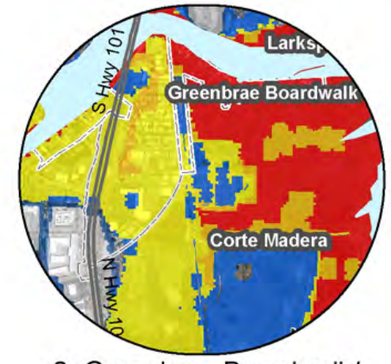
Location Indicators

- Unincorporated
- Municipality
- Road
- Bay

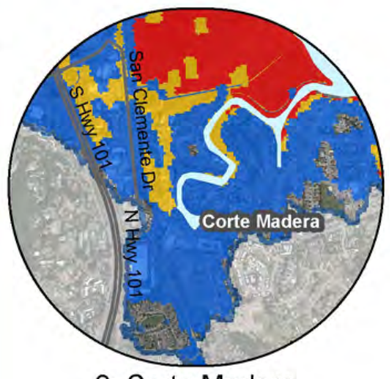




1: Canal Neighborhood

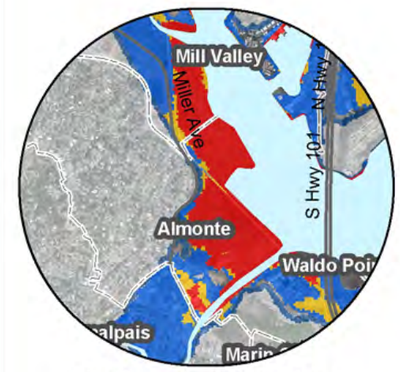


2: Greenbrae Boardwalk/ Larkspur/Corte Madera

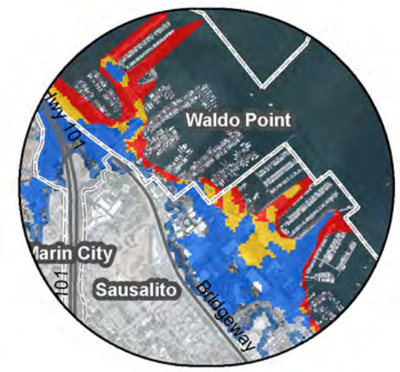


3: Corte Madera

4: Belvedere/Tiburon



5: Almonte/Mill Valley



6: Marinship

CONSULTING

Date: 1/7/2017

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Figure 3-14: Southern Study Area SLR Scenarios

SAFETY ELEMENT VULNERABILITY ASSESSMENT

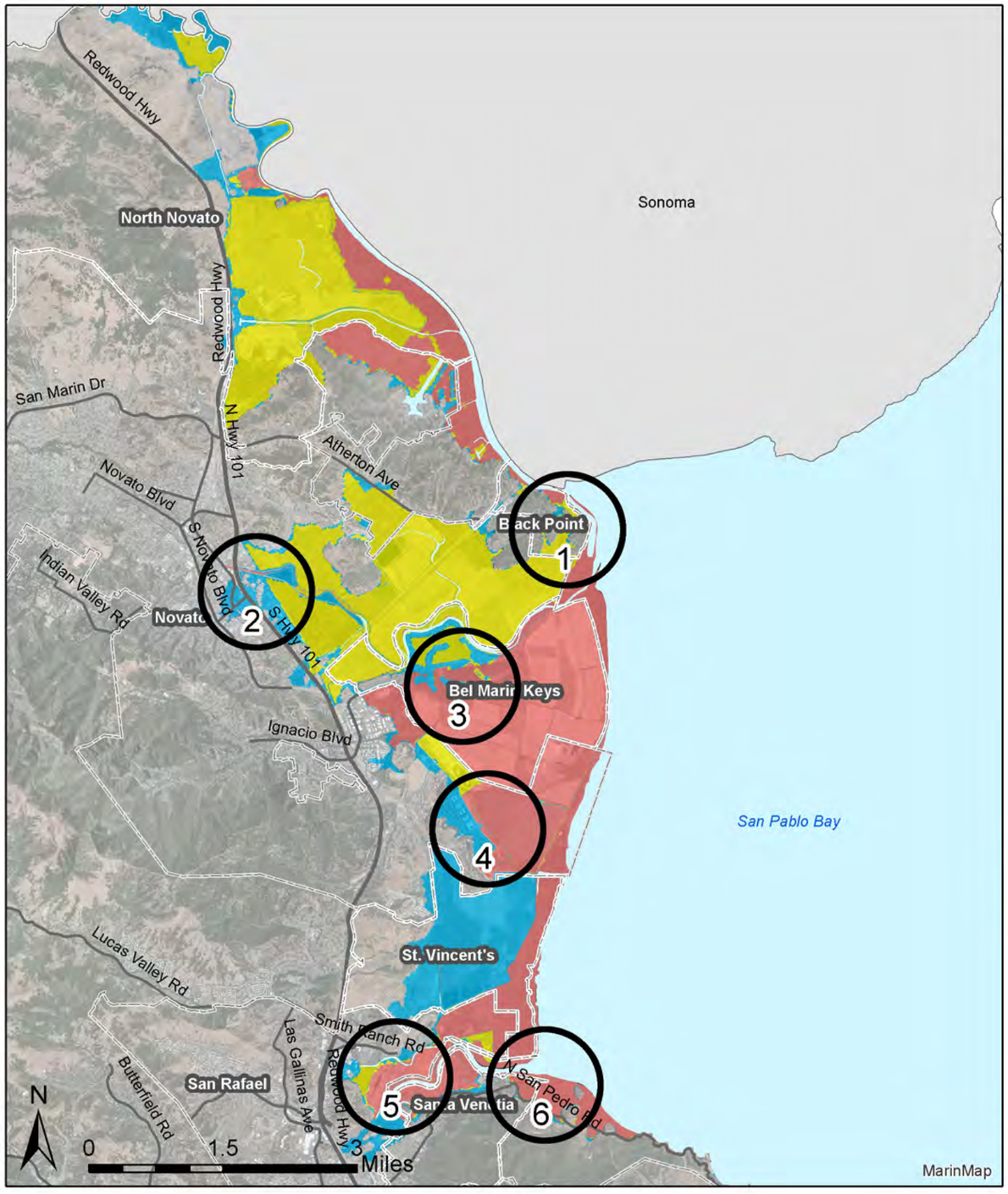
Source: Marin Shoreline Sea Level Rise Vulnerability Assessment

BayWAVE Sea Level Rise (SLR) & 100-year Storm Surge Scenarios

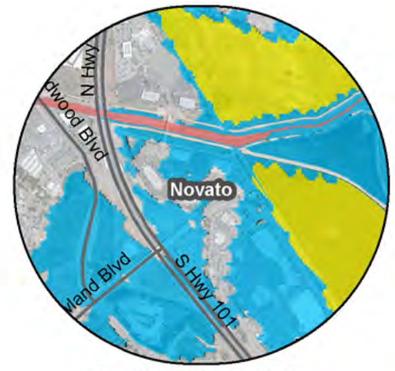
- Scen 2: 10"SLR+Storm Surge
- Scen 4: 20"SLR+Storm Surge
- Scen 6: 60"SLR+Storm Surge

Location Indicators

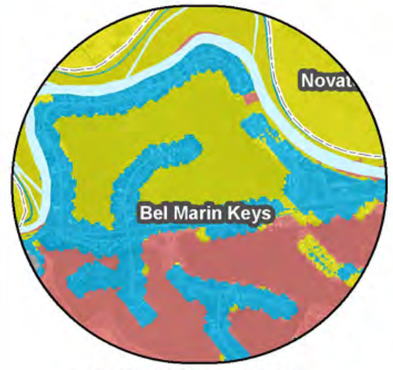
- Unincorporated
- Municipality
- Road
- Bay



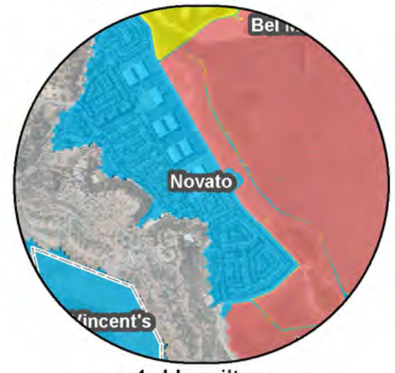
1: Black Point/Green Point



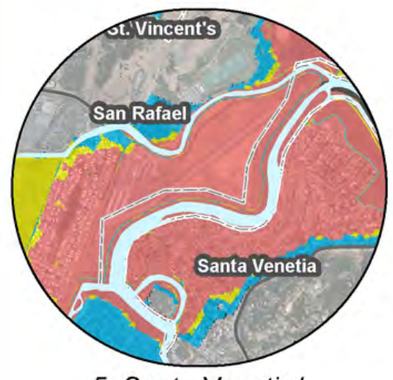
2: U.S. Hwy. 101 @ Rowland Blvd.



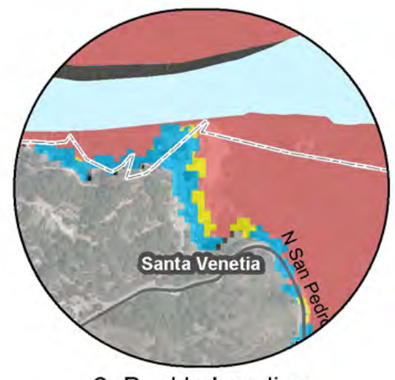
3: Bel Marin Keys



4: Hamilton



5: Santa Venetia/ Marin Lagoon



6: Buck's Landing

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

EVB CONSULTING

Date: 4/1/2017

OCOF CoSMoS

Figure 3-15: Northern Study Area SLR and 100-Year Storm Surge Scenarios

SAFETY ELEMENT VULNERABILITY ASSESSMENT

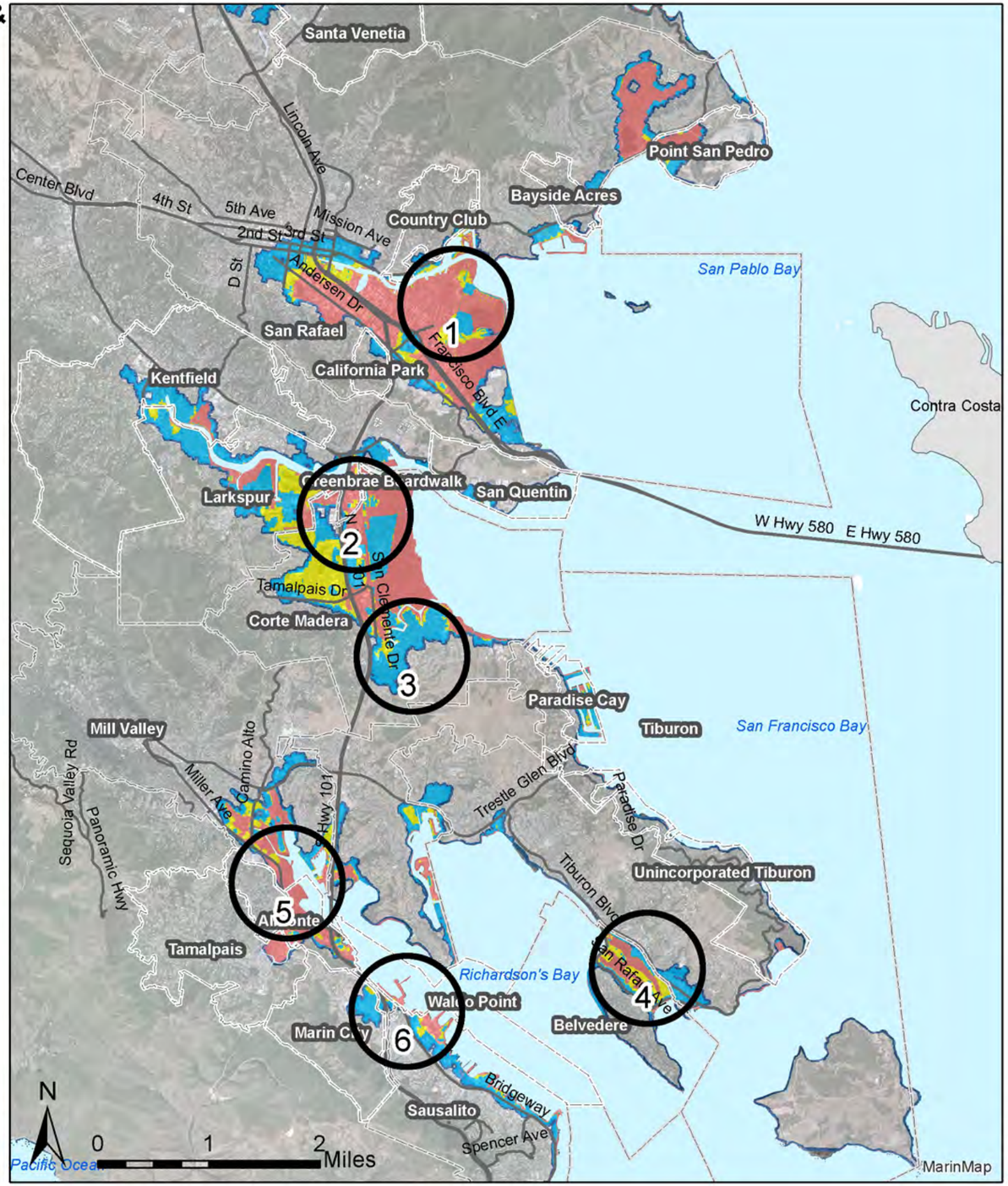
Source: Marin Shoreline Sea Level Rise Vulnerability Assessment

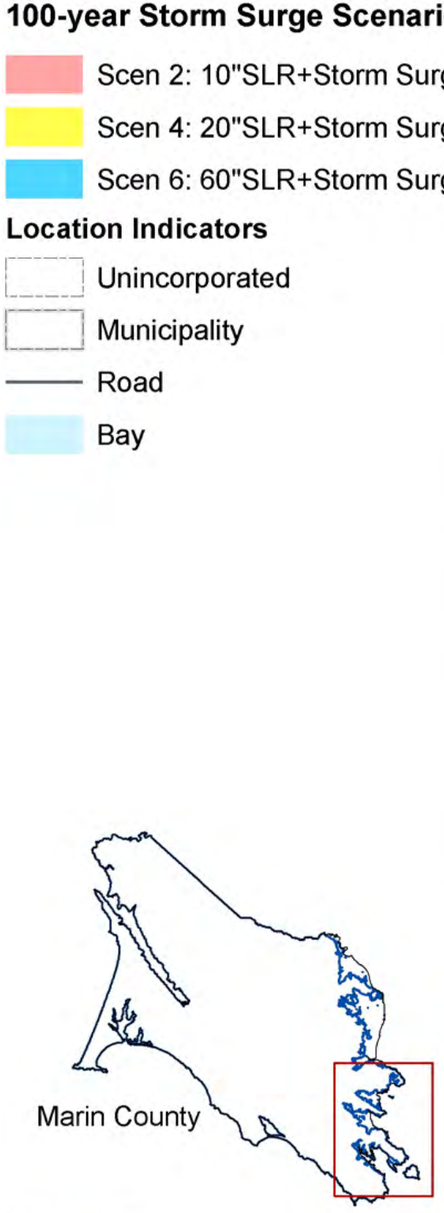
BayWAVE Sea Level Rise (SLR) & 100-year Storm Surge Scenarios

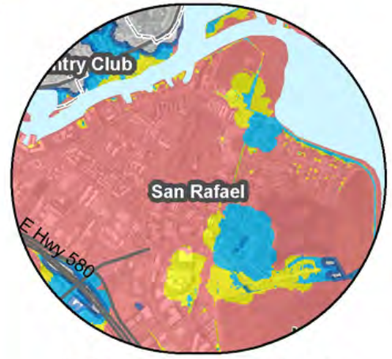
- Scen 2: 10"SLR+Storm Surge
- Scen 4: 20"SLR+Storm Surge
- Scen 6: 60"SLR+Storm Surge

Location Indicators

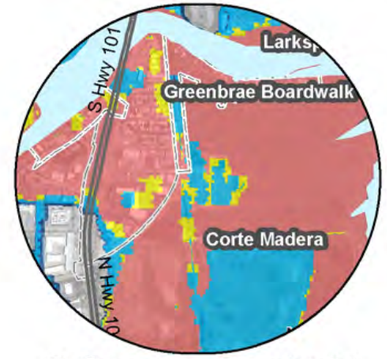
- Unincorporated
- Municipality
- Road
- Bay



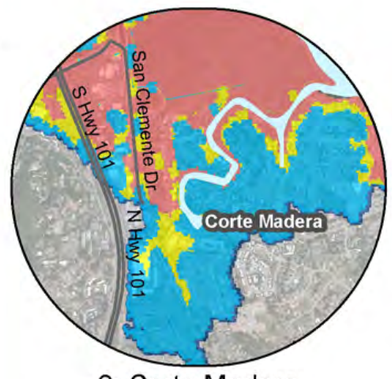




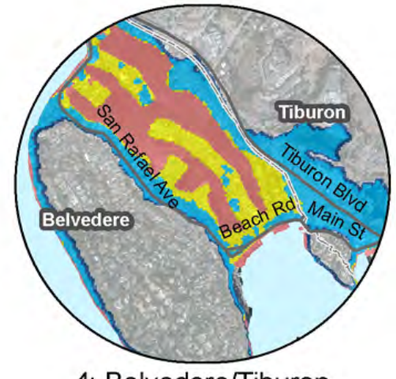
1: Canal Neighborhood



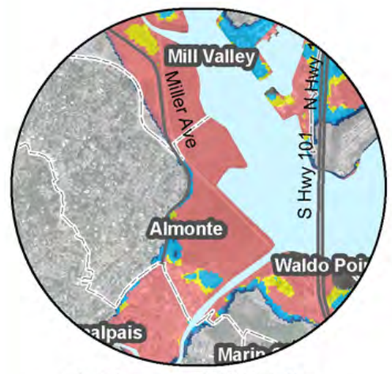
2: Greenbrae Boardwalk/ Larkspur/Corte Madera



3: Corte Madera



4: Belvedere/Tiburon



5: Almonte/Mill Valley

6: Marinship

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

EVB CONSULTING

Date: 1/7/2017

OCOF CoSMoS

Figure 3-16: Southern Study Area SLR and 100-Year Storm Surge Scenarios

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin Shoreline Sea Level Rise Vulnerability Assessment

Low-lying roads and paths in Marin's coastal communities, including the Stinson Beach's Calle Del Arroyo, the Mill Valley/Sausalito Multi-modal Pathway, and others, are already susceptible to flooding at high tides, especially king tides and storms.[56]

A number of locations along the Richardson Bay shoreline flood during the semi-annual, high king tides.[57] Manzanita, Almonte; Miller Avenue in Mill Valley; the Marinship area in Sausalito; US Highway 101 in Marin City; Corte Madera; Larkspur; and State Route 37 in Novato all see flooding during king tides.

Vulnerability

Communities

In the Marin Coastal Zone, communities most vulnerable to the impacts of sea level rise include Muir Beach, Stinson Beach, Bolinas, Inverness, Pt. Reyes Station, East Shore, and Dillon Beach.[58]

On the bayside, the most vulnerable assets in Marin County's unincorporated communities in the near-term are Shoreline Highway through Almonte, Waldo Point Harbor houseboats and facilities, Greenbrae homes and facilities, and Paradise Cay homes and marina. The elevated homes on Greenbrae Boardwalk and floating homes in Waldo Point Harbor may be more adaptable in the near term than homes with solid foundations. In the medium-term, portions of Bel Marin Keys could face impacts, as would Santa Venetia homes, Tamalpais Valley homes, and the Greenwood Cove, Strawberry Circle, Strawberry Village Shopping Center, homes along Seminary Drive in Strawberry, and Kentfield creek side homes. In the long-term, Black Point and North Novato could anticipate damaging impacts.[59]

In the medium-term timeframe, regular high tide tidal flooding could adversely impact the same locations tidally flooded in the near-term, though more severely. Storm surge flooding would impact the same locations as in near-term BayWAVE scenario 2 (near-term), 10 inches with a 100-year storm surge, and extends further inland beyond the marshy areas of Mill Valley, Strawberry, San Rafael, St. Vincent's, and North Novato.

In the long-term, regular tidal flooding could adversely impact the same locations impacted in the near- and medium-terms and significant portions of what would have previously only flooded from the 100-year storm surge. The additional areas that would tidally flood at 60 inches of sea level rise are:

---

[56] Ibid.

[57] Marin County Flood Control & Water Conservation District. 2015. Richardson Bay Shoreline Study. Evaluation of Sea Level Rise Impacts and Adaptation Alternatives. Public Review Draft. October 14, 2015.

[58] Marin County Community Development Agency. 2015. Marin Ocean Coast Sea Level Rise Vulnerability Assessment. September 2015.

[59] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

- Tamalpais Valley,
- Mill Valley from the Richardson's Bay shoreline up to and beyond Camino Alto between Miller and East Blithedale Avenues,
- Mill Valley and Strawberry fronting US Highway 101 between Seminary Drive and Tiburon Boulevard,
- Santa Venetia north of N. San Pedro Boulevard,
- Cove Neighborhood, Tiburon,
- Belvedere Lagoon neighborhood,
- Paradise Cay
- Mariner Cove, Marina Village, Madera Gardens, and major retail centers lining US Highway 101,
- Riviera Circle, Creekside, and Heatherwood neighborhoods, Larkspur,
- Interstate 580 and westward towards Andersen Drive in San Rafael and the community of California Park,
- Marin Lagoon and Peacock Gap neighborhoods, San Rafael,
- Bel Marin Keys northern and southern lagoon areas,
- Hamilton, Vintage Oaks, and pockets of development east of US Highway 101 at Rowland Boulevard and State Route 37 in Novato, and
- North Novato at US Highway 101 and Binford Road.

Bayside areas that could anticipate increased storm surge flooding are:

- Sausalito west of Bridgeway,
- Marin City neighborhood,
- Mill Valley east of East Blithedale Avenue at Alto Shopping Center,
- Las Gallinas and North San Pedro Boulevard, east of US Highway 101, San Rafael,
- Bayside Acres,
- Country Club, and
- Kentfield.

Infrastructure

Pacific Ocean Coastline

In their current conditions, the most vulnerable coastal Marin infrastructure, in order of onset and flood depth, includes:[60]

Near-term (C-SMART scenarios 1 & 2)

- Beaches, underground on-site wastewater treatment systems (OWTS), buildings, and streets in Stinson Beach west of Shoreline Highway.
- Shoreline Highway between Stinson Beach and Bolinas, at Green Bridge over Lagunitas Creek in Pt. Reyes Station, the Walker Creek crossing in Marshall, and bridges on Middle Road and Valley Ford Lincoln School Road.
- Beaches and beach front and downtown buildings and streets in Bolinas.
- Septic systems, beaches, marshes, and buildings along the eastern and western shores of Tomales Bay.

[60] Marin County Community Development Agency. 2015. Marin Ocean Coast Sea Level Rise Vulnerability Assessment. September 2015.

- The water distribution pipe underneath Shoreline Highway and Sir Francis Drake Boulevard serving many Inverness residents.
- Intertidal rocky lands in Muir Beach and Duxbury Reef in Bolinas.
- Fire service facilities and tsunami evacuation routes in Stinson Beach.
- Recreational facilities at Dillon Beach Resort and Lawson's Landing.
- Blufftop buildings in Muir Beach, Bolinas, and Dillon Beach may be vulnerable to accelerated erosion.

Medium-term (C-SMART scenario 3)

- Olema-Bolinas Road, which is the only road to Downtown Bolinas.
- Additional buildings and streets in downtown Bolinas, including the historic district.
- Bolinas Public Utilities District lift station at the end of Wharf Road.
- Shoreline Highway in Pt. Reyes Station and East Shore, and Sir Francis Drake Blvd. in Inverness.

Long-term (C-SMART scenarios 4 & 5)

- Shoreline Highway along the East Shore.
- Buildings in Inverness west of Sir Francis Drake Blvd.
- Downtown Bolinas up to Brighton Road, including the market, library, community center, gas station, museum, and other valued places.

Over 20 percent of the parcels and 14 percent of buildings in the study area are exposed at the low end of the long-term scenario (C-SMART scenario 4) and 25 percent of the parcels and 18 percent of the buildings are exposed at the high end of the long-term scenario (C-SMART scenario 5).

San Francisco Bay Shoreline

Along the bay shoreline, in the near-term timeframe, tidal flooding at 10 inches of sea level rise (MHHW) could reach 5,000 acres, 1,300 parcels, and 700 buildings, potentially impacting tens of thousands of residents, employees, and visitors. With an additional 100-year storm surge, the previously impacted acres, parcels, and buildings could face tidal and storm surge flooding. An additional 3,000 acres, 2,500 parcels, and 3,800 buildings could anticipate storm surge flooding. Eight miles of road could expect tidal flooding.[61]

Water travel infrastructure could be compromised at ferry facilities in Larkspur, Tiburon, and Sausalito preventing commuters from traveling to work. Smaller public and private and marinas and boat launches along the bay in Sausalito, Mill Valley, Strawberry, Tiburon, Belvedere, Bel Marin Keys, and Black Point could be flooded out and unusable. Storm surges can be powerful enough to damage and sink boats, including those belonging to the Southern Marin Fire Protection and Sausalito Police Department. Most concerning, however, is the potential inability of emergency professionals and vehicles to access people in or through flooded areas.

[61] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

In this medium-term timeframe, tidal flooding at 20 inches of sea level rise (MHHW) could reach nearly 7,000 acres, 3,000 parcels, and 2,000 buildings, potentially impacting even more residents, employees, and visitors than in the near-term. With an additional 100-year storm surge, the previously impacted acres, parcels, and buildings could face tidal and storm surge flooding, and an additional 7,000 acres, 2,200 parcels, and 3,600 buildings could anticipate storm surge flooding. Most levees south of Novato are not designed to withstand this level of flooding and could be overtopped.

Eighteen miles of roadway, ten more miles than in the near-term, could expect tidal flooding. Many of the impacted roads are the same as those impacted in the near-term, though much greater lengths could anticipate tidal flooding and flooding depths would increase. Storm surge flooding could reach a total of 44 additional miles of roadway. Water travel could experience similar outcomes as in the near-term, though the highest high tides and storms surges would cause even more damage than weathered twenty years earlier.

Pipelines under vulnerable roads, and lateral pipes to vulnerable properties, would become squeezed between rising groundwater and the confining roadway. This could cause pipes to bend and break, and could even damage roadways. In the medium-term, impacts to the North Marin Water District service area would impact water service in Bel Marin Keys and unincorporated Novato. Vulnerable substations, electrical transmission towers and lines, and underground natural gas pipelines along the shoreline would be compromised by flooding and subsidence. Disruptions or failures in this network could also have far reaching impacts in transportation, sanitary service, stormwater management facilities, food storage, communications, and general public safety.

In this long-term timeframe, tidal flooding at 60 inches of sea level rise (MHHW) could reach nearly 7,000 acres, 8,000 parcels, and 9,000 buildings, potentially impacting hundreds of thousands of residents, employees, and visitors. In long-term scenario 6, storm surge flooding could occur on nearly 13,500 acres hosting 12,600 parcels with 12,000 buildings, potentially impacting 200,000 residents, thousands of employees, and several million visitors.

One-hundred miles of public and private roadways could be vulnerable to tidal exposure. Roads could degrade more quickly, or if flood waters are deep enough, become impassable. Lane miles could be more than double this figure. An additional 30 miles of roadway could be vulnerable at 60 inches of sea level rise and a 100-year storm surge. Moreover, several park and rides, several hundred bus stops, and bus transit and SMART rail routes could flood. The San Rafael Transit Center, where the SMART train and nearly all local and regional buses stop, could expect tidal flooding at MHHW and storm surge flooding in the long-term. Breakdowns in the transportation network would have major impacts on the economy and daily life functions. In addition, significant safety hazards could cause injury or loss of life. Flooding at the SASM and Novato Sanitary Wastewater Treatment Plants is a significant vulnerability that could arise, potentially disrupting hundreds of thousands of people. By this time, much of the low-lying shoreline sanitary sewer and stormwater infrastructure could be flooded out.

By the end of the century, sea level rise could have direct impacts to Tiburon Fire Station No. 1, Corte Madera Station No. 13, and Novato Atherton Avenue Fire Station. A few emergency shelters in Southern Marin communities could be vulnerable to tidal flooding, and several more could expect storm surge flooding and may not be available when needed most.

Natural Resources

Beaches, estuaries, marshes, wetlands, and intertidal areas on the Marin coast as vulnerable to sea level rise and storms.[62] Nearly all beaches in the study area, except Dillon Beach and the federal portion of Stinson Beach, could be lost entirely in the long-term. Roughly 9,000 acres in the estuaries of Tomales Bay, Bolinas Lagoon, and Esteros Americano and San Antonio, 1,800 acres of wetlands and marshlands could be impacted to varying degrees across all of the scenarios in all of the communities. Sea level rise may push coastal habitats inland where possible, flooding tidal areas more frequently and new inland areas with saltwater. The *North-central California Coast and Ocean Vulnerability Assessment* identified the five most vulnerable species to sea level rise are the Western snowy plover, black oystercatcher, black rail, California mussel, and red abalone.

On the bayside, the marshlands that buffer the shoreline communities from high tides and storm surges could begin to experience transitions in habitat, especially those in Southern Marin where they are typically bordered by urban development.[63] Consequently, the waters here would get deeper and flood out the existing habitat, shifting high marsh to low marsh, low marsh to mud flat, and mud flats to open water. Without adequate light of shallow water, eelgrass beds would shrink. Collectively, these habitat shifts could have significant impacts on vulnerable species such as the salt marsh harvest mouse, Ridgway's Rail, or the long-fin smelt.

A twenty-inch increase in sea level in the medium-term would continue to shrink Southern Marin, Tiburon Peninsula, and Pt. San Pedro marsh and tidal habitats.

Southern Marin marshes may no longer exist by the end of the century, destroying the habitat of several shoreline birds and mammals. Northern Marin marshes would become increasingly tidally influenced, with tide water reaching US Highway 101 in Bel Marin Keys and North Novato up the Petaluma River.[64] Typically freshwater marshes west of US Highway 101, for example, Sutton Marsh, could also expect damaging salinity impacts. Tidal marsh lands may increase in Northern Marin if they are not prevented from migrating inland. Approximately 1,358 acres on 30 agricultural parcels could be vulnerable to sea level rise and storm conditions. Another 3,000 acres are public agency lands near Bel Marin Keys, Hamilton Field, and the Novato Sanitary District that are leased for agricultural use. Higher high tides could push brackish conditions inland, reducing grazing, manure spreading, and cultivation area.

Populations

Loss of or compromised emergency services could be more devastating to communities with higher populations that fall into certain demographic categories. Marin County populations that are most vulnerable to the effects of sea level rise include:

- Low-income households, and
- Households in poverty.

---

[62] Marin County Community Development Agency. 2015. Marin Ocean Coast Sea Level Rise Vulnerability Assessment. September 2015.

[63] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

[64] Ibid.

Communities with higher populations that fall into these categories include Marin City and the Canal neighborhoods in San Rafael.

Severe Weather

Hazard Profile

Severe weather includes strong winds, hail, and lightning. Severe weather is usually caused by intense storm systems, although types of strong winds can occur without a storm. The types of dangers posed by severe weather vary widely and may include injuries or deaths, damage to buildings and structures, fallen trees, roads and railways blocked by debris, and fires sparked by lightning.

A dominating factor in the weather of California is the semipermanent high-pressure area of the North Pacific Ocean, sometimes called the Pacific High. This pressure center moves northward in summer, holding storm tracks well to the north, and as a result California receives little or no precipitation during that period. The Pacific High decreases in intensity in winter and moves farther south, permitting storms to move into and across the state and producing strong winds, widespread rain at low elevations, and snow at high elevations. From mid-autumn to mid-spring is the rainy season. During these months, storms may occur. In addition to strong winds and flooding, storms on rare occasions can bring hail and/or lightning to all areas of the County.[65]

Marin County is bounded by the cool waters of the Pacific Ocean to the west, the San Francisco and Richardson Bays to the southeast, the San Pablo Bay to the east, and Sonoma County agricultural lands to the north. The combination of these large bodies of water, location in the mid-latitudes, and the persistent high pressure over the eastern Pacific Ocean results in several micro-climates. Weather in the county consists of warm, dry summers and cool, wet winters. The climate in early fall and late spring is generally similar to the summer, and late fall is similar to winter. Spring is generally cool, but not as wet as the winter.[66]

Disaster History

Based on recent history, severe winter storms occur every year, but those leading to federally declared disasters seem to occur about every 10 years – often in clusters and associated with high tides and/or atmospheric rivers.[67]

[65] Marin County. 2018. Marin County Multi-Jurisdiction Local Hazard Mitigation Plan.

[66] Marin County Fire Department. 2016. Community Wildfire Protection Plan.

[67] Marin County. 2018. Marin County Multi-Jurisdiction Local Hazard Mitigation Plan.

Marin County was included in the Presidential Disaster Declarations for Severe Winter Storms, Flooding, Mudslides on April 1, 2017; February 14, 2017; June 5, 2006; and February 3, 2006; making severe storms the most frequent cause of major disasters affecting Marin in the last 20 years. A review of the National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center (NCDC) database reveals that, although most not considered disasters, 113 major severe storm events occurred in Marin County between 1996 and 2010. Of these events, 12 caused deaths or injuries, and 65 damaged properties. According to NOAA, total property damage estimates (including crops) during this period were $278 million. [68]

In August 2020, thousands of dry lightning strikes occurred over several days and ignited over 600 fires in seven counties.[69] Historically, lightning strikes have accounted for many wildfires throughout the state.

Probability of Future Events

Climate change increases the variance of weather patterns which means the occurrence of events at the edges of the observed range increases. This could be intense rainfall, wind, heat, powerful hurricanes, or any other climate change-influenced event. For example, severe coastal storms may increase in frequency and severity.[70] Climate change will likely increase the frequency and intensity of storm events in Marin County,[71] which in turn would increase the potential for hazards related to severe weather.

---

[68] Ibid.

[69] California Department of Forestry and Fire Protection (CAL FIRE). 2021. 2020 Incident Archive. https://www.fire.ca.gov/incidents/2020/

[70] California Governor's Office of Emergency Services. 2018. 2018 State of California Multi-Hazard Mitigation Plan. http://www.caloes.ca.gov/for-individuals-families/hazard-mitigation-planning/statehazard-mitigation-plan.

[71] County of Marin. 2020. Marin County Unincorporated Area Climate Action Plan 2030. December 2020.

Recent modeling indicates that climate change-induced warming may lead to increased lighting, which in turn may increase the number of lightning-caused wildfires that occur throughout the state. The overall incidence of lightning across the continental United States could increase by 12 percent for every 1°C rise in global average air temperature by 50 percent by the end of the 21st century, though increases would vary by local climate.[72]

Vulnerability

Infrastructure

The entire county is susceptible to storms and damage from heavy wind and rain. The coastal and mountainous areas are particularly susceptible to wind, although wind has caused damages throughout the county. Coastal areas are susceptible to storm surge and high tides. Flash flooding primarily affects interior valleys, although there are some coastal streams prone to flash flooding. Localized stormwater ponding and clogged drainage occurs in countless areas throughout Marin during storms, particularly to vehicles when the depth of water is greater than 6" in the road.[73]

A storm can cause heavy rains, flash flooding, tidal flooding, and wind speeds of up to 70 miles per hour. Hazards related to severe storms include debris flow (see Landslides, Debris Flows, and Post-Fire Debris Flows above), flooding (see Flooding above), and wind. Strong wind can lead to power outages and/or road closures, clogged creeks and culverts, damage to structures and cars due to fallen trees, and damage resulting from wind-driven wave erosion.[74]

Populations

Marin County populations that are most vulnerable to the effects of severe weather events include:

- Low-income households,
- Households in poverty,
- Cost-burdened households,
- Mobile home owners,
- Persons without access to transportation or telecommunications,
- Low-resourced racial or ethnic minorities,
- Outdoor workers,
- Healthcare workers, first responders, and protective service occupations, and
- Houseless population.

[72] D. M. Romps, J. T. Seeley, D. Vollaro, J. Molinari, Projected increase in lightning strikes in the United States due to global warming. *Science* 346, 851–854 (2014). https://doi.org/10.1126/science.1259100

[73] Marin County. 2018. Marin County Multi-Jurisdiction Local Hazard Mitigation Plan.

[74] Ibid.

Subsidence

Hazard Profile

Land subsidence is a gradual settling or sudden sinking of the Earth's surface due to removal or displacement of subsurface earth materials.[75] The main cause of subsidence in California is groundwater pumping. Other causes include drainage and compression of organic soils or Bay Mud, underground mining, and natural compaction or collapse. The effects of subsidence include damage to buildings and infrastructure, increased flood risk in low-lying areas, and lasting damage to groundwater aquifers and aquatic ecosystems.

Disaster History

In the low-lying exposed areas in nearly every community, except Kentfield, subsidence is an ongoing issue. Roadways throughout the County along the shoreline, notably US Highway 101, and roads in lower Paradise Cay, already experience subsidence.[76]

Probability of Future Events

Many shoreline properties in Marin County are built on fill and mud, and underlying soils will become more saturated under sea level rise conditions and, consequently, vulnerable to increasing rates of subsidence.[77] Subsidence is already a factor for many roads and will likely worsen as the ground becomes saturated with bay or coastal waters further inland. Utilities infrastructure located along the shoreline on fill and mud and in the bay itself, which already experiences the effects of subsidence, will be subject to increased levels of subsidence in the future.

---

[75] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

[76] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

[77] Ibid.

Vulnerability

Infrastructure

Subsidence can severely impact public facilities and infrastructure as well as private development in areas where it occurs through the damage or compete failure of underground utilities, damaged building or utility infrastructure foundations, damaged roadways, etc.[78]

Vulnerable substations; electrical transmission towers and lines; underground natural gas water supply, and sanitary sewer pipelines; pump stations; and other facilities and infrastructure along the shoreline would be compromised by subsidence. Subsidence can place pressure on underground utility pipelines when roadways begin to sink around the pipes, causing them to bend. Electrical transmission towers, including land-based towers east of Bel Marin Keys and South of Novato over to the Sonoma County border and in the bay off the shores of Corte Madera and Mill Valley, are subject to increased rates of subsidence, which can impact the mounting platforms that support the towers. Landfills are often subjected to subsidence because they are typically located where marshes once existed, and because buried materials settle over time. Jetties, which are structures built into the water to protect a harbor or shore, are also prone to subsidence.

Transportation facilities along the County's coastline are vulnerable to subsidence. Increased subsidence could warp the buildings and runways at Marin County Gnoss Field Airport in North Novato and San Rafael Airport. Parking and access areas along Richardson Bay, including those in Waldo Point Harbor, are also prone to continuous subsidence. As discussed above, roadways and highways along the shoreline also suffer from subsidence.

Important cultural resources, including archaeological sites at or near the edge of the bay may be vulnerable to subsidence. Vulnerable sites include permanent settlements represented by shell mounds or middens associated with marshes and other locations at or near the edge of the bay where shellfish/marine resources were available.

In general, Marin County shoreline properties, especially those in Southern Marin on fill in the low-lying areas east of US Highway 101, are the most exposed and vulnerable to subsidence.[79] Almonte, Belvedere, Santa Venetia, Paradise Cay, Bel Marin Keys, the Corte Madera shoreline, the Marinship neighborhood of Sausalito, and shoreline and downtown portions of San Rafael were built on bay fill and mud, and already experience subsidence. This impacts buildings, roads, and utility infrastructure. These areas could anticipate increased rates of subsidence as bay waters saturate the soil from the below.

[78] Ibid.

[79] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

Populations

Subsidence is an ongoing issue in the low-lying exposed areas of nearly every unincorporated Bayshore community, except for Kentfield, and sea level rise would only exacerbate existing subsidence impacts.[80] Marin County populations most vulnerable to subsidence impacts include:

- Households in poverty.

Wildfire

The Marin County Fire Department in collaboration with FIRESafe Marin finalized the Marin County Community Wildfire Protection Plan (CWPP) in December 2020. This discussion is summarized from the CWPP unless otherwise indicated.

Hazard Profile

A wildfire is any uncontrolled fire occurring on undeveloped land that requires fire suppression. Wildfires can occur naturally, such as those ignited by lightning, and are important to many ecosystem processes; however, most are started by human activity such as smoking, campfires, equipment use, and arson. Recently, wildfires in Northern California have been started by vegetation blowing into power lines. The mix of weather, diverse vegetation and fuel characteristics, complex topography, and land use and development patterns in Marin County are important contributors to the fire environment.

Topography characterizes the land surface features of an area in terms of elevation, aspect, and slope. Marin County is topographically diverse, with rolling hills, valleys, and ridges that trend from northwest to southeast. Elevation throughout the county varies considerably and there is considerable diversity in slope percentages. The San Geronimo Valley slopes run from level (in the valley itself) to near 70%. Mt. Barnabe has slopes that run from 20% to 70%, and Throckmorton Ridge has slopes that range in steepness from 40% to 100%. These slope changes can make fighting fires extremely difficult.

[80] Ibid.

Vegetation, which in the context of wildland fire is also referred to as fuel, plays a major role in fire behavior and potential fire hazard. A fuel's composition (including moisture level, chemical makeup, and density) determines its degree of flammability. Of these, fuel moisture is the most important consideration. Environmental factors, such as temperature, precipitation, soil type, aspect, slope, and land use history, all help determine the existing vegetation at any given location. Marin County has extensive topographic diversity that supports a variety of vegetation types (see Figure 3-17). In the central and eastern parts of the county, north-facing slopes are usually densely wooded from lower elevations to ridge peaks with a mixture of mostly hardwood tree species such as coast live oak, California bay, Pacific madrone, and other oak species. Marshlands are also present throughout the county; once ignited, marsh fires can be difficult to contain and extinguish.

Grasslands with a mixture of native and nonnative annual and perennial plant species occur most often in the northern and western parts of the county. Grassland fires are dangerous even without extreme fire weather scenarios because of the rapid rate of fire spread; in some cases, fires spread so quickly that large areas can burn before response resources are able to arrive.

In the west portion of the County closer to the coast, most areas are densely forested with conifer species (i.e., Bishop pine, Douglas fir, and coast redwood) and associated hardwood species. Chaparral vegetation also occurs in parts of the county. This densely forested areas mixed with chaparral results in higher fuel loads and potentially higher fire intensity. Expansion of the residential communities into areas of heavier vegetation has resulted in homes existing in close proximity to dense natural foliage; these homes are often completely surrounded by highly combustible or tall vegetation, increasing the potential that wildland fires could impact them.

The 2020 CWPP included an updated 2018 fuel model map that represents the most current and highest-resolution vegetation coverage data available for the County. The 2018 fuel model map is presented as Figure 3-18. It shows 22 types of vegetation and their distribution throughout the County.

Approximately 60,000 acres—18% of the County's land area—falls within the wildland urban interface (WUI) where residences (i.e., homes and structures) are adjacent to or intermixed with open space and wildland vegetation. Figure 3-19 shows a map of the WUI in Marin County. The term "WUI" is not a designation of potential wildfire severity, but a defined description of an area where urban development meets undeveloped lands at risk of wildfires. The federal definition of WUI excludes areas where development falls below a certain threshold, so a single house far from other structures may not be considered in the WUI even though it is in the middle of a wild area. Conversely, areas with dense development may not be considered WUI because of the housing density, even though they may be close to wildlands.

A recent assessment based on the latest tax assessor parcel data shows that there are approximately 69,400 living units valued at $58.5 billion within the WUI. Because of the mix and density of structures with natural fuels in close proximity to each other, combined with more limited access and egress routes, fire management is more complex in WUI environments. In Marin County specifically, many of the access roads within the WUI are narrow and winding and are often on hillsides with overgrown vegetation, making it even more difficult and costly to reduce fire hazards, fight wildfires, and protect homes and lives in these areas.

Generally, the WUI boundaries shown in Figure 3-19 are based on areas with high structure density and proximity to high density of burnable fuels. While most of the towns and cities in

Marin County are “built-out,” resulting in modest levels of new development, some residential development has occurred and/or is planned. Because the official WUI map is several years old, it may not capture development that has occurred within the past ten years.

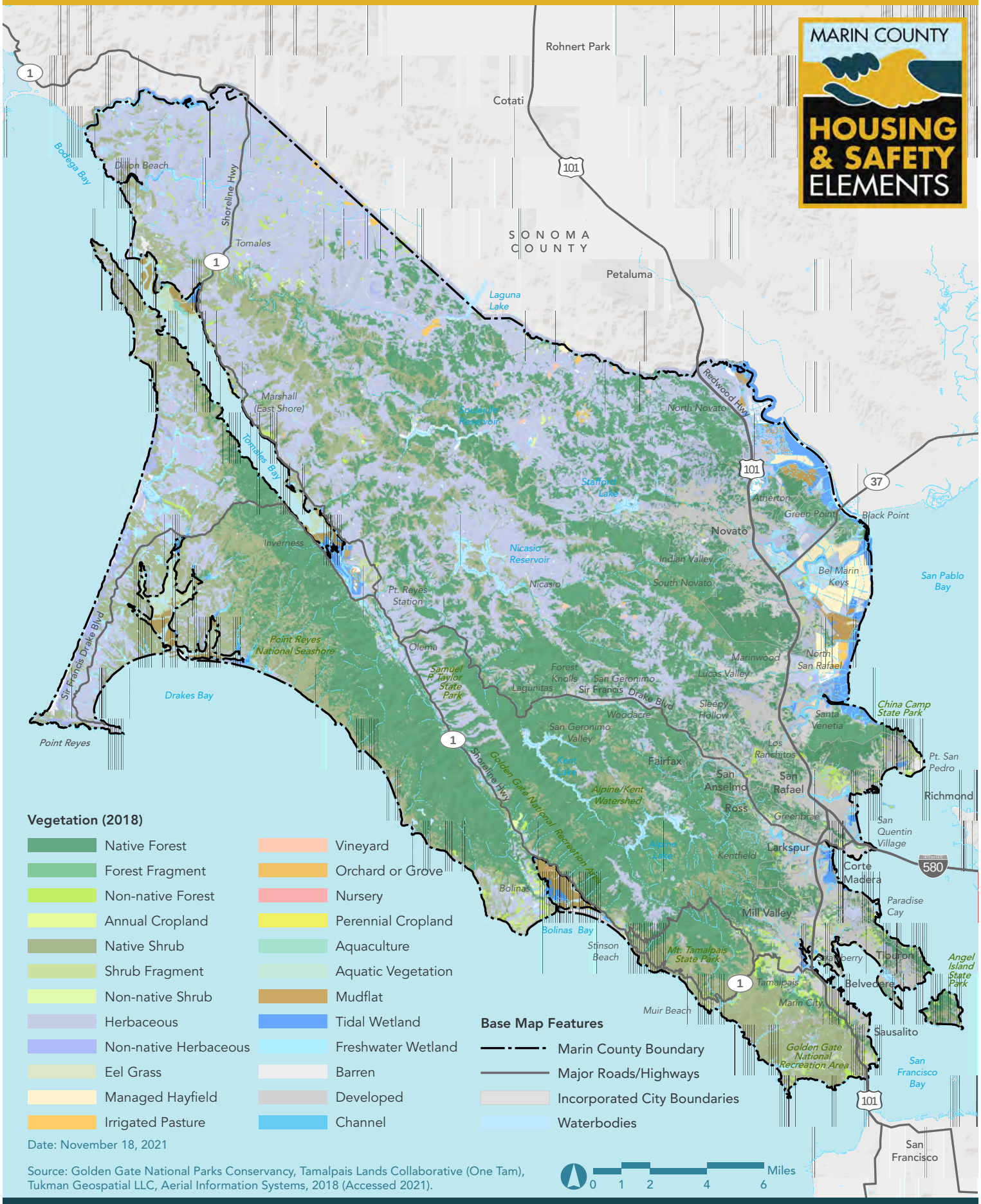


Figure 3-17: Vegetation

SAFETY ELEMENT VULNERABILITY ASSESSMENT

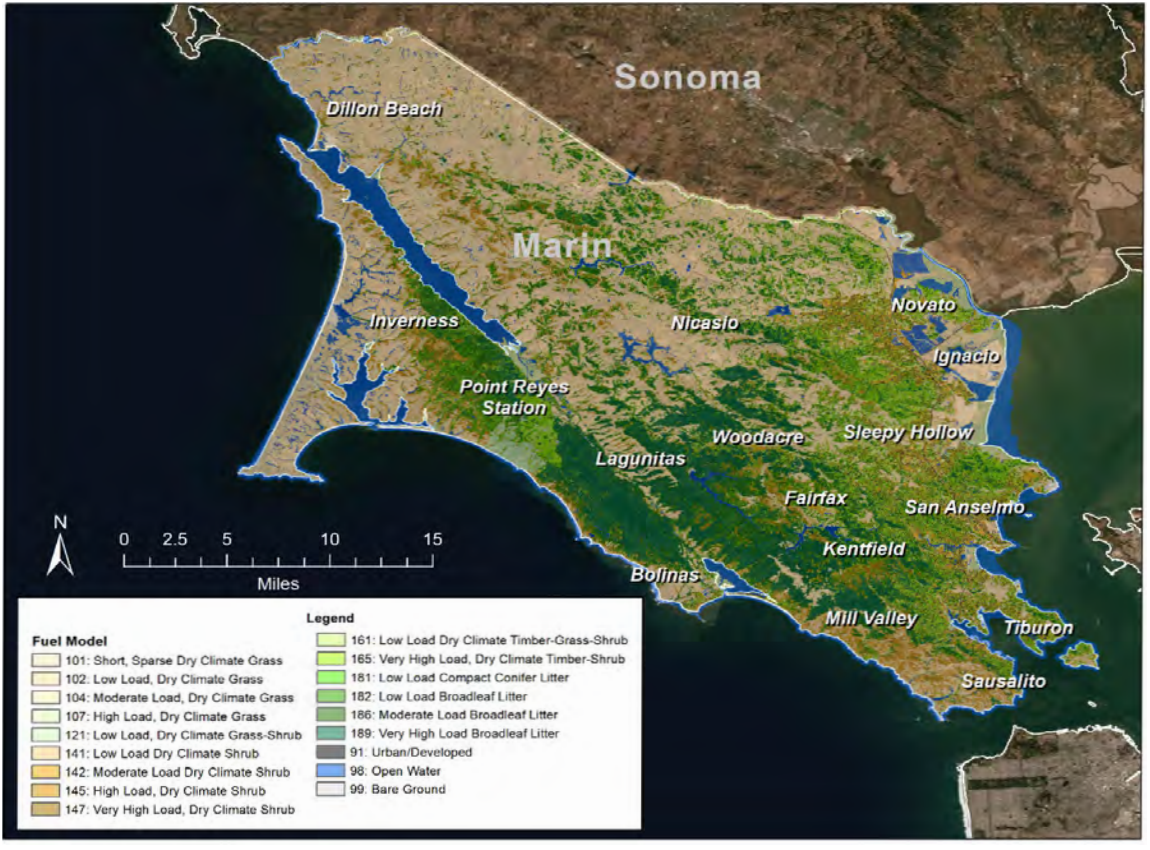


Figure 3-18: Fuel Model Map

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin Community Wildfire Protection Plan

This page intentionally left blank.

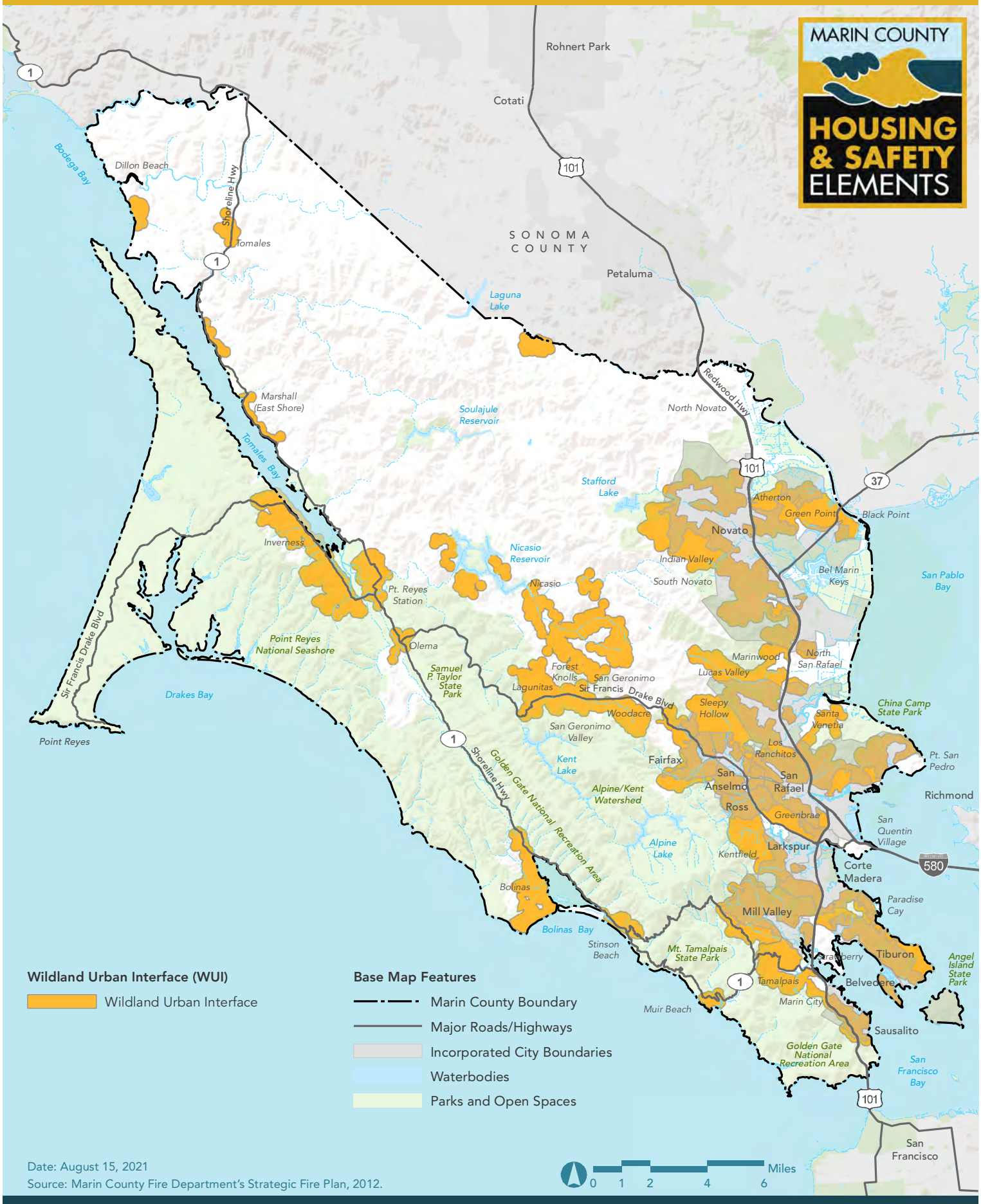


Figure 3-19: Wildland Urban Interface

SAFETY ELEMENT VULNERABILITY ASSESSMENT

CAL FIRE is required by law to map areas of significant fire hazards based on fuels, terrain, weather, and other relevant factors. These zones, referred to as Fire Hazard Severity Zones (FHSZ), influence how people construct buildings and protect property to reduce risk associated with wildland fires. The maps were last updated in the mid-1980s and early 1990s. A countywide assessment of the wildland fire threat undertaken by CAL FIRE revealed that nearly 313,000 acres (approximately 82% of the total land area of the county) are ranked as having moderate to very high fire hazard severity zone ratings. The fire hazard severity zones in the County are shown in Figure 3-20.

Fire protection in California is the responsibility of either the federal, state, or local government. On federally owned land, or federal responsibility areas (FRA), fire protection is provided by the federal government, often in partnership with local grants and contracts. In state responsibility areas (SRA), which are defined according to land ownership, population density, and land use, CAL FIRE has a legal responsibility to provide fire protection. CAL FIRE is not responsible for densely populated areas, incorporated cities, agricultural lands, or federal lands. Local responsibility areas (LRA) include incorporated cities and cultivated agriculture lands. In LRAs, fire protection is provided by city fire departments, fire protection districts, or counties, or by CAL FIRE under contract to local government. Figure 3-21 shows the FRA, SRA, and LRA in Marin County.

In Marin County, CAL FIRE contracts with the Marin County Fire Department (MCFD) to provide wildland fire protection and associated fire prevention activities for the SRA, which comprises more than half of the total land area in Marin. The MCFD is responsible for the protection of approximately 200,000 acres of SRA within the county and is the primary agency that handles wildland fires. MCFD also provides similar protection services to approximately 100,000 acres of FRA in the Golden Gate National Recreation Area (GGNRA), Muir Woods National Monument, and Point Reyes National Seashore.

In addition to MCFD, there are twelve fire service agencies and one volunteer department—Tomales Volunteer Fire Company (TVFC)—that provide fire services in Marin County. Figure 3-22 depicts the service areas of the fire service agencies in the County. Eight of these fire service

agencies serve unincorporated Marin County, including the Marin County Fire Department, Bolinas Fire Protection District, Inverness Volunteer Fire Department, Kentfield Fire Protection District, Marinwood Fire Department, Novato Fire Protection District, Southern Marin Fire Protection District, and Stinson Beach Fire Protection District. The Novato Fire Protection District serves both the City of Novato and surrounding unincorporated areas in northern Marin. In addition, one private fire brigade, Skywalker Fire, is situated on the Lucas Valley Ranch.

Disaster History

Historical records show that many large wildfires (greater than 500 acres) have occurred in Marin since 1850.

Fire records for Marin are incomplete, but historic newspaper articles and old fire planning studies document an active fire history going back to the early 20th century. The most recent fire in Marin was the Woodward Fire which started on August 17, 2020 by lightning from a rare dry lightning weather event. The Woodward Fire was contained by October 9, 2020 at 4,929 acres.

The last fire in Marin that resulted in significant structure loss was the Vision Fire in 1995, which destroyed 48 structures in the community of Inverness. In 1929, the base of Mt. Tamalpais—specifically the community of Mill Valley—experienced a significant fire known as the Great Mill Valley Fire. That fire's footprint is now developed with more than 1,100 homes (valued at over $1 billion) which have significantly altered the natural vegetation through urban and suburban development.

Figure 3-23 shows the perimeters of historic fire in Marin County for which records are available.

CAL FIRE incident information identifies eight wildfires in Marin County since 2008. Marin County has been included in no federal wildfire disaster declarations and no federal fire management declaration events, for a total of zero federal declarations since 1980.[81]

Probability of Future Events

Recent research indicates that higher summer temperatures will likely increase fire severity in California. Future changes in fire frequency and severity are difficult to predict; however, regional climate change associated with elevated greenhouse gas concentrations could alter large weather patterns and produce conditions conducive to extreme fire behavior. A warmer climate will bring drier winters and higher spring temperatures. Combined with drought conditions, this leads to drier soils in early summer, drier vegetation, and an increase in the number of days in the year with flammable fuels, all which further raise the likelihood of fires.

[81] Marin Municipal Water District. 2021. Hazard Mitigation Plan Public Review Draft. September 2021

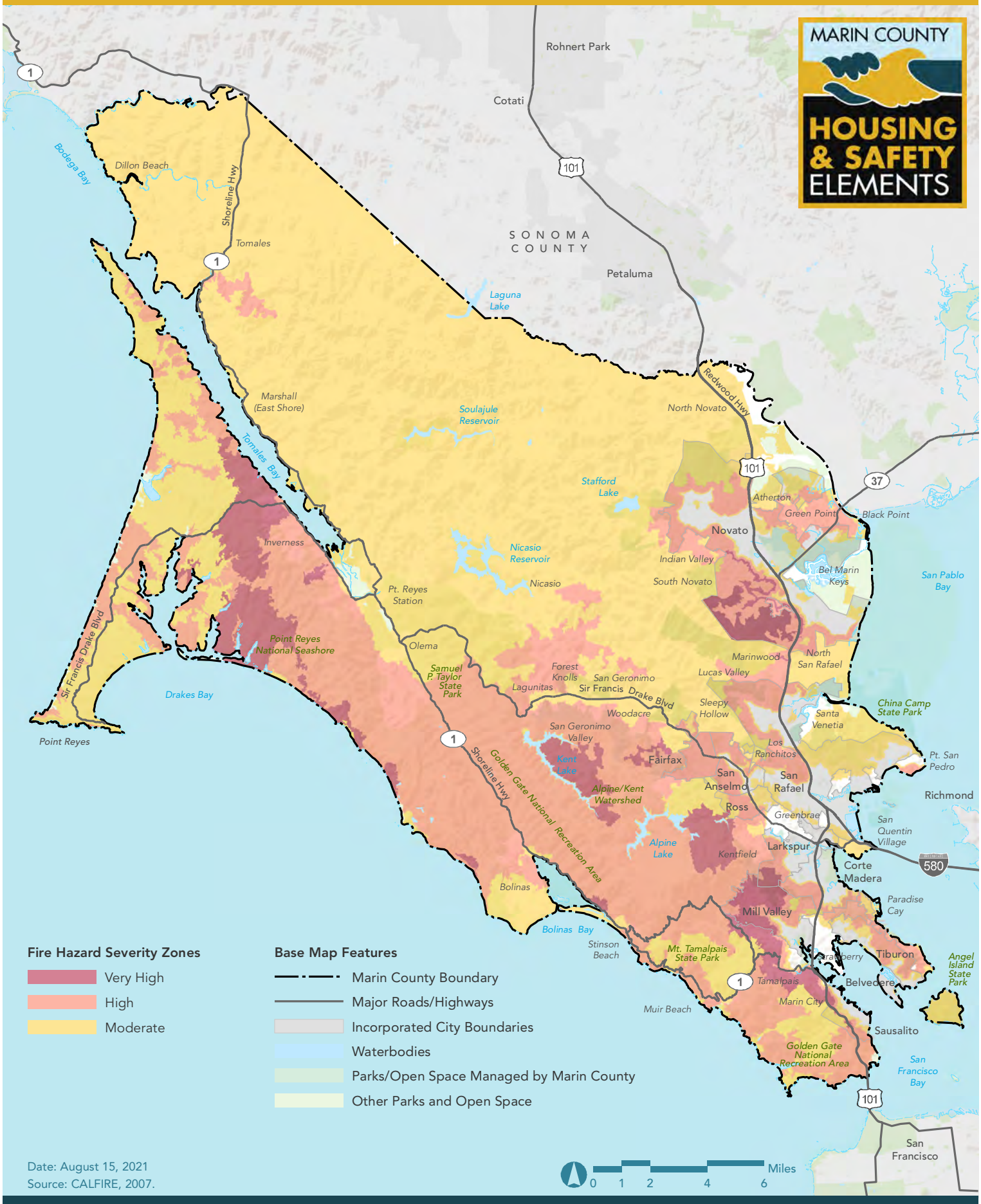


Figure 3-20: Fire Hazard Severity Zones

SAFETY ELEMENT VULNERABILITY ASSESSMENT

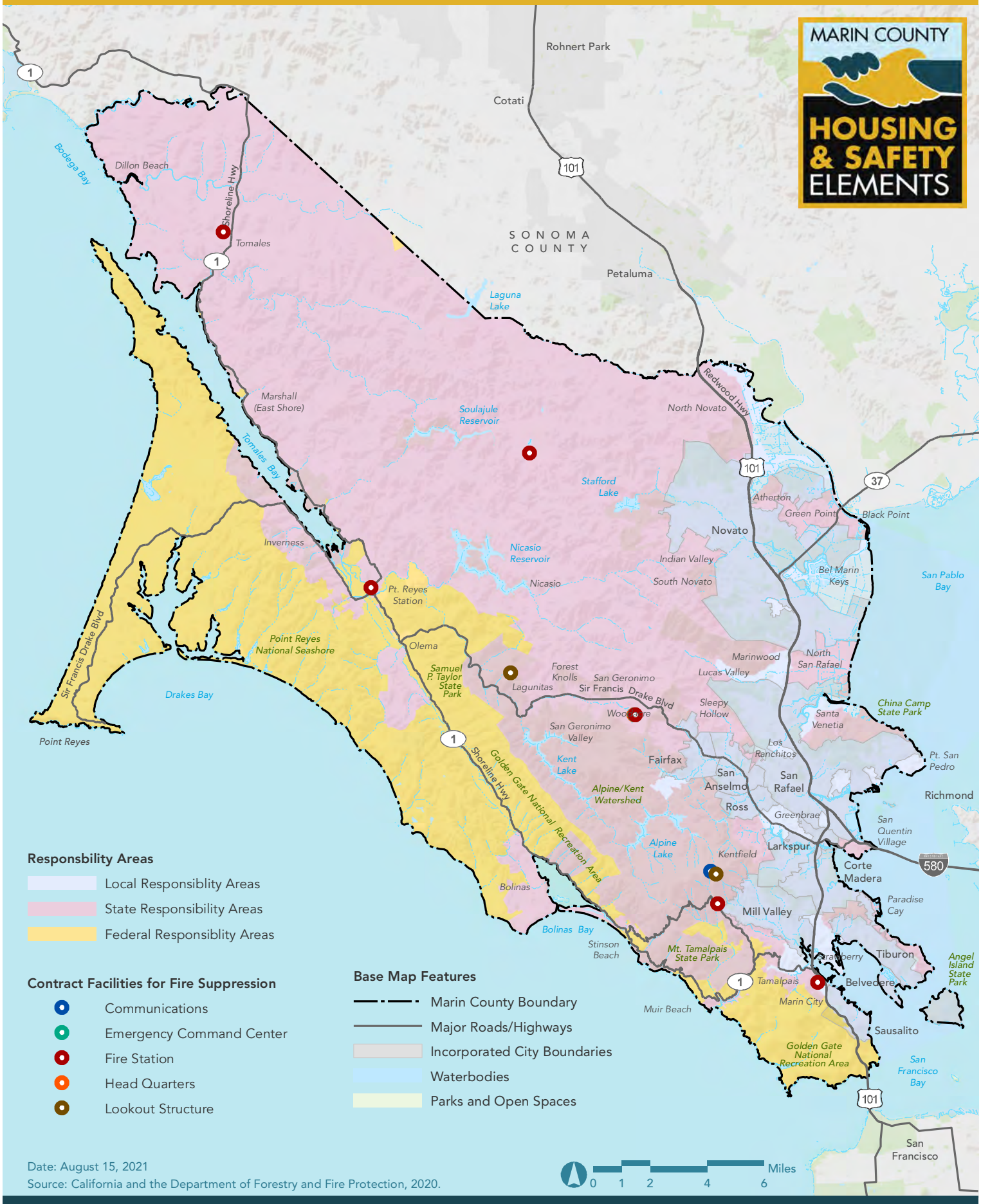


Figure 3-21: FRA, SRA, and LRA

SAFETY ELEMENT VULNERABILITY ASSESSMENT

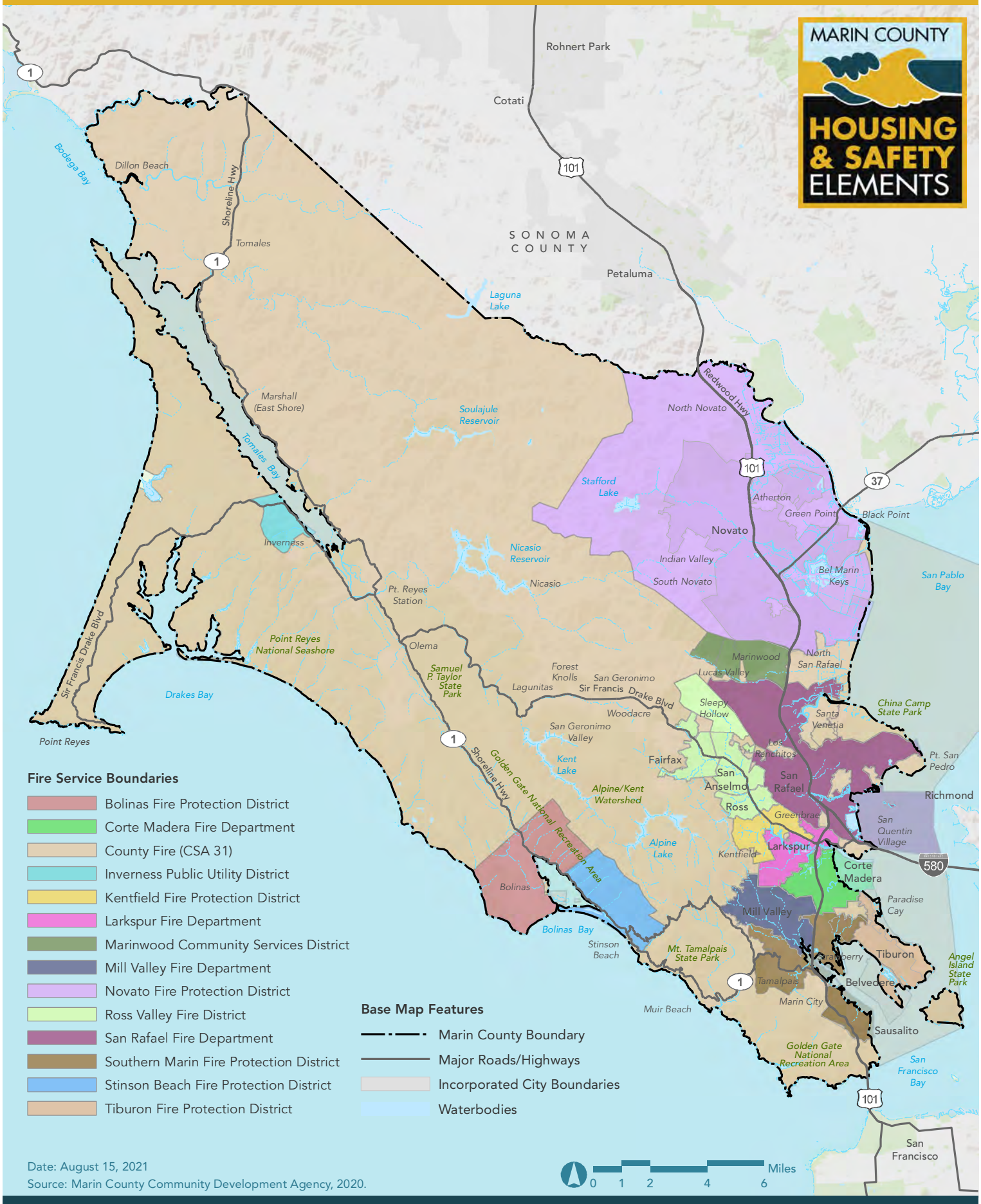


Figure 3-22: Fire Service Agency Jurisdictions

SAFETY ELEMENT VULNERABILITY ASSESSMENT

The western U.S. is likely to continue its trend toward warmer and drier conditions, on average, with warmer spring and summer temperatures, reduced snowpack and earlier snowmelts, and longer, drier summer fire seasons. Models and observations predict that warming and drying conditions are likely to cause increased fire activity in the future, including reconstructions of fire and climate in the past; trends over the last few decades; and predictive models.

The 2020 CWPP developed a series of models of the wildfire hazards, assets, and risks in the County. One model was the average fire season flame length, with lengths above 8 feet possibly exhibiting the more extreme fire behavior and be relatively more hazardous from a fire suppression perspective. Rate of spread is defined as the rate of forward spread of the fire head expressed in feet per minute. The higher the rate of spread, the more difficult a fire is to suppress. A composite map of the flame length, rate of spread, and population density for the average fire season and peak fire season scenarios are shown in Figures 3-24 and 3-25; orange and red show areas where more extreme fire behavior is likely given an ignition.

Vulnerability

Infrastructure

Assets at risk are structures, infrastructure, and other resources that can be damaged or destroyed by a wildland fire. Assets and infrastructure at risk in Marin County include real estate (homes and businesses), emergency communication facilities, transportation and utility infrastructure, public buildings and facilities, watersheds, protected wildlands, tourist and recreation areas, and agricultural lands. The potential for significant damage to life and property exists in areas designated as “wildland-urban interface areas,” where development is adjacent to densely vegetated areas. There are no recorded incidents of loss of life from wildfires in the planning area.[82]

Structure vulnerability can be somewhat managed by active vegetation management programs and compliance with fire safety building codes. Property owners have a responsibility to prepare their homes and property to reduce structural ignitability by complying with WUI building codes and ordinances, providing adequate defensible space, and hardening their homes from ember penetration.

Pacific Gas & Electric Company (PG&E) operates a total of 1,179 miles of overhead electricity transmission and distribution lines in Marin County.[83] Overhead electricity lines and poles can be damaged or downed under severe weather conditions, particularly severe wind conditions, which increases the potential for wildfire ignition. 52 percent of PG&E’s overhead distribution lines and 41 percent of its overhead transmission lines are located in California Public Utilities Commission (CPUC)-identified High-Fire Threat Districts subject to elevated or extreme fire risk. PG&E is currently planning and implementing safety measures to prevent wildfires and reduce the impacts of Public Safety Power Shutoff (PSPS) events on communities in Marin and throughout California.

---

[82] Ibid.

[83] PG&E. 2020. Community Wildfire Safety Program Marin County. June 3, 2020. https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/Wildfire-Safety-Working-Session-Marin-County-May-2020.pdf

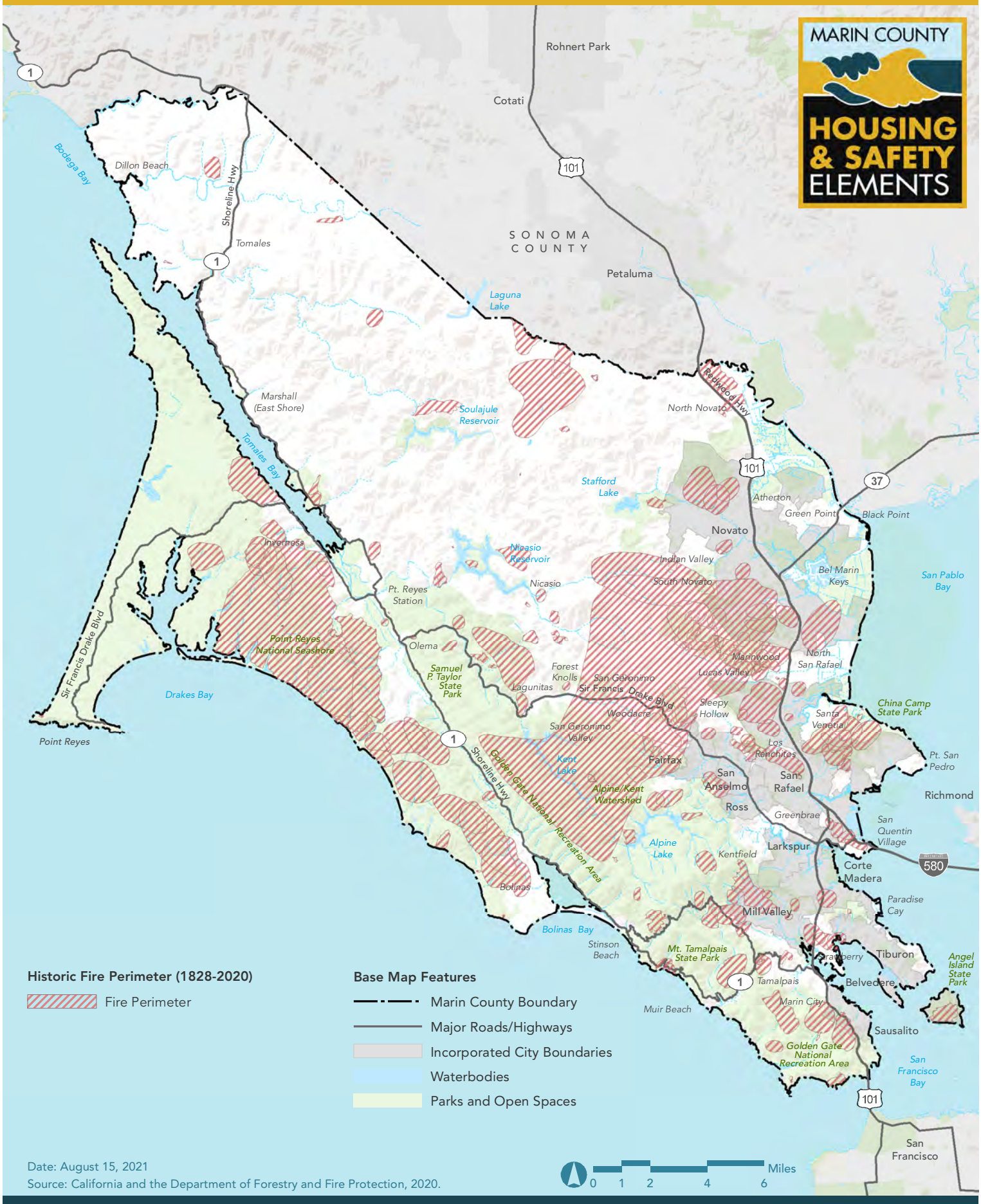


Figure 3-23: Historic Fire Perimeters

SAFETY ELEMENT VULNERABILITY ASSESSMENT

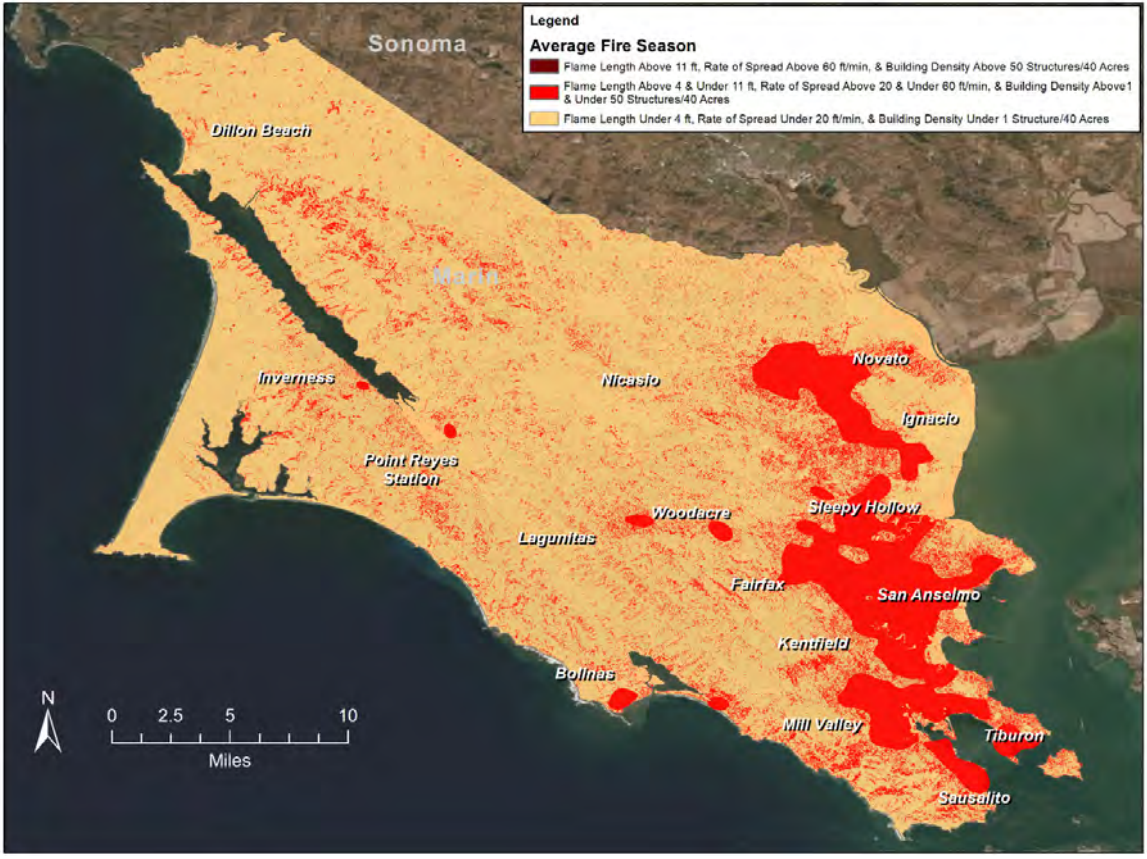


Figure 3-24: Modeling Results for Average Fire Season Scenario

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin Community Wildfire Protection Plan

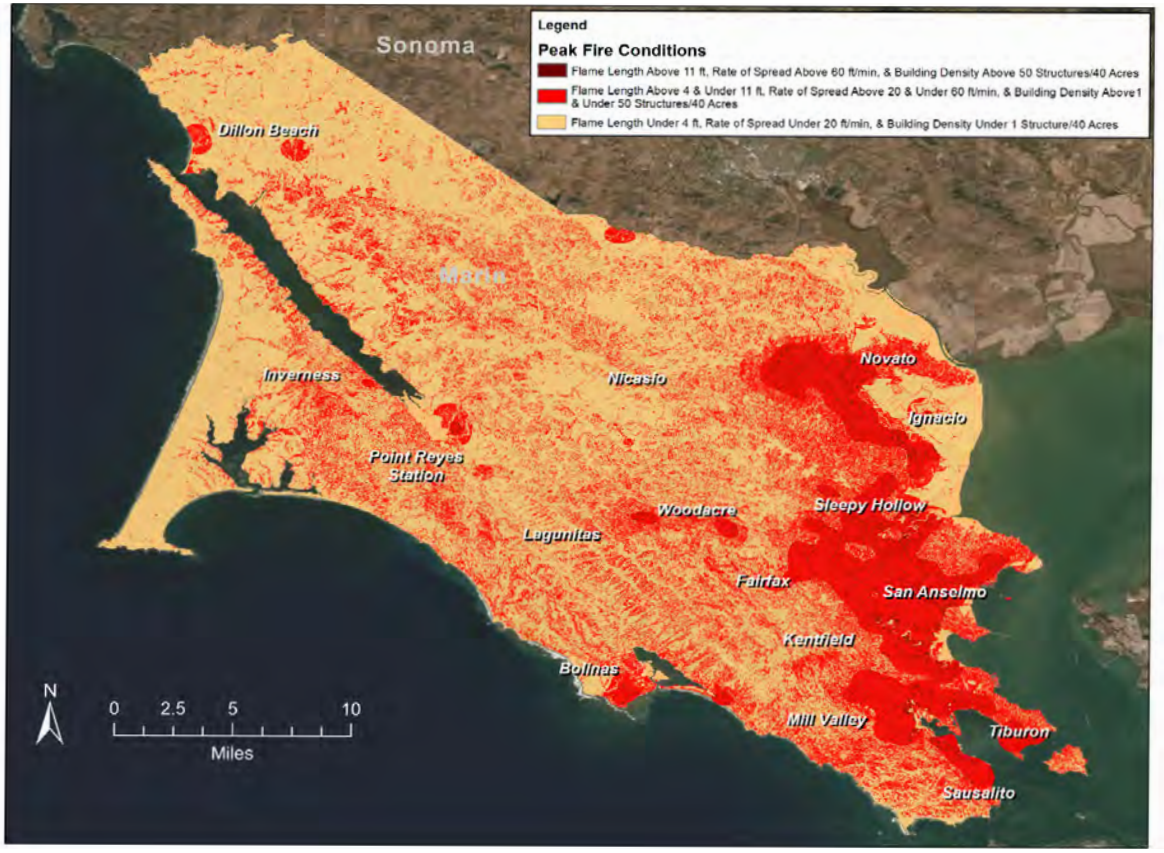


Figure 3-25: Modeling Results for Peak Fire Season Scenario

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Marin Community Wildfire Protection Plan

These measures include installing weather stations; installing high-definition cameras; installing sectionalizing devices on its overhead lines to separate the grid into smaller sections; hardening the system by installing stronger power poles, covering lines, and undergrounding lines in targeted areas; creating temporary microgrids to provide electricity during PSPS events; and enhancing existing vegetation management activities. From 2018 to July 2021, PG&E hardened three miles of overhead lines, installed 68 transmission and distribution sectionalizing devices, completed enhanced vegetation management on approximately 51 of overhead line miles, installed 28 weather stations, and installed 12 high definition cameras in Marin County.[84]

Unincorporated rural areas within the County include the coastal communities of Muir Beach, Stinson Beach, and Bolinas; communities near Tomales Bay including Olema, Point Reyes Station, Inverness, Inverness Park, Marshall, Tomales, and Dillon Beach; and rural areas in the interior valleys including Nicasio, Lagunitas, Forest Knolls, San Geronimo, and Woodacre. These communities are primarily situated within or adjacent to the WUI, with moderate to dense concentrations of structures. Marin County has approximately 60,000 acres of WUI adjacent to 200,000 acres of watershed. Many homes in Marin County stand on hillsides and ridges, with narrow and winding roads providing the only access routes through neighborhoods and communities. Response times in these communities present significant challenges to firefighting as emergency fire access and evacuation egress is limited by narrow, winding roads lined with dense vegetation. Future development trends in the County may result in more development being located in the WUI or immediately adjacent to the WUI, increasing the risk of hazard to these areas.

Populations

To help protect people and property from potential catastrophic wildfire, the United States Department of the Interior (DOI) and the United States Department of Agriculture (USDA) developed a National Fire Plan in 2000 that identifies communities that are at high risk of damage from wildfire. These high-risk communities identified within the WUI were listed in the Federal Register in 2001. In California, CAL FIRE has the responsibility for managing the list. With California's extensive WUI situation, the list of communities extends beyond just those adjacent to Federal lands; there are 1,329 communities currently on the California Communities at Risk List. Marin County has 23 of these at-risk communities, listed below.

- Bolinas
- Corte Madera
- Fairfax
- Inverness
- Inverness Park
- Kentfield
- Lagunitas-Forest Knolls
- Larkspur
- Lucas Valley-Marinwood
- Marin City
- Mill Valley
- Novato
- Olema
- Point Reyes
- Ross
- San Anselmo
- San Rafael
- Santa Venetia
- Sausalito
- Stinson Beach

[84] PG&E. 2021. Community Wildfire Safety Program 6/30/2021 Summer Progress Update. https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/PSPS-Local-Progress-Update-by-County.pdf

- Strawberry
- Tamalpais-Homestead Valley
- Tiburon
- Tomales
- Woodacre

Marin County populations within the above-listed communities that are most vulnerable to the effects of wildfire include:

- Low-income households,
- Households in poverty,
- Persons living on single access roads,
- Mobile home owners,
- Persons without access to transportation or telecommunications,
- Outdoor workers,
- Healthcare workers, first responders, and protective service occupations,
- Houseless population,
- Children,
- Persons with disabilities,
- Persons with chronic health problems,
- Senior citizens, and
- Persons living alone.

4. SELECTED POPULATIONS AND ASSETS

This chapter describes the potential impacts of climate change hazards on selected populations and physical assets. The selected populations and assets are first identified and described. Then the potential impacts to these populations and assets are summarized in tables.

Climate change effects will impact different areas of the unincorporated county in varying ways, depending on physical location and proximity to an environmental hazard. Additionally, certain population groups and assets will have greater capacity to respond to the hazard than others. Key populations and assets identified in the unincorporated county are organized into the following categories:

FIGURE 4-1: POPULATION AND ASSET CATEGORIES

Populations	Assets
• Financially Constrained Households • Isolated and Rural Communities • Persons with High Outdoor or Hazard Exposure • Persons with Limited Resources • Persons with Limited Mobility, Chronic Health Conditions, or Who May Be Dependent on Individuals or Services	• Roads and Road Infrastructure • Airports • Transit Routes • Railroads • Energy Infrastructure • Water and Wastewater Infrastructure • Flood Control Infrastructure • Key Services • Buildings • Natural and Managed Resources • Economic Drivers

While selecting and assessing various populations and assets to include in this Vulnerability Assessment, Marin County kept a few considerations in mind, including 1) differences in the population sample pool between datasets, 2) the limitations of the data sources that were used to prepare this assessment, and 3) how some population and asset categories may appear to refer to the same thing in different tables.

Virtually all people and assets in a community will be affected by climate change in some way. However, it is not feasible to assess the vulnerability of every population group or every asset in the community. At the same time, the County wanted to ensure the assessment does not exclude populations and assets that face greater harm or

WHAT IS A PHYSICAL ASSET?

An asset is any feature of a community that is not a person or group of people. Assets include the natural environment as well as the built environment, such as buildings and infrastructure systems.

SOURCE: 2020 APG 2.0

are critical to the community's well-being. The project team considered the following questions[85] when deciding which populations and assets to include:

- Is the population or asset likely to face substantive harm from climate-related effects?
- Is the population or asset likely susceptible to climate-related effects in a unique way, different from most other populations or assets in the community?
- If the population or asset is substantially harmed, are there significant negative consequences to the community? Consider both direct and indirect consequences and remember that consequences may not be evident until well after the harm occurs.
- Is the population or asset key to achieving overarching resiliency goals?

Overlapping Assets

Several assets appear multiple times under different categories. For example, energy delivery (considered a service) and energy infrastructure are both listed as assets under different categories. This is because energy infrastructure may be physically damaged by climate hazards but may not result in a large interruption to energy service delivery. On the other hand, power shut offs may occur (disruption of electric service) due to threat of wildfire even if the infrastructure is not damaged. Similarly, farms, orchards, and vineyards are a managed resource and also an economic driver in the County. To review assets in a comprehensive manner, the Vulnerability Assessment considers assets from a variety of angles, from their physical form, benefits they provide, or services they deliver.

Data Limitations

This Vulnerability Assessment presents data from a wide array of sources. Marin County only used reliable, credible sources with the best available information. In some cases, the Vulnerability Assessment was constrained by the lack of detailed information or spatial information about the geographic distribution of certain populations or assets.

Much of the demographic data used in this Vulnerability Assessment comes from the US Census Bureau's American Community Survey (ACS), which has a sample pool of either all residents or all households in the unincorporated county. This does not affect the outcome of the vulnerability assessment but can create slight differences in the number of people counted as part of each population.

Non-Climate Stressors

Climate change impacts are often compounded with existing "stressors" or pre-existing conditions. Examples of non-climate stressors for populations include poverty, mobility or health issues, language barriers, or lack of access to communication, healthcare, or transit. Examples of non-climate stressors for assets include lack of funding for routine maintenance and upgrading, undersized infrastructure to support the existing population, or aging buildings and infrastructure.

[85] 2020 California Adaptation Planning Guide (APG 2.0)

The ability of populations and assets to adapt to climate change will be further challenged when considering the effects of these other stressors. The overall vulnerability of populations and assets may be primarily driven by the severity of these non-climate stressors and by how they interact with climate change.

Selected Populations

The Vulnerability Assessment evaluated 19 populations that may be disproportionately harmed by climate hazards. The list of selected populations is based on the guidance of the 2020 California Adaptation Planning Guide (APG 2.0) and the 2018 Integrated Climate Adaptation and Resiliency Program (ICARP) guide "Defining Vulnerable Communities in the Context of Climate Adaption" and County input. Selected populations are grouped together under a broader category based on similar climate impacts and characteristics, although different categories may face similar impacts.

The APG 2.0 provides direction on how to decide which groups of people to evaluate for climate-related susceptibility. The APG 2.0 directs that vulnerability analyses focus on populations who are likely to face the most harm from climate change. These persons are sometimes said to be "socially vulnerable" or to have "social vulnerability."[86] This does not mean that they lack resilient qualities. Many socially vulnerable people have historically faced, and continue to face, systemic social, economic, and political marginalization and injustice. By identifying groups that are socially vulnerable, communities acknowledge the systemic discrimination that many such persons have faced and seek to correct these wrongs and build resiliency in a manner that is equitable and just.

This Vulnerability Assessment follows the APG 2.0 guidance and identifies and discusses climate change impacts to socially vulnerable populations in Marin County. The statistics presented below are from the US Census Bureau and reflect only the unincorporated areas of the County.

Financially Constrained Households

Low-Income Households

Households with an income below $146,350 for a household of four in Marin County based on the State Income Limit from Department of Housing and Community Development. There are an estimated 64,171 households in Marin County with an income below $146,350.[87]

Households in Poverty

Households with an income below the 2021 federal poverty level, which is $26,500 for a household of four. There are approximately 11,256 households with an income below the federal poverty level or 10.6 percent of occupied housing units.[88]

---

[86] 2020 California Adaptation Planning Guide (APG 2.0)

[87] 2019 ACS 5-Year Estimates Detailed Tables, S2503: Financial Characteristics

[88] 2019 ACS 5-Year Estimates Detailed Tables, S1701: Poverty Status in the Past 12 Months

Cost-burdened Households

Households paying over 30 percent of their income towards housing-related expenses, including mortgage and rental payments, real estate taxes, homeowner's insurance, and utilities. There are approximately 6,441 cost-burdened households in the County, or 6.1 percent of the total occupied housing units.[89]

Overcrowded Households

Persons living in households with more than one person per room (including all rooms except bathrooms) are considered overcrowded. Persons living in households with more than 1.5 persons per room are considered severely overcrowded. There are approximately 4,904 overcrowded households in the unincorporated county, or 4.7 percent of all households.[90]

Renters

Persons who do not own the household in which they reside. Approximately 36 percent of occupied housing units in Marin County are rented.[91]

Physically or Socially Isolated Communities

Persons Living on Single Access Roads

Persons living on roadways with only one access point in or out of the neighborhood or community.

Mobile Homes

Households living in prefabricated structures, built in a factory before being transported to the site. There are 588 mobile homes in Marin County.[92]

Persons Without Access to Transportation or Telecommunications

Persons without access to a car, transit, or communication systems (internet and phone services). There are 4,892 occupied housing units in Marin County that have no access to a vehicle, making up 4.6% of the County's population.[93] An estimated 6,596 households in Marin County do not have internet access.[94]

Linguistically Isolated Communities

A "limited English speaking household" is one in which no member 14 years old and over (1) speaks only English or (2) speaks a non-English language and speaks English "very well." In other words, all members 14 years old and over have at least some difficulty with English.

---

[89] 2019 ACS 5-Year Estimates Detailed Tables, S2503: Financial Characteristics

[90] 2019 ACS 5-Year Estimates Detailed Tables, B25014: Tenure by Occupants Per Room

[91] 2019 ACS 5-Year Estimates Detailed Tables, S2503: Financial Characteristics

[92] California Department of Finance, Demographic Research Unit, May 2021.

[93] 2019 ACS 5-Year Estimates Detailed Tables, B25044: Tenure by Vehicles Available

[94] 2019 ACS 5-Year Estimates Detailed Tables, B28011: Internet Subscriptions in Household

There are 4,588 households Marin County with limited English proficiency, which accounts for approximately 4.4% of the County's population.[95]

Persons with High Outdoor or Hazard Exposure

Outdoor Workers

Persons in industries that require them to be outdoors, such as agriculture, outdoor recreation, construction, and landscaping. Approximately 6.5 percent of Marin workers are outdoor workers, slightly lower than the state average of 8.6 percent. The majority of Marin County's outdoor workers are employed in construction rather than agriculture, forestry, fishing and hunting, and mining.

Healthcare Workers, First Responders, and Protective Service Occupations

This category includes healthcare practitioners, health technologists and technicians, healthcare support occupations, firefighting and prevention and other protective service workers including supervisors, and law enforcement workers including supervisors. There are an estimated 12,155 workers in the unincorporated county that fall into these categories.[96]

Houseless Population

Persons experiencing homelessness are individuals with a primary nighttime residence that is in a public or private space not designed for use as a regular sleeping accommodation for human beings. The 2019 Marin County Point-in-Time Count was a community-wide effort conducted on January 28th, 2019. In 2019, there were 1,034 houseless persons in Marin County with 172 located in unincorporated areas.[97]

Low-Resourced Racial or Ethnic Minorities

Low-Resourced Racial or Ethnic Minorities

Persons identifying as a member of a racial and/or ethnic minority facing limited access to financial, social, healthcare, or educational resources. Individuals in this category may lack access to a car, may be uninsured, or below the poverty level. Marin County has an estimated 18,174 individuals or 22.5% of the County's population that identify as a member of a racial and/or ethnic minority.[98] Of this population, several of the characteristics listed in the table below increase the vulnerability of individuals in this community.

[95] 2019 ACS 5-Year Estimates Detailed Tables, S1602: Limited English Speaking Households

[96] 2019 ACS 5-Year Estimates Detailed Tables

[97] Jaross, M., Kwak, Y., & Gallant J. 2019 Marin County Homeless Point-in-Time County & Survey

[98] 2019 ACS 5-Year Estimates Detailed Tables, B03002: Origin By Race

TABLE 4-1: ADDITIONAL POPULATION CHARACTERISTICS FOR LOW RESOURCED ETHNIC MINORITIES

Population Characteristics	Number of Individuals	Percent of Total Population
Speak English Less Than Very Well	3,571	4.4%
Person with a Disability	2,412	3.0%
Persons Below Poverty	4,306	5.3%

Source: U.S. Census Bureau, American Community Survey (2015-2019: 5-Year estimates)

Persons with Limited Mobility, Chronic Health Conditions, or Who May Be Dependent on Individuals or Services

Children

Persons 14 years of age or younger. Marin County has 42,968 individuals aged 14 or younger, making up 16.6% of the County's total population.[99]

Persons with Disabilities

Persons with a physical condition that limits their movements, senses, or activities, including those with access and functional needs; and persons with psychological conditions, including mental, behavioral, cognitive, and developmental disabilities. There are an estimated 23,346 individuals in Marin County with one or more disabilities.[100]

Persons with Chronic Health Problems

Persons with a persistent or long-lasting illness or disease, including those with compromised immune systems. Based on the California Health Care Almanac study of asthma, diabetes, heart disease, high blood pressure, and serious psychological distress, an estimated 31 percent of Marin's population or 61,000 individuals have at least one chronic condition out of the five identified. [101]

Senior Citizens

Persons 65 years of age or older. There are 56,170 individuals in Marin County aged 65 or older. Marin County has a higher percentage of the population aged 65 or older with 21.6 percent compared to the state at large which has 14 percent.[102]

---

[99] 2019 ACS 5-Year Estimates Detailed Tables, S0101: Age and Sex

[100] 2019 ACS 5-Year Estimates Detailed Tables, S1810: Disability Characteristics

[101] California Health Care Almanac, Californians with the Top Chronic Conditions, accessed from https://www.chcf.org/wp-content/uploads/2017/12/PDF-ChronicConditionsCaliforniansCHIS2015.pdf

[102] 2019 ACS 5-Year Estimates Detailed Tables, S0101: Age and Sex

Persons Living Alone

Individuals aged 18 and older living by themselves. Marin County has 31,548 individuals living alone, 16,893 of which are seniors living alone.[103]

Population Impacts

Table 4-2 summarizes the anticipated climate change impacts to the 19 selected populations. The table groups each population under a broader category, identifies the climate hazards a population category is exposed to, identifies non-climate stressors, and describes the overall climate impact. In addition to the data sources used to identify, determine, and define populations, the impact descriptions rely upon information contained in County planning documents as well as California's Fourth Climate Assessment and the Safeguarding California Plan which provide background information and evidence of regional climate change impacts as well as strategies to reduce impacts.

Impact scores to each population are included in Appendix B.

[103] 2019 ACS 5-Year Estimates Detailed Tables, DP02: Selected Social Characteristics in the United States

TABLE 4-2: IMPACTS TO SELECTED POPULATIONS

Population Category	Population	Non-Climate Stressors	Climate Exposures	Impact Description
Financially Constrained Households	• Low-Income Households • Households in Poverty • Cost-Burdened Households • Overcrowded Households • Renters	• Financial instability • Lack of affordable or quality housing • Lack of air conditioning or heating • Lack of insurance	• Drought • Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Flooding and severe weather can damage homes or cause mold to grow, which can make unhealthy living conditions. Extreme heat can cause indoor air temperatures to skyrocket, causing dehydration and other heat-related illnesses for those inhabiting the structures. These populations may have limited capacity to retrofit, maintain, or rebuild homes to resist damage from hazards or recover from hazard damage due to financial capacity or home ownership. Financial assistance programs may be available to help with upgrades or repairs to homes, but households may be unaware or unable to participate. These households are also highly vulnerable to drought and extreme weather due to extra costs associated with increased utility prices and property maintenance associated with adapting to these hazards. Smoke from wildfires impacts households with limited financial resources as they may be unable to seek refuge or if they cannot afford air filtration devices, or may not be able to seek medical attention due to lack of medical insurance or transportation. These populations may be unable to evacuate during emergencies due to limited financial resources, lack of transportation, or lack of temporary housing.

Physically or Socially Isolated Communities	• Persons Living on Single Access Roads • Mobile Homes • Persons Without Access to Transportation or Telecommunications • Linguistically Isolated Communities	• Remote location or limited access to housing • Lack of access to communication • Lack of access to transportation • Language barriers • Lack of insurance	• Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Persons belonging to these communities can be highly impacted by climate hazards as they can easily be cut off from the rest of the region and from receiving vital communications, goods, and services. Water or energy supply may be limited for these communities and can be damaged by drought, flooding, landslides, subsidence, severe weather, and wildfire, leaving people without water or electricity. These populations may face difficulties during emergencies that require evacuations, because potentially lower levels of social capital and language barriers may prevent adequate preparation and warnings for evacuations. Isolated, rural areas in Marin County frequently do not have cell phone service and maybe unable to receive timely emergency evacuation notices or evacuation route information. In coastal areas, communities reliant on Highway 1 can become even more isolated due to flooding, landslides, sea level rise, or subsidence if the highway is damaged or impassable.
Persons with High Outdoor or Hazard Exposure	• Outdoor Workers • Healthcare Workers, First Responders, and Protective Service Occupations • Houseless Population	• Lack of air conditioning or heating • Often inflexible occupational demands	• Drought • Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather	Individuals in these categories face greater exposure to climate hazards because they do not work in sheltered locations, often have physically intensive work, or may be responding to a hazard or have unavoidable work duties despite the hazard. The houseless population is continually exposed to weather conditions and may not be able to relocate to a safe area without assistance. Persons with high outdoor exposure may be unable to seek adequate shelter, evacuate, or be aware that hazardous conditions are occurring due to occupation or working conditions. Outdoor workers can easily face economic hardship if work is halted or

			• Subsidence • Wildfire	delayed. Extreme heat can cause individuals to overheat and cause dehydration and heat stroke, and smoke and ash can irritate the respiratory system and create difficulty breathing with extended exposure. Programs such as cooling centers, homeless shelters, and adult education programs are available in some areas of the county. However, these populations can be difficult to reach during emergencies.
Persons with Limited or Constrained Resources	• Low-Resourced Racial and Ethnic Minorities	• Financial instability • Lack of affordable or quality housing • Lack of access to healthcare or communication • Lack of insurance	• Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Disparities in living conditions and institutional biases may cause persons with limited resources to prepare for or recover from hazardous events. Language barriers or lower levels of social capital may also prevent individuals from receiving evacuation and other emergency notifications, decreasing their ability to adequately prepare for and respond to hazardous events. These populations may have limited capacity to retrofit, maintain, or rebuild homes to resist damage from hazards or recover from hazard damage due to financial capacity or home ownership.
Persons with Limited Mobility, Chronic Health Conditions, or Who May be Dependent on Individuals or Services	• Children • Senior Citizens • Persons Living Alone • Persons with Disabilities • Persons with Chronic Health Problems	• Mobility and/or health issues • Lack of access to healthcare, transportation, or communication • Lack of insurance	• Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather	Senior citizens, particularly senior citizens living alone are vulnerable to several different climate change hazards due to health and mobility factors. Seniors are usually more susceptible to heat-related illnesses or smoke conditions because they are more likely to have medical conditions that can worsen with extreme heat, and often take medicine that makes it harder for them to stay cool. Senior citizens and persons with chronic health problems are more susceptible to poor air quality associated with wildfires, and seniors and persons with

			• Subsidence • Wildfire	disabilities may have a decreased awareness of impending fire events. Additionally, they may have reduced mobility that makes it difficult to quickly evacuate in hazardous conditions. Children often have a lower level of awareness about heat-related illnesses and may not have access to air-conditioned spaces. Persons with limited mobility or chronic illnesses may have difficulty evacuating due to medicine or equipment needs and may not be able to drive themselves. They may also experience equipment issues if there are interruptions to electric, water, or wastewater supply. Extreme heat or smoke-filled air can worsen existing medical conditions. Existing chronic illnesses can also make new illnesses from climate change hazards more difficult to treat. Individuals in this category may depend on others for assistance during a hazard event in order to evacuate or shelter safely.

This page intentionally left blank.

Selected Assets

43 types of assets are considered in this Vulnerability Assessment. Some infrastructure is publicly owned by Marin County or other government agencies, and others are privately owned. Information in this section is largely sourced from MarinMap, the 2018 MCM LHMP, or other online data resources.

Roads and Road Infrastructure

Major Roads and Highways

Marin County's major roads and highways connect individual communities to others in the region and beyond. Major highways include US 101, Interstate 580, CA 1, CA 37, and CA 131. Major roads include Lucas Valley Road, Nicasio Valley Road, Novato Boulevard, Panoramic Highway, Pt Reyes – Petaluma Road, Tomales Petaluma Road, San Antonio Road, D Street, Sir Francis Drake Boulevard, North San Pedro Road, Hicks Valley Road, Sequoia Valley Road, Miller Avenue, Camino Alto, East Blithedale Avenue, Bridgeway, Paradise Drive, Trestle Glen Boulevard, Andersen Drive, Center Boulevard, Butterfield Road, Laas Gallinas Avenue, Manuel T Freitas Parkway, Ignacio Boulevard, Rowland Boulevard, Redwood Boulevard, San Marin Drive, Indian Valley Road, Grand Avenue, Bellam Boulevard, Canal Street, and Atherton Avenue. Roads and highways in Marin are shown in Figure 4-2.

Single Access Roads

Single access roads are roadways that only have one access point in or out of a neighborhood or region. Many single access roads in Marin communities are located in wildfire prone areas. The single or limited number of entry and exit points does not make the road itself more vulnerable than other roads, but loss of these roadways can effectively cut off large numbers of people from the rest of Marin County and impair evacuation and emergency response efforts, especially during wildfires.

Substandard roads, such as roads that a fire truck cannot navigate due to width or slope differentials, further limit emergency ingress and egress and impair evacuation response. Additional analysis is required to identify and analyze the effect of substandard roads on evacuation and emergency response efforts.[104]

Evacuation Routes

Major roadways or access roads can act as emergency evacuation routes during disasters. Evacuation routes are not themselves more vulnerable to hazards than other roads, but the impaired function of evacuation routes can greatly reduce the capacity of communities to evacuate and emergency services to respond during emergencies.

Fire Safe Marin and many Marin fire agencies, cities and towns, and other partners, are working together to develop improved wildfire evacuation maps and messaging for residents of Marin's

[104] The Marin Wildfire Protection Authority (MWPA) is conducting a program to create a rating system of roads, presenting a visual risk assessment of the County's roadways at various levels of aggregation (geographic areas, evacuation zones, or other). In addition to the software platform, a report will also present an initial list of risk factors for improvement by area, by risk category, and by responsible agency.

wildland urban interface (WUI) communities. These FireClear maps, funded by fire agencies, cities, and towns, and a grant from CAL FIRE, were published over the course of 2020, though additional maps may be forthcoming. The FireClear evacuation maps show both evacuation zones and evacuation routes, as shown in Figure 4-3, the FireClear map for Inverness.

The Marin County Sheriff's Office, Marin Wildfire Prevention Authority (MWPA), and all Marin municipalities are launching ZoneHaven, a community evacuation interface that allows the public access to real-time status updates and instructions for their evacuation zone and provides County municipalities and fire responders with an evacuation planning application. Agencies in Marin will be able to use ZoneHaven to send evacuation warnings to evacuation zones in Novato, San Rafael, Ross Valley, Southern Marin, and West Marin.

Bridges and Tunnels

Bridges may carry roads, rails, or trails. Bridges in unincorporated Marin include major bridges such as US 101 bridges, I 580 bridge, Alpine Dam Bridge, Lagunitas Creek Bridge, and Shafter Bridge, and many smaller bridges over local drainages or creeks.

Tunnels in unincorporated Marin include the Baker-Barry Tunnel, Robin Williams Tunnel, and Cal Park Hill Tunnel.

Airports

Airports and the associated facilities serving Marin County. Marin County has two airports. Gnoss Field, a public airport, in unincorporated Marin and the San Rafael Airport, a private airport, in the City of San Rafael (Figure 4-2).

Transit Routes

Bicycle Routes

Paved or unpaved trails that are mostly intended for bicycling activities. The existing bikeway system in Marin County's unincorporated area consists of an incomplete system of approximately 135.37 miles of bikeways with 11.3 miles of Class I Bikeways or Multi-Use pathways, 31.0 miles of Class II on-street bicycle lanes, and 93.8 miles of bicycles routes.[105]

Bus Routes

Marin County Transit District and Golden Gate Transit are the primary transit providers in the County of Marin. Special transportation providers include Marin Access, Vivalon Rides, Western Eagle Shuttle, Marin Airporter, Sonoma & Marin Airport Express, and the West Marin Stagecoach. Most bus routes serve bayside communities with few routes into unincorporated Marin. The communities of Inverness and Bolinas are on Marin Transit bus routes.[106] Bus stops in Marin are shown in Figure 4-2.

---

[105] Marin County Unincorporated Area Bicycle and Pedestrian Master Plan, 2018 Update, accessed from http://walkbikemarin.org/documents/BMP/2018%20Plan/UnincorpAreaBikePedPlanBOSDraft.pdf

[106] Marin Transit, Service Map, accessed from https://marintransit.org/map

Railroads

Railroads

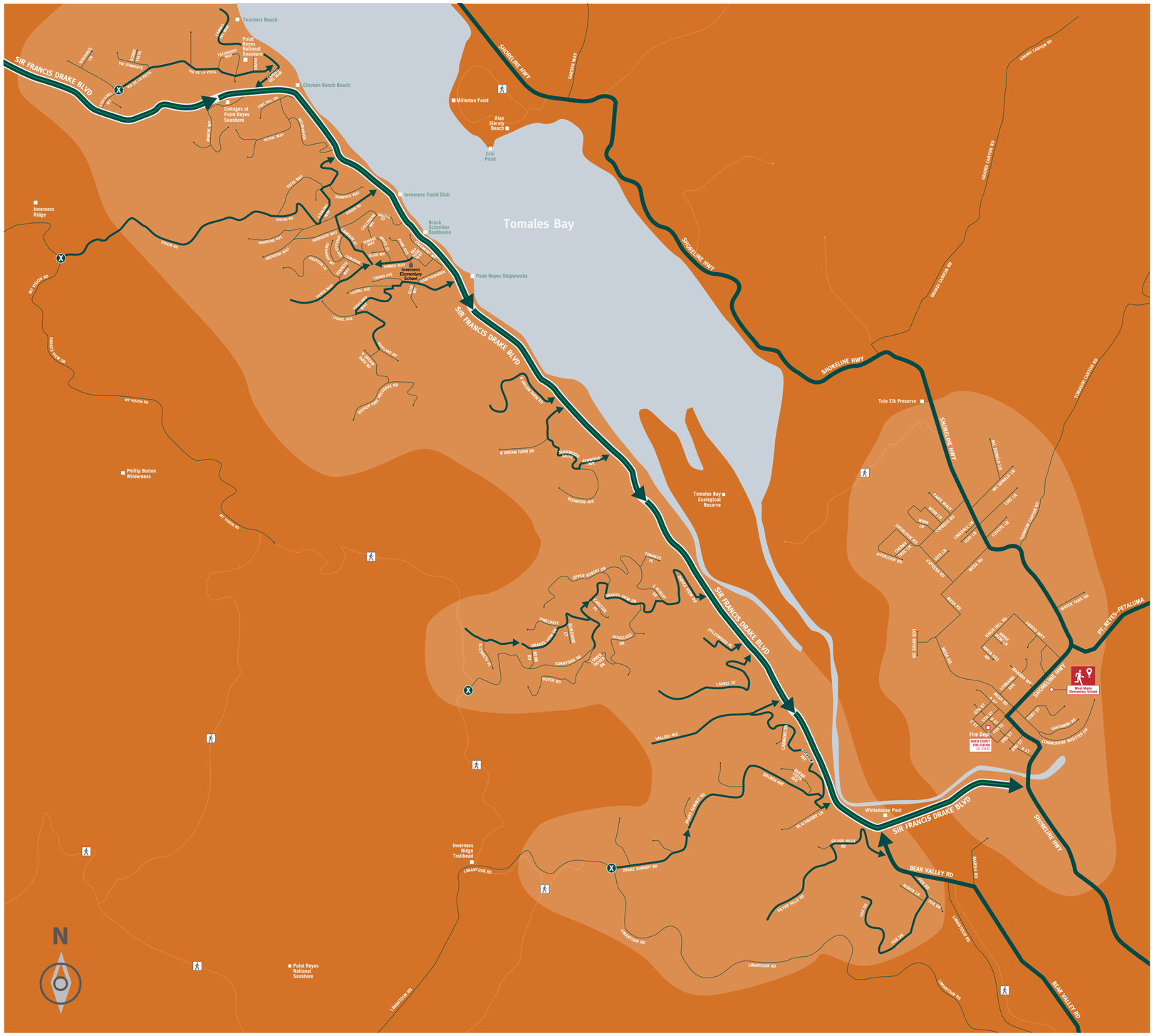
Sonoma-Marin Area Rail Transit (SMART) is the main passenger rail service in the County. It includes 45 miles of railway lines and includes stations in the Sonoma County Airport area, Santa Rosa, Rohnert Park, Cotati, Petaluma, Novato, San Rafael, and Larkspur. Rail lines and stations in Marin are shown in Figure 4-2.

Figure 4-2: Transportation Facilities and Infrastructure

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Know your way out. YOUR CITYWIDE EVACUATION ROUTES.

Familiarize yourself with major routes and at least two ways out of your neighborhood in case of an evacuation.



SCAN THIS QR CODE TO DOWNLOAD THESE MAPS

In Marin, authorities will use the terms **evacuation order, evacuation warning,** and **shelter-in-place** to alert you to the significance of the danger and provide basic instructions.

EMERGENCY TERMINOLOGY

EVACUATION ORDER

Leave now! Evacuate immediately with family and pets. Dress appropriately and take only your Go Kit(s). Do not delay to gather belongings or prepare your home. Follow any directions provided in the evacuation order.

EVACUATION WARNING

Prepare to evacuate as soon as possible. A short delay to gather valuables and prepare your home may be ok (see **Evacuation Checklist** on individual zone maps) may be ok. Leave if you feel unsafe or conditions change.

SHELTER IN PLACE

Stay in your current location or the safest nearby building or temporary refuge area. May be required when evacuation isn't necessary or is too dangerous.

Inverness

- **WUI Elevated Risk**
- **Schools**
- **Safety Buffer on Sir Francis Drake Blvd**
- **Fire Dept**
- **Evacuation Routes**
- **Gate / No Access**
- **Temporary Refuge Area** (LAST RESORT IF YOU CAN'T EVACUATE)

MARIN COUNTY FIRE DEPT
www.marincountyfire.org

FIRE Safe MARIN
www.firesafemarin.org

MARIN COUNTY FIRE DEPT.

DESIGN AND FIRECLEAR MAP PROVIDED BY CLAUDINE JAENICHEN
DESIGN NETWORK FOR EMERGENCY MANAGEMENT

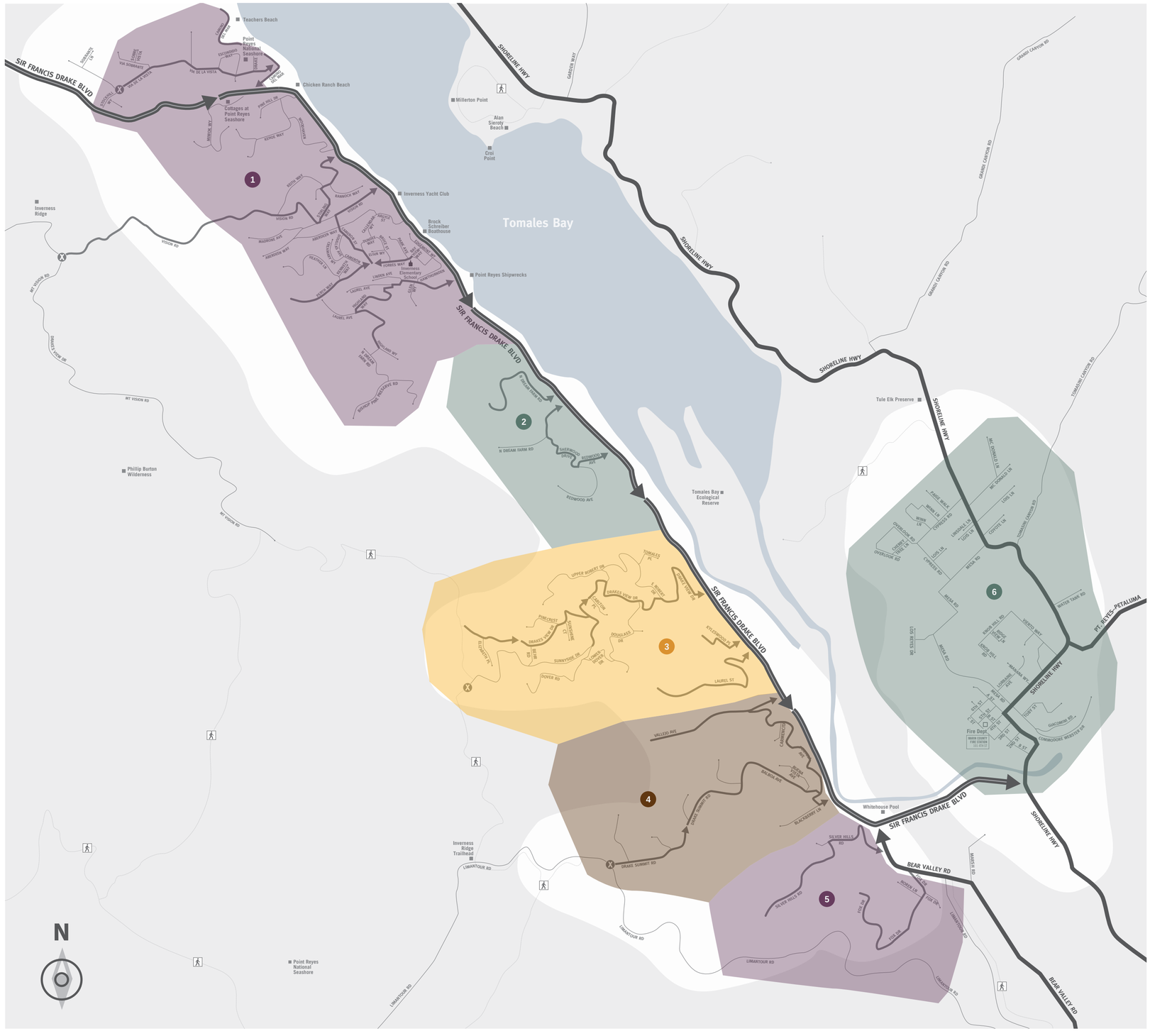
Figure 4-3: FireClear Evacuation Map for Inverness

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Fire Safe Marin

Your neighborhood zones.

Note where you and your family members live, work and go to school. Then mark down these locations on this map.



Inverness

Download the individual zone map for alert and warning information and further sources.

ZONE AREA 1 **Inverness**

ZONE AREA 2 **Dreamfarm**

ZONE AREA 3 **Drakes View**

ZONE AREA 4 **Inverness Park**

ZONE AREA 5 **Silverhills**

ZONE AREA 6 **Point Reyes**

MARIN COUNTY FIRE DEPT
www.marincountyfire.org

FIRE Safe MARIN
www.firesafemarin.org

DESIGN AND FIRECLEAR MAP PROVIDED BY CLAUDINE JAENICHEN
DESIGN NETWORK FOR EMERGENCY MANAGEMENT

Figure 4-3: FireClear Evacuation Map for Inverness

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Source: Fire Safe Marin

Energy Infrastructure

Electrical Substations

Electrical substations are facilities that convert electricity from one voltage to another, making it suitable for long-distance transmission or for use by homes, businesses, and other electrical customers.

Electrical substations, all owned and operated by PG&E, in unincorporated Marin are located in or near Bolinas, Olema, Tocaloma, Stafford Junction, Woodacre, Bel Marin Keys, and Sausalito (Figure 4-4).

Electrical Transmission and Distribution Lines

Electrical transmission lines are power lines that carry high-voltage electricity long distances between power plants and electrical customers. Electrical distribution lines transport lower voltage electricity over shorter distances. PG&E operates 1,024 miles of overhead distribution lines and 155 miles of overhead transmission lines in the County.[107] Electrical transmission and distribution lines are located throughout unincorporated Marin (Figure 4-4).

Power Plants

Power plants generate large amounts of electricity that is distributed through the state and regional electrical grid. One biomass plant, the Redwood Renewable Energy Facility, is located in unincorporated Marin County in Burdell, CA near San Antonio Creek.[108]

Oil and Gas Infrastructure

This infrastructure includes oil and gas wells, pipelines (including natural gas), oil fields, refineries, and other facilities that extract, process, and transfer oil and gas products in the county. There are no oil or gas wells, oil fields, or refineries in Marin County.[109] PG&E natural gas transmission lines run roughly along US 101 from North Novato near the border with Sonoma County south to Mill Valley/Tiburon, and are largely located in incorporated areas (Figure 4-4).

Water and Wastewater Infrastructure

These facilities provide potable water for public use and treat wastewater so it can be safely discharged into the environment. They include surface storage reservoirs, potable water distribution systems (pipelines and pumps), State Water Project facilities, water treatment facilities, and wastewater treatment facilities. Coastal communities primarily rely on septic systems or shared septic and sewage systems and many use groundwater wells for potable water supply.

---

[107] PG&E. 2020. Community Wildfire Safety Program Marin County. June 3, 2020. https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/Wildfire-Safety-Working-Session-Marin-County-May-2020.pdf

[108] Ibid.

[109] California Geologic Energy Management Division (CalGEM). https://www.conservation.ca.gov/calgem/Pages/wellfinder.aspx

There are six water districts supplying water to Marin residents. The Marin Municipal Water District (MMWD) and the North Marin Water District (NMWD) are the principal entities managing and delivering water to residential and commercial consumers. The Marin Municipal Water District serves the largest customer base in Marin, providing water to the eastern corridor of Marin County from the Golden Gate Bridge northward up to, but not including, Novato, and encompasses an area covering 147 square miles.[110] The NMWD serves the City of Novato and the Point Reyes area of West Marin. Imported water is from the Sonoma County Water Agency (SCWA) which serves over 600,000 residents in Sonoma and Marin counties.[111]

There are four wastewater treatment plants in unincorporated Marin County, the Tomales Village Community Services District (TVCSD) Treatment Plant, the Sausalito-Marin City Sanitary District (SMCSC) Fort Baker Treatment Plant, the Marin County Sanitary District No. 5 Paradise Cove Treatment Plant in unincorporated Tiburon, and the Las Gallinas Valley Sanitary District Treatment Plant (Figure 4-4).

Sanitary sewer and water distribution pipelines are located throughout Marin County, though they are less prevalent in the more remote areas of the county, as many unincorporated areas rely on groundwater wells and septic systems to obtain water and dispose of wastewater.

Flood Control Infrastructure

This infrastructure includes levees, drainage channels, and other infrastructure meant to help prevent the rivers, creeks, and other water bodies in Marin County from overflowing their banks and causing floods. Levees are typically earthen embankments designed to contain, control, or divert the flow of water to provide some level of protection from flooding. Several Marin Communities, such as Tamalpais-Homestead Valley, Santa Venetia, Corte Madera, Belvedere, and parts of Strawberry, Novato, and Ross Valley are protected by levees.[112] Levees in the County are shown in Figure 3-5 in Chapter 3.

Solid Waste Infrastructure

Solid waste infrastructure includes sites used for the transfer or disposal of solid waste materials. There is one transfer station in Marin County associated with the Marin Resource Recovery Center in San Rafael.[113] Marin County has two landfills, both of which are located in unincorporated areas. The West Marin Sanitary Landfill, which is inactive but still contains waste materials onsite, is located in Point Reyes Station and the Redwood Landfill and Recycling Center is located north of Novato (Figure 4-4).

---

[110] Marin County Housing Element 2015-2023. Adopted by the Marin County Board of Supervisors on December 9, 2014.

[111] Ibid.

[112] County of Marin. 2018. Marin County Multi-Jurisdictional Local Hazard Mitigation Plan.

[113] County of Marin. 2007. Marin Countywide Plan. November 6, 2007.

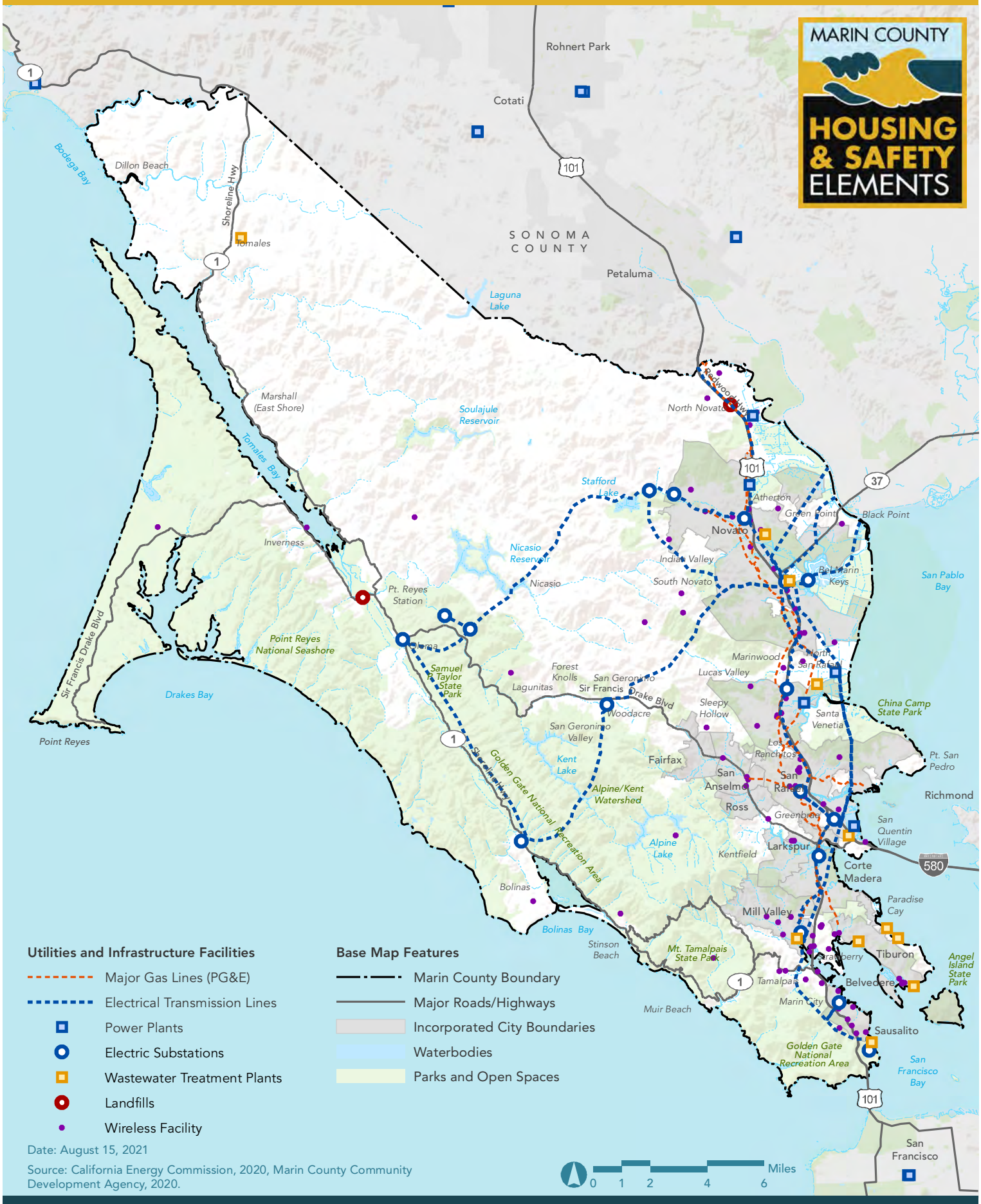


Figure 4-4: Utilities Infrastructure and Facilities

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Key Services

Emergency Services (law enforcement, hospitals, and fire department)

Emergency medical response services are usually ambulances but may also be fire or police respondents if ambulances are not available. In remote areas away from roads, emergency medical response may arrive by helicopter. These services are critical in providing rapid and urgent medical care.

Fire stations are operated by fire protection agencies and volunteer fire departments are located throughout the unincorporated county in Tomales, Inverness, Nicasio, Bolinas, Pt. Reyes, Lucas Valley, Woodacre, Kentfield, Strawberry, Marin City, Hicks Valley, Throckmorton, Mt. Tamalpais, Hagmire, Muir Beach, Stinson Beach, Green Point, and the Golden Gate National Recreation Area (Figure 4-5).

Law enforcement facilities in the unincorporated county are located in Pt. Reyes, Marin City, and Kentfield (Figure 4-5). Police/sheriff stations that may serve unincorporated areas are also located in the cities on the bayside.

There is one hospital in the unincorporated county, the Marin General Hospital in Kentfield (Figure 4-5). Hospitals in incorporated areas include the Novato Community Hospital (Novato) and the Kaiser Foundation Hospital (San Rafael). Coastal Health Alliance operates clinics and offices in Stinson Beach, Bolinas, and Inverness.

Communication

Communication services include radio, television, cellular and landline phone, and Internet. These services can be delivered via wires or wirelessly, and most are delivered by private companies. Communication services are often used for entertainment but are also for vital information sharing and remaining connected.

Most wireless communications facilities in the county are located in incorporated areas. Wireless facilities in the unincorporated county are located in Nicasio, North Novato, South Novato, Lucas Valley, Bolinas, Stinson, Beach, Muir Beach, Lagunitas/Forest Knolls, Inverness, Sleepy Hollow, Marin City, Tamalpais-Homestead Valley, and, to a lesser extent, in the remote wildlands (Figure 4-4).

Energy Delivery

Energy services in Marin County include electricity and natural gas delivered through high-capacity utility lines. Energy is needed for vital functions such as space heating and telecommunications as well as many other forms of entertainment and comfort. Most energy in the county and state is imported, and Pacific Gas and Electric (PG&E) is the sole distributor of electricity and natural gas locally.

Electrical transmission and distribution lines are located throughout unincorporated Marin (Figure 4-4).

Water and Wastewater Service

These services involve treating and transporting water to be used by customers and transporting and treating wastewater so it can be safely released into the environment. Water and wastewater services are provided by a number of agencies and small private organizations throughout Marin County and are critical to ensuring public and environmental health.

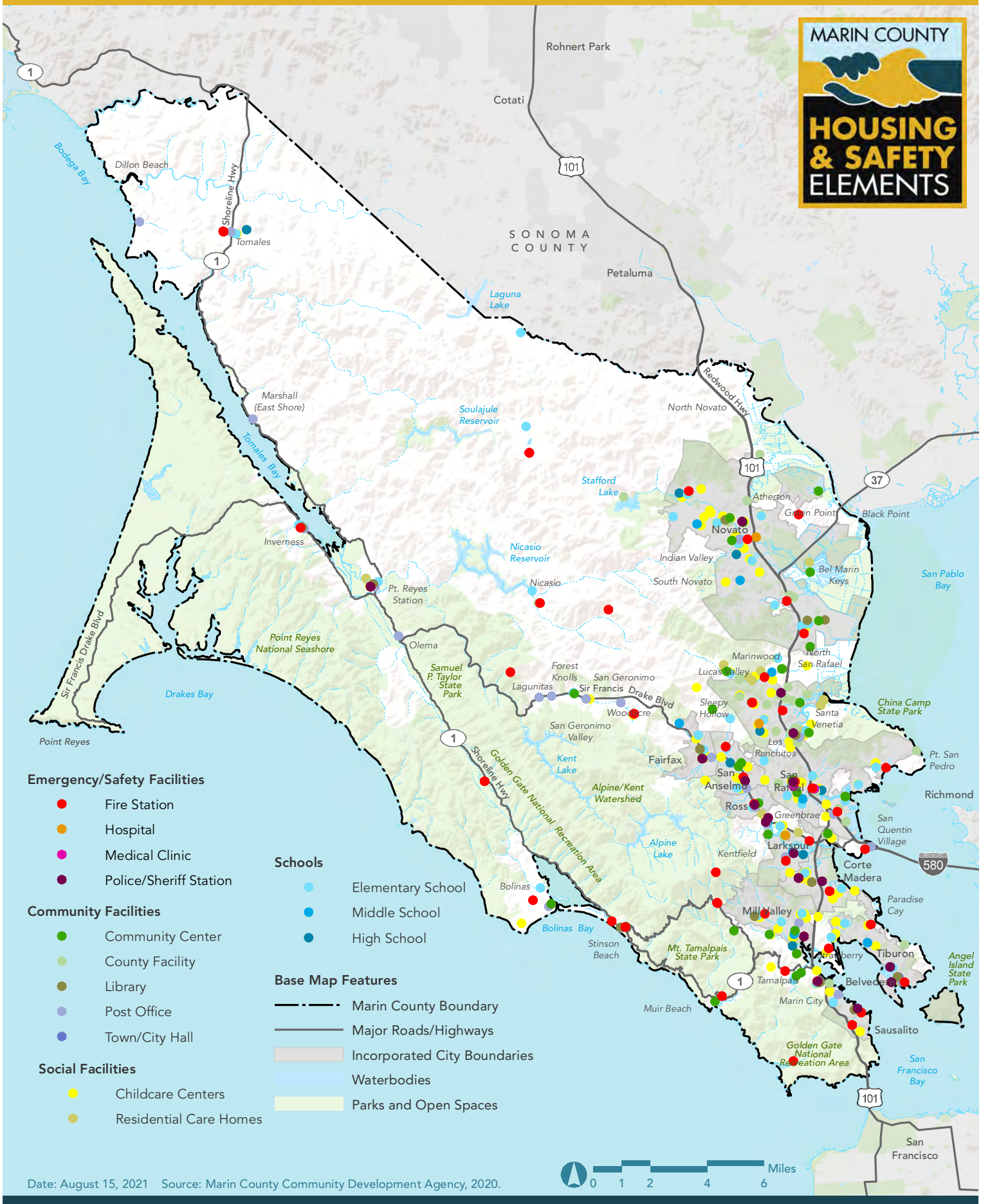


Figure 4-5: Public Facilities

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Buildings

Areas of concentrated residential development

Marin County has many small unincorporated communities. Unincorporated communities in Marin County include Greenbrae, Kentfield, Marshall, Nicasio, Olema, San Geronimo, Woodacre, Bolinas, Dillon Beach, Forest Knolls, Inverness, Inverness Park, Muir Beach, Lagunitas, Stinson Beach, Tomales, Point Reyes Station, Sleepy Hollow, Santa Venetia, Indian Valley, Strawberry, Tamalpais-Homestead Valley, Bel Marin Keys, Black Point-Green Point, Hamilton, Lucas Valley-Marinwood, Las Gallinas, Terra Linda, Dogtown, and Marin City. These communities do not support high density-residential development, but residential development in the unincorporated county is concentrated in these areas.

Community Centers

Community centers are public properties that provide gathering and activities spaces, such as youth centers, senior centers, veterans' centers, and other community centers.

Community centers in unincorporated Marin are located in Bel Marin Keys, Lagunitas-Forest Knolls, Bolinas, Stinson Beach, Muir Beach, Sleepy Hollow, Lucas Valley-Marinwood, Tamalpais-Homestead Valley, Marin City, and unincorporated areas outside Mill Valley (Figure 4-5).

Evacuation and Homeless Shelters

Facilities that provide housing and shelter for persons experiencing homelessness or for evacuees that do not have other housing options. Marin Civic Center Fairgrounds is a pre-designated evacuation facility, small-scale local evacuations may use local schools, community centers, or large parking lots. Homeward Bound of Marin provides emergency, transition, and long-term housing and other services at their facilities which include: Family Emergency Center, Family Resource Center, Mill Street Center, New Beginnings Center, Voyager Carmel Center, Fourth Street Center, Meadow Park, Family Park, and Palm Court.

Government Buildings and Sites

Buildings and sites owned and/or operated by Marin County that provide administrative and other services. Government facilities could act as operations hubs for emergency services and emergency public works projects during disasters. These include the Marin County Civic Center, community centers, libraries, post offices, and district offices. Government facilities in the unincorporated county are shown in Figure 4-5.

Hazardous Material Facilities

Hazardous materials facilities include commercial, industrial, and manufacturing facilities that use, produce, sell, or transport hazardous materials, and large pipelines that convey volatile materials, such as oil.

The Marin Household Hazardous Waste Facility, which accepts residential and commercial waste, is located in San Rafael. Hazardous materials facilities, such as gas stations, are typically located in or near commercial and industrial centers. Hazardous materials may also be used and stored on proprieties with agricultural uses, which are largely located in the north and northwest county.

Historic Buildings and Facilities

Buildings, facilities, and sites on Marin County's List of Historic Landmarks. There are 52 properties and districts listed on the National Register in the county.

Key Employment or Commercial Centers

Major employers, banks, and commercial establishments such as grocery stores, hardware stores, and gas stations. Key commercial areas are mostly located in or around developed communities, although some businesses are in more remote areas. Most communities in unincorporated Marin have small commercial centers clustered around the main thoroughfare in the community.

Medical and Care Facilities

In Marin County, primary medical facilities include but are not limited to: Marin Health Medical Center (Marin General Hospital), Marin Community Clinic, Medical Center of Marin, Kaiser Permanente San Rafael Medical Center, Novato Community Hospital, and West Marin Medical Center. Coastal Health Alliance operates clinics and offices in Stinson Beach, Bolinas, and Inverness. Hospitals in Marin are shown in Figure 4-5.

Public Safety Buildings

Police and sheriff buildings, fire stations, CA highway patrol facilities, and related structures like dispatch centers, correction facilities, animal shelters, and emergency operation centers. Public safety buildings in Marin are shown in Figure 4-5.

Schools

Schools in the unincorporated areas of Marin County include elementary schools, middle schools, and high schools, and continuing education and special education facilities owned and managed by the school districts. Less than 20 of Marin County's 123 schools are located in unincorporated areas. Schools in Marin are shown in Figure 4-6.

Natural and Managed Resources

The description below is a summary of a detailed and comprehensive description of Marin's Natural and Managed Resources presented in Appendix A.

Ecosystems

Natural communities in Marin County support a wide diversity of plant and animal species, including a high number of special-status species. Natural community types in the County include: mixed evergreen forest, oak woodland, pine forest, douglas fir/redwood forest, grassland, coastal beach dune, northern coastal scrub, chaparral, coastal salt marsh, riparian, and freshwater marsh (see Figure 3-17). Major distinguishable characteristics include: the extensive grasslands to the north which intergrade with scrub and forest lands in the Point Reyes Peninsula; the forests, woodland, and chaparral covered slopes of Mt. Tamalpais; the grasslands and woodlands of the northcentral and northwestern part of the County; and a mosaic of grassland, woodland, and urban development in the City-Centered Corridor.[114]

[114] Marin County Community Development Agency, Planning Division. 2005 (November). Marin Countywide Plan Biological and Wetland Protection Technical Background Report.

Beaches and Coastal Dunes

Marin County is bordered by the Pacific Ocean to the west and the San Francisco Bay to the east and contains numerous National, State, County, and local public lands along the coast, many of which include beaches or coastal dunes. Figure 4-7 Protected Open Space shows the location of these coastal parklands.

Figure 4-6: Schools

SAFETY ELEMENT VULNERABILITY ASSESSMENT

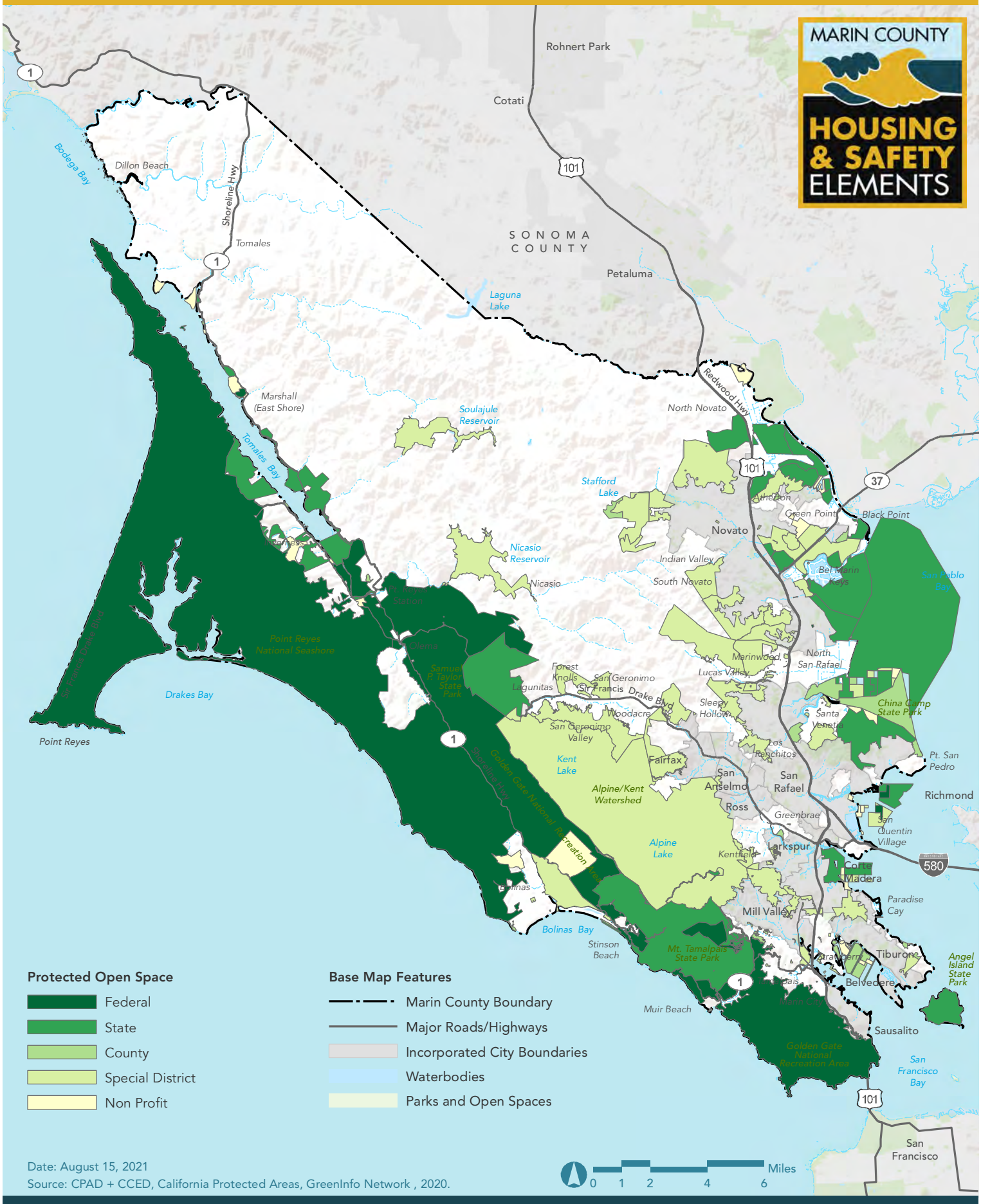


Figure 4-7: Protected Open Space

SAFETY ELEMENT VULNERABILITY ASSESSMENT

The Marin County Coastal Zone contains a broad range of estuarine and marine environments, tidal marshes, freshwater wetlands, stream corridors, upland forests, chaparral, and grasslands. Other sensitive biological resources in the County's coastal zone include dunes and beaches, salt marshes, freshwater marshes, tidal freshwater wetlands, riparian corridors, chaparral, and grasslands.[115]

The coastal dune communities provide habitat for several species of plants and animals that have adapted to the harsh environment of the shoreline and provide protection to inland areas from wave run-up generated by prolonged storms and high seas. The list of unique species and habitats of the Coastal Zone is extensive.[116]

Endangered, threatened, and sensitive species

Special-status species are plants and animals that are legally protected under the State and/or federal Endangered Species Acts or other regulations, as well as other species that are considered rare enough by the scientific community and trustee agencies to warrant special consideration.

A total of 75 animal species and 78 plant species are reported from Marin County. Areas of designated critical habitat mapped by the USFWS for a number of federally-listed species are shown in Appendix A. Species with designated critical habitat within or extending into parts of Marin County include: coho salmon, winter run chinook salmon, steelhead, marbled murrelet, western snowy plover, Steller sea-lion, Baker's larkspur, and yellow larkspur.[117]

Marshes, Wetlands, and Streams

Wetlands can include freshwater and saltwater features, and primarily consist of freshwater marsh and vernal pools, which are non-tidal marshes that contain freshwater and are continuously or frequently flooded.

Characteristic wetland types in Marin include coastal saltmarsh, brackish marsh, freshwater marsh, the lower channel slopes of streams and riparian habitat, seasonal wetlands, vernal pools, and freshwater seeps and springs. The baylands ecosystem in Marin forms a varied pattern of open water, tidal marshes and mudflats, rocky shoreline, seasonal wetlands, and adjacent uplands.[118]

Marin County has over 3,000 miles of natural creeks. Some of the creeks remain relatively natural, while others have undergone many changes such as dams and channel alteration resulting from development within the watershed.[119] Major creeks and watersheds of Marin County include Bolinas Lagoon, Estero Americano, Gallinas Creek, Lagunitas/Tomales Bay, Miller

---

[115] Marin County Community Development Agency. 2015. Marin County Local Coastal Program Land Use Plan. Board of Supervisors Adopted August 25, 2015.

[116] Ibid.

[117] Ibid.

[118] Ibid.

[119] County of Marin, Public Works Department. 2021. Everything Creeks! Accessed October 6, 2021 at: https://www.marincounty.org/depts/pw/divisions/creeks-bay-and-flood/mcstoppp/protecting-our-water/everything-creeks

Creek, Novato Creek, Point Reyes National Seashore Creeks, Richardson Bay, Rush Creek, San Antonio Creek, San Rafael Creek, Southern Coastal Creeks, and Stemple Creek.[120] Figure 4-8 shows the watersheds in the County. Figure 4-9 shows streams in the County.

Farms, orchards, and vineyards

As of 2017, Marin County had 140.075 acres of farmland and 343 farms with an average size of 403 acres.[121] The gross value of all agricultural production in Marin County in 2020 was $101,840,000, most of which was from livestock (39%) or livestock production (38%). Other products were field crops (14%), fruit, vegetable, and nursery crops (5%), and aquaculture (4%).[122] Map 2-20 of the Marin Countywide Plan shows the locations of important agricultural lands in the County.[123]

Hiking and biking trails

The countywide trail system connects environmentally important areas (such as bayland, coastal, and ridgeline areas), parks and open space, and greenbelts between urban areas. Marin County has approximately 641 miles of public trails. Table 4-3 lists agencies which maintain trails and the approximate milage they are responsible for.

TABLE 4-3: MILES OF TRAILS IN MARIN COUNTY BY MANAGING AGENCY

Agency	Total Miles
Marin County Open Space District	190 (100 miles are unpaved fire protection roads)
Marin Municipal Water District	149 (91 miles are unpaved fire protection roads)
Golden Gate National Recreation Area and Point Reyes National Seashore	212
California State Parks	88
North Marin Water District	2
Total	641

Source: Marin County Community Development Agency, Planning Division. 2007. Marin Countywide Plan. Adopted November 6, 2007.

[120] Marin Watershed Program. 2021. Creeks & Watersheds: Interactive Map. Accessed October 6, 2021 at: https://www.marinwatersheds.org/creeks-watersheds/interactive-map

[121] United States Department of Agriculture National Agricultural Statistics Service. 2017 Census of Agriculture County Profile: Marin County, California.

[122] Marin County Department of Agriculture. 2020. Marin County Crop & Livestock Report 2020.

[123] Marin County. 2007. Marin Countywide Plan, Map 2-20 Protected Agricultural Lands. https://www.marincounty.org/-/media/files/departments/cd/planning/currentplanning/publications/county-wide-plan/cwp_2015_update_r.pdf?la=en

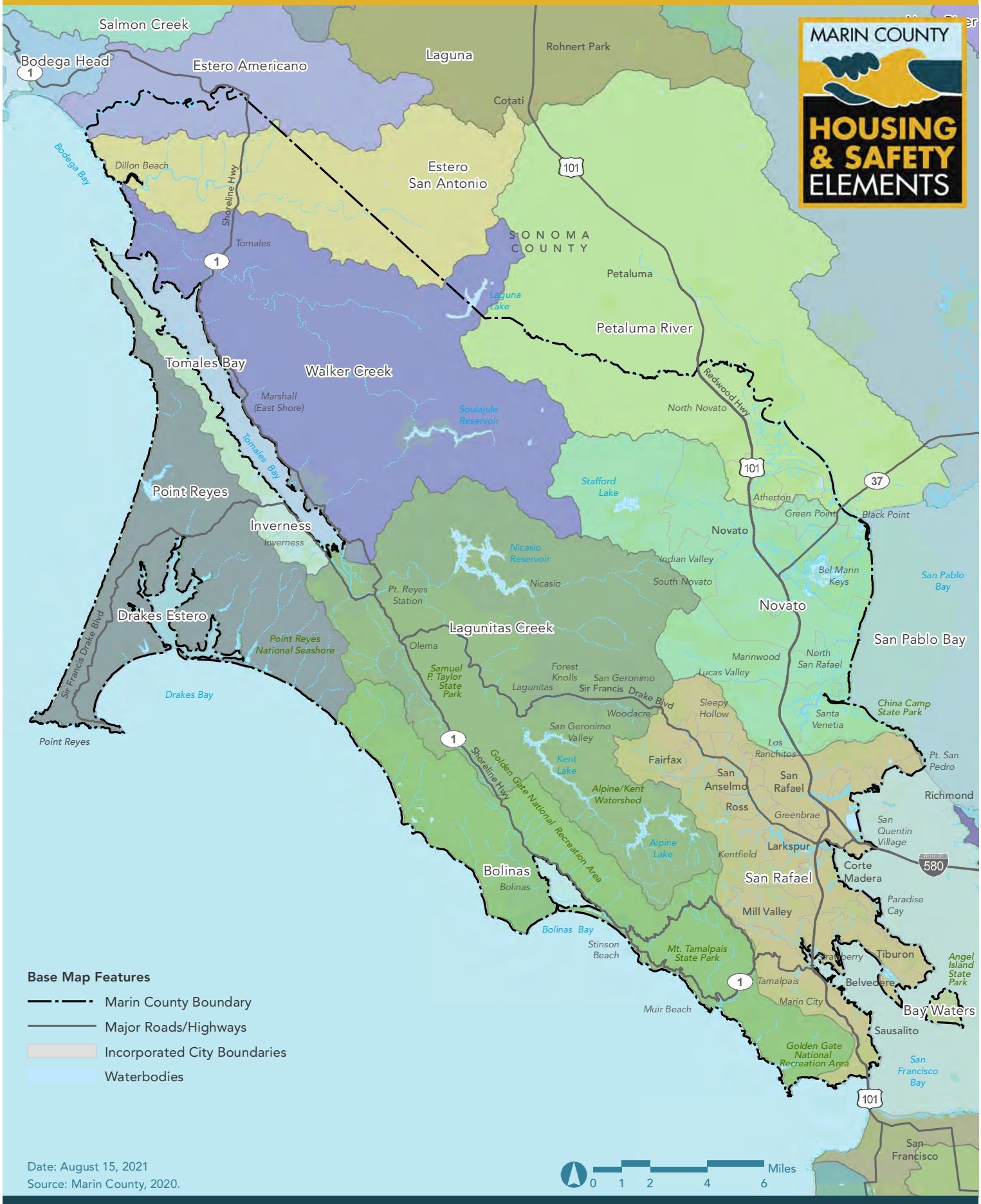


Figure 4-8: Watersheds

SAFETY ELEMENT VULNERABILITY ASSESSMENT

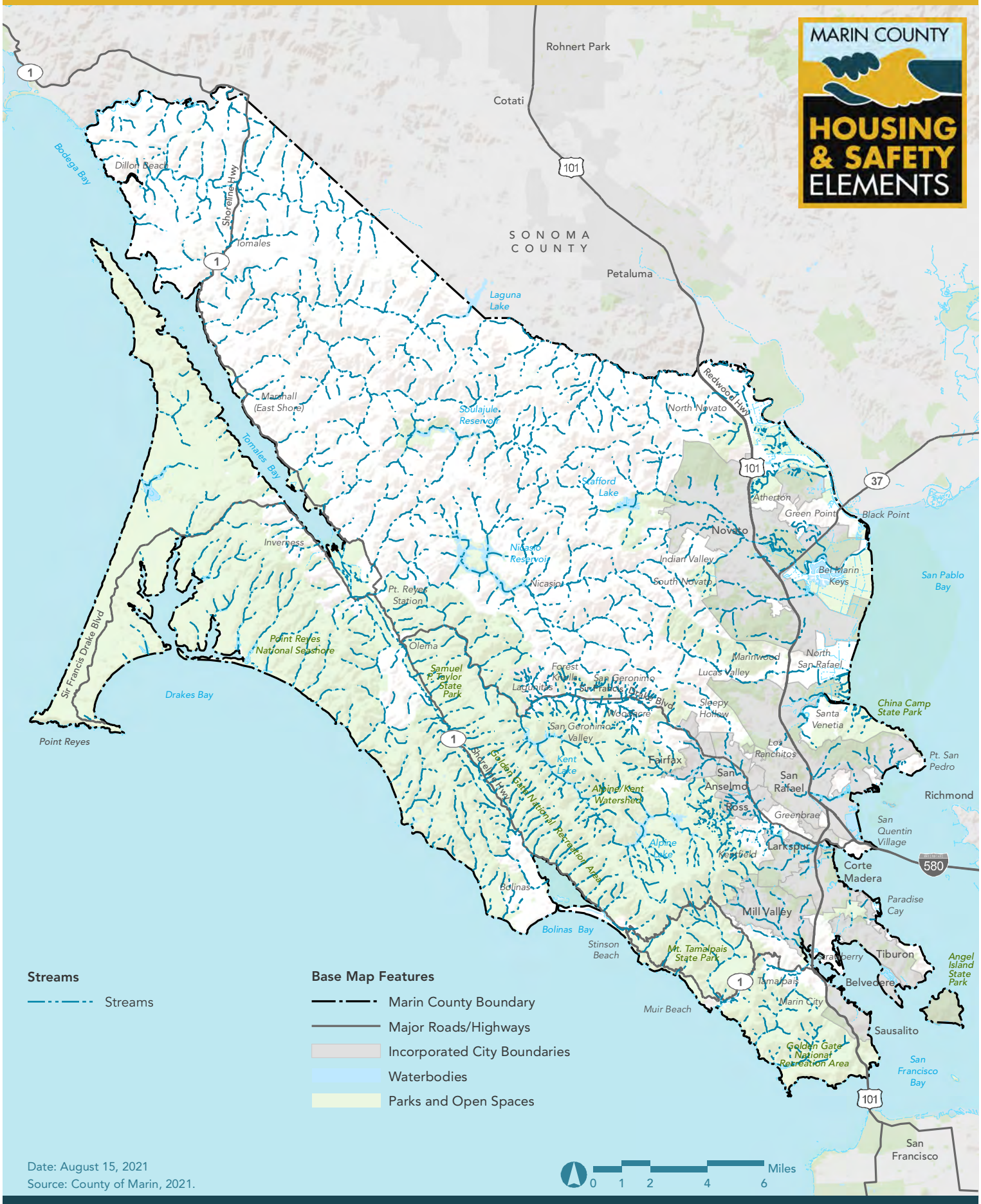


Figure 4-9: Streams

SAFETY ELEMENT VULNERABILITY ASSESSMENT

Scenic views or ridgelines

Marin County has a unique visual environment with an attractiveness and diversity of landscape that includes views of open space, ocean vistas and beaches, San Francisco Bay shoreline, hills and ridgelines, agriculture lands, stands of various types of trees and other natural features. Nearly half of the county's land base is protected by park or open space status. With the largest amount of public land in the nine-county Bay Area, Marin County's 118,669 acres of park and open space make up 30 percent of the County's land base, while water area and watershed lands comprise another 20 percent. Agriculture, mainly cattle grazing, and privately-owned open space contracts occupy 26 percent of the County's land base.[124]

Many of the roadways throughout Marin County offer views of some of the County's most scenic resources. There are currently no designated State Scenic Highways or National Scenic Byways within Marin County.

Historic and cultural resource areas

Marin County contains important Native American cultural resource sites, archaeological sites, historic districts, historic sites and buildings, The State of California recognizes 630 archaeological sites in Marin County including, permanent Miwok settlements, seasonal camps, hunting camps/special use sites, quarries and extractive sites, trails and petroglyphs.[125] Rural areas in West Marin are defined by historic ranches and small towns. Figure 4-10 shows the federal and state historic resources in Marin County.

[124] County of Marin Community Development Agency. 2007. Marin Countywide Plan Update Draft Environmental Impact Report. State Clearinghouse Number 2004022076.

[125] Marin County Community Development Agency, Planning Division. 2003 (February). Marin Countywide Plan Cultural Resources Technical Background Report.

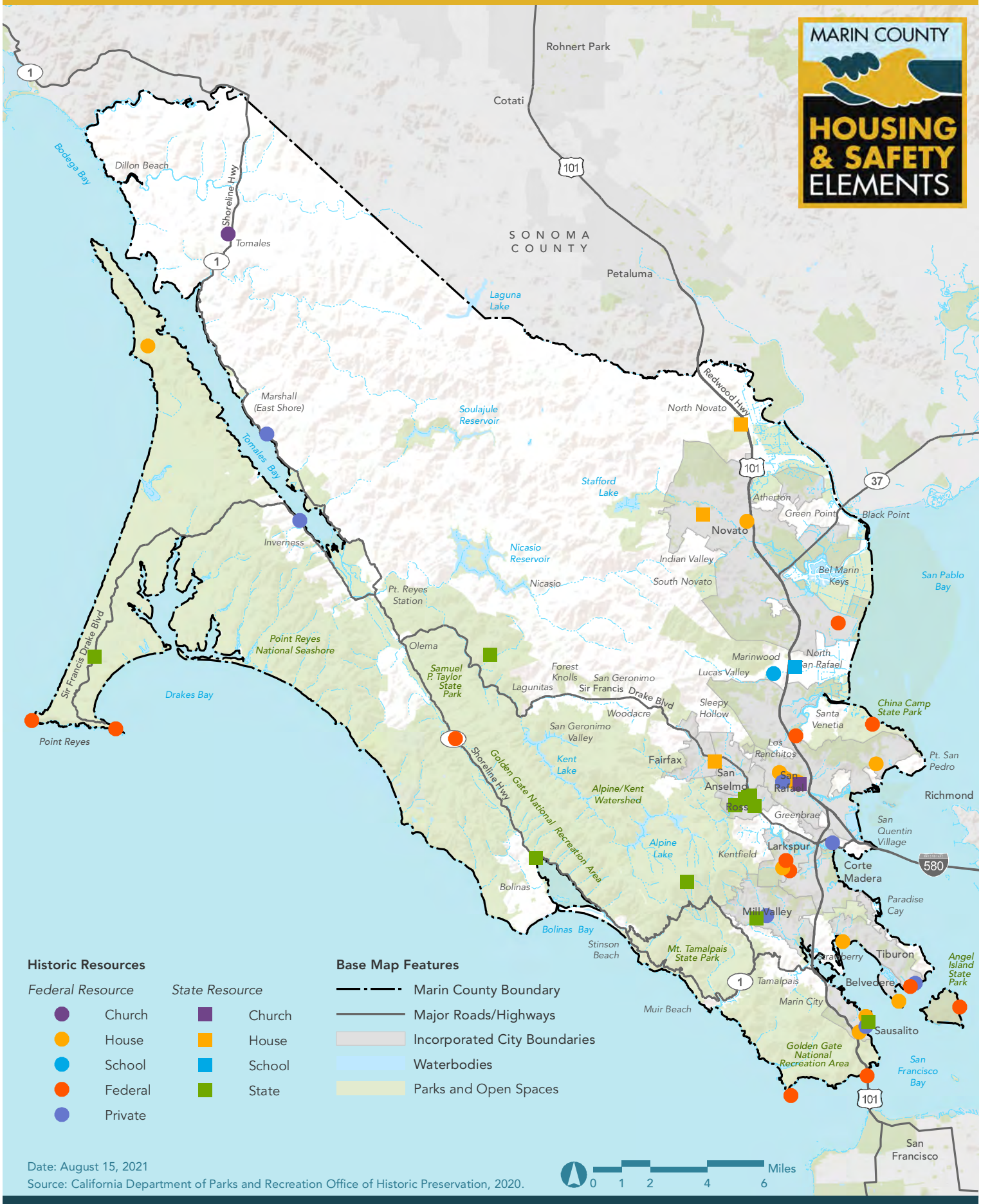


Figure 4-10: Historic Resources

SAFETY ELEMENT VULNERABILITY ASSESSMENT

State and national parks, forests, wilderness areas, and other protected locations

In Marin County, there are three federal and seven State lands accessible for recreation purposes as well as 459 acres of County-owned parks and 1,491 acres of local parks owned by local municipalities. There are also a handful of facilities operated by private non-profit organizations.[126] National and State Parks in Marin County are described in Table 4-4 below.

TABLE 4-4: NATIONAL AND STATE PARKS IN MARIN COUNTY

Park Name	Description
National Parks	
Golden Gate National Recreation Area	Includes Fort Baker, Marin Headlands, Muir Beach, Muir Beach Overlook, Nike Missile Site, Stinson Beach, and Tennessee Valley.
Muir Woods National Monument	Only old growth coastal redwood forest in the Bay Area.
Point Reyes National Seashore	Point Reyes National Seashore is a 71,028-acre (287.44 km^2) park preserve located on the Point Reyes Peninsula.
State Parks	
Angel Island State Park	In the middle of San Francisco Bay sits Angel Island State Park.
China Camp State Park	Located on San Pablo Bay, visitors can enjoy wildlife-watching, and hiking.
Mount Tamalpais State Park	6,300 acres of redwood groves and oak woodlands with a spectacular view.
Oolampali State Park	The Park overlooks the Petaluma River and San Pablo Bay from the east.
Samual P Taylor State Park	Contains over 2,780 acres of wooded countryside in the rolling hills of Marin.
Tomales Bay State Park	The Coast Miwok people were the first to inhabit the coastal area.

Sources: 1. National Park Service. 2021. Golden Gate National Recreation Area: Marin County Sites. Accessed October 7, 2021 at: https://www.nps.gov/goga/planyourvisit/marin-county-sites.htm 2. County of Marin. 2021. State Parks in Marin County. Accessed October 7, 2021 at: https://www.marincounty.org/recreation/parks-in-marin/state-parks-in-marin

The parks and facilities owned and operated by the County vary widely in type and size. They include specialized facilities (boat launches and the Civic Center facilities); a community park (Deer Park); a neighborhood park (Bolinas); beaches (Agate Beach, as well as beaches at McNear's and Paradise Parks); and the nature preserve at the Tiburon Uplands.

[126] County of Marin Community Development Agency. 2007. Marin Countywide Plan Update Draft Environmental Impact Report. State Clearinghouse Number 2004022076.

Economic Drivers

Marin County's natural resources, open space, and parks draw in many day visitors each year. In 2018, Marin County averaged between 12 to 14 million annual visits and the traveler spending exceeded $743 million.[127] Marin County visitor spending, if seen as business revenues, is about 3.2 percent of total business revenues in 2018 for Marin County's economy overall.[128]

Farms, Orchards, and Vineyards

This category includes the production of fruit and nut crops, livestock, nursery products, vegetable crops, and field crops. The economic activities provided by wineries, festivals, U-pick operations, and other agriculture-based tourism activities are included under this category. Agriculture in Marin contributes over $100 million annually to the local economy, with milk, poultry, and livestock making up over two thirds of the total value.[129]

Major Employers

This category includes economic activities provided by major employers, outside of public agencies, that support residents or are located in the unincorporated areas of the county. The largest private-sector employers in Marin County include Kaiser Permanente, Marin General Hospital, Fireman's Fund Insurance Company, Autodesk, BioMarin Pharmaceutical, and Safeway Inc.

Outdoor Recreation

This category includes economic activities provided by beaches, historic landmarks, parks and open space, hiking trails, bicycling routes, and shorelines along Marin's Coast. It also includes sailing, boating, whale-watching, and other tourism oriented around the Pacific Ocean.

State and National Protected Lands

State and federal land in the county provide a base for outdoor recreation and tourism and contribute to the economic activity with the County. These areas include the Golden Gate National Recreation Area, Muir Wood National Monument, Point Reyes National Seashore, China Camp State Park, and Mount Tamalpais State Park. Marin County also had three of the top 100 most visiting national parks in the United States.

---

[127] Marin Convention and Visitors Bureau. 2020. 2019 Annual Report, accessed from https://www.visitmarin.org/media/annual-reports/

[128] Marin Economic Forum. 2019. Marin County Visitor's Bureau State of the Visitor Industry in Marin County Economic Report, accessed from http://www.marineconomicforum.org/wp-content/uploads/2020/02/MCVB-visitors-study-120619-Final.pdf

[129] Halstead, Richard. 2021. "Marin ag production rises in 2020 despite pandemic, drought," accessed from https://www.marinij.com/2021/07/15/marin-ag-production-rises-in-2020-despite-pandemic-drought/

TABLE 4-5: NATIONAL PARK LAND VISITOR NUMBERS

	2019
Point Reyes National Seashore	2,265,301
Muir Woods National Monument	812,073
Golden Gate National Recreation Area	15,002,227
Total	*18,079,601*

Source: Ziesler PS. 2020. Statistical abstract: 2019. Natural Resource Data Series. NPS/NRSS/EQD/NRDS—2020/1272. National Park Service. Fort Collins, Colorado

Asset Impacts

Tables 4-6 through 4-10 on the following pages summarize the climate impacts to the 41 selected assets. The tables group each asset under a broader category, identify the climate hazards an asset category is exposed to, identifies non-climate stressors, and describes the overall climate impact. As stated at the beginning of this chapter, there are redundancies and overlap between assets. For example, energy delivery and energy infrastructure are both listed as assets under different categories. This is because energy infrastructure may be physically damaged by climate hazards but may not result in a large interruption to energy service delivery. On the other hand, power shut offs may occur due to threat of wildfire even if the infrastructure is not damaged.

In addition to the data sources used to identify, determine, and define assets, the impact descriptions rely upon information contained in County planning documents as well as California's Fourth Climate Assessment and the Safeguarding California Plan which provide background information and evidence of regional climate change impacts as well as strategies to reduce impacts.

Impact scores to each asset are included in Appendix B.

TABLE 4-6: IMPACTS TO INFRASTRUCTURE

Asset Category	Assets	Non-Climate Stressors	Climate Exposures	Impact Description
Roads and Road Infrastructure	• Major Roads and Highways • Single Access Roads • Evacuation Routes • Bridges and Tunnels	• Age of facility • Undersized or overused • Not routinely maintained • Poorly designed for current needs	• Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Subsidence • Wildfire	Low lying roads in the county are already susceptible to coastal or bay flooding during storm events or at high tides, and some roadways may become completely inundated most hours of the day or degraded and eroded beyond repair under Sea Level Rise conditions. Roadways are also compromised by flooding from freshwater creeks during storms. Major roads and highways along the shoreline will be susceptible to damage from increased subsidence, which may cause them to sink in some locations. Fire service agencies may need to close stretches of major roads and highways during wildfires to reduce threats to the public, which would result in disruptions to regular commuting. Wildfires may also make roads dangerous or unpassable if trees overhang the road or bridges have been burned. When a road network is compromised, communities are extremely vulnerable to reduced goods movement and limited access to supplies essential for daily living. Emergency and other public services could be interrupted and commuting, and tourism capacity could be reduced.[130]

[130] Ibid.

				Single access roadways are severely vulnerable to wildfire and flooding, which can block or inundate single access roads, making them impassable.[131] In steep areas of the county, landslides can damage the foundations or completely cover single access roads. In coastal areas, single access roadways can be damaged or destroyed by dune and bluff erosion that completely undermine the foundation of the roadways. Single access roads in highly forested areas are at risk of a dead or diseased tree falling on the road and making it impassable. Any single access roadway that becomes blocked to vehicle traffic can prevent residents, visitors, and business owners from effectively evacuating during an emergency. As with roads in general, single access roads along the shoreline and coast can sink due to increased subsidence. Flooding due to sea level rise in the medium- and long-term and due to severe storms could impact evacuation routes when they are most needed. Evacuation routes that are poorly maintained or have not received adequate fuel reduction may not function as anticipated during wildfires. Post-fire landslides and debris flows can damage

[131] County of Mendocino. 2021. Mendocino County Safety Element Update. Climate Vulnerability Assessment Report. March 2021.

				pavement and roadbeds and impair evacuation efforts. While many bridges in Marin are elevated above future flood levels, some lower bridges may be vulnerable to damage from sea level rise and overtopping during storm surges. Flooding may impact taller bridges, including bridges on Highways US 101 and I 580, as flooding at higher levels on the support pillars, and the weight of water at the low ends of a bridge could cause increased wear and tear and compromise structural integrity.[132] Aging or poorly constructed tunnels can be damaged by or collapse due to wildfires and landslides. Post-wildfire landslides and debris flow can block tunnels and impair the movement of vehicles, which can impact commuting and emergency vehicle access to more remote parts of the County.
Transit Routes	• Bicycle Routes • Bus Routes	• Lack of funding and staff capacity for retrofits, repairs, and/or upgrades • Lack of alternatives or redundancy	• Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence	Flooding, even over short periods of time, can result in the closure of bicycle routes, which may impact commuting. Shoreline bicycle trails could flood out and require increased maintenance from repeated saltwater exposure due to sea level rise.[133] Portions of shoreline bicycle trails may also sink due to increased subsidence. Several hundred bus stops and bus transit routes in the county could flood under

[132] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

[133] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

		• Aging infrastructure • Difficulty in relocating	• Wildfire	future sea level rise scenarios. Bus transit would be vulnerable to dangerous conditions and loss of access at stops due to winds and flooding associated with strong storms.[134] Shoreline roadways upon which buses operate could be damaged by subsidence. Breakdowns in the transportation network would have major impacts on the economy and daily life functions. Severe weather can cause landslides and debris flows that could block transit routes. Sea Level Rise can flood roadways or undermine the roadbed, causing transit providers to find alternate routes or delay service. The roads transit operators use could be impacted by wildfire if the fire creates lasting hazardous conditions.
Airports	• Airports	• Lack of funding and staff capacity for retrofits, repairs, and/or upgrades • Lack of alternatives or redundancy • Aging infrastructure • Difficulty in relocating	• Flooding • Sea Level Rise • Severe Weather • Subsidence	Airports in the county are located in the eastern areas and are protected by levees; however, the airfields would be vulnerable to impacts from flooding due to high tides and Sea Level Rise in the medium-term and long-term. Flooding would cause difficulties in reaching the airport on the road network, flooding of the runways would cause flight cancellations and delays and damage the integrity of the runway. Flooding of the airport property would damage airplane, fuel, and equipment storage areas, and airplanes stored on site. Increased subsidence could warp buildings and runways. Severe weather, including strong

[134] Marin County Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. June 2017.

				winds, heavy rains, and storm surge, could cause power outages and impact flight times.
Railroads	• Railroads	• Lack of funding and staff capacity for retrofits, repairs, and/or upgrades • Lack of alternatives or redundancy • Aging infrastructure • Difficulty in relocating	• Flooding • Sea Level Rise • Subsidence • Wildfires	The SMART rail line could flood at several locations due to sea level rise and storm surge during severe weather events. Light rail service may also be impacted due to electricity outages during severe storm events. Rail lines located near the shoreline are also susceptible to damage from increased subsidence.
Energy Infrastructure	• Electrical Substations • Electrical Transmission and Distribution Lines • Power Plants • Oil and Gas Infrastructure	• Lack of funding and staff capacity for retrofits, repairs, and/or upgrades • Lack of alternatives or redundancy	• Drought • Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Electricity infrastructure can be damaged or destroyed by climate change hazards, preventing electricity from traveling to residents and businesses in the county.[135] Extreme heat conditions increases use of air conditioning which can stress and overload the grid, causing power outages and potential damage to electricity transmission lines and substations. During severe wind events, electrical transmission lines can be damaged or turned off by PG&E, causing widespread power outages and hardships for County residents. Drought can reduce hydroelectric generation, which can harm statewide electricity transmission networks.

[135] County of Santa Barbara. 2021. Santa Barbara County Climate Change Vulnerability Assessment. Public Review Draft. September 2021.

				Electrical system infrastructure is often not designed to withstand prolonged extreme heat and may shut down or be damaged under extreme heat conditions. Electricity for air conditioning and other uses increases greatly during extreme heat events, which may result in intentional blackouts to reduce strain on the system or unintentional blackouts due to an overloaded system. Electrical substations and individual power poles are vulnerable to post-fire debris-flow. Transmission and distribution lines can be brought down by strong winds and wildfire and can be impacted by flooding and subsidence where transmission towers are located along the shoreline and susceptible to these hazards. Oil and gas infrastructure, including wells, pipelines, and storage facilities, can be damaged by inundation from coastal storms, undermined by landslides, or burned by wildfires.[136] Natural gas transmission lines are vulnerable to subsidence. Damage to these facilities can cause toxic materials to be released into the surrounding air, water, and soil. This can negatively affect both the local economy and public health.

[136] County of Santa Barbara. 2021. Santa Barbara County Climate Change Vulnerability Assessment. Public Review Draft. September 2021.

Water and Wastewater Infrastructure	• Water Supply and Wastewater Pipelines • Wastewater Treatment Plants and pipelines	• Lack of funding and staff capacity for retrofits, repairs, and/or upgrades • Lack of alternatives or redundancy • Lack of potable water or lack of capacity in the wastewater treatment plant • Difficulty in relocating	• Drought • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Drought can prevent water infrastructure from functioning properly because of very low reservoir levels. Water and wastewater infrastructure can become overwhelmed by stormwater runoff and debris from flooding, causing them to malfunction and become damaged.[137] Water and wastewater pipelines are vulnerable to subsidence when located along the shoreline and post-fire landslides and debris flows when located in landslide prone areas. The extreme heat of wildfires may also burn and damage the water supply distribution system such as pump stations. Wastewater treatment facilities located near the shoreline are vulnerable to sea level rise, flooding, and storm surge, which can overtop levees, compromising wastewater treatment and interrupt wastewater services.
Flood Control Infrastructure	• Drainage Channels • Levees • Tidal Gates • Retention Basins	• Lack of funding and staff capacity for retrofits, repairs, and/or upgrades • Lack of alternatives or redundancy	• Flooding • Sea Level Rise • Severe Weather • Subsidence	Flood control infrastructure can become overwhelmed by water and debris from severe weather, causing it to malfunction and become damaged.[138] Flood waters may overtop flood control infrastructure during high tide and storm surge events. Further, sea level rise may threaten the integrity of levees and other infrastructure along the shoreline.

[137] County of Santa Barbara. 2021. Santa Barbara County Climate Change Vulnerability Assessment. Public Review Draft. September 2021.
[138] County of Santa Barbara. 2021. Santa Barbara County Climate Change Vulnerability Assessment. Public Review Draft. September 2021.

		• Difficulty in relocating		Subsidence along shoreline areas could cause levees to sink which would compromise their structural integrity.
Solid Waste Infrastructure	• Landfills	• Lack of funding and staff capacity for retrofits, repairs, and/or upgrades • Difficulty in relocating	• Flooding • Sea Level Rise • Severe Weather • Wildfire	Landfills in flood prone areas can be damaged by flood waters that move the materials stored at these facilities. Sea level rise may exacerbate inland flooding, increasing the chance that flood waters overtop the levees, dikes, or floodwalls that protect these facilities. Severe weather can create hazardous operating conditions and cause power outages impacting landfill operations. Wildfire could threaten landfill facilities and equipment.

TABLE 4-7: IMPACTS TO KEY SERVICES

Asset Category	Assets	Non-Climate Stressors	Climate Exposures	Impact Description
Emergency Services	• Police, fire, and ambulance stations • Emergency command centers • Emergency shelters • Emergency health care facilities	• Aging infrastructure and technology • Reliance on transportation infrastructure • Staff capacity • Reduced funding • Increase in County population • Disruption of services from the failure of buildings or infrastructure during repairs	• Flooding • Extreme Heat • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Emergency services are highly dependent on transportation and energy infrastructure to deliver services and therefore can be disrupted by flooding, Sea Level Rise, landslides and debris flows, subsidence, and wildfire.[139] Extreme heat events could fatigue emergency responders and frontline health care workers Wildfires require all emergency services to be activated in dangerous conditions and impact the ability of emergency responders to reach and transport residents. Cascading and compounding effects of climate change impacts will increase the frequency and amount of emergency services needed to address hazards, straining staffing, and resources, interrupting staff time dedicated to non-response activities, projects, and programs.
Communication Services	• Communication facilities	• Aging infrastructure and technology	• Flooding • Landslides, Debris Flows,	Communication facilities located in flood prone areas or Sea Level Rise areas could be damaged by water or the footings of cell towers could be compromised by erosion from flood waters.

[139] County of Santa Barbara. 2021. Santa Barbara County Climate Change Vulnerability Assessment. Public Review Draft. September 2021.

		• Reliance on transportation infrastructure • Staff capacity • Reduced funding • Increase in County population • Disruption of services from the failure of buildings or infrastructure during repairs	and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Wildfire	Communication services are highly vulnerable to landslides, severe weather, and wildfires.[140] Communication systems, such as phone poles or cell towers, in landslide prone areas of the county can be damaged when landslides and debris flows undermine the foundations supporting these systems.[141] Severe winds on these steep slopes can also damage communication facilities. Public Safety Power Shutoffs can shut off the power supply to these facilities. Phone and internet service are already unreliable in some areas of the county and hazardous events can worsen these conditions. These hazards can damage communication facilities or cut off the power to them, preventing communities from receiving or relaying emergency notifications and other essential communications. Wildfires can also cause more public safety personnel to travel to the County to help fight the fires. This can overwhelm the limited communication system in isolated or rural areas, causing degradation of service.
Energy Delivery	• Electricity Infrastructure	• Aging infrastructure and technology	• Flooding • Extreme Heat • Landslides, Debris Flows, and Post-Fire	Energy delivery service is dependent on overhead power lines and underground natural gas pipelines owned and operated by PG&E, which are susceptible to damage from flooding or sea level rise, extreme

[140] County of Mendocino. 2021. Mendocino County Safety Element Update. Climate Vulnerability Assessment Report. March 2021.
[141] County of Santa Barbara. 2021. Santa Barbara County Climate Change Vulnerability Assessment. Public Review Draft. September 2021.

		• Reliance on transportation infrastructure • Staff capacity • Reduced funding • Increase in County population • Disruption of services from the failure of buildings or infrastructure during repairs	Debris Flows • Sea Level Rise • Severe Weather • Wildfire	heat, fallen trees from high winds, landslides and debris flows, and wildfire.[142] Extreme heat can cause power outages due to mechanical failure of electrical equipment, heat damage to the above-ground infrastructure, and a high demand for electricity due to air conditioning needs and water usage. Solar and hydroelectric energy production could also decrease due to reductions in solar panel efficiency and increased evaporation from extreme heat. Electrical lines that are close to forested areas could be damaged by falling trees that result from severe weather. Landslides can damage both electrical transmission lines and natural gas pipelines if their foundations are undermined or fail. High winds from severe weather can also cause PG&E to turn off electricity to prevent sparks, as part of a Public Safety Power Shutoff, which disrupts energy delivery to nearly every area of the county. Wildfires can also damage power lines, natural gas lines, and substations.
Water and Wastewater Service	• Dams • Potable water pipelines and pumps • Wastewater treatment plant	• Aging infrastructure and technology • Inflexible infrastructure • Staff capacity	• Drought • Flooding • Sea Level Rise • Severe Weather • Subsidence	Water service is highly vulnerable to drought. Extended droughts can cause significant reduction in water supplies for communities that rely primarily on surface waters. Reduced water supplies throughout the county could reduce the overall

[142] County of Mendocino. 2021. Mendocino County Safety Element Update. Climate Vulnerability Assessment Report. March 2021.

	• Sewage pipeline system • Treated wastewater disposal system	• Reduced funding • Increasing service population • Disruption of services from the failure of buildings or infrastructure during repairs	• Wildfire	quantity of water available for agriculture, commercial, and residential demands. Water and wastewater services located in flood prone areas could be disrupted due to impacts wastewater treatment plants. Sea level rise can cause increased subsidence along shorelines, which may damage underground water and wastewater pipelines and disrupt services. Severe weather that causes power outages could impact water and wastewater services or require the use of gas-powered generators to power key functions. Wildfires could affect reservoir water sources by decreasing water quality due to ash and fire retardant.

TABLE 4-8: IMPACTS TO BUILDINGS

Asset Category	Assets	Non-Climate Stressors	Climate Exposures	Impact Description
Residential Areas	• Areas of Concentrated Residential Development	• Lack of funding or insurance for retrofits, repairs, and/or upgrades • Lack of available housing stock to move to • Aging buildings • Difficulty in relocating • High rent • Rental units not maintained properly	• Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Older residential buildings may have greater heating/cooling needs or be more susceptible to damage from severe weather, flooding, and wildfire. Homes can be damaged or destroyed by shoreline and inland flooding, severe weather, and wildfires.[143] On the steeper slopes in the county, building foundations can be undermined by landslides, post-fire landslides and debris flows caused by heavy rain events. Along the shoreline and coast, residential buildings can also be inundated, damaged, or foundations crumbled due to storm surge and sea level rise. These hazards can cause unhealthy indoor air quality, unsafe living conditions, or completely destroy homes, reducing the numbers of homes available to meet the needs of county residents. Residential buildings that have wood shingle (shake) roofing are particularly vulnerable to wildfire damage. Approximately 3% of residential structures on 8,700 properties inspected in 2018-2020

[143] County of Santa Barbara. 2021. Santa Barbara County Climate Change Vulnerability Assessment. Public Review Draft. September 2021.

				have wood shingle roofs.[144] Many of these structures are located in fire hazard zones.
Community and Government facilities	• Community Centers • Government Buildings and Sites	• Lack of funding for retrofits, repairs, and/or upgrades • Lack of sites to relocate facility • Aging buildings	• Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Subsidence • Wildfire	The Marin County Civic Center is located in a flood hazard zone and is vulnerable to damage or destruction from inland flooding. Government buildings in the county are vulnerable to flooding, landslides or debris flows, subsidence, sea level rise, and wildfire. The California Highway Patrol Marin Office, post offices, fire stations, and other government buildings along the county's coastlines are vulnerable to sea level rise and storm surge. Fire stations, post offices, libraries, and other government facilities in fire hazard areas are vulnerable to wildfire and may be vulnerable to post-fire debris flows. Damage to these facilities could cause them to become unusable to the community until repaired or rebuilt. Community centers in Marin are vulnerable to damage or destruction by inland and shoreline flooding, sea level rise, landslides and debris flows, and wildfire. Damage to these facilities could cause them to become unusable to the community until repaired or rebuilt.
Evacuation and Homeless Shelters	• Evacuation centers • Homeless shelters and day use centers	• Lack of funding for retrofits, repairs, and/or upgrades	• Extreme Heat • Flooding	Evacuation sites in the county may be threatened by flooding, sea level rise and storm surges, landslides and debris flows, and wildfire.

[144] FIRESafe Marin. 2020. Marin Community Wildfire Protection Plan. December 2020.

		• Lack of alternative sites • Aging buildings	• Landslides, Debris Flow, and Post-Fire Debris Flow • Severe Weather • Wildfire	For example, the Marin County Expo Center is located in a flood hazard zone so its ability to serve as an evacuation site would potentially be compromised by sea level rise, inland flooding, and severe weather (storm surge).
Hazardous Material Facilities	• Hazardous Materials disposal facilities • Storage facilities designed for safe storage of hazardous materials	• Lack of funding to maintain facility properly • Lack of properly trained staff • Poorly designed facility	• Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Wildfire	Hazardous materials storage and disposal facilities are vulnerable to flooding and sea level rise, landslides, and wildfire. If damaged these facilities could release toxic or hazardous materials into the environment.
Historic Buildings and Facilities	• Historic Buildings and Facilities	• Lack of funding or staff capacity for retrofits, repairs, and/or upgrades • Aging buildings • Difficulty in relocating	• Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Wildfire	Historic buildings, which are typically older structures that may not be structurally sound, are vulnerable to flooding, severe weather, sea level rise, and wildfire. If damaged, these buildings and sites may lose all or part of their historical significance.
Key Employment or Commercial Centers	• Commercial buildings • Hospitals • Schools/colleges	• Lack of funding for retrofits, repairs, and/or upgrades • Lack of alternative sites	• Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise	Commercial buildings along Marin shorelines are highly vulnerable to damage and destruction by inland flooding, storm surges caused by severe weather, and sea level rise. If not destroyed, mold and mildew can grow, creating unhealthy indoor air quality. This may become chronic as

		• Aging buildings • Difficulty in relocating	• Severe Weather • Wildfire	severe rainstorms occurring more frequently and intensely. Employment centers in areas subject to landslides and debris flows may be more frequently impacted as more frequent severe storm events bring heavy rainfall triggering soil movement. Wildfires can severely damage or destroy commercial buildings in unincorporated communities. The destruction of commercial centers reduces opportunities for residents to access daily necessities, including food and medical supplies.
Medical and Care Facilities	• Hospitals and clinics • Elder care facilities • Hospice care facilities	• Lack of funding for retrofits, repairs, and/or upgrades • Lack of alternative sites • Difficulty Relocating	• Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Medical and care facilities throughout the county could be damaged or destroyed by inland flooding or sea level rise, landslides and debris flows, severe weather events, subsidence, and wildfire.[145] Damage to these facilities could cause them to become unusable to the community until repaired or rebuilt, which would impact both routine and emergency medical services. Disruptions in emergency medical services would be particularly debilitating during disaster events and recovery efforts when emergency care is critical.
Public Safety Buildings	• Police & Fire Stations • Emergency command center • Evacuation centers	• Lack of funding for retrofits, repairs, and/or upgrades	• Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows	Evacuation centers and police or fire stations throughout the county could be damaged or destroyed by inland flooding or sea level rise, landslides and debris flows, severe weather events, subsidence, and wildfire.

[145] Marin County Community Development Agency. 2015. Marin Ocean Coast Sea Level Rise Vulnerability Assessment. September 2015.

		• Lack of alternative site • Aging buildings	• Sea Level Rise • Severe Weather • Subsidence • Wildfire	If not destroyed, these buildings may have mold and mildew growth as a result of being flooded or smoke damage that make them unusable until they are repaired.
Education Buildings	• Schools	• Lack of funding for retrofits, repairs, and/or upgrades • Lack of alternative sites • Aging buildings	• Extreme Heat • Flooding • Landslides, Debris Flow, and Post-Fire Debris Flow • Sea Level Rise • Severe Weather • Subsidence • Wildfire	School buildings throughout the county could be damaged or destroyed by inland flooding or sea level rise, landslides and debris flows, severe weather events, subsidence, and wildfire. If not destroyed, these buildings may have mold and mildew growth because of being flooded or smoke damage that make them unusable until they are repaired These facilities may also not have adequate heating, ventilation, and air conditioning systems to maintain healthy air temperatures during extreme heat events.

TABLE 4-9: IMPACTS TO NATURAL AND MANAGED RESOURCES

Asset Category	Assets	Non-Climate Stressors	Climate Exposures	Impact Description
Natural and Sensitive Resources	• Ecosystems • Beaches and Coastal Dunes • Endangered, Threatened, and Sensitive Species • Marshes, Wetlands, and Streams	• Existing poor water, air, or soil quality • Habitat fragmentation • Contamination from agricultural or industrial activities • Encroachment of development • Invasive species (plants and pest species) • Degraded from human use and lack of management	• Drought • Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Wildfire	Freshwater ecosystems can be harmed by changes in water quality and quantity due to climate change hazards. Drought can exacerbate this condition as less freshwater flows into estuarine habitats. A reduction in fog and increase in severe weather can kill dune grass and other species on sandy beach and coastal dune habitat. Extreme heat and drought conditions can cause harmful algal blooms that affect fish and wildlife species. Wetland habitats can be altered to the point that native vegetation can no longer survive, which can cause conversion to ruderal areas or encroachment of tree and shrub habitat. Rising sea levels can increase the salinity of the water in these habitats, harming plant and wildlife species that depend on fresh water. The increased depth of waters due to sea level rise converts intertidal wetlands to open water. Other hazards can cause pollutants and sediment to flood into these ecosystems, preventing them from functioning properly. As sea levels rise, coastal hazards can increase causing more wave action that harms marine and coastal ecosystems. Some ecosystems, such as sandy beaches and coastal dunes may disappear because

				of sea level rise. Sloughs and coastal marshes, which have delicate water chemistries, are already seeing higher saltwater levels, which disrupt physical and biological aspects of the ecosystem. Shrublands, woodland, and forest ecosystems can be harmed by drought, extreme heat, and a decrease in fog conditions that stress trees and plant life, weaken them, and make them more susceptible to other hazard conditions, such as pest infestations and wildfire. In some cases, woodland and forest ecosystems can be replaced by grassland or shrubland ecosystems. These ecosystems have historically been accustomed to wildfire conditions; however, increased wildfire frequency and intensity can result in type conversion, where existing habitats are converted to other habitat types that do not provide the same ecosystem services. In woodland and savannah ecosystems, severe wind can spread "sudden oak death," which harms the trees that are a foundation for the ecosystem.
Farms, Orchards, and Vineyards	• Agriculture Farms • Ranches for livestock raising • Orchards	• Resistance or lack of capital to change in business practices	• Drought • Extreme Heat • Flooding • Severe Weather	Agriculture can be affected by the primary and secondary impacts of climate change. Crops and livestock become more stressed by heat and drought conditions.[146] Inland flooding, severe weather, and wildfire can also decimate crops and livestock, causing major economic hardships for farmers,

[146] County of Santa Barbara. 2021. Santa Barbara County Climate Change Vulnerability Assessment. Public Review Draft. September 2021.

	• Vineyards	• Lack of alternative crops • Rising costs to produce crops • Existing water quality or quantity issues • Difficulty in relocation • Large scale economic fluctuations: changes to economic sectors or recessions	• Wildfire	ranchers, and wineries that depend on these products. Extreme heat and smoke from wildfires can harm outdoor workers, preventing operations from functioning adequately. Drought, extreme heat, severe weather and wildfire can impact agricultural animals, cause farmers/ranchers to reduce herd or flock size and require evacuation or protection during wildfire events. Agricultural operations may also be disrupted by hazards that prevent farm and ranch owners from accessing their properties or by power shut-offs that prevent wells and other infrastructure from functioning properly.
Recreation Areas and Other Protected Locations	• Hiking and Biking Trails • Scenic Views or Ridgelines • Historic and Cultural Resource Areas • State and National Parks, Forests, Wilderness Areas, and Other Protected Locations	• Lack of alternative buildings or infrastructure • Lack of employees • Reliance on the ecosystem services • Difficulty in relocation	• Drought • Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Wildlands and protected open spaces in Marin are the basis for much of the recreation tourism in the County. The health of these natural resource may be severely impacted by climate change impacts, particularly drought and wildfires, but also extreme heat, flooding, and landslides. Landowners and managers will need to proactively manage these natural resources as best as possible given the climate conditions.

TABLE 4-10: IMPACTS TO ECONOMIC DRIVERS

Asset Category	Assets	Non-Climate Stressors	Climate Exposures	Impact Description
Farms, Orchards, and Vineyards	• Agriculture • Agritourism • Livestock	• Resistance or lack of financial means to changing business practices • Lack of alternatives • Difficulty relocating • Economic fluctuations	• Drought • Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Subsidence • Wildfire	Agriculture can be affected by fungal pathogens, invasive disease vectors, and animal pathogens due to climate change hazards. These pests and diseases can worsen as crops and livestock become more stressed by heat and drought conditions. Inland flooding, severe weather, and wildfire can also decimate crops and livestock, causing major economic hardships for farm workers, farmers, ranchers, and wineries that depend on these products. Vector borne illness, extreme heat, and smoke from wildfires can harm outdoor workers, preventing operations from functioning adequately. Operations may also be disrupted by hazards that prevent farm and ranch owners from accessing their properties or by power shut-offs that prevent wells and other infrastructure from functioning properly
Major Employers	• Major Employers	• Resistance or lack of financial means • Difficulty in relocating	• Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise	Climate hazards can disrupt supply chains, increase insurance costs, and create labor challenges. Employees may have difficulty reporting to work during hazard events. Major employers may also shut down during hazard events.

		• Economic fluctuations	• Subsidence	
Outdoor Recreation	• Beaches and Shorelines • Parks and Open Space • Hiking Trails • Biking Routes • Cultural and Historic Sites	• Reliance on ecosystem • Lack of alternatives	• Drought • Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather • Wildfire	Outdoor recreation and tourism are essential components of the county's economy and can be directly affected by drought, extreme heat, flooding, landslides, severe weather, sea level rise, and wildfire. The recreation and tourism industry relies on local users and visitors from out of the region. Visitors may be deterred from traveling to the county if the road system is damaged or partially closed, recreational assets and sites are damaged and become unusable due to climate change hazards. Visitors may also be deterred from visiting the area due to lower water levels, extreme heat, severe weather, or smoke from wildfires that make recreation activities unhealthy, dangerous, or reduce the quality of the activity. Outdoor recreation facilities may also shut down during these conditions and affect financial viability of continuing operations.
State and National Protected Lands	• State Parks, Beaches, Forests, and Protected Areas • National Parks, Beaches, Forests, and Protected Areas	• Reliance on ecosystem • Lack of alternatives	• Drought • Extreme Heat • Flooding • Landslides, Debris Flows, and Post-Fire Debris Flows • Sea Level Rise • Severe Weather	Natural lands largely cannot be protected against drought, extreme heat, flooding, landslides, severe weather, and sea level rise, and wildfire. Regrowth after fire or over time may, under new climate conditions, convert forest to scrub or grassland, reducing recreational desirability. Though ecosystems will likely eventually recover, a park's scenic and recreational appeal can be diminished in the meantime. Similar to other outdoor recreational assets, visitors may be

			• Wildfire	deterred from visiting these sites due to effects of climate exposures. Ultimately, the damage to these lands can significantly reduce the number of visitors, decreasing economic activity.

5. ADAPTIVE CAPACITY

Existing Resiliency Planning Efforts

The County and regional partners and agencies have established plans, policies, and programs that address climate change impacts. However, the County does not have comprehensively identify strategies that address the full scope and magnitude of potential climate change impacts. Additionally, existing County policies do not necessarily meet all the new mandated Safety Element requirements. A summary of the County's existing efforts to adapt to climate change effects is presented below.

Marin Countywide Plan (updated 2007)

The Countywide Plan, most recently updated in 2007, serves as Marin's comprehensive long-range general plan, guiding land use and development in the unincorporated areas of Marin County. The Plan serves as the basis for most County regulatory documents and addresses a range of topics including land use, natural resources, agriculture, housing, transportation, noise, energy and emissions, public safety, and recreation. The overarching theme and foundation of the document is planning sustainable communities and climate change adaptation and resilience goals and policies are spread throughout the plan.

The report can be found here: Marin Countywide Plan

Marin County Multi-Jurisdictional Local Hazard Mitigation Plan (2018, update anticipated 2023)

The Marin County Multi-Jurisdictional Local Hazard Mitigation Plan (MCM LHMP) focuses on nine hazards: earthquake and liquefaction, dam failure/inundation, severe storm, debris flow (landslides), flooding, wind, tsunami, wildfire, and post-fire debris flow. Each hazard has a profile which includes disaster history, location, probability of future events, extent, impacts and vulnerability. For hazards which the County was found to be vulnerable to, potential mitigation actions were developed. The MCM LHMP also includes prioritization criteria for implementing projects over the plan's five-year lifetime.

The report can be found here: Marin County Multi-Jurisdictional Local Hazard Mitigation Plan

Climate Action Plan (updated 2020)

The Climate Action Plan (CAP) specifically addressed the unincorporated areas of Marin County. For this reason, many of the actions identified in this plan will require the coordinated effort of Marin's local governments. The actions included in this plan draw on a model climate action plan developed by the Marin Climate and Energy Partnership (MCEP), which is a partnership program of Marin cities and towns, the County, and Marin regional agencies. The MCEP model climate action plan is intended to support countywide implementation efforts. Through the actions outlined in the plan, such as increasing energy efficiency in buildings, electrifying buildings and appliances, accelerating zero emission vehicle adoption, and using clean, renewable energy sources, the community can experience lower fuel and energy bills, improved air quality, reduced emissions, and an enhanced quality of life. The County's preparation of GHG emissions inventories and Climate Action Plans are part of an ongoing planning process that includes reducing the County's GHG emissions, as well as assessing, planning, mitigating, and adapting to climate change.

The County first adopted a GHG Reduction Plan in 2006 based on a long-standing commitment to environmental stewardship and sustainability. The Plan established GHG emission levels for 1990 and established a goal to reduce emissions 15% below 1990 levels by 2020. In 2015, the County adopted an updated Climate Action Plan that set a more aggressive target to reduce emissions 30% below 1990 levels. As of 2018, the County had reduced emissions 23% below 2005 levels, which is equivalent to 9% below 1990 levels. Although the County has not yet met the 2020 targets established in the previous plans, it has met the statewide goal to reduce emissions to 1990 levels by 2020, which is 15% below 2005 levels.

The report can be found here: Climate Action Plan 2030

Marin Community Wildfire Protection Plan (2020)

This plan is Marin County's most recent Community Wildfire Protection Plan (CWPP), replacing the 2016 Marin CWPP. The 2020 CWPP was prepared by the Marin County Fire Department and FIRESafe Marin in collaboration with local fire agencies, county officials, land management agencies, and the community.

The CWPP addresses wildfire hazard and threats to economic assets, including homes and infrastructure, and ecological resources in the wildland urban interface (WUI). The CWPP provides an overview of County WUI areas, fire agencies, land ownership, population and population influx, natural resources, road networks, weather, fuel characteristics, topography, fire history, ignition history, and climate variability, all for the purpose of documenting factors that wildfire risk and the ability of the relevant fire agencies to respond to these wildfire hazards.

The report can be found here: Marin Community Wildfire Protection Plan

Marin County Local Coastal Program Amendments (updated 2021)

The Local Coastal Program (LCP) is a planning document that identifies the location, type, and density of land use, and other ground rules for development in the County's coastal zone. The purpose of the LCP is to implement the provisions of the California Coastal Act of 1976 at a local level. The Marin County LCP has two main components: the land use plan and the zoning/implementation plan. The LCP requires applications for proposed development in potentially hazardous locations to demonstrate the development would be stable and not exacerbate hazards. Key components of draft policies currently being considered for the LCP related to climate adaptation and resiliency planning focus on sea level rise and include relocation, prohibition of the creation of new shoreline lots, raising of existing structures above flood heights, and comprehensive standards for blufftop development.

The report can be found here: Marin County Local Coastal Program Amendments

Marin Ocean Coast Sea Level Rise Vulnerability Assessment (2016)

As a first step in sea level rise planning, the 2016 C-SMART Marin Ocean Coast Sea Level Rise Vulnerability Assessment presents community assets profiles and describes their vulnerability. The document identifies coastal assets that could be impacted for five sea level rise scenarios ranging from near term scenarios to long term scenarios. The report includes asset profiles describing vulnerabilities of parcels and buildings, transportation and utility infrastructure, working lands, natural resources, recreation, emergency services, and historic and archaeological resources; and community profiles highlighting vulnerabilities of Muir Beach, Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore, and Dillon Beach.

Vulnerability is based on an asset's exposure, sensitivity, and adaptive capacity to rising waters and storm threats. If an exposed asset is moderately or highly sensitive to sea level rise impacts, with low to no adaptive capacity, the asset is considered vulnerable. The document only explores vulnerability and does not contain adaption polices or programs.

The report can be found here: Marin Ocean Coast Sea Level Rise Vulnerability Assessment

Marin Ocean Coast Sea Level Rise Adaptation Report (2018)

This report is based on the C-SMART Marin Ocean Coast Sea Level Rise Vulnerability Assessment described above and presents potential actions to accommodate, protect against, or retreat from the threats of sea level rise and coastal hazards along the Pacific Ocean coastline that can be considered by communities, homeowners, and asset managers. Possible adaptation options are broken down by the asset and community profiles categories used in the 2016 and 2017 Vulnerability Assessment.

The report presents options for increasing resiliency in existing natural and built assets and systems in the face of increased sea level rise and coastal storms; the strategies are not intended to facilitate new development in hazard areas. Adaptation strategies generally fall into three main categories: 1) protect, through nature-based or engineered solutions, 2) accommodate, and 3) retreat.

The report can be found here: Marin Ocean Coast Sea Level Rise Adaptation Report

Marin Shoreline Sea Level Rise Vulnerability Assessment (2017)

BayWAVE's 2017 Vulnerability Assessment identifies bay shoreline assets that could be impacted over six sea level rise scenarios from near to long term. The report seeks to provide context and estimates of the physical and fiscal impacts across the County's bayside shoreline over the coming decades. Asset profiles present potential consequences for parcels and buildings, transportation networks, utilities, working lands, natural resources, recreational assets, emergency services, and cultural resources. Asset profiles include economic, environmental, equity, and management considerations related to sea level rise vulnerability. Similar to the Ocean Coast SLR Vulnerability Assessment, vulnerability is based on an asset's exposure, sensitivity, and adaptive capacity to rising waters and storm threats and vulnerability was scored the same way. The document only explores vulnerability and does not contain adaptation policies or programs.

The report can be found here: Marin Shoreline Sea Level Rise Vulnerability Assessment

Marin Operational Area Emergency Operations Plan (2014, update in process)

The Marin Operational Area (OA) Emergency Operations Plan (EOP) addresses the planned response to extraordinary emergency situations associated with large-scale disasters affecting Marin County. The plan is based on the functions and principles of the California Standardized Emergency Management System (SEMS), the National Incident Management System (NIMS), and the California Incident Command System (ICS). It identifies how the Marin County emergency operational system fits into the overall California and National risk-based, all-hazard emergency response and recovery operations plan. It serves as a planning reference and as a basis for effective response to any hazard that threatens Marin County including floods, fires, storms, landslides, droughts, sea level rise, and extreme temperatures.

The plan identifies departments within the county and other agencies that have roles and responsibilities in emergency responses.

The report can be found here: Marin Operational Area Emergency Operations Plan

Marin Municipal Water District Local Hazard Mitigation Plan (draft released 2021)

Marin Water is developing a Local Hazard Mitigation Plan (LHMP) to inventory potential hazards that Marin Water is most vulnerable to, assess risks to the district's infrastructure and critical facilities, and develop a mitigation strategy to reduce the risk of exposure and allow a swift and organized recovery should a disaster occur. The water district provides water services in southeastern Marin County and serves 191,000 customers. The LHMP addresses dam failure, drought, earthquake, flood, mass movements (landslides), severe weather, tsunami, wildfire, and climate change. The plan contains goals and recommendations to implement identified hazard mitigation actions.

The public review draft can be found here: Marin Municipal Water District Hazard Mitigation Plan

Other Resiliency Planning Efforts

The plans, programs, and studies below represent additional resiliency planning efforts undertaken for or by private agencies. While the documents below may not apply on a larger regional-scale or identify County-actions for adaptation, it is important to acknowledge these planning efforts in identifying, understanding, and finding solution for climate hazard impacts.

- Richardson Bay Shoreline Study (2015). The study, prepared by the Marin County Flood Control & Water Conservation District, evaluates both impacts and costs for a range of potential adaptation options to address direct coastal flooding along the Richardson Bay shoreline under three potential scenarios of sea level rise conditions. The report can be found here: Richardson Bay Shoreline Study
- Richardson Bay Resilience Story Map (2021). The story map provides an interactive look at local sea level rise impacts in Southern Marin. The story map can be found here: Richardson Bay Resilience
- Marin City Flood Drainage Study (2018). The report discusses the main causes of infrastructure flooding in Marin City and presents a series of flood reduction alternatives and associated costs. The report can be found here: Marin City Drainage Study
- PG&E Community Wildfire Safety Program (Ongoing). The program was launched in 2018 to respond to the growing wildfire risk. Nearly one-third of the electric lines that provide PG&E customers with power are now in High Fire-Threat District areas, as designated by the California Public Utilities Commission. The program includes a Wildfire Mitigation Plan (2021), vegetation management, adaptation strategies, and new technology. Information on the program and Wildfire Mitigation Plan can be found here: PG&E Community Wildfire Safety Program

Summary of Adaptive Capacity Based on Current Planning Efforts

The table below evaluates the specific climate change effects covered under each of the plans and reports discussed above. As shown in the table, multiple planning documents include some policies or programs to address the climate change-related impacts that are expected to impact the unincorporated county. Mitigation and adaptation measures for existing hazards including

flooding, storms and extreme weather events, and wildfires are well documented in these plans and reports. Other climate change-related hazards such as drought and available water supply, extreme heat, landslides and debris flows, and sea-level rise are mentioned in various regional planning efforts. The goals and policies developed for the Countywide Plan Safety Element will aim to fill the gaps that have not been addressed in other County or regional planning efforts.

In addition to the data sources used to identify, determine, and define populations, the adaptive descriptions rely upon information contained in County planning documents as well as California's Fourth Climate Assessment and the Safeguarding California Plan which provide background information and evidence of regional climate change impacts as well as strategies to reduce impacts and improve adaptive capacity.

Adaptive Capacity Summary

The County, partner agencies, and countywide organizations have already taken steps to build resilience and protect sensitive populations and assets from climate change hazards. Overall, the County has been proactive in addressing impacts from sea level rise through the preparation of multiple sea level rise planning documents and in planning for wildfire through participation in CWPP programs. The planning for other climate change hazards has not been so robust or coordinated at a regional level. While many of the existing climate change planning documents identify similar vulnerable populations and assets as described in this Vulnerability Assessment, the County has not yet adopted an overarching approach to resiliency planning which focuses on the identified populations or assets.

This section presents a summary description of the existing adaptive capacity of the County's vulnerable populations and assets based on the description of climate change exposure described in Chapter 3, the description of vulnerable populations and assets presented in Chapter 4, and the existing adopted planning documents described above. The tables below are organized by the populations and assets described in Chapter 4 and presents a high-level overview of their adaptive capacity. The unincorporated county's vulnerability to each identified climate change exposure is assessed based on the magnitude of risk posed to populations and assets, and any existing measures in place to mitigate for these impacts. When combined with a population or assets impact score, adaptive capacity scores ultimately feed into determining each population and assets' vulnerability to climate change hazards.

Based on the results of the adaptive capacity assessment, each population or asset was ranked on a three-point scale (1-3) ranging from Low Capacity to High Capacity. Adaptive capacity scoring for each population and asset is included in Appendix B.

TABLE 5-1: ADAPTIVE CAPACITY IN COUNTYWIDE EXISTING PLANS AND REPORTS

Document	Drought	Extreme Heat	Flooding	Landslides, Debris Flows & Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Countywide Plan	X		X	X	X	X	X	X
Local Hazard Mitigation Plan (MCM LHMP)	X	-[1]	X	X	X	X		X
Climate Action Plan					X			X
Community Wildfire Protection Plan								X
Local Coastal Program (LCP)			X	X	X		X	
Marin Ocean Coast SLR Adaptation Report					X			
Marin Ocean Coast Sea Level Rise Vulnerability Assessment			-[2]		-[2]			
Marin Shoreline Sea Level Rise Vulnerability Assessment			-[2]		-[2]			
Marin Operations Area Emergency Operations Plan	X	X	X	X	X	X		X
Marin Municipal Water District LHMP[3]	X	X	X	X	X	X		X

[1]Heat is addressed under wildfire, not as an impact of climate change.
[2] While the vulnerability assessments explore how sea level rise will affect Marin's assets, they do not contain adaptation strategies or recommendations.
[3] While not a final draft, it is anticipated the identified topics will be addressed in the final version.

.

TABLE 5-2: ADAPTIVE CAPACITY OF POPULATIONS

Population Category	Populations	Adaptive Capacity Description
Financially Constrained Households	• Low-Income Households • Households in Poverty • Cost-Burdened Households • Overcrowded Households • Renters	*Climate Exposures: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, Wildfire* Financially constrained households throughout the county are exposed to all climate change hazards addressed in this Vulnerability Assessment. Lacking financial resources, these households generally have limited ability to respond to the climate change hazards and their adaptive capacity is considered low. Financially constrained households likely have limited capacity to evacuate for an extended period of time, or to retrofit homes to resist damage or recover from hazard damage. Retrofitting construction work is expensive and not financially feasible for many of these populations. There are assistance programs that can help retrofit homes or recover from climate events, however these communities may be unaware of these programs and how to participate or may not be able to qualify and the assistance programs are unlikely to pay the entire cost of retro fit/repair. Financially constrained households that rent are subject to the maintenance practices of the landlord who may not invest in protecting the home against climate change impacts. Communities that are financially constrained may not have health insurance or access to healthcare to treat illnesses or conditions created or worsened by climate change impacts.
Physically por Socially Isolated Communities	• Persons Living on Single Access Roads • Mobile Homes • Persons Without Access to Transportation or Telecommunications • Linguistically Isolated Communities	*Climate Exposures: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, Wildfire* Depending on their location, isolated and rural communities could be exposed to all climate change hazards addressed in this Vulnerability Assessment. Because of the remote locations these populations live in and the difficulties in preparing for and responding to climate hazards these populations may have limited adaptive capacity to certain hazards. Persons living in remote areas with limited access can prepare themselves through retrofitting buildings and infrastructure, creating emergency preparedness kits, and working with others in their community on emergency evacuations and operations. While vegetation management and prescribed burns may increase adaptive capacity regarding wildfire, actions or programs may not extend over multiple properties due to different ownership or management. These communities may be unable to receive emergency notifications because of lack of cell phone service or may not have access to alternative roadways to evacuate, or utilities may not be available to provide or quickly restore services to the area.

		Language barriers or lower levels of social capital may also impact emergency preparedness or evacuation.
Persons with High Outdoor or Hazard Exposure	• Outdoor Workers • Healthcare Workers, First Responders, and Protective Service Occupations • Houseless Population	*Climate Exposures: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Persons with high outdoor exposure may be unable to seek adequate shelter or evacuate during hazardous conditions or be aware that hazardous conditions are occurring due to age, working conditions, or living conditions. Programs such as cooling centers, adequate farm worker housing, homeless shelters, and adult education programs are available in some areas of the county. However, these populations can be difficult to reach during emergencies. Outdoor work sites can make water, shelter, and protective gear available, although not all sites may do so even when required to. Persons working outdoors are often aware of the warning signs of heat-related illnesses, although access to medical care may be more limited in remote outdoor work sites. Drought and agricultural or forestry pests and diseases can harm crops, vineyards, and trees, which can reduce the amount of outdoor work available to this population and create economic hardships for outdoor workers. Persons employed in this category may be able to transfer industries through educational programs, however, this may not be feasible for all individuals.
Persons with Limited or Constrained Resources	• Low-Resourced Racial and Ethnic Minorities	*Climate Exposures: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Disparities in living conditions and institutional biases may hinder persons with limited resources in preparing for or recovering from hazardous events. Due to citizenship status or language barriers, these persons may be afraid to seek help, qualify for, or connect with disaster relief services during, or after a disaster. Language barriers may also prevent this group from receiving evacuation and other emergency notifications, decreasing their ability to adequately prepare for and respond to hazardous events.
Persons with Limited Mobility, Chronic Health Conditions, or Who May be Dependent on Individuals or Services	• Children / Senior Citizens • Persons Living Alone • Persons with Disabilities • Persons with Chronic Health Problems	*Climate Exposures: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Persons with chronic health problems have existing conditions that make it difficult to adapt to climate change hazards. These persons may find it difficult to adapt to increases in extreme heat and smoke from wildfires, or to effectively evacuate during flooding or wildfire events. These persons may also rely on life supporting equipment or treatment machines, such as dialysis or breathing equipment, which requires electricity, which can be turned off or lost during severe weather conditions. Agencies or groups may maintain evacuation assistance lists to locate vulnerable populations and help them evacuate safely. However, communities may be unaware of these services.

TABLE 5-3: ADAPTIVE CAPACITY OF INFRASTRUCTURE

Asset Category	Assets	Adaptive Capacity Description
Roads and Road Infrastructure	• Major Roads and Highways • Single Access Roads • Evacuation Routes • Bridges and Tunnels	*Climate Exposures: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Highways, major roads, and road infrastructure, can be protected from flooding, retrofitted to resist landslides, and repaired when damaged, and cleared of vegetation to protect it during wildfire events. It may also be possible to harden, raise, upgrade, or relocate roads and road infrastructure so it is protected from environmental hazards. However, major roads and highways are the primary method of travel in the county for both residents and visitors, and therefore any disruptions could harm the economy and quality of life. The infrastructure may not be usable for days or weeks if it is damaged by climate change hazards and requires repairs. In some areas of the county, there are no or few alternative transportation infrastructure options that can be brought online.
Transit Routes	• Bicycle Routes • Bus Routes • Railroads	*Climate Exposures: Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Transit routes can be hardened, raised, moved further inland, or upgraded. However, it may not be financially feasible for all transit routes and in some areas there are no route alternatives. In particular railroads are very difficult to relocate, if not impossible.
Airports	• Airports	*Climate Exposures: Flooding, Sea Level Rise, Severe Weather, Subsidence, and Wildfires* Airports can be protected from flooding with levees and other flood control improvements and hardened against certain severe weather impacts. However, airports experience temporary closures during severe storm events. Airports can also be protected from subsidence impacts or repaired when damage occurs. An airport in a wildfire zone can be protected with vegetation management and firefighting capabilities. However, protecting airports from floods and sea level rise could be very difficult and expensive, and larger airports would be difficult if not impossible to relocate outside of certain hazard zones as few alternative locations exist in Marin County. Additionally, airports need functioning roads and transportation system to operate properly and sea level rise could impact Marin's road network.
Railroads	• Railroads	*Climate Exposures: Flooding, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Although expensive, measures can be taken to retrofit railroad to protect against flooding, sea level rise, and subsidence. Railroads can be protected from wildfire by vegetation management and firefighting capabilities. Protecting railroads from flooding and sea level rise could be difficult and costly, and

		protecting the railroad infrastructure from subsidence impacts would be an on-going maintenance commitment. Alternative solutions may require funding and coordination across multiple agencies and jurisdictions.
Energy Infrastructure	• Electrical Substations, Electrical Transmission, and Distribution Lines • Power Plants, Oil and Gas Infrastructure	*Climate Exposures: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Electrical infrastructure can be protected from environmental hazards but depending on the specific hazard, the infrastructure may still suffer damage such as from being inundated during a flooding or sea level rise, covered in landslide, impacted by severe wind, subsidence ,or wildfire. Pieces of the energy infrastructure maybe undergrounded to avoid certain hazards such as severe weather and wildfire. However, this can be expensive and due to the large size of the system, this could take years to complete. Electric vehicle charging stations and fuel pumps may be able to install backup battery systems to ensure that people can still use the charging infrastructure during power outages. To prevent secondary damage, electricity infrastructure can be turned off; however, this causes secondary affects to those relying on the electricity for critical services.
Water and Wastewater Infrastructure	• Water Supply and Wastewater Pipelines • Wastewater Treatment Plants	*Climate Exposures: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Water and Wastewater infrastructure can be protected from environmental hazards but depending on the specific hazard, the infrastructure may still suffer damage such as from being inundated during a flooding or sea level rise, covered or dislocated in a landslide, impacted by subsidence or wildfire. Pipeline alignments are underground and thus would avoid certain hazards such as impacts from severe weather or wildfire. However, underground pipelines would still be vulnerable to subsidence and sea level rise. Protecting this infrastructure can be expensive and due to the large size of the system, this could take years to complete. Water and wastewater infrastructure is highly regulated and protection from climate change hazards will eventually be required. However, this infrastructure is very difficult and expensive to move or place outside of a hazard prone area. Additional pumping or pipeline systems may have to be installed to keep this infrastructure functioning properly. Water conservation measures, use of more recycled water, and more extensive filtering equipment can protect the water services throughout the county. Wastewater services may have a more difficult time adapting due to the expensive nature of moving wastewater infrastructure.
Flood Control Infrastructure	• Levees • Drainage Channels • Tidal gates	*Climate Exposures: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Subsidence* Flood control infrastructure is highly regulated and can be hardened to prevent damage from climate change hazards. However, this infrastructure is very difficult and expensive to move or raise outside of a hazard prone area.

TABLE 5-4: ADAPTIVE CAPACITY OF KEY SERVICES

Asset Category	Assets	Adaptive Capacity Description
Emergency Services	• Police, fire, and ambulance stations • Emergency command centers • Emergency shelters • Emergency health care facilities	*Climate Exposure: Flooding, Extreme Heat, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Wildfire* The ability to provide emergency services can be impacted by many of the climate change hazards discussed in this Vulnerability Assessment. Emergency service providers can plan for climate change hazards and the disruptions to service that may occur. Service providers can provide additional training in how to avoid service disruptions during an event, they can provide additional equipment, establish command centers and shelters outside of all known hazard areas, and plan for such events as power outages. Local and regional medical centers and providers can strengthen medical supply chains and prepare emergency contingency plans for if/when hazards increase in frequency and intensity. However, this may take time and require extensive coordination and redundancy within the emergency service system. Communication systems can also be retrofitted to prevent damage and keep communication capabilities working during hazard events. Retrofitting, maintaining, or realigning the road network can help ensure emergency service access, however this may not be feasible for all areas of the County.
Communication Services	• Communication facilities	*Climate Exposure: Flooding, Extreme Heat, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Wildfire* The ability to provide communication services can be impacted by many of the climate change hazards discussed in this Vulnerability Assessment. Communication service providers can plan for climate change hazards and the disruptions to service that may occur. Service providers can provide additional training in how to avoid service disruptions during an event, they can provide additional equipment, have repair crews on standby, and plan for such events as power outages. Communication service infrastructure can be protected to some level to ensure services are not disrupted. Some alternatives are available and could be implemented, including cell tower location or design, which have more reliable services during hazard events.
Energy Delivery Services	• Electricity Infrastructure	*Climate Exposure: Flooding, Extreme Heat, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* The ability to provide energy delivery services can be impacted by most of the climate change hazards discussed in this Vulnerability Assessment. Energy delivery service providers can plan for climate

		change hazards and the disruptions to service that may occur. Service providers can provide additional training in how to avoid service disruptions during an event, they can provide additional equipment, establish response procedures for climate hazard impacts. Energy service infrastructure can be protected to some level to ensure services are not disrupted (see Table 5-3, above). PG&E can retrofit power lines and other equipment to insulate them against extreme heat events and severe weather and remove vegetation surrounding the lines to protect them from falling branches and trees, and wildfires. However, these measures can both be expensive and require yearly or seasonal management activities.
Water and Wastewater Services	• Dams • Potable water pipelines and pumps • Wastewater treatment plant • Sewage pipeline system • Treated wastewater disposal system	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Water and wastewater service systems travel many miles and have numerous components and are difficult to protect from certain climate change impacts such as flooding, sea level rise, landslides, and subsidence. Service providers can plan for climate change hazards and the disruptions to service that may occur. Service providers can provide additional training in how to avoid service disruptions during an event, they can build redundancy into the system, provide additional equipment, keep spare equipment or parts on hand, establish key operations centers outside of all known hazard areas, and plan for such events in long range planning documents. Water and wastewater systems can span large areas and are complex, with little to no redundancies, and therefore cannot easily be rerouted if facilities are damaged. Some facilities can be hardened or protected to maintain service during hazardous events. However, increased frequency of drought conditions may make it more difficult for water and wastewater services to provide services and price increases may be put in place to supplement decreased water usage and increased maintenance costs.

TABLE 5-5: ADAPTIVE CAPACITY OF BUILDINGS

Asset Category	Assets	Adaptive Capacity Description
Residential Buildings	• Areas of Concentrated Residential Development	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Homes can be partially protected against flooding, landslides, severe weather, and damage from wildfires. However, these adaptive options can be expensive and are not always feasible for residents. It is extremely difficult for individual property owners to protect or repair their property from large scale hazards like flooding, sea level rise, subsidence, and wildfire. Although steps to harden specific buildings can be taken, more complete protection from these hazards is best approached at a local or regional scale. Chronic climate change hazards could cause buildings to become permanently uninhabitable.
Community and Government Facilities	• Community Centers • Government Buildings and Sites	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Community and government facilities can be partially protected against flooding, landslides, severe weather, and damage from wildfires. However, these adaptive options can be expensive and do not always provide complete protection. It is extremely difficult to protect or repair individual buildings from large scale hazards like flooding, sea level rise, subsidence, and wildfire. Although steps to harden specific buildings can be taken, more complete protection from these hazards is best approached at a local or regional scale. Chronic climate change hazards could cause buildings to become permanently uninhabitable. Although retrofits and other fire-safe strategies can help reduce the risk, limited budgets and the nonvital nature of many community facilities can make them a lower priority for fire protection activities or flood and sea level rise retrofitting.
Evacuation and Homeless Shelters	• Evacuation Centers • Homeless Shelters and Day Use Centers	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Evacuation and homeless shelters can be protected against flooding and landslides, and defensible space can be created to prevent damage from wildfires. However, these adaptive options can be expensive and do not always provide complete protection. It is extremely difficult to protect or repair individual buildings from large scale hazards like flooding, sea level rise, subsidence, and wildfire. Although steps to harden specific buildings can be taken, more complete protection from these

		hazards is best approached at a local or regional scale. Chronic climate change hazards could cause buildings to become permanently uninhabitable. Evacuation centers that are not equipped with generators would be impacted by electrical outages, both planned and unplanned, which may then impact facility air conditioning and the ability of personnel to provide resources during extreme heat events. Evacuation shelters, homeless shelters, and day use centers can be retrofitted, raised, or relocated to prevent damage from climate change hazards. However, this could be expensive and financially infeasible for the County or school districts.
Hazardous Material Facilities	• Hazardous Materials Storage and Disposal Facilities • Storage facilities designed for safe storage of hazardous materials	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Defensible space can be created around sites to prevent damage from wildfires and retrofits can be made to harden against flooding, sea level rise, and other hazards. The cost of implementing the protective measures may make them infeasible. Alternative locations may be nonexistent or cost prohibitive. These sites pose a threat to local communities if chronic damage causes a release of contaminants into the surrounding environment.
Historic Buildings and Facilities	• Historic Buildings and Facilities	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* While retrofitting, hardening, and defensible space can make historic buildings and facilities more resistant to climate change hazards, it is extremely difficult to protect or repair individual buildings from large scale hazards like flooding, sea level rise, subsidence, and wildfire. Although steps to harden specific buildings can be taken, more complete protection from these hazards is best approached at a local or regional scale. Chronic climate change hazards could cause these sites to lose all or part of their historical significance.
Key Employment or Commercial Centers	• Commercial buildings • Hospitals • Schools/colleges	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* These areas can be hardened against flooding and landslides, and defensible space can be created to reduce risk of wildfires. Chronic climate change hazards could cause buildings to become unusable. Relocation may be feasible, although expensive. Property financing programs could help building owners retrofit building to resist damage

Medical and Care Facilities	• Hospitals and clinics • Elder care facilities • Hospice care facilities	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* Interruptions in the function of medical and care facilities can have catastrophic events for people if buildings are not usable for days or weeks due to damage from climate change hazards. The nature of their service makes them a priority for retrofitting, hardening, and other improvements which can help reduce the risks of climate change hazards. It is extremely difficult to protect or repair individual buildings from large scale hazards like flooding, sea level rise, subsidence, and wildfire. Although steps to harden specific buildings can be taken, more complete protection from these hazards is best approached at a local or regional scale.
Public Safety Buildings	• Police & Fire stations • Emergency command center • Evacuation centers	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* These buildings can be retrofitted to help prevent damage from climate change hazards. However, this could be expensive and financially infeasible for the County and due to the lack of alternatives, damage to these buildings reduces the level of response to disasters and hazards. It is extremely difficult to protect or repair individual buildings from large scale hazards like flooding, sea level rise, subsidence, and wildfire. Although steps to harden specific buildings can be taken, more complete protection from these hazards is best approached at a local or regional scale.
Education Buildings	• Schools	*Climate Exposure: Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, Subsidence, and Wildfire* There are few alternative school locations that could be used if the elementary school or high school were to be damaged by hazard events. Schools can be retrofitted and upgraded to resist damage for hazards; however, this can be expensive for school districts to complete for all schools.

TABLE 5-6: ADAPTIVE CAPACITY OF NATURAL AND MANAGED RESOURCES

Asset Category	Assets	Adaptive Capacity Description
Natural and Sensitive Resources	• Ecosystems • Beaches and Coastal Dunes • Endangered, threated, and sensitive species • Marshes, Wetlands, and Streams	*Climate Exposure: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Wildfire* Extreme heat can raise water temperatures in aquatic systems, increasing dissolved oxygen content and decreasing overall water quality. With rainfall and cooler temperatures, species and water quality may recover. But higher temperatures also contribute to algal blooms, which fish and plant populations may not be able to fully recover from. In coastal areas, sea level rise can cause salt water to infiltrate freshwater systems further inland. Freshwater ecosystems can migrate inland, but upstream hydrology may not be suitable for estuarine habitat. Ecosystems can be impacted for localized landslides severe weather, and wildfire, although healthy ecosystems would eventually recover for localized impacts. Nature-based projects, such as living shorelines can enhance ecosystems and provide protection from moderate climate change impacts. Similarly, carbon farming can both enhance rangelands and sequester carbon.
Farms, Orchards, and Vineyards	• Agriculture Farms • Livestock • Ranches • Orchards • Vineyards	*Climate Exposure: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Wildfire* Rainwater capture systems, trucked water, or other alternative water supply measures may help farms, orchards, and vineyards in drought years. However, these measures are expensive and may not always be available due to lack of rainfall in the wet season or water shortage restrictions. Assistance programs may also be available to help farms, orchards, and vineyards recover from hazards. Agricultural operations may recover from decimated crops or livestock overtime; however, if climate change hazards happen year after year, they may not be able to recover as well, and operations may be reduced in scale or cease.

Recreation Areas and Other Protected Locations	• Hiking and Biking Trails • Scenic Views or Ridgelines • Historic and Cultural Resource Areas • State and National Parks, Forests, Wilderness Areas, and Other Protected Locations	*Climate Exposure: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Wildfire* While landowners and property managers can implement management practices that could help reduce the effects of climate change on natural and open space lands, it is not possible to protect large tracts of natural land from the impacts of drought, extreme heat, or wildfire. Relocation of recreation areas and other protected locations is not feasible due to the nature of these assets. Additionally, chronic climate change hazards can reduce the quality of these resources.

TABLE 5-7: ADAPTIVE CAPACITY OF ECONOMIC DRIVERS

Asset Category	Assets	Adaptive Capacity Description
Farms, Orchards, and Vineyards	• Agriculture • Agritourism • Livestock	*Climate Exposure: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Wildfire* Agricultural animals and crops by be protected from some of the effects of climate change but the cost of protection is high and is difficult to achieve for large numbers of animals or acreages of crops. Assistance programs may be available to help farms, orchards, and vineyards prepare for climate change events or recover from hazards. Agricultural operations may recover from decimated crops or livestock overtime; however, if climate change hazards happen year after year, they may not be able to recover as well, and operations may be reduced in scale or cease. Chronic climate hazards may also reduce the scenic or natural resources to a degree where visitor levels decrease or disappear altogether.
Major Employers	• Major Employers	*Climate Exposure: Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Wildfire* Steps can be taken to harden business operations from the impacts of climate hazards. However, the nature of the market or business practices may make adaptation infeasible or cost prohibitive.
Outdoor Recreation	• Beaches and Shorelines • Parks and Open Space • Hiking Trails • Biking Routes • Cultural and Historic Sites	*Climate Exposure: Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Wildfire* While landowners and property managers can implement management practices that could help reduce certain effects of climate change on park and recreation lands, it is not possible to protect large tracts of natural land from the impacts of drought, extreme heat, sea level rise, or wildfire. Climate change impacts on outdoor recreation has a high likelihood of temporarily and possibly permanently changing recreation opportunities and the resulting tourism. Certain recreation areas may be able to be protected from certain kinds of hazards such as flooding and severe weather (with expensive protection measures) but it is not possible to completely protect natural lands from drought, landslides, sea level rise and wildfire. Alternative recreation and tourism lands may be available in other areas of a subregion or in other subregions of the county where hazards may not be occurring. However, this would still

		negatively affect local tourism areas. No alternative source of water is usually available for water recreation, and though other activities that are less dependent on water may be an option at some sites, these options are limited and could be cost prohibitive. Some outdoor activities can temporarily move indoors avoiding harm to participants; however, these alternatives may not be viable for all activities.
State and National Protected Lands	• State Parks, Beaches, Forests, and Protected Areas • National Parks, Beaches, Forests, and Protected Areas	*Climate Exposure: Drought, Extreme Heat, Flooding, Landslides/Debris Flows, Sea Level Rise, Severe Weather, and Wildfire* While landowners and property managers can implement management practices that could help reduce certain effects of climate change on natural and open space lands, it is not possible to protect large tracts of natural land from the impacts of drought, extreme heat, sea level rise, or wildfire. Climate change impacts on natural lands has a high likelihood of temporarily and possibly permanently changing recreation opportunities and the resulting tourism. Certain areas may be able to be protected from certain kinds of hazards such as flooding and severe weather (with expensive protection measures) but it is not possible to completely protect natural lands from drought, landslides, sea level rise, and wildfire.

This page intentionally left blank.

6. VULNERABILITY SCORING

As described in Chapter 1, the vulnerability assessment evaluates the impact and adaptive capacity of each population and asset for each relevant exposure and assigns a final vulnerability score on a scale of 1 to 5 (adjusted for risk and onset of the exposure). The vulnerability score reflects how susceptible the population or asset is to the harm posed by the exposure. For the purposes of this vulnerability assessment, a score of V4 or V5 is considered significant. Populations and assets that score at least a V4 for one or more exposures are considered substantially vulnerable.

TABLE 6-1: VULNERABILITY SCORING MATRIX

		Impact Score		
		Low Impact	*Medium Impact*	*High Impact*
Adaptive Capacity Score	*Low Capacity*	V3	V4	V5
	Some Capacity	V2	V3	V4
	High Capacity	V1	V2	V3

In total, this vulnerability assessment assigns vulnerability scores to 338 different pairings of populations and assets and the hazards they are exposed to. Although there are 488 potential scores, many populations or assets were not given a score because the exposure is not applicable to the population or asset. For example, no score was given to drought hazards to buildings or infrastructure because drought does not pose a hazard to certain infrastructure or buildings.

While the summaries in **this chapter focus on scores of at least V4**, lower scores should not be ignored, and Marin County will include adaptation strategies to improve resilience for populations and assets that scored a V3 or below for certain exposures in the Safety Element.

This chapter discusses the significant vulnerabilities within each of the six main categories of sensitivities (populations, infrastructure, key services, buildings, natural and managed resources, and economic drivers). **Blank squares in the tables** mean that a climate hazard exposure is not applicable to the population or asset, and **gray squares indicate** that the hazard is applicable, but the score is less than V4 (highly vulnerable). For a complete listing of the vulnerability scores for all sensitivities and exposures for each population and asset, see Table B-3 in Appendix B.

Moving forward, the County will develop Safety Element goals and policies to address these issues and improve community resilience.

Vulnerable Populations

Exposure to extreme heat, flooding, and wildfire leaves many populations highly or severely vulnerable due to the high impacts of exposure and lower levels of adaptive capacity. Adaptation to these hazards may not be possible or financially feasible for some populations.

People who have limited financial resources or who do not own their home are more limited in their emergency response capacity and therefore vulnerable to climate hazards. Households in poverty (11,256 households) have a higher vulnerability to climate hazards than low-income households (64,171 households) because of the differences in financial resources between the two household categories (low-income households having more assets than households in poverty).

Language barriers and lower levels of social capital, or the network of relationships an individual or population has, can increase vulnerability. Many communities in Marin may be unable to receive emergency notifications, may not be able to evacuate, or evacuate quickly due to financial, social, or infrastructure limitations.

People with disabilities, the elderly, and others who are not as mobile face challenges in evacuating and thus are considered highly vulnerable to climate hazards which may require evacuation. Additionally, persons with disabilities, chronic illnesses, or seniors may rely on medical equipment that cannot be transported easily.

Marin's outdoor workers and houseless populations are highly vulnerable to many different climate hazards due to their high outdoor exposure and lack of alternative options that would reduce impacts of climate hazards.

FIGURE 6-2: HIGHLY AND SEVERELY VULNERABLE POPULATIONS

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Populations								
Low-Income Households	_	V5	V5	V5	V5	V4		V4
Households in Poverty	_	V5	V5	V5	V5	V5	V4	V5
Cost-Burdened Households	_					V4		
Overcrowded Households	_				_			
Renters	_		V4	V4	_		_	
Persons Living on Single Access Roads			V4	V5				V5
Mobile Homes			V4			V4		V4
Persons Without Access to Transportation or Telecommunications	_	V4	V5	V5		V5		V5
Linguistically Isolated Communities	_		V4		_		_	
Low-Resourced Racial or Ethnic Minorities	_	V4	V4		_	V4	_	
Outdoor Workers	V5	V5	V4	V4		V5	_	V5
Healthcare Workers, First Responders, and Protective Service Occupations	_	V4	V4			V4	_	V4
Houseless Population	_	V5	V5	V4		V5	_	V5
Children	_	V5			_		_	V5
Persons with Disabilities	_	V4	V4	V4			_	V5
Persons with Chronic Health Problems	_	V4					_	V5
Senior Citizens	_	V4						V5
Persons Living Alone	_				_			V4

Vulnerable Infrastructure

Many of the infrastructure networks (roads, water systems, wastewater systems, electricity grid) in Marin County are vulnerable to climate change hazards due to their expensive and complex nature, high exposure to hazards, and lack of alternative options.

Key infrastructure, including roads, electrical lines, and communication facilities, traverse through areas at risk for hazards, increasing the chance of disruption or impact. Major roadways throughout the county are vulnerable to landslides, wildfires, inland flooding, and sea level rise which can cause them to close or become impassable, isolating residents and business owners.

Because these roads are critical for access to various communities and neighborhoods, any damage or closure can effectively isolate these communities, potentially creating severe health and safety risks. Single access roadways are severely vulnerable to wildfire and flooding, which can block or inundate single access roads, making them impassable. The railroad line in Marin is highly vulnerable to sea level rise impacts.

FIGURE 6-3: HIGHLY AND SEVERELY VULNERABLE INFRASTRUCTURE

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Infrastructure								
Airports	_	_	V5	_	V5			_
Bicycle Routes	_	_						
Bus Routes	_	_	V4	V5				
Major Roads and Highways	_	_	V4	V5	V4			V4
Single Access Roads	_	_	V4	V5		V4		V4
Evacuation Routes	_	_	V5	V5	V5	V4		V5
Railroads	_	_	V5	_	V5			_
Bridges and Tunnels	_	_		V4		_	_	
Electrical Substations	_	V4	V5	V4	V5	V4	_	V5
Electrical Transmission and Distribution Lines	_	V4	V4	V5	V5	V4		V5
Power Plants	_	_	V4	_	_		_	_
Oil and Gas Infrastructure	_	_		V4				V4
Water and Wastewater Infrastructure		_	V4	V5	V5			V4
Flood Control Infrastructure	_	_	V4		V4	V4	_	_
Solid Waste Infrastructure	_	_	V4	_			_	_

Vulnerable Key Services

Water and wastewater services are vulnerable key services. Water services are highly dependent on surface and groundwater supplies, whose amount or quality can be depleted by drought. The facilities that support this service can be damaged or destroyed by flooding, landslides, sea level rise, severe weather, and wildfires. Water and wastewater lines are typically located under roads, making them vulnerable to impact to roads. Electricity service is also highly vulnerable because it is highly dependent on electrical transmission lines and substations functioning properly. Few feasible alternatives exist to adapt key services to climate hazards due to their complexity (integration within the system) and the coordination and cost necessary to redesign or relocate the infrastructure.

Emergency and communication services are key services but because the physical infrastructure investment is less than for other services, and emergency services are based personnel and staffing rather than physical infrastructure, these services are considered more adaptable than the water, wastewater, and electricity services.

Climate-smart emergency management activities will likely require an increased commitment of staff time and expertise, materials and equipment, and other resources. Multi-jurisdictional emergency management efforts can allow for communities to effectively share resources but ensure that there is also a sufficient supply if all participating communities are simultaneously affected by a major disaster.

FIGURE 6-4: HIGHLY AND SEVERELY VULNERABLE KEY SERVICES

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Key Services								
Emergency Services	_	V4	V4			V4		V4
Communication	_			V4	V4		_	V4
Energy Delivery	_	V4		V4	V4	V4		V4
Water and Wastewater Service	V5	_	V4	V4	V5			V5

Vulnerable Buildings

Structures can be retrofitted, upgraded, or raised to prevent damage from climate hazards, but these solutions can be expensive or infeasible for property owners to complete and are not always effective in protecting the building from certain hazards. A building's location may also mean increased hazard exposure as climate events become more frequent. Areas of concentrated residential development are highly or severely vulnerable to several hazards. However, some homeowners, especially low-income or cost-burdened households, may not have the appropriate disaster insurance or the ability to pay to fix structure damage. Chronic climate change hazards could cause buildings to become permanently uninhabitable.

FIGURE 6-5: HIGHLY AND SEVERELY VULNERABLE BUILDINGS

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Buildings								
Areas of Concentrated Residential Development	_	_	V5	V5	V5			V5
Community Centers	_	_	V4	V4	V4		_	V5
Evacuation and Homeless Shelters	_	V4	V4		_		_	V4
Government Buildings and Sites	_	_		V4			_	V4
Hazardous Materials Facilities	_	_				_	_	
Historic Buildings and Facilities	_	_	V4	V5	V4	V4		V5
Key Employment or Commercial Centers	_	_	V4	_				V4
Medical Care Facilities	_	_		_			_	V4
Public Safety Buildings	_	_		V5		_	_	V4
Schools	_	V4		V5			_	V5

Vulnerable Natural and Managed Resources

Aquatic ecosystems are highly susceptible to damage from drought and extreme heat in the inland areas of the county and sea level rise in the coastal areas. Drought can lower water levels and water quality, and stress plants and animals. In coastal areas, sea level rise can cause salt water to infiltrate freshwater systems further inland. Higher temperatures and lack of water from drought or decreases in fog can stress Marin's forests and make them more susceptible to damage from pest infestations and wildfires. Natural and Managed Resources are also extremily vulnerable to wildfire.

Marin's managed resources, such as hiking and biking trails, state and national lands, and historic and cultural resource areas are also vulnerable. The draw of these managed assets is dependent on the aesthetics and quality of the County's natural resources which are highly exposed to hazards.

FIGURE 6-6: HIGHLY AND SEVERELY VULNERABLE MANAGED RESOURCES

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Natural and Managed Resources								
Ecosystems	V5				V4		_	V4
Beaches and Coastal Dunes	_	_	V5		V5	V4	_	_
Endangered, Threatened, and Sensitive Species	V5	V4			V4	_	_	V4
Marshes, Wetlands, and Streams	V5		V4		V4		_	
Farms, Orchards, and Vineyards	V5	V5			_		_	V5
Hiking and Biking Trails	_	_		V4			_	V4
Scenic Views or Ridgelines	_	_	_		_	V4	_	V5
Historic and Cultural Resource Areas	_	_	V5		V4	V4	_	V5
State and National Parks, Forests, Wilderness Areas, and Other Protected Locations	V4			V4		V4	_	V5

Vulnerable Economic Drivers

Of the economic drivers discussed in this Vulnerability Assessment, farms, orchards, vineyards, outdoor recreation, and state and national protected lands have a high level of vulnerability to a number of different exposures. Marin County's natural resources, open space, and parks draw in many day visitors each year. Agriculture in Marin contributes over $100 million annually to the local economy while in 2018 Marin County averaged between 12 to 14 million annual visits and the traveler's spending exceeded $743 million.

While specific protective actions can be taken to reduce the risk of climate hazard impacts, these economic drivers are heavily reliant on natural lands and resources which face high hazard impacts and have low adaptive capacities. The natural beauty of outdoor recreation areas and state and national protected lands can be diminished by climate hazards. While they may have the ability to recover from individual climate hazards, if climate change hazards become chronic, some may lose their current value to the public and management agencies may be unable to continue operations due to a lack of alternatives.

FIGURE 6-7: HIGHLY AND SEVERELY VULNERABLE ECONOMIC DRIVERS

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Economic Drivers								
Farms, Orchards, and Vineyards	V5	V5			_	V4		V5
Major Employers	_				_	_	_	
Outdoor Recreation	V4	V4			V4	V4		V5
State and National Protected Lands	V4	V4			V4	V4		V5

.

This page intentionally left blank.

REFERENCES

Clearwater Hydrology. 2005. Marin Countywide Plan Flooding Technical Background Report. November 2005

California Coastal Commission. 2020. Sea Level Rise Principles, Exhibit 1 – "Making California's Coast Resilient to Sea Level Rise: Principles for Aligned State Action." May 1, 2020. https://documents.coastal.ca.gov/reports/2020/5/w6g/w6g-5-2020-exhibits.pdf

California Department of Forestry and Fire Protection (CAL FIRE). 2021. 2020 Incident Archive. https://www.fire.ca.gov/incidents/2020/

California Natural Resources Agency, Governor's Office of Planning and Research, and California Energy Commission. 2018. California's Fourth Climate Change Assessment; Statewide Summary Report. Available: https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018- 013_Statewide_Summary_Report_ADA.pdf.

California Natural Resources Agency, Governor's Office of Planning and Research, and California Energy Commission. 2018. California's Fourth Climate Change Assessment: San Francisco Bay Area Region Report. Available: https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-005_SanFranciscoBayArea_ADA.pdf

County of Marin, Community Development Agency. 2007. Marin Countywide Plan. Available: https://www.marincounty.org/-/media/files/departments/cd/planning/currentplanning/publications/county-wide-plan/cwp_2015_update_r.pdf?la=en

County of Marin, Department of Public Works. 2017. Marin Shoreline Sea Level Rise Vulnerability Assessment. Available: https://www.marincounty.org/-/media/files/departments/cd/planning/slr/baywave/vulnerability-assessment-final/final_allpages_bvbconsulting_reduced.pdf?la=en

County of Marin. 2018. Marin County Multi-Jurisdictional Local Hazard Mitigation Plan. Available: https://www.marinwatersheds.org/sites/default/files/2020-07/Marin%20County%20Multi-Jurisdictional%20Local%20Hazard%20Mitigation%20Plan%202018.pdf

County of Marin, Community Development Agency. 2018. Marin Ocean Coast Sea Level Rise Adaptation Report. Available: https://www.marincounty.org/-/media/files/departments/cd/planning/slr/c-smart/2019/181211_csmart_adaptation_report_final_small.pdf?la=en

County of Marin, Community Development Agency. 2019. Marin County Local Coastal Program. Available: https://www.marincounty.org/depts/cd/divisions/planning/local-coastal-program/plans-and-docs?panelnum=1

County of Marin, Community Development Agency. 2020. Climate Action Plan 2030. Available: https://www.marincounty.org/-/media/files/departments/cd/planning/sustainability/climate-and-adaptation/cap-2030_12082020final.pdf?la=en

County of Marin. 2020. Marin County Community Wildfire Protection Plan. Available: https://firesafemarin.org/wp-content/uploads/CWPP_2020_Final_1-4-2021_FSM_published.pdf

County of Marin. 2021. Parks in Marin. Accessed October 6, 2021 at: https://www.marincounty.org/recreation/parks-in-marin

County of Marin. 2021. State Parks in Marin County. Accessed October 7, 2021 at: https://www.marincounty.org/recreation/parks-in-marin/state-parks-in-marin.

County of Marin, Public Works Department. 2021. Everything Creeks! Accessed October 6, 2021 at: https://www.marincounty.org/depts/pw/divisions/creeks-bay-and-flood/mcstoppp/protecting-our-water/everything-creeks

D. M. Romps, J. T. Seeley, D. Vollaro, J. Molinari, Projected increase in lightning strikes in the United States due to global warming. *Science* 346, 851–854 (2014). https://doi.org/10.1126/science.1259100

Governor's Office of Planning and Research. 2019. Planning and Investing for a Resilient California. Available: http://opr.ca.gov/planning/icarp/resilient-ca.html

Governor's Office of Emergency Services. 2020. California Adaptation Planning Guide 2.0. Available: https://www.caloes.ca.gov/HazardMitigationSite/Documents/CA-Adaptation-Planning-Guide-FINAL-June2020-Accessible.pdf.

Halstead, Richard. 2021. "Marin ag production rises in 2020 despite pandemic, drought," accessed from https://www.marinij.com/2021/07/15/marin-ag-production-rises-in-2020-despite-pandemic-drought/

Marin Convention and Visitors Bureau. Marin Convention and Visitors Bureau. 2020. 2019 Annual Report, accessed from https://www.visitmarin.org/media/annual-reports/

Marin Convention and Visitors Bureau. 2021. Beaches in Marin County. Accessed October 6, 2021 at: https://www.visitmarin.org/things-to-do/outdoor-activities/beaches-in-marin-county/.

Marin County Community Development Agency, Planning Division. 2005. Marin Countywide Plan Biological and Wetland Protection Technical Background Report. November 2005

Marin County Department of Agriculture. 2020. Marin County Crop & Livestock Report 2020.

Marin County Flood Control & Water Conservation District. 2015. Richardson Bay Shoreline Study. Available: https://www.marinwatersheds.org/sites/default/files/2017-07/2015.10.12_RichardsonBayShorelineStudy_000.pdf

Marin Economic Forum. 2019. Marin County Visitor's Bureau State of the Visitor Industry in Marin County Economic Report, accessed from http://www.marineconomicforum.org/wp-content/uploads/2020/02/MCVB-visitors-study-120619-Final.pdf

Marin Geohub Map Data. Available: https://gisopendata.marincounty.org

Marin Municipal Water District. Draft 2021. Marin Municipal Water District Hazard Mitigation Plan. Available: https://www.marinwater.org/sites/default/files/2021-09/2021-09_MarinMuniWaterHMP_PublicReviewDraft.pdf

Marin Watershed Program. 2021. Creeks & Watersheds: Interactive Map. Accessed October 6, 2021 at: https://www.marinwatersheds.org/creeks-watersheds/interactive-map

National Park Service. 2021. Golden Gate National Recreation Area. Accessed October 6, 2021 at: https://www.nps.gov/goga/index.htm.

National Park Service. 2021. Golden Gate National Recreation Area: Marin County Sites. Accessed October 7, 2021 at: https://www.nps.gov/goga/planyourvisit/marin-county-sites.htm

Public Health Alliance of Southern California, 2018. Healthy Places Index. https://map.healthyplacesindex.org/.

Office of Environmental Health Hazard Assessment, 2018. CalEnviroScreen 3.0. https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

Office of Emergency Services, Marin County Sheriff. 2014. Marin Operational Area Emergency Operations Plan. Available: https://www.marinsheriff.org/assets/downloads/OES/EOP-Final-Draft-10.14.2014.pdf

Sea-Level Marin Adaptation Response Team & Marin County Community Development Agency. 2015. Marin Ocean Coast Sea Level Rise Vulnerability Assessment. Available: https://www.marincounty.org/~/media/files/departments/cd/planning/slr/vulnerability-assessment/part-01_draft_marin_coast_slr_va_v2.pdf?la=en

United States Department of Agriculture National Agricultural Statistics Service. 2017 Census of Agriculture County Profile: Marin County, California.

This page intentionally left blank.

GLOSSARY OF TERMS

The 2020 APG 2.0 uses the following key terms and definitions:

Adaptive Capacity

The "combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities". The ability to adjust to potential damage, to take advantage of opportunities, or to respond to consequence.

Climate Change

Climate change refers to a change in the climate that can be identified by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer.

Climate Change Adaptation

Climate change adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, and which moderates harm or exploits beneficial opportunities. Climate change adaptation is focused on long-term threats to human life, property, economic continuity, ecological integrity, and community function.

Climate Change Hazard

A climate change hazard is a dangerous or potentially dangerous condition created by the effects of the local climate.

Exposure

The presence of people, infrastructure, natural systems, and economic, cultural, and social resources in areas that are subject to harm.

Hazard

An event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural losses, damage to the environment, interruption of business, or other types of harm or loss.

Impact

In the context of climate adaptation, the effects (especially the negative effects) of a hazard or other conditions associated with climate change. Impact is often considered the combination of exposure and sensitivity. Impacts are sometimes discussed in terms of direct or indirect impacts. Direct impacts on physical assets or immediate operations can lead to more indirect impacts on the broader system or community

Mitigation

Mitigation is an act or sustained actions to reduce, eliminate, or avoid negative impacts or effects. Hazard mitigation is a sustained action taken to reduce or eliminate the long-term risk to human life and property through actions that reduce hazard, exposure, and vulnerability. Hazard mitigation can be one component of climate change adaptation. Climate change mitigation, also referred to as GHG mitigation or GHG reduction, refers to actions to reduce GHG emissions to reduce the severity of climate change.

Sensitivity

The level to which a species, natural system, or community, government, etc., would be affected by changing climate conditions.

Resilience

Resilience is the "capacity of any entity—an individual, a community, an organization, or a natural system—to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience." Adaptation actions contribute to resilience, which is a desired outcome or state of being.

Risk

Risk for the purpose of hazard mitigation planning, is the potential for damage or loss created by the interaction of hazards with assets such as buildings, infrastructure, or natural and cultural resources. For natural hazards, risk tends to be calculated based on evaluation of the probability (likelihood) of a hazard event occurring, vulnerability, and the event's potential consequences. This method uses data from the past to establish the probability and, in the case of climate change, includes future projections of probability.

Vulnerability

Vulnerability is the exposure of human life and property to damage from natural and human-made hazards. Climate vulnerability describes the degree to which natural, built, and human systems are at risk of exposure to climate change impacts. Differences in exposure, sensitivity, and adaptive capacity affect an individual's or community's vulnerability to climate change. Vulnerability can increase because of physical (built and environmental), social, political, and/or economic factor(s). Vulnerability is considered a function of exposure, sensitivity, and adaptive capacity.

APPENDIX A
NATURAL AND MANAGED RESOURCES MEMO

VULNERABILITY ASSESSMENT
Marin Countywide Plan Safety Element Update

FINAL
JANUARY 2022

MARIN COUNTY
HOUSING & SAFETY ELEMENTS

Marin County Vulnerability Assessment
Natural and Managed Resources Memo

DATE: **January 13, 2022**

SUBJECT: **Marin County Safety Element Vulnerability Assessment - Description of Natural and Managed Resources in Marin County**

Introduction

Marin County is updating its Housing and Safety Elements, key parts of Marin County's General Plan. New state law (California Government Code § 65302(g)) requires Safety Elements to address climate adaptation and resiliency planning. Marin County has prepared a climate change and adaptation Vulnerability Assessment as the first step in updating the Safety Element to include climate adaptation and resiliency planning. The Vulnerability Assessment focuses on environmental hazards worsened by climate change (drought, flooding, sea level rise, landslides, etc.).

The Vulnerability Assessment follows the recommended process in the 2020 California Adaptation Planning Guide 2.0 (APG) prepared by the California Governor's Office of Emergency Services (Cal OES). The Adaptation Planning Guides recommends the analysis of a number of sectors in vulnerability assessments, including natural and managed resources sectors which covers both natural resources and ecosystems and managed resources such as parks and farmland. This memo provides a description of the natural and managed resources evaluated the Safety Element Vulnerability Assessment.

Natural and Managed Resources

Ecosystems

Natural communities in Marin County support a wide diversity of plant and animal species, including a high number of special-status species (See Figure 1 Vegetation). Natural community types in the County include: mixed evergreen forest, oak woodland, pine forest, douglas fir/redwood forest, grassland, coastal beach dune, northern coastal scrub, chaparral, coastal salt marsh, riparian, and freshwater marsh. Figure 2 shows the distribution of vegetative cover in the county, modified from the 2004 CalVeg mapping program of the U.S. Forest Service. Major distinguishable characteristics include: the extensive grasslands to the north which intergrade with scrub and forest lands in the Point Reyes Peninsula; the forests, woodland, and chaparral covered slopes of Mt. Tamalpais; the grasslands and woodlands of the northcentral and northwestern part of the County; and a mosaic of grassland, woodland, and urban development in the City-Centered Corridor.[1]

Historic land use has altered much of the landscape in the County, including the plant communities and wildlife dependent upon them. Beginning in the mid-nineteenth century and

[1] Marin County Community Development Agency, Planning Division. 2005. Marin Countywide Plan Biological and Wetland Protection Technical Background Report. November 2005

continuing into the present, activities such as livestock grazing, timber operations, clearing and disking for agricultural production, road building, and urban and suburban development have markedly altered the remaining natural communities. Native perennial grasslands have been largely replaced by non-native annual grasslands, and a number of highly invasive species now threaten the remaining grasslands.

Fire suppression, livestock grazing, and more recently the effects of Sudden Oak Death have greatly altered the extent of woodland and forest cover. The past effects of timber harvesting and overgrazing continue to affect the aquatic habitat of the streams and creeks in the County, and limits the viability of the anadromous fisheries.

These influences on the natural landscape have changed in the past few decades, from one of primarily agricultural-related activities to one of increased development pressure, particularly along the western fringe of the City-Centered Corridor and scattered locations in the Inland Rural and Coastal Recreation Corridors. Urban and suburban development has contributed to considerable fragmentation of the remaining natural areas associated with the system of local parks and open space lands along stream corridors and ridgelines throughout the City-Centered Corridor.[2]

Beaches and Coastal Dunes

Marin County is bordered by the Pacific Ocean to the west and the San Francisco Bay to the east and contains numerous National, State, County, and local public lands along the ocean coastline, and bay shoreline. Many of the public lands along the ocean coastline include beaches or coastal dunes.

National land along the coast is present in the 111- square mile Point Reyes National Seashore, which includes beaches such as Limantour and Drakes Beach. In addition, Kirby Cove Beach, Black Sands Beach, South Rodeo Beach, Rodeo Beach, Pirate's Cove Beach, Slide Ranch Beach, Stinson Beach and Muir Beach are part of the Golden Gate National Recreation Area, which spans parts of Marin, San Mateo, and San Francisco counties.[3]

State Parks in Marin County with coastal access and/or beaches include Angel Island State Park, China Camp State Beach, and Tomales Bay State Park. Marin County has beaches and coastal preserves include Agate Beach, Bolinas Lagoon Preserve, and Bothin Marsh Preserve. Locally managed beaches and coastal preserves include Audubon Canyon Ranch, Bayfront Park, and Upton Beach Park.[4]

Recreational opportunities at beaches in Marin County include beachcombing, tide-pooling, wave-watching, bird watching, sunbathing, kayaking, and boating.[5]

The Marin County Coastal Zone contains a broad range of estuarine and marine environments, tidal marshes, freshwater wetlands, stream corridors, upland forests, chaparral, and grasslands. Other sensitive biological resources in the County's coastal zone include dunes and beaches,

---

[2] Ibid.

[3] National Park Service. 2021. Golden Gate National Recreation Area. Accessed October 6, 2021 at: https://www.nps.gov/goga/index.htm

[4] County of Marin. 2021. Parks in Marin. Accessed October 6, 2021 at: https://www.marincounty.org/recreation/parks-in-marin

[5] Marin Convention and Visitors Bureau. 2021. Beaches in Marin County. Accessed October 6, 2021 at: https://www.visitmarin.org/things-to-do/outdoor-activities/beaches-in-marin-county/

salt marshes, fresh-water marshes, tidal freshwater wetlands, riparian corridors, chaparral, and grasslands.[6]

The coastal dune communities provide habitat for several species of plants and animals that have adapted to the harsh environment of the shoreline and provide protection to inland areas from wave run-up generated by prolonged storms and high seas. The list of unique species and habitats of the Coastal Zone is extensive.[7]

Endangered, threatened, and sensitive species

Special-status species are plants and animals that are legally protected under the State and/or federal Endangered Species Acts or other regulations, as well as other species that are considered rare enough by the scientific community and trustee agencies to warrant special consideration, particularly with regard to protection of isolated populations, nesting or denning locations, communal roosts, and other essential habitat. The primary information source on the distribution of special-status species in California is the California Natural Diversity Database (CNDDB) inventory, which is maintained by the Natural Heritage Division of the California Department of Fish and Wildlife (CDFW). Occurrence data is obtained from a variety of scientific, academic, and professional organizations, private consulting firms, and knowledgeable individuals, and entered into the inventory as expeditiously as possible.[8]

The records of the CNDDB indicate that special-status plant and animal species occur in a wide range of habitat types throughout all of Marin County. Most of the reported occurrences are from the National Park Service lands of Point Reyes National Seashore and Golden Gate National Recreation Area, and the State Park and Marin Municipal Water District watershed lands on Mount Tamalpais. Many others occur along the shoreline of the bay, or unique habitat types such as the serpentine-derived soils and outcrops along the Tiburon Ridge. Still others are dependent on the creeks and streams throughout the County for dispersal and essential breeding habitat. A total of 75 animal species and 78 plant species reported from Marin County are monitored by the CNDDB, and the County also has several listed, proposed, and candidate species not carefully monitored by the CNDDB. Figure 2 shows the distribution of special-status plant and animal species throughout the County based on the CNDDB occurrence records, with the highest concentrations in the undeveloped lands of West Marin, the Mount Tamalpais vicinity, and shoreline of the bay.[9]

Areas of designated critical habitat mapped by the USFWS for a number of federally-listed species are also shown in Figure 2. Species with designated critical habitat within or extending into parts of Marin County include: coho salmon, winter run chinook salmon, steelhead, marbled murrelet, western snowy plover, Steller sea-lion, Baker's larkspur, and yellow larkspur.[10]

For many of the special-status species known from Marin County, habitat suitability is severely limited by the direct and indirect effects of development. These include the direct loss of habitat because of conversion to urban uses, effects of on-going habitat modifications due to vegetation

---

[6] Marin County Community Development Agency. 2015. Marin County Local Coastal Program Land Use Plan. Board of Supervisors Adopted August 25, 2015.

[7] Ibid.

[8] Marin County Community Development Agency, Planning Division. 2005. Marin Countywide Plan Biological and Wetland Protection Technical Background Report. November 2005

[9] Ibid.

[10] Ibid.

management and agricultural practices, and indirect effects such as non-point discharge into aquatic habitat and recreational activities in the open space lands. The effect of habitat fragmentation is an important consideration in evaluating the recovery of listed species and the viability of natural communities as a whole.[11]

Marshes, Wetlands, and Streams

Wetlands can include freshwater and saltwater features, and primarily consist of freshwater marsh and vernal pools, which are non-tidal marshes that contain freshwater and are continuously or frequently flooded. Vernal pools specifically are seasonal wetlands that occur along the west coast of the United States. Wetlands are considered important natural resources because of their high inherent value to fish and wildlife, their role as storage areas for storm and floodwaters, and their water recharge, filtration, and purification functions. They provide essential habitat for aquatic invertebrates, amphibians, and fish; they are important for large numbers of bird and mammal species; and freshwater wetlands are an important source of drinking water for terrestrial species.[12]

Characteristic wetland types in Marin include coastal saltmarsh, brackish marsh, freshwater marsh, the lower channel slopes of streams and riparian habitat, seasonal wetlands, vernal pools, and freshwater seeps and springs. The baylands ecosystem in Marin forms a varied pattern of open water, tidal marshes and mudflats, rocky shoreline, seasonal wetlands, and adjacent uplands.[13]

Streams convey, filter, and store sediment and nutrients. Their floodplains are important for recharge of groundwater aquifers and flood prevention. They also provide critical wildlife movement corridors between important habitats for both aquatic and terrestrial species. Ephemeral channels are important for maintaining healthy watersheds. Perennial and intermittent streams provide more permanent aquatic habitat and serve as fish migration, spawning, and rearing habitat. Riparian vegetation is essential to proper functioning of stream systems and is a critical component of high-quality fish habitat. Woody vegetation provides shade that keeps water temperatures within tolerable ranges for fish and other aquatic organisms, stabilizes streambanks and floodplains, provides protective cover for wildlife, and contributes debris to stream channels for fish habitat structure. Herbaceous vegetation helps stabilize streambanks, and filters and traps sediments and pollutants.[14]

Marin County has over 3,000 miles of natural creeks. Some of the creeks remain relatively natural, while others have undergone many changes such as dams and channel alteration resulting from development within the watershed.[15] Major creeks and watersheds of Marin County include Bolinas Lagoon, Estero Americano, Gallinas Creek, Lagunitas/Tomales Bay,

[11] Ibid.

[12] Marin County Community Development Agency, Planning Division. 2007. Marin Countywide Plan. Adopted November 6, 2007.

[13] Ibid.

[14] Ibid.

[15] County of Marin, Public Works Department. 2021. Everything Creeks! Accessed October 6, 2021 at: https://www.marincounty.org/depts/pw/divisions/creeks-bay-and-flood/mcstoppp/protecting-our-water/everything-creeks

Miller Creek, Novato Creek, Point Reyes National Seashore Creeks, Richardson Bay, Rush Creek, San Antonio Creek, San Rafael Creek, Southern Coastal Creeks, and Stemple Creek.[16]

Farms, orchards, and vineyards

As of 2017, Marin County had 140.075 acres of farmland and 343 farms with an average size of 403 acres.[17] The gross value of all agricultural production in Marin County in 2020 was $101,840,000, most of which was from livestock (39%) or livestock production (38%). Other products were field crops (14%), fruit, vegetable, and nursery crops (5%), and aquaculture (4%).[18]

In Marin County, agriculture is important as an essential livelihood, a foundation for regional economic activity, and a local source of food for residents of the Bay Area and beyond. It is estimated that every dollar of agricultural production yields a multiple of 2.5 additional dollars contributed to the local economy in employment opportunities, support industries, and tourism. In addition to economic benefits, agricultural land use also provides crucial ecosystem services such as the maintenance of soil fertility and structure, wildlife habitat and biodiversity, watershed benefits, nutrient cycling, and carbon sequestration.[19]

Nearly one-fourth of Marin's agricultural land has been permanently protected from subdivision and development, but working ranches are increasingly threatened by the prospect of conversion to single-family residential estates. The majority of local agricultural operations are only marginally profitable. Major issues facing local agriculture include the high cost of land, regulation by multiple agencies, and difficulty recruiting younger generations to work in agriculture. Many local operations have begun diversifying to increase their viability, producing row crops and value-added products such as cheese, butter, organic foods, and grass-fed beef. Although agriculture is not technically considered a "natural system," most ranchers and farmers in Marin conduct agricultural activities in a manner compatible with the natural environment.[20]

Hiking and biking trails

Trails enhance the quality of life in Marin and the health of the public by offering opportunities to enjoy the wealth of parks and open space in Marin County. Trails originated in Marin as links between Native American communities. The transportation needs of missions, logging enterprises, and ranches resulted in an expansion of this original trail system in the 19th and early-20th centuries. Some of these old trails and roads have become part of Marin's road system, while others have disappeared through disuse. Still others survive to this day on public parks and open space lands, ranches, and elsewhere. The current public trail network was created over decades, segment by segment, mile by mile, as public agencies acquired land and made it accessible to the public. Some of these agencies have acquired public trail easements through private lands, expanding the public trail network beyond the boundaries of public lands

[16] Marin Watershed Program. 2021. Creeks & Watersheds: Interactive Map. Accessed October 6, 2021 at: https://www.marinwatersheds.org/creeks-watersheds/interactive-map

[17] United States Department of Agriculture National Agricultural Statistics Service. 2017 Census of Agriculture County Profile: Marin County, California.

[18] Marin County Department of Agriculture. 2020. Marin County Crop & Livestock Report 2020.

[19] Marin County Community Development Agency. 2015. Marin County Local Coastal Program Land Use Plan. Board of Supervisors Adopted August 25, 2015.

[20] Marin County Community Development Agency, Planning Division. 2007. Marin Countywide Plan. Adopted November 6, 2007.

and creating trail connections between public lands and Marin's communities. Expanding the public trail network still further, some of Marin's public trails are — or could be — part of regional or statewide trail systems such as the State Coastal Trail, the Bay Area Ridge Trail, and the San Francisco Bay Trail.[21]

The countywide trail system connects environmentally important areas (such as bayland, coastal, and ridgeland areas), parks and open space, and greenbelts between urban areas. Marin County has approximately 641 miles of public trails. Table 1 lists agencies which maintain trails and the approximate milage they are responsible for.

TABLE 1. MILES OF TRAILS IN MARIN COUNTY BY MANAGING AGENCY

Agency	Total Miles
Marin County Open Space District	190 (100 miles are unpaved fire protection roads)
Marin Municipal Water District	149 (91 miles are unpaved fire protection roads)
Golden Gate National Recreation Area and Point Reyes National Seashore	212
California State Parks	88
North Marin Water District	2
Total	641

Source: Marin County Community Development Agency, Planning Division. 2007. Marin Countywide Plan. Adopted November 6, 2007.

Scenic views or ridgelines

Marin County has a unique visual environment with an attractiveness and diversity of landscape that includes views of open space, ocean vistas and beaches, San Francisco Bay shoreline, hills and ridgelines, agriculture lands, stands of various types of trees and other natural features. Nearly half of the county's land base is protected by park or open space status. With the largest amount of public land in the nine-county Bay Area, Marin County's 118,669 acres of park and open space make up 30 percent of the County's land base, while water area and watershed lands comprise another 20 percent. Agriculture, mainly cattle grazing, and privately-owned open space contracts occupy 26 percent of the County's land base.[22]

Many of the roadways throughout Marin County offer views of some of the County's most scenic resources. There are currently no designated State Scenic Highways or National Scenic Byways within Marin County. However, the entire stretch of State Route 1 running through the county is eligible to be a State Scenic Highway as well as sections of U.S. 101. State Route 37,

[21] Ibid.

[22] County of Marin Community Development Agency. 2007. Marin Countywide Plan Update Draft Environmental Impact Report. State Clearinghouse Number 2004022076.

which runs west to east through a mid-portion of the county, is designated as an "unconstructed state highway eligible for Scenic Designation." The criteria for official designation and eligibility includes the scenic quality of the landscape, how much of the natural landscape can be seen by travelers, and to the extent to which development intrudes upon the traveler's enjoyment of the view.[23]

Historic and cultural resource areas

For thousands of years, Marin County was home to the Coastal Miwok Indians, who left behind a rich legacy in various archaeological sites throughout the county. The Miwok Indians declined when European settlers arrived in the early 1800s. The Coastal Miwok are now referred to as the Federated Indians of Graton Rancheria (FIGR), including the Coast Miwok and Southern Pomo, and they continue to have a rich cultural heritage that includes, among other things, basket making, dances and ceremonies, and a complex and intricate language.[24]

The majority of archaeological sites in the county exist in the rural areas and inland along the bay. Key resources include historic districts in Sausalito, Belvedere, Tiburon, San Rafael, Hamilton in Novato, and China Camp State Park. The State of California recognizes 630 archaeological sites in Marin County including, permanent Miwok settlements, seasonal camps, hunting camps/special use sites, quarries and extractive sites, trails and petroglyphs.[25]

State and national parks, forests, wilderness areas, and other protected locations

In Marin County, there are three federal and seven State lands accessible for recreation purposes as well as 459 acres of County-owned parks and 1,491 acres of local parks owned by local municipalities. There are also a handful of facilities operated by private non-profit organizations.[26] National and State Parks in Marin County are described in Table 2 below.

TABLE 2 NATIONAL AND STATE PARKS IN MARIN COUNTY

Park Name	**Description**
National Parks	
Golden Gate National Recreation Area	Includes Fort Baker, Marin Headlands, Muir Beach, Muir Beach Overlook, Nike Missile Site, Stinson Beach, and Tennessee Valley.
Muir Woods National Monument	Only old growth coastal redwood forest in the Bay Area.

[23] Ibid.

[24] Marin County Community Development Agency, Planning Division. 2007. Marin Countywide Plan. Adopted November 6, 2007.

[25] Marin County Community Development Agency, Planning Division. 2003 (February). Marin Countywide Plan Cultural Resources Technical Background Report.

[26] County of Marin Community Development Agency. 2007. Marin Countywide Plan Update Draft Environmental Impact Report. State Clearinghouse Number 2004022076.

Point Reyes National Seashore	*Point Reyes National Seashore* is a 71,028-acre (287.44 km^2) park preserve located on the Point Reyes Peninsula.
State Parks	
Angel Island State Park	In the middle of San Francisco Bay sits Angel Island State Park.
China Camp State Park	Located on San Pablo Bay, visitors can enjoy wildlife-watching, and hiking.
Mount Tamalpais State Park	6,300 acres of redwood groves and oak woodlands with a spectacular view.
Oolampali State Park	The park overlooks the Petaluma River and San Pablo Bay from the east.
Samual P Taylor State Park	Contains over 2,780 acres of wooded countryside in the rolling hills of Marin.
Tomales Bay State Park	The Coast Miwok people were the first to inhabit the coastal area.

Sources: 1. National Park Service. 2021. Golden Gate National Recreation Area: Marin County Sites. Accessed October 7, 2021 at: https://www.nps.gov/goga/planyourvisit/marin-county-sites.htm 2. County of Marin. 2021. State Parks in Marin County. Accessed October 7, 2021 at: https://www.marincounty.org/recreation/parks-in-marin/state-parks-in-marin

The parks and facilities owned and operated by the County vary widely in type and size. They include: specialized facilities (boat launches and the Civic Center facilities); a community park (Deer Park); a neighborhood park (Bolinas); beaches (Agate Beach, as well as beaches at McNear's and Paradise Parks); and the nature preserve at the Tiburon Uplands. Although McNear's Beach and Paradise County Parks serve a countywide function and are thus classified as regional, only Stafford Lake and McInnis Parks meet the size and service area criteria for a true regional park. The total of 589 acres in these two parks represent a small portion of the 4,430 acres needed to meet the countywide regional parks standard. County regional park acreage meets the standard only in central Marin, in the Las Gallinas planning area where McInnis Park is located. While the standard may be unrealistic in light of Marin's extensive open space, it helps underscore a demonstrated need for additional countywide parks for active recreation.[27]

Economic Drivers

Farms, Orchards, and Vineyards

This category includes the production of fruit and nut crops, livestock, nursery products, vegetable crops, and field crops. The economic activities provided by wineries, festivals, U-pick

[27] Marin County Community Development Agency, Planning Division. 2005. Marin Countywide Plan Parks and Recreation Technical Background Report.

operations, and other agriculture-based tourism activities are included under this category. Agriculture in Marin contributes over $100 million annually to the local economy, with milk, poultry and livestock making up over two thirds of the total value.[28]

Outdoor Recreation

This category includes economic activities provided by beaches, historic landmarks, parks and open space, hiking trails, bicycling routes, and shorelines along Marin's Coast. It also includes sailing, boating, whale-watching, and other tourism oriented around the Pacific Ocean.

State and National Protected Lands

This category includes economic activities provided by state and federal land in the county, including Golden Gate National Recreation Area, Muir Wood National Monument, Point Reyes National Seashore, China Camp State Park, and Mount Tamalpais State Park.

References

County of Marin. 2021. Parks in Marin. Accessed October 6, 2021 at: https://www.marincounty.org/recreation/parks-in-marin

County of Marin. 2021. State Parks in Marin County. Accessed October 7, 2021 at: https://www.marincounty.org/recreation/parks-in-marin/state-parks-in-marin.

County of Marin, Public Works Department. 2021. Everything Creeks! Accessed October 6, 2021 at: https://www.marincounty.org/depts/pw/divisions/creeks-bay-and-flood/mcstoppp/protecting-our-water/everything-creeks

Halstead, Richard. 2021. "Marin ag production rises in 2020 despite pandemic, drought," accessed from https://www.marinij.com/2021/07/15/marin-ag-production-rises-in-2020-despite-pandemic-drought/

Marin Convention and Visitors Bureau. 2021. Beaches in Marin County. Accessed October 6, 2021 at: https://www.visitmarin.org/things-to-do/outdoor-activities/beaches-in-marin-county/.

Marin County Community Development Agency. 2015. Marin County Local Coastal Program Land Use Plan. Board of Supervisors Adopted August 25, 2015.

Marin County Community Development Agency, Planning Division. 2005. Marin Countywide Plan Biological and Wetland Protection Technical Background Report. November 2005

Marin County Community Development Agency, Planning Division. 2007. Marin Countywide Plan. Adopted November 6, 2007

Marin County Department of Agriculture. 2020. Marin County Crop & Livestock Report 2020.

Marin Watershed Program. 2021. Creeks & Watersheds: Interactive Map. Accessed October 6, 2021 at: https://www.marinwatersheds.org/creeks-watersheds/interactive-map.

National Park Service. 2021. Golden Gate National Recreation Area. Accessed October 6, 2021 at: https://www.nps.gov/goga/index.htm.

[28] Halstead, Richard. 2021. "Marin ag production rises in 2020 despite pandemic, drought," accessed from https://www.marinij.com/2021/07/15/marin-ag-production-rises-in-2020-despite-pandemic-drought/

National Park Service. 2021. Golden Gate National Recreation Area: Marin County Sites. Accessed October 7, 2021 at: https://www.nps.gov/goga/planyourvisit/marin-county-sites.htm

United States Department of Agriculture National Agricultural Statistics Service. 2017 Census of Agriculture County Profile: Marin County, California.

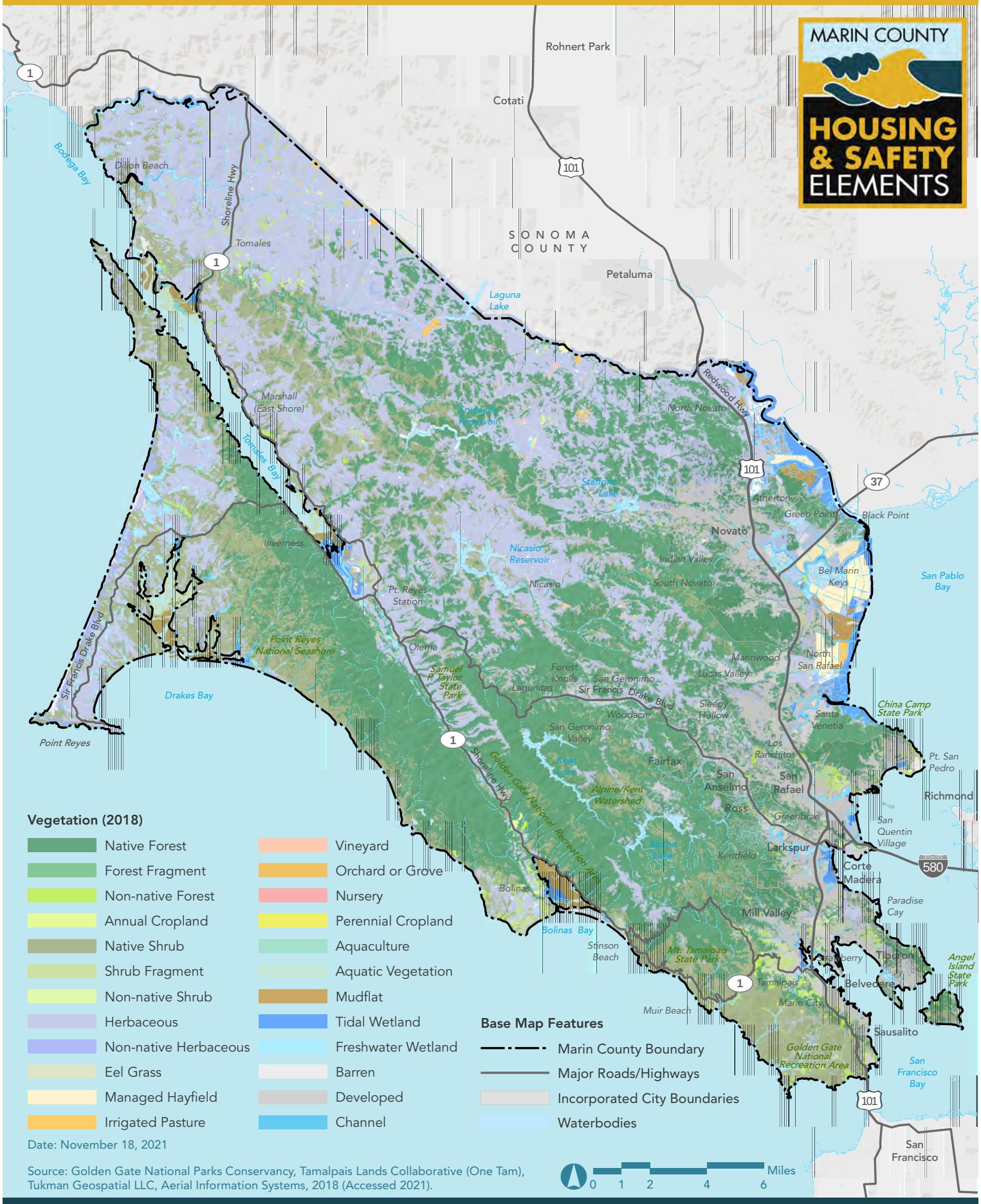
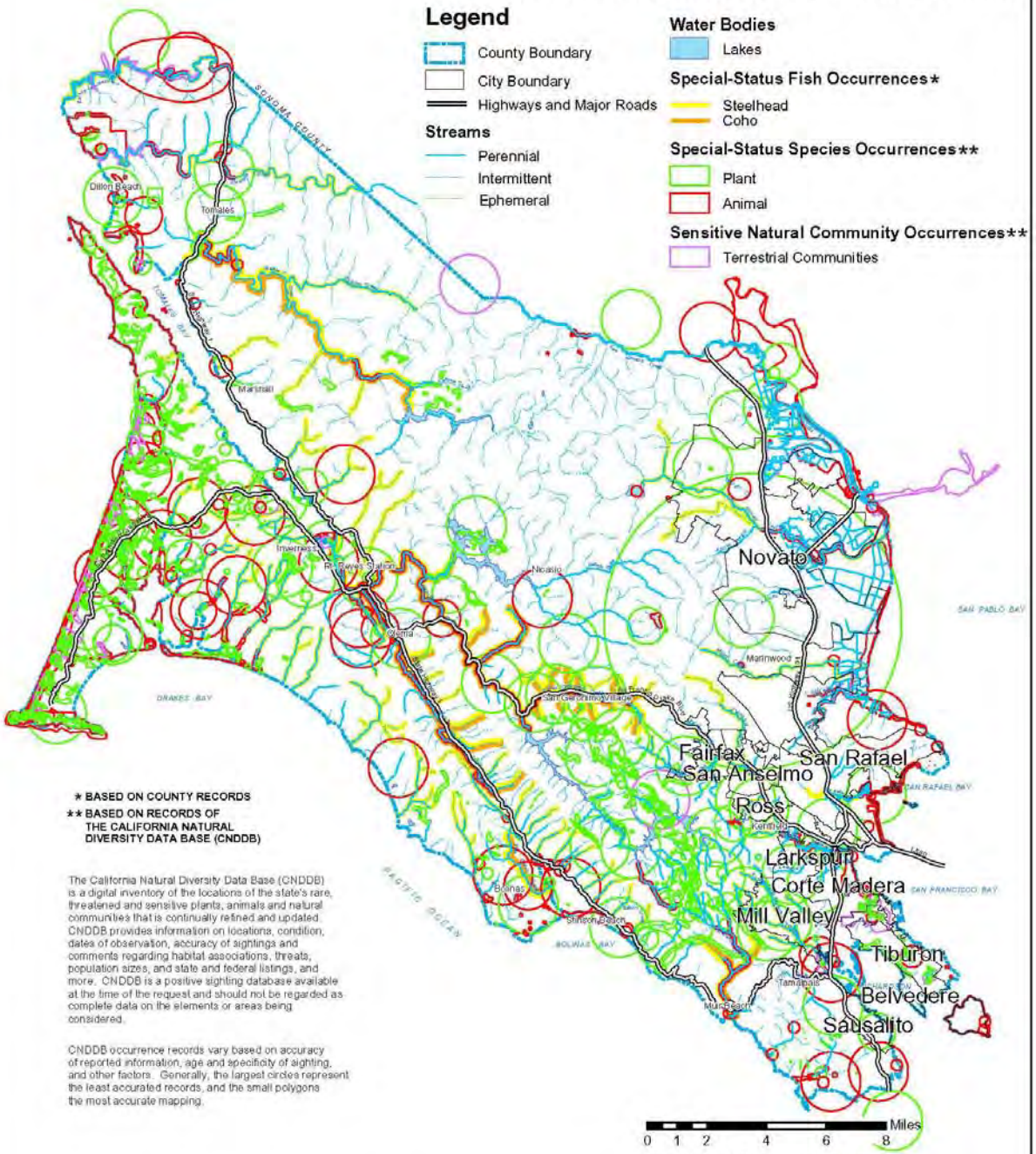


Figure 1: Vegetation

SAFETY ELEMENT VULNERABILITY ASSESSMENT

EXHIBIT 2

SPECIAL-STATUS SPECIES AND SENSITIVE NATURAL COMMUNITIES



* BASED ON COUNTY RECORDS

** BASED ON RECORDS OF THE CALIFORNIA NATURAL DIVERSITY DATA BASE (CNDDB)

The California Natural Diversity Data Base (CNDDB) is a digital inventory of the locations of the state's rare, threatened and sensitive plants, animals and natural communities that is continually refined and updated. CNDDB provides information on locations, condition, dates of observation, accuracy of sightings and comments regarding habitat associations, threats, population sizes, and state and federal listings, and more. CNDDB is a positive sighting database available at the time of the request and should not be regarded as complete data on the elements or areas being considered.

CNDDB occurrence records vary based on accuracy of reported information, age and specificity of sighting, and other factors. Generally, the largest circles represent the least accurated records, and the small polygons the most accurate mapping.

SOURCE: Modified from California Department of Fish & Game California Natural Diversity Data Base. Additional information available at: www.dfg.ca.gov

THIS MAP WAS DEVELOPED FOR GENERAL PLAN PURPOSES. THE COUNTY OF MARIN IS NOT RESPONSIBLE OR LIABLE FOR USE OF THIS MAP BEYOND ITS INTENDED PURPOSE.

Date: June 13, 2005 File: CNDDB_2-2.mxd

APPENDIX B

VULNERABILITY ASSESSMENT SCORING MATRICES

VULNERABILITY ASSESSMENT

Marin Countywide Plan Safety Element Update

FINAL
JANUARY 2022

SCORING GUIDES

IMPACT SCORING

Impact Score	*Impact Meaning to Population or Ecosystem*	*Impact Meaning to Assets*
1- Low Impact	Impact is unlikely based on projected exposure; would result in minor consequences to public health, safety, and/or other metrics of concern. Some may not experience or notice any change.	There are minor interruptions in service, damage or negative effects on the economy. Effects may be small or intermittent enough to go mostly unnoticed.
2- Medium Impact	Impact is somewhat likely based on projected exposure; would result in some consequences to public health, safety, and/or other metrics of concern.	Damage, service interruptions, and other impacts are clearly evident. Impacts may be chronic and occasionally substantial.
3- High Impact	Impact is highly likely based on projected exposure; would result in substantial consequences to public health, safety, and/or other metrics of concern. This includes widespread injury or death to people or significant or total ecosystem loss.	Impacts are chronic. Buildings, infrastructure, and services may be often or always unable to meet community demand and cannot function as intended or needed. Large sections of the economy experience major hardships.

ADAPTIVE CAPACITY SCORING

Adaptive Capacity Score	*Meaning (all Populations and Assets)*
1 - Low Capacity	Adaptive solutions are available, but they are expensive, technologically difficult, and/or politically unpopular. Alternatives may not exist that can provide similar services.
2 - Some Capacity	Some adaptation methods are available, but not always feasible. Adapting may create significant challenges for some sensitivities. Some alternatives exist within the jurisdiction area that can provide similar services.
3 - High Capacity	Adaptation solutions are feasible for most or all sensitivities. There may be occasional or small-scale challenges to implementing adaptation methods. Many alternatives exist in the area that can provide similar services.

VULNERABILITY SCORING

		Impact Score		
		Low Impact	*Medium Impact*	*High Impact*
Adaptive Capacity Score	*Low Capacity*	V3	V4	V5
	Medium Capacity	V2	V3	V4
	High Capacity	V1	V2	V3

IMPACT SCORING

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Populations								
Low-Income Households	_	High	High	High	High	High	Medium	High
Households in Poverty	_	High	High	High	High	High	Medium	High
Cost-Burdened Households	_	Low	Medium	Medium	Medium	High	Low	Medium
Overcrowded Households	_	Medium	Medium	Medium	_	Low	Low	Medium
Renters	_	Medium	Medium	Medium	_	Low	_	Medium
Persons Living on Single Access Roads	Medium	Low	High	High	Medium	High	Medium	High
Mobile Homes	Medium	Medium	High	Medium	Medium	High	Medium	High
Persons Without Access to Transportation or Telecommunications	_	Medium	High	High	Low	High	Low	High
Linguistically Isolated Communities	_	Medium	High	Medium	_	Medium	_	Medium
Low-Resourced Racial or Ethnic Minorities	_	Medium	Medium	Medium	_	Medium	_	Medium
Outdoor Workers	High	High	Medium	Medium	Low	High	_	High
Healthcare Workers, First Responders, and Protective Service Occupations	_	High	High	High	Low	High	_	High
Houseless Population	_	High	High	Medium	Low	High	_	High
Children	_	High	Medium	Medium	_	Medium	_	High
Persons with Disabilities	_	High	Medium	Medium	Low	Medium	_	High
Persons with Chronic Health Problems	_	High	Medium	Medium	Low	Medium	_	High
Senior Citizens	_	High	Medium	Medium	Low	Medium	Medium	High
Persons Living Alone	_	Medium	Low	Medium	_	Medium	Low	High
Infrastructure								
Airports	_	_	High	_	High	Medium	Medium	_
Bicycle Routes	_	_	Medium	Medium	Medium	Medium	Medium	Low
Bus Routes	_	_	High	High	Low	Medium	Medium	Medium
Major Roads and Highways	_	_	High	High	High	Medium	Medium	High
Single Access Roads	_	_	High	High	Medium	High	Medium	High
Evacuation Routes	_	_	High	High	High	High	Medium	High
Railroads	_	_	High	_	High	Medium	Low	_
Bridges and Tunnels	_	_	Low	Medium	Medium	_	_	Low
Electrical Substations	_	High	High	High	High	High	_	High
Electrical Transmission and Distribution Lines	_	High	High	High	High	High	Medium	High
Power Plants	_	_	Medium	_	_	Medium	_	_
Oil and Gas Infrastructure	_	_	High	Medium	Medium	Medium	Medium	High
Water and Wastewater Infrastructure	Medium	_	Medium	High	High	Medium	Medium	High
Flood Control Infrastructure	_	_	High	Low	High	High	_	_
Solid Waste Infrastructure	_	_	High	_	Medium	Medium	_	_

Key Services								
Emergency Services	_	High	High	Medium	Low	High	Medium	High
Communication	_	Low	Medium	High	High	High	_	High
Energy Delivery	_	High	Low	Medium	High	High	Low	High
Water and Wastewater Service	High	_	High	Medium	High	Low	Low	High
Buildings								
Areas of Concentrated Residential Development	_	_	High	High	High	Medium	Medium	High
Community Centers	_	_	Medium	Medium	Medium	Low	_	High
Evacuation and Homeless Shelters	_	Medium	Medium	Low	_	Low	_	Medium
Government Buildings and Sites	_	_	Medium	Medium	Low	Low	_	High
Hazardous Materials Facilities	_	_	Low	Low	Low	_	_	Medium
Historic Buildings and Facilities	_	_	Medium	High	Medium	High	Low	High
Key Employment or Commercial Centers	_	_	High	_	Medium	Medium	Medium	High
Medical Care Facilities	_	_	Medium	_	Medium	Medium	_	Medium
Public Safety Buildings	_	_	Medium	High	Medium	_	_	High
Schools	_	Medium	Low	High	Medium	Medium	_	High
Natural and Managed Resources								
Ecosystems	High	Medium	Medium	Low	High	Low	_	High
Beaches and Coastal Dunes	_	_	High	Medium	High	Medium	_	_
Endangered, Threatened, and Sensitive Species	High	High	Medium	Low	High	_	_	High
Marshes, Wetlands, and Streams	High	Medium	Medium	Medium	High	Low	_	Medium
Farms, Orchards, and Vineyards	High	High	Medium	Medium	_	Medium	_	High
Hiking and Biking Trails	_	_	Medium	Medium	Medium	Low	_	Medium
Scenic Views or Ridgelines	_	_	_	Low	_	Medium	_	High
Historic and Cultural Resource Areas	_	_	High	Low	Medium	Medium	_	High
State and National Parks, Forests, Wilderness Areas, and Other Protected Locations	High	Medium	Medium	Medium	Low	High	_	High
Economic Drivers								
Farms, Orchards, and Vineyards	High	High	Medium	Low	_	Medium	Low	High
Major Employers	_	Low	Low	Low	_	_	_	High
Outdoor Recreation	Medium	Medium	Medium	Medium	Medium	Medium	Low	High
State and National Protected Lands	Medium	Medium	Medium	Medium	Medium	Medium	Low	High

ADAPTIVE CAPACITY SCORING

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Populations								
Low-Income Households	_	Low	Low	Low	Low	Some	Some	Some
Households in Poverty	_	Low	Low	Low	Low	Low	Low	Low
Cost-Burdened Households	_	Low	Some	Some	Some	Some	Some	Some
Overcrowded Households	_	Some	Some	Some	_	Some	Some	Some
Renters	_	Some	Low	Low	_	Low	_	Some
Persons Living on Single Access Roads	Some	Some	Some	Low	Some	High	Some	Low
Mobile Homes	Some	Some	Some	Some	Some	Some	Some	Some
Persons Without Access to Transportation or Telecommunications	_	Low	Low	Low	Some	Low	Low	Low
Linguistically Isolated Communities	_	Some	Some	Some	_	Some	_	Some
Low-Resourced Racial or Ethnic Minorities	_	Low	Low	Some	_	Low	_	Some
Outdoor Workers	Low	Low	Low	Low	Some	Low	_	Low
Healthcare Workers, First Responders, and Protective Service Occupations	_	Some	Some	High	High	Some	_	Some
Houseless Population	_	Low	Low	Low	Some	Low	_	Low
Children	_	Low	Some	Some	_	Some	_	Low
Persons with Disabilities	_	Some	Low	Low	Some	Some	_	Low
Persons with Chronic Health Problems	_	Some	Some	Some	Some	Some	_	Low
Senior Citizens	_	Some	Some	Some	Some	Some	Some	Low
Persons Living Alone	_	Some	Some	Some	_	Some	Some	Some
Infrastructure								
Airports	_	_	Low	_	Low	Some	Some	_
Bicycle Routes	_	_	Some	Some	Some	High	Some	Some
Bus Routes	_	_	Some	Low	Some	High	Some	Some
Major Roads and Highways	_	_	Some	Low	Some	High	Some	Some
Single Access Roads	_	_	Some	Low	Some	Some	Some	Some
Evacuation Routes	_	_	Low	Low	Low	Some	Some	Low
Low	_	_	Low	_	Low	High	Some	_
Bridges and Tunnels	_	_	Low	Low	Some	_	_	High
Electrical Substations	_	Some	Some	Some	Some	Some	_	Low
Electrical Transmission and Distribution Lines	_	Some	Some	Low	Low	Some	High	Low
Power Plants	_	_	Low	_	_	Some	_	_
Oil and Gas Infrastructure	_	_	Some	Low	Some	Some	Some	Some
Water and Wastewater Infrastructure	Some	_	Low	Low	Low	Some	Some	Some
Flood Control Infrastructure	_	_	Some	Some	Some	Some	_	_
Solid Waste Infrastructure	_	_	Some	_	Some	Some	_	_

Key Services								
Emergency Services	_	Some	Some	Some	Some	Some	Some	Some
Communication	_	Some	High	Some	Some	High	_	Some
Energy Delivery	_	Some	High	Low	Some	Some	High	Some
Water and Wastewater Service	Low	_	Some	Low	Low	Low	Low	Low
Buildings								
Areas of Concentrated Residential Development	_	_	Low	Low	Low	Some	Some	Low
Community Centers	_	_	Low	Low	Low	Some	_	Low
Evacuation and Homeless Shelters	_	Low	Low	Low	_	Some	_	Low
Government Buildings and Sites	_	_	Some	Low	Some	High	_	Some
Hazardous Materials Facilities	_	_	Some	Some	Some	_	_	Some
Historic Buildings and Facilities	_	_	Low	Low	Low	Some	Low	Low
Key Employment or Commercial Centers	_	_	Some	_	Some	Some	Some	Some
Medical Care Facilities	_	_	Some	_	Some	High	_	Some
Public Safety Buildings	_	_	Some	Low	Some	_	_	Some
Schools	_	Low	Low	Low	Some	Some	_	Low
Natural and Managed Resources								
Ecosystems	Low	Some	Some	High	Some	High	_	Some
Beaches and Coastal Dunes	_	_	Low	Some	Low	Low	_	_
Endangered, Threatened, and Sensitive Species	Low	Some	Some	High	Some	_	_	Some
Marshes, Wetlands, and Streams	Low	Some	Low	Some	Some	High	_	Some
Farms, Orchards, and Vineyards	Low	Low	Some	Some	_	Some	_	Low
Hiking and Biking Trails	_	_	Some	Low	Some	Some	_	Low
Scenic Views or Ridgelines	_	_	_	High	_	Low	_	Low
Historic and Cultural Resource Areas	_	_	Low	Low	Low	Low	_	Low
State and National Parks, Forests, Wilderness Areas, and Other Protected Locations	Some	Some	Some	Low	Some	Some	_	Low
Economic Drivers								
Farms, Orchards, and Vineyards	Low	Low	Some	Some	_	Low	High	Low
Major Employers	_	High	Some	Some	_	_	_	High
Outdoor Recreation	Low	Low	Some	Some	Low	Low	High	Low
State and National Protected Lands	Low	Low	Some	Some	Low	Low	High	Low

VULNERABILITY SCORING

	Drought	Extreme Heat	Flooding	Landslides, Debris Flows, and Post-Fire Debris Flows	Sea Level Rise	Severe Weather	Subsidence	Wildfire
Populations								
Low-Income Households	_	V5	V5	V5	V5	V4	V2	V4
Households in Poverty	_	V5	V5	V5	V5	V5	V4	V5
Cost-Burdened Households	_	V3	V3	V3	V3	V4	V2	V3
Overcrowded Households	_	V3	V3	V3	_	V2	V2	V3
Renters	_	V3	V4	V4	_	V3	_	V3
Persons Living on Single Access Roads	V3	V2	V4	V5	V3	V3	V3	V5
Mobile Homes	V3	V3	V4	V3	V3	V4	V3	V4
Persons Without Access to Transportation or Telecommunications	_	V4	V5	V5	V2	V5	V3	V5
Linguistically Isolated Communities	_	V3	V4	V3	_	V3	_	V3
Low-Resourced Racial or Ethnic Minorities	_	V4	V4	V3	_	V4	_	V3
Outdoor Workers	V5	V5	V4	V4	V2	V5	_	V5
Healthcare Workers, First Responders, and Protective Service Occupations	_	V4	V4	V3	V1	V4	_	V4
Houseless Population	_	V5	V5	V4	V2	V5	_	V5
Children	_	V5	V3	V3	_	V3	_	V5
Persons with Disabilities	_	V4	V4	V4	V2	V3	_	V5
Persons with Chronic Health Problems	_	V4	V3	V3	V2	V3	_	V5
Senior Citizens	_	V4	V3	V3	V2	V3	V3	V5
Persons Living Alone	_	V3	V2	V3	_	V3	V2	V4
Infrastructure								
Airports	_	_	V5	_	V5	V3	V2	_
Bicycle Routes	_	_	V3	V3	V3	V2	V2	V2
Bus Routes	_	_	V4	V5	V2	V2	V1	V3
Major Roads and Highways	_	_	V4	V5	V4	V2	V1	V4
Single Access Roads	_	_	V4	V5	V3	V4	V1	V4
Evacuation Routes	_	_	V5	V5	V5	V4	V1	V5
Railroads	_	_	V5	_	V5	V2	V2	_
Bridges and Tunnels	_	_	V3	V4	V3	_	_	V1
Electrical Substations	_	V4	V5	V4	V5	V4	_	V5
Electrical Transmission and Distribution Lines	_	V4	V4	V5	V5	V4	V2	V5
Power Plants	_	_	V4	_	_	V3	_	_
Oil and Gas Infrastructure	_	_	V3	V4	V3	V3	V3	V4
Water and Wastewater Infrastructure	V3	_	V4	V5	V5	V3	V3	V4
Flood Control Infrastructure	_	_	V4	V2	V4	V4	_	_
Solid Waste Infrastructure	_	_	V4	_	V3	V3	_	_

Key Services								
Emergency Services	_	V4	V4	V3	V2	V4	V3	V4
Communication	_	V2	V1	V4	V4	V3	_	V4
Energy Delivery	_	V4	V1	V4	V4	V4	V1	V4
Water and Wastewater Service	V5	_	V4	V4	V5	V3	V3	V5
Buildings								
Areas of Concentrated Residential Development	_	_	V5	V5	V5	V3	V3	V5
Community Centers	_	_	V4	V4	V4	V2	_	V5
Evacuation and Homeless Shelters	_	V4	V4	V3	_	V2	_	V4
Government Buildings and Sites	_	_	V3	V4	V2	V1	_	V4
Hazardous Materials Facilities	_	_	V2	V3	V2	_	_	V3
Historic Buildings and Facilities	_	_	V4	V5	V4	V4	V3	V5
Key Employment or Commercial Centers	_	_	V4	_	V3	V3	V3	V4
Medical Care Facilities	_	_	V3	_	V3	V2	_	V4
Public Safety Buildings	_	_	V3	V5	V3	_	_	V4
Schools	_	V4	V3	V5	V3	V3	_	V5
Natural and Managed Resources								
Ecosystems	V5	V3	V3	V1	V4	V1	_	V4
Beaches and Coastal Dunes	_	_	V5	V3	V5	V4	_	_
Endangered, Threatened, and Sensitive Species	V5	V4	V3	V1	V4	_	_	V4
Marshes, Wetlands, and Streams	V5	V3	V4	V3	V4	V1	_	V3
Farms, Orchards, and Vineyards	V5	V5	V3	V3	_	V3	_	V5
Hiking and Biking Trails	_	_	V3	V4	V3	V2	_	V4
Scenic Views or Ridgelines	_	_	_	V1	_	V4	_	V5
Historic and Cultural Resource Areas	_	_	V5	V3	V4	V4	_	V5
State and National Parks, Forests, Wilderness Areas, and Other Protected Locations	V4	V3	V3	V4	V2	V4	_	V5
Economic Drivers								
Farms, Orchards, and Vineyards	V5	V5	V3	V2	_	V4	V1	V5
Major Employers	_	V1	V2	V2	_	_	_	V3
Outdoor Recreation	V4	V4	V3	V3	V4	V4	V1	V5
State and National Protected Lands	V4	V4	V3	V3	V4	V4	V1	V5