Resilience | Russian River Watershed

Russian River Watershed Resilience Plan

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Prepared by Sonoma Water and Jacobs with support from ESA and Kearns & West

Sonoma Water

Jacobs

Acknowledgments

The Russian River Watershed Resilience Pilot is the result of a broad regional effort supported by many organizations and individuals who contributed their insight, time, and commitment throughout the planning process. This initiative reflects collaboration across water agencies, Tribal partners, community organizations, technical experts, and watershed residents: these valued collaborators helped shape a shared understanding of climate vulnerabilities and opportunities for long-term resilience.

We recognize the California Department of Water Resources for funding and supporting this pilot under the Watershed Resilience Program. Their investment allowed the project team to integrate climate science, vulnerability assessment, and watershed-scale collaboration across the Russian River watershed.
We acknowledge Sonoma Water for convening and providing leadership and coordination in carrying this Pilot forward. Sonoma Water ensured that a wide range of local, regional, and community viewpoints were reflected in the planning process.

Watershed Network, Tribal Partners, and Community Contributors

We thank the Watershed Network members who contributed perspectives across sectors: surface water, groundwater, flood management, water quality, ecosystem, recreation, hydropower, and community and equity. Their involvement supported the development of a truly collaborative watershed vision.
We also acknowledge the Tribal partners who participated in meetings and consultations, sharing insights, stewardship practices, and community priorities. Their involvement remains essential as the region continues to advance watershed resilience. We also extend our appreciation to the many community-based organizations, technical experts, and local residents who participated in workshops, reviewed materials, provided comments, and contributed local knowledge throughout the pilot process.

Project Team

We would also like to thank the project team members from Sonoma Water, Jacobs, ESA, and Kearns & West who supported development, facilitation, engagement, technical analyses, and plan integration. Their work provided the science-based foundation and collaborative framework needed to advance a comprehensive watershed resilience plan.

Letter From the Russian River Watershed Network (Network)

To our partners, collaborators, champions, and stewards of the Russian River watershed,

Something meaningful is taking shape alongside the Russian River.

A Network of deliberately diverse and deeply informed agencies, Tribes, NGOs, land and water managers, and community members came together with a shared belief that this watershed, its ecosystems, and its communities are worth protecting, and that we are stronger in that effort together. We have crafted more than a document; it is a shared roadmap and a powerful demonstration that cross-sector collaboration is not only possible, but already flourishing.

Our Network participants are clear: the Russian River Watershed Resilience Plan inspires real hope. It has offered a credible foundation for attracting resources, aligning priorities, and transforming climate adaptation from an overwhelming challenge into a set of concrete, fundable strategies. The issues facing our community due to climate change are expansive and complex, and so is resilience.

The relationships and trust cultivated through this process are among our greatest assets. We have shown that coordination, when it is well-resourced and working toward true inclusion, becomes the mechanism through which lasting change happens in the places and communities that need it most. We look forward to continuing to build on this foundation for the mutual benefit of everyone involved.

Strategic resource planning will be key as we take the next steps together, from coordination and information sharing to a more robust, resourced organizational structure in which participants can align their efforts and investments and direct them toward the right projects, in the right places, at the right time. The foundation of trust and shared purpose we have built makes that evolution a natural next step.

Our collective vision for the future is vivid: we want to continue cross-sector, intergenerational watershed planning that deepens trust, sharpens priorities, and draws greater investment into the watershed.

- Moving forward collaboratively is strategic; it directs our collective energy toward what is both highly implementable and most impactful.
- There is an opportunity here for leadership. By synthesizing the best available science and planning, we elevate the Russian River as an example worth replicating across California and beyond. What we do matters not just for our organizations, but ripples beyond our region and out for future generations.
- The Network can be a growing voice for the watershed to attract the resources required to meet the moment. To be successful, we must focus on defining the organization and roles and responsibilities for the Network going forward.

The momentum is real. The community is engaged and ready. The path forward, shaped by all of us, is full of promise.

With gratitude and shared excitement for what's ahead,

Russian River Watershed Network

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Acronyms and Abbreviations

Acronym	Description
AF	acre-foot/feet
AFY	acre-foot/feet per year
AMS	American Meteorological Society
AR	atmospheric river
BCM	Basin Characterization Model
BRIC	Building Resilient Infrastructure and Communities
CAP	Climate Adaptation Plan
CBPR	Community-Based Participatory Research
CDFW	California Department of Fish and Wildlife
CDIP	Coastal Data Information Program
cfs	cubic foot/feet per second
CIEA	California Indian Environmental Alliance
CMIP6	Coupled Model Intercomparison Project Phase 6
CNRA	California Natural Resources Agency
CNRFC	California Nevada River Forecast Center
COAD	Sonoma County, Community Organizations Active in Disaster
CRPS	continuous rank probability score
CUL	Native American culture beneficial use
CW3E	Center for Western Weather and Water Extremes at Scripps Institution of Oceanography
CWA	Clean Water Act
CWMS	Corps Water Management System
CWSRF	Clean Water State Revolving Fund

Acronym	Description
DSM	Sonoma Water's Decision Support Model
DWR	California Department of Water Resources
DWSRF	Drinking Water State Revolving Fund
EFO	Ensemble Forecast Operations (model name)
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ET	evapotranspiration
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FFF	Fish Friendly Farming
FIRO	Forecast-Informed Reservoir Operations
FIRO Pool	FIRO buffer pool
FISH	Native American subsistence fishing beneficial use
FVA	final viability assessment
GCM	global climate model
GEFS	Global Ensemble Forecast System
GSA	Groundwater Sustainability Agency
GSFLOW	Coupled Groundwater and Surface-Water Flow Model
GSP	Groundwater Sustainability Plan
HEC	Hydrologic Engineering Center
HEFS	Hydrologic Ensemble Forecast System
HMS	Hydrologic Modeling System
IRWM	Integrated Regional Water Management
LOCA2-Hybrid	Localized Constructed Analogs Version 2 Hybrid

Acronym	Description
Marin Water	Marin Municipal Water District
MEFP	Meteorological Ensemble Forecast Processor
MLSTEP	Mendocino, Lake, Sonoma Tribal Environmental Professionals
NBCAI	North Bay Climate Adaptation Initiative
NBS	nature-based solutions
NCRP	North Coast Resource Partnership
NERF	New Eel Russian Facility
NMFS	National Marine Fisheries Service
No FIRO	operations without FIRO
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OBBBA	One Big Beautiful Bill Act
Partnership	Sonoma-Marin Saving Water Partnership
PG&E	Pacific Gas and Electric Company
Pilot	Russian River Watershed Resilience Pilot
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PVA	preliminary viability assessment
PVP	Potter Valley Project
QCM	Quantified Conceptual Model
R3MP	Russian River Regional Monitoring Program
RAS	River Analysis System
RCD	Resource Conservation District
RCPA	Regional Climate Protection Authority
ResSim	Reservoir System Simulation

Acronym	Description
RRIHM	Russian River Integrated Hydrologic Model
RRWA	Russian River Watershed Association
RRWQM	Russian River HEC-ResSim Water Quality Model
RWQCB	Regional Water Quality Control Board
S2S	subseasonal to seasonal
SDF	stream depletion factor
SDWA	Safe Drinking Water Act
SGMA	California Sustainable Groundwater Management Act
SHAD	Suitable Habitat Acre-Day
SMP	Stream Maintenance Program
Sonoma Water	Sonoma County Water Agency
SRPHM	Santa Rosa Plain Hydrologic Model
SSP	shared socioeconomic pathways
Steering Committee	Lake Mendocino Steering Committee
TAC	Sonoma Water's Board of Directors, Technical Advisory Committee
TAF	thousand acre-feet
TBU	Tribal beneficial use
TEK	Traditional Ecological Knowledge
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VCP	Vulnerable Communities Platform
WAC	Sonoma Water's Board of Directors, Water Advisory Committee
Water Control Manual	Coyote Valley Dam Water Control Manual

Acronym	Description
WBA	water budget area
WRP	Russian River Watershed Resilience Plan
WWAO	Western Water Action Office

1. Watershed Resilience Program and Pilot Overview

1.1 Watershed Resilience Program Overview

The Russian River Watershed Resilience Plan is building on a solid foundation of watershed planning, science, collaboration, and innovation by the engaged watershed community. They have come together now as a Watershed Network to ensure their efforts are coordinated towards a climate resilient future.

To strengthen California's ability to adapt to climate change, the California Department of Water Resources (DWR) launched the Watershed Resilience Program as part of the 2023 California Water Plan. This program emphasizes the need to assess climate risks at the watershed scale and develop strategies that address those challenges through collaboration and integrated solutions. It builds on the foundation of the Integrated Regional Water Management (IRWM) Program, deepening its focus on climate vulnerability assessments, adaptation planning, watershed-based planning, multi-sector collaboration, and equity and inclusiveness. The program also prioritizes cross-sector collaboration across water supply, flood management, groundwater, water quality, forest and fire resilience, ecosystems, and land use. Initial funding from the 2021 and 2022 Budget Acts enabled DWR to launch five 2-year pilot planning projects. These pilots are applying and testing the watershed resilience approach in diverse regions across the state, laying the groundwork for future efforts. The five pilot watersheds were selected by DWR and include the Russian River, American River, Ventura River, Pajaro River, and Calaveras River watersheds (https://water.ca.gov/Work-With-Us/Grants-And-Loans/watershed-resilience-program).

Pilot watersheds received funding and guidance from DWR to convene broad, inclusive watershed networks of local agencies, Tribal governments, community leaders, non-profit organizations, and other partners. DWR envisions equity and inclusion as being a critical focus for watershed networks. These locally led networks collaborate across their watershed to quantify their greatest climate vulnerabilities and develop multi-benefit adaptation strategies and projects to increase climate change resilience. Lessons learned from these pilots will inform future state funding programs. If additional funding becomes available, DWR intends to incentivize this watershed resilience approach in other watersheds throughout the state.

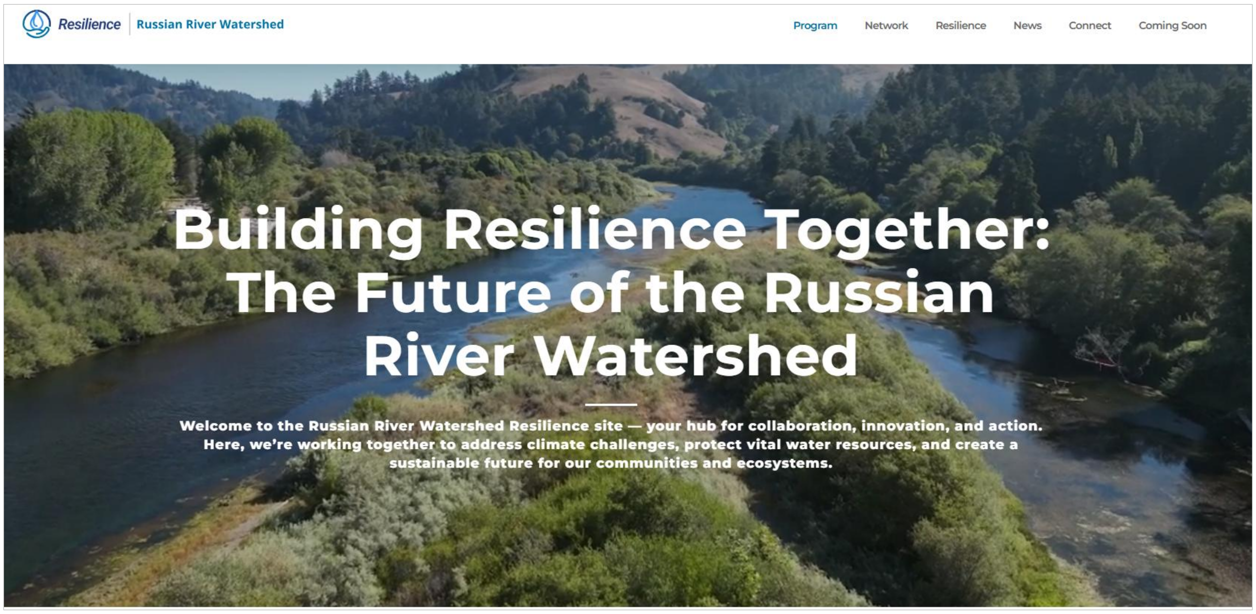
The Russian River Watershed Resilience Pilot (Pilot) was initiated in April of 2024 when DWR formally awarded grants to the five pilots. This Russian River Watershed Resilience Plan (WRP) describes and documents the process, analysis, and findings of the Pilot. Details about the Pilot and the WRP process can be reviewed at the Pilot website: http://russianriverwatershedresilience.org (Figure 1-1).

1.2 Russian River Watershed Resilience Pilot Overview

The Pilot, led by the Sonoma County Water Agency (Sonoma Water), is a $2 million initiative funded by DWR to develop a climate-resilient management plan for the 1,500-square-mile watershed. The Pilot study area supports over 700,000 people, 238 streams, and critical habitats for endangered salmonids and other species. The Pilot aligns with California's Water Plan Update 2023 and focuses on:

- **Climate Vulnerability Assessment:** Quantifying risks from reduced precipitation, drought, floods, extreme heat, and sea level rise
- **Multi-Sector Integration:** Coordinating water supply, flood management, ecosystems, and land use planning across jurisdictional boundaries
- **Equity-Centered Planning:** Engaging Tribes, disadvantaged and frontline communities, and agricultural communities and individuals in decision-making

Figure 1-1. Russian River Watershed Resilience Pilot Website



The Russian River Watershed Resilience website summarizes the process and provides data and documents about the Pilot and Plan.

1.3 Watershed Resilience Planning Process

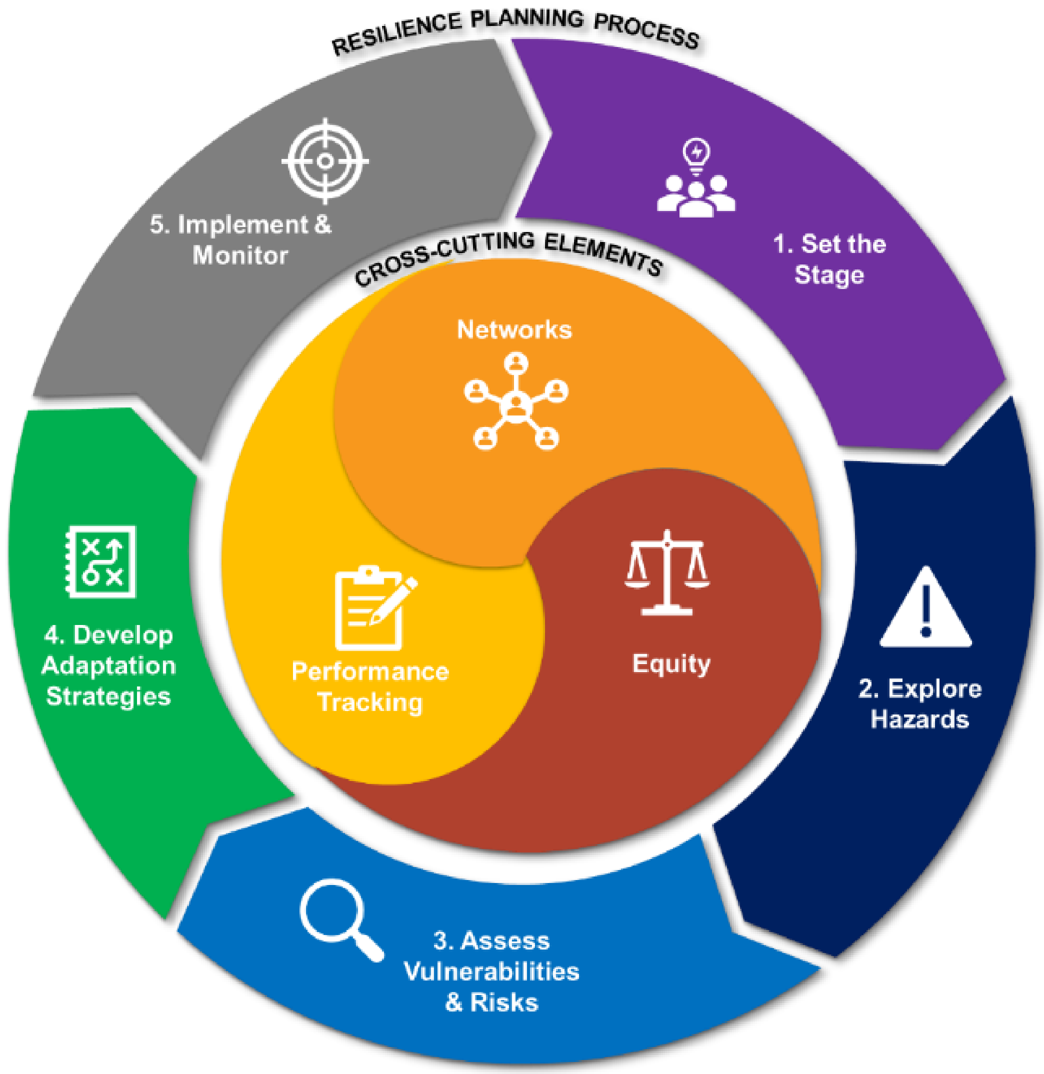
The Russian River Watershed Resilience Pilot applies a five-step resilience planning framework. This framework is consistent with DWR's Watershed Resilience Program resilience planning framework, with locally tailored priorities specific for the Russian River watershed.

1. **Set the Stage**
2. **Explore Hazards**
3. **Assess Vulnerabilities**
4. **Develop Strategies**
5. **Implement and Monitor**

Watershed resilience involves a deep understanding of the water resources, ecosystems, and communities of the Russian River watershed; a review of current and future vulnerabilities in the watershed; and strategies that can help move the needle toward greater watershed resilience.

The framework consists of five main steps, as illustrated on Figure 1-2. At the center of this figure are three elements that are integral to each of the steps. The Watershed Network is the driving force for each of these steps, providing critical direction, input, and review. Equity is woven into the whole process beginning with the composition of the Watershed Network, ensuring there is an inclusive membership engaged, and conducting an equity analysis and embedding equity criteria into the development of adaptation strategies to ensure that adaptation strategies address disproportionate impacts to vulnerable communities. Finally, performance tracking allows specific vulnerability indicators and metrics to be adapted to measure performance based on achievement of the WRP goals and on the risks and objectives for each of the adaptation strategies.

Figure 1-2. Watershed Resilience Planning Process



1. **Set the Stage –** Convene a diverse and inclusive Watershed Network, set vision and goals for this resilience planning effort, and identify the components, interdependencies, and bounds of the planning effort.
2. **Explore Hazards –** Understand current state of the system, historical climate influences on the system, and future projections and uncertainty.
3. **Assess Vulnerabilities and Risks –** Identify water resource and socioeconomic indicators, assess the vulnerability of watershed systems to current and possible future climate conditions, and use risk analysis to identify high-priority focus areas.
4. **Develop Adaptation Strategies –** Identify and evaluate a wide spectrum of adaptation options for high-priority focus areas, consider sustainability principles, and recommend no- or low-regret strategies considering uncertainty.
5. **Implement and Monitor –** Develop the timeline and triggers for implementing selected strategies through on-the-ground actions; fund, implement, and monitor the performance of actions; and adapt strategies as needed.

This WRP documents the overall resilience process undertaken during the Pilot. A summary of the contents is below:

- **Chapter 2, Russian River Watershed and Study Area** describes the characteristics of the watershed, focusing on geography and patterns of settlement, including Tribal history in the watershed and current demographics. Additionally, the water resource sectors are defined and described.
- **Chapter 3, Building Resilience with a Watershed Network** describes the purpose and development of the collaborative Watershed Network formed and convened during the development of the WRP.
- **Chapter 4, Climate Change in the Watershed** presents the historical, current, and future climate hazards used as the foundation for risk and vulnerability analysis.
- **Chapter 5, Water Resource Vulnerabilities** presents the findings of the vulnerability and risk assessment for each of the water resources sectors, including water supply, groundwater, water quality, ecosystems, wildfire, recreation, and hydroelectric.
- **Chapter 6, Adaptation Strategies to Increase Resilience** presents the range of adaptation strategies that were identified to increase resilience to the risks to water resource sectors and evaluates them against several performance criteria.
- **Chapter 7, Implementation Strategies** explores both governance and funding approaches that may be effective in future implementation of the identified adaptation strategies.
- **Chapter 8, Performance Tracking** describes the importance of performance tracking as the WRP moves from planning to implementation, defines the types of indicators and metrics that will be used and how they will be applied to track and support improvements in resilience.
- **Chapter 9, Recommendations** lays out recommendations for next steps to transition from a plan to action.
- **Chapter 10, References** provides the list of resources cited in this document.

2. Russian River Watershed and Study Area

2.1 Watershed Overview

The Russian River watershed is a crucial resource for Northern California, supplying drinking water to more than 700,000 residents across Sonoma, Mendocino, and Marin counties, including numerous Native American Tribes. The health and resilience of the Russian River watershed are central to sustaining the environment, local economies, and quality of life for the many communities that depend on it.

Stretching approximately 110 miles from its headwaters in the Redwood and Potter Valleys to its mouth at the Pacific Ocean in Jenner, the Russian River and its watershed encompass almost 1,500 square miles. This region features a rich mosaic of forests, agricultural lands (most notably vineyards), wetlands, and urban communities.

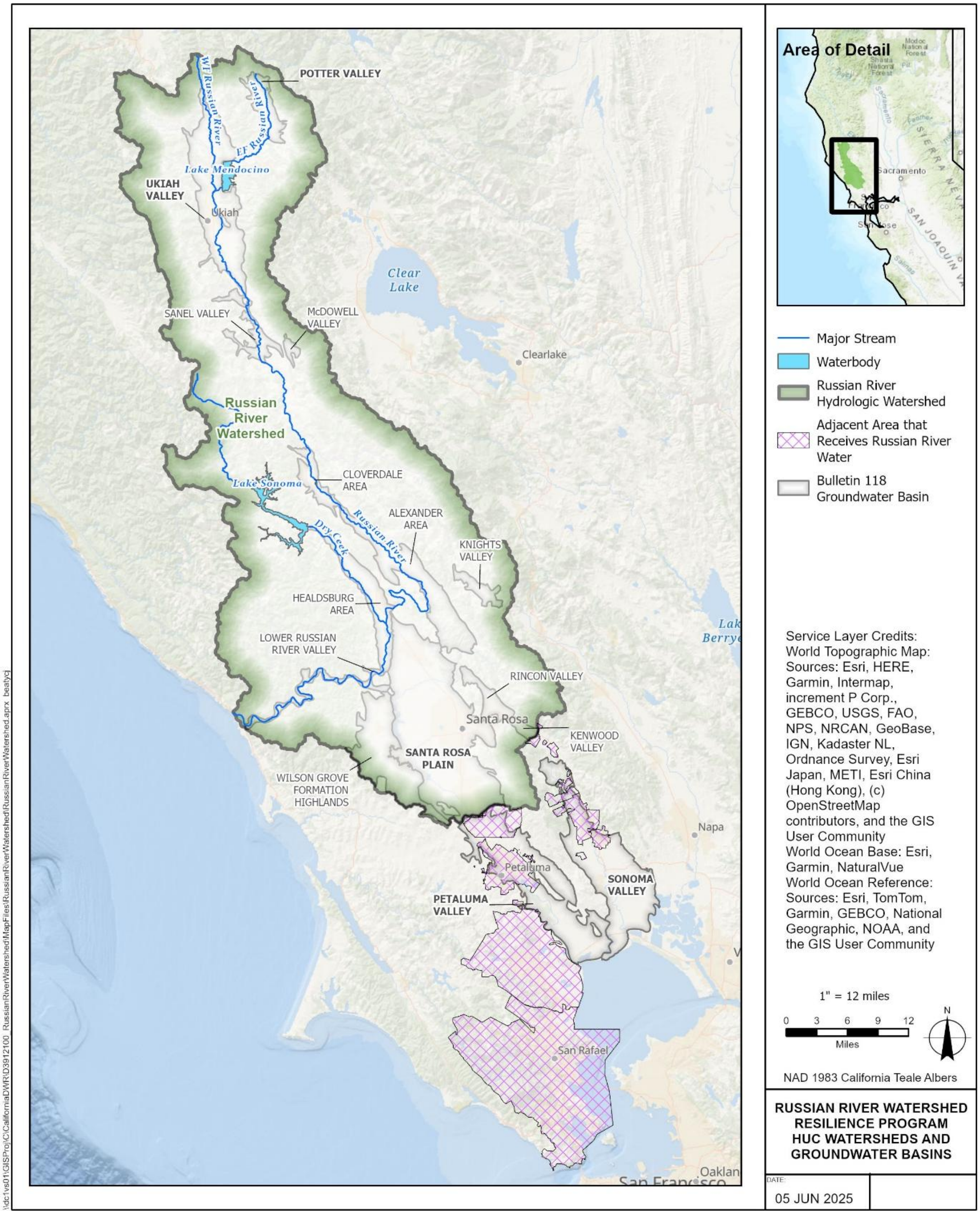
The Russian River's hydrology is defined by a complex network of tributaries, reservoirs, and managed flow regimes that support water supply, flood control, ecosystem functions, and recreation across Sonoma and Mendocino counties. Five principal tributaries—the East and West Forks of the Russian River, Big Sulphur Creek, Mark West Creek-Laguna de Santa Rosa, Maacama Creek, and Dry Creek—contribute to the river's approximately 1,500-square-mile drainage area. The East Fork flows through Potter Valley into Lake Mendocino, while the West Fork begins at the tip of the northern end of Redwood Valley and joins the East Fork southwest of the reservoir. From there, the river flows south through agricultural valleys and the communities of Ukiah, Hopland, Cloverdale, and Healdsburg before being joined by Dry Creek. Downstream of Healdsburg, the river meanders west through the lower Russian River Valley—passing Rio Nido, Guerneville, Monte Rio, Sheridan, and Duncan Mills—before reaching its outlet at Jenner on the Pacific coast. As it meanders through the watershed, the Russian River mainstem is joined by numerous other tributaries as shown on Figure 2-1.

Lake Mendocino and Lake Sonoma provide the watershed's primary managed water storage and flood protection. Lake Mendocino, created by the Coyote Valley Dam on the East Fork in 1958, and Lake Sonoma, formed by Warm Springs Dam on Dry Creek in 1982, are dual-purpose systems that provide both flood control and water supply storage. Flood operations at both reservoirs are managed by the U.S. Army Corps of Engineers (USACE), while Sonoma Water, as the local sponsor, operates water supply releases in accordance with its water right permits and the State Water Resources Control Board's Decision 1610. This decision establishes minimum instream flow requirements in the Russian River and Dry Creek to support municipal, agricultural, and industrial water uses, as well as critical beneficial uses including fisheries, recreation, and aquatic habitat. Additionally, the North Coast Water Board has adopted Tribal Beneficial Use (TBU) definitions for Tribal Tradition and Culture (CUL) and for Tribal Subsistence Fishing (T-SUB). These are recognized beneficial-use categories, but they are not yet assigned to specific water bodies in the Russian River watershed. More information on the potential for TBU designations in the watershed is included in Chapter 5. This coordinated management framework for the watershed's hydrologic system aims to balance human water needs with ecological protections across a highly variable watershed influenced by seasonal precipitation, climate variability, and interannual hydrologic extremes.

2.2 Study Area

For the Russian River Pilot, the study area boundary adopts the HUC-8 Russian River watershed delineation from the *California Watershed Resilience Assessment* (DWR 2024) and adds adjacent areas that receive Russian River water supply. Figure 2-1 shows the watershed study area. The study area includes all or the portions of the following HUC-8s: Russian River (18010110), portions of San Pablo Bay (18050002) overlapping with Sonoma Water service areas, and portions of Tomales-Drake Bays (18050005) overlapping with Sonoma Water service areas. Figure 2-1 shows the Russian River hydrological watershed with an outline in green and the adjacent areas to the south of the watershed that receive Russian River water as hatched areas. Additional details on the study area delineation are provided in Appendix F.

Figure 2-1. Russian River Watershed Resilience Pilot Study Area



The study area includes the entire Russian River watershed, including important hydrological features such as Lake Mendocino and Lake Sonoma; Potter Valley, Ukiah Valley, Santa Rosa Plain, and Alexander Valley groundwater basins; and the Laguna de Santa Rosa and Russian River Estuary. The study area also includes adjacent areas that receive Russian River water, also termed "plus" areas. These areas encompass portions of the North Bay watershed (i.e., Sonoma Water service areas), including the portions of the Sonoma Valley and Petaluma Valley groundwater basins that underlie the Sonoma Water's service area, and Sonoma Water's service areas in the City of Petaluma, Valley of the Moon Water District, City of Sonoma, North Marin Water District (Novato), and Marin Municipal Water District's (Marin Water) service area. This "plus" area expansion ensures that the hydrologic and hydrogeologic conditions of the Russian River watershed that affect water supply to all relevant communities, infrastructure, and populations are being considered for this effort.

The study area encompasses the upland headwaters and tributaries of the Russian River in addition to the significant resources along the mainstem Russian River. The boundary includes two federally owned reservoirs that affect flows in the Russian River watershed, Lake Mendocino, and Lake Sonoma. USACE owns these facilities and manages releases from the respective flood pools while Sonoma Water, as the local sponsor, controls and manages releases from the water conservation pools to meet consumptive demands by authorized users and minimum instream flow requirements pursuant to State Water Resources Control Board Decision 1610. Releases from Lake Mendocino, located in the upper Russian River watershed near Ukiah, into the Russian River meet minimum instream flow requirements and downstream water demands for the Upper Russian River, a 63-mile stretch of the Russian River from Coyote Valley Dam to the confluence of Dry Creek near Healdsburg. Sonoma Water also manages water supply releases from Lake Sonoma, located in the lower watershed, into Dry Creek to meet minimum instream flow requirements and downstream demands for a 14-mile stretch of Dry Creek to the confluence of the Russian River, as well for the 31-mile stretch of the Russian River from the confluence of Dry Creek to the Pacific Ocean near Jenner. Sonoma Water diverts water from the Russian River at its Wohler and Mirabel diversion facilities located near the town of Forestville and delivers potable water via its regional transmission system to its water contractors and customers in Sonoma and Marin counties. The Russian River also receives trans-basin imports from the Eel River through the Potter Valley Project (PVP), a hydroelectric facility owned and operated by the Pacific Gas and Electric Company (PG&E). Imports from the PVP are released into the upper reach of the East Fork Russian River approximately 12 miles upstream of Lake Mendocino. In addition, the study area includes reservoirs managed by Marin Water and North Marin Water District. North Marin Water District and Marin Water supplement their local water supply with Russian River water that is delivered through Sonoma Water's transmission system.

The comprehensive climate vulnerability assessment for the Russian River Pilot was conducted for the Russian River hydrologic watershed. A limited evaluation of water supply, both surface water and groundwater, was conducted in the "plus" areas outside the Russian River watershed that are included in the study area boundary.

2.3 History of the Study Area

The Russian River watershed has a long and dynamic history shaped by Indigenous stewardship, European settlement, and modern development. In the early 19th century, Russian fur traders established settlements along the coast, giving the river its current name, followed by American settlers whose logging, agriculture, and urbanization transformed the landscape. This intervention by settlers with a focus on resource extraction irreversibly altered the lands and the cultural landscape that had been shaped and sustainably tended to by Indigenous communities in the watershed for thousands of years. Over time, the watershed's resources have become a critical resource for farming, particularly vineyards, and for the expanding communities of Sonoma and Mendocino counties. Today, the Russian River watershed serves as a critical environmental and economic foundation that supplies drinking water to more than 700,000 people including Tribal communities, supports agriculture, and attracts millions of recreational visitors each year. In addition to ongoing challenges of population growth and resource conflicts, the region now faces growing pressures from climate change, including drought, flooding, and threats to water quality and endangered species.

2.4 Indigenous Peoples of the Watershed

The Indigenous peoples of the Russian River watershed are the original stewards of the area. Indigenous land management practices, including controlled burning, selective harvesting, and traditional resource stewardship, shaped the watershed's ecology and continue to influence hydrology in the present. These practices created resilient landscapes that supported diverse ecosystems and sustained communities through careful observation and adaptive management. Their ongoing relationship with the watershed represents the deepest form of ecological resilience and their collective stewardship created the resilient landscapes that European settlers encountered upon their arrival in the 1800s.

European colonization beginning in the 1800s resulted in forced displacement and decimation of Indigenous populations, introduction of new land and water management systems, and restricted access to traditional territories. The construction of dams altered river flows and blocked historical salmon migration routes. Water management policies developed during this period generally did not incorporate Traditional Ecological Knowledge (TEK) or include Indigenous governance structures.

Tribal governments and communities continue to engage in watershed planning and management activities. Their participation brings multi-generational knowledge of local ecosystems, historical ecological conditions, and traditional management practices to contemporary water resource decisions. Since time immemorial, Indigenous and Tribal people have observed, adapted to, and influenced hydrological patterns through sophisticated practices that maintained watershed health across generations. This knowledge encompasses deep understanding of seasonal water cycles, species interrelationships, land-water connections, and the long-term impacts of a co-managed approach to watershed resiliency. Traditional practices complement and often exceed the temporal and spatial scales of conventional water management. Meaningful collaboration with Tribal governments and knowledge holders requires respect and reciprocity, recognizing Tribal sovereignty over their knowledge systems and ensuring that Indigenous voices have decision-making authority in watershed planning and management.

Multiple Tribes maintain connections to the watershed, including: Bear River Band of Rohnerville Rancheria, Big Valley Band of Pomo Indians of the Big Valley Rancheria, Cahto Tribe, Cloverdale Rancheria of Pomo Indians, Coyote Valley Band of Pomo Indians, Dry Creek Rancheria of Pomo Indians, Elem Indian Colony Pomo Tribe, Estom Yumeka Maidu Tribe of the Enterprise Rancheria, Federated Indians of Graton Rancheria, Grindstone Rancheria of Wintun-Wailaki, Guidiville Rancheria of California, Habematolel Pomo of Upper Lake, Hopland Band of Pomo Indians, Kashia Band of Pomo Indians of the Stewarts Point Rancheria, Koi Nation, Lytton Rancheria, Manchester Band of Pomo Indians of the Manchester Rancheria, Middletown Rancheria of Pomo Indians of California, Mishewal-Wappo Tribe of Alexander Valley, Muwekma Ohlone Tribe of the San Francisco Bay Area, Noyo River Indian Community, Pinoleville Pomo Nation, Potter Valley Tribe, Redwood Valley or Little River Band of Pomo Indians, Robinson Rancheria of Pomo Indians, Round Valley Reservation/Covelo Indian Community, Scotts Valley Band of Pomo, Sherwood Valley Rancheria of Pomo, and the Yokayo Tribe.

2.5 Water Resource Sectors

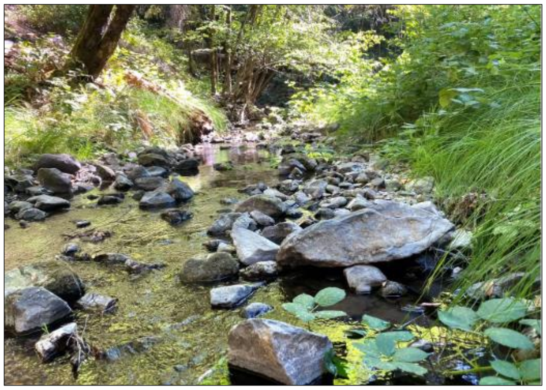
Guidance from DWR for the WRP and each of the pilots included addressing each of the following seven water resource sectors. These are sectors that are dependent on, or impacted by, variation in the hydrologic cycle as driven by climate change.

- Surface Water Supply
- Groundwater Supply
- Flood Management
- Ecosystems
- Water Quality
- Recreation
- Hydropower

2.5.1 Surface Water Supply

The Russian River watershed is a vital water source for Northern California, encompassing about 1,500 square miles across Mendocino and Sonoma counties. The surface water resources of the Russian River watershed serve as the region's primary water source, supplying over 700,000 residents in Sonoma, Mendocino, and Marin counties. Water from the Russian River and its tributaries support a wide range of uses, including residential, commercial, agricultural, and environmental needs. Russian River water is stored in two major reservoirs: Lake Mendocino and Lake Sonoma within the watershed.

2.5.2 Groundwater Supply



Groundwater is a critical part of the Russian River watershed's water supply, supporting homes, farms, ecosystems, and businesses across Sonoma and Mendocino counties. Many residents—especially those in rural areas—depend on groundwater wells for their drinking and irrigation water, while agriculture and municipal systems also rely on groundwater to meet demand when surface water supply is limited. Climate change is expected to reduce natural recharge rates due to less frequent and more intense precipitation events, increased evaporation, and shorter, warmer winters.

2.5.3 Flood Management

Atmospheric rivers are responsible for over 99% of flood damages in Sonoma County, with all major Russian River floods since 1997 linked to these events (Corringham et al. 2019). The lower Russian River's narrow floodplain and steep terrain accelerate and deepen floodwaters, increasing flooding and risk to communities like Guerneville and Monte Rio. Flooding is compounded by sedimentation from upland erosion and post-fire runoff, which reduces channel capacity and increases the likelihood of levee overtopping and infrastructure damage. Additionally, increase in impervious surfaces, particularly in the Santa Rosa Plain area, contribute to flooding impacts in the lower Russian River. Flood management is further complicated by aging infrastructure and high-risk development in flood-prone areas.

2.5.4 Ecosystems

Ecosystems in the Russian River watershed are fundamental to the region's health and resilience, providing a wide array of benefits that support both people and nature. In the upper reaches, redwood forests and oak woodlands provide habitat for a variety of plants and animals, while lush riparian corridors along the riverbanks help filter water, stabilize soils, and offer critical refuge for endangered coho salmon and threatened steelhead trout (California Department of Fish and Wildlife 2023; Sonoma County Water Agency 2024). Wetlands and floodplains enhance biodiversity, reduce flood risks, and serve as important stopovers for migratory birds (NOAA Fisheries 2024). However, development in the basin has encroached on the historical floodplain and, along with managed flows, reduced the river's access to its historical floodplains and caused down-cutting, which has compromised access to floodplains, impacting ecosystem and flood management benefits. Nonetheless, these interconnected habitats do sustain unique species, such as the Pacific lamprey, California roach, and iconic redwoods protected in parks like Armstrong Redwoods State Natural Reserve (California State Parks 2024). Ongoing conservation efforts by Tribes, local agencies, conservation groups, and federal partners aim to balance ecological health with community needs, striving to improve conditions in the watershed to ensure that the Russian River's ecosystems will provide clean water, recreation, and resilience against climate change (Sonoma County Water Agency 2024; NOAA Fisheries 2024). Ecosystem health in the Russian River watershed is directly threatened by climate-driven changes, such as warmer stream temperatures, reduced flows, and increased sedimentation—especially after wildfires and during drought. These conditions have led to documented strandings and mortality of endangered salmon and steelhead in the upper and lower watershed, including in tributaries like Mill Creek, Green Valley Creek, and Dutch Bill Creek during dry years, while post-fire sediment runoff, such as after the Walbridge Fire, has degraded critical habitats and increased risks to aquatic life.

2.5.5 Water Quality

Many water bodies in the Russian River watershed are listed under Clean Water Act Section 303(d) due to water quality impairments caused by several different pollutants. The Russian River watershed is impaired for sediment and temperature as well as pathogen, mercury, phosphorus, and dissolved oxygen impairments identified in water bodies throughout the watershed. Water quality is at risk due to a combination of drought, wildfire, and wastewater (urban and agricultural runoff). Drought concentrates pollutants and nutrients, increasing the likelihood of harmful algal blooms and degraded drinking water. Post-fire runoff increases sediment and ash and other pollutants in waterways, threatening both water supply (notably Lake Sonoma's drinking water) and aquatic species.

2.5.6 Recreation

The Russian River is a major recreational asset for the region. Visitors and locals enjoy canoeing, kayaking, tubing, and even some whitewater rafting along the river's scenic stretches, while over 100 miles of trails invite hikers, runners, mountain bikers, and horseback riders to explore the region's redwoods and rolling hills. Fishing is a popular activity, and several beaches—including Johnson's Beach and Memorial Beach—provide great spots for swimming, picnicking, and relaxing by the water. Recreation is closely tied to watershed health. The Lake Mendocino and Lake Sonoma recreation areas offer a variety of recreational activities, including boating, water skiing, swimming, camping, fishing, hunting, picnicking, mountain biking, horseback riding, and sightseeing. The impacts of climate change, including floods, droughts, and wildfires can restrict access, degrade water quality, and reduce opportunities for boating, fishing, and other activities.

2.5.7 Hydropower

Within the Russian River watershed, hydropower is generated by water released from Lake Mendocino at Coyote Valley Dam and from Lake Sonoma at Warm Springs Dam. The hydropower generation at each of these dams is primarily opportunistic, subject to releases for water supply, flood management, and instream flow purposes. For over a century, the PVP, owned and operated by PG&E, has imported water from the Eel River to generate hydropower. However, PG&E stopped generating power at the facility in 2021 due to failure of a transformer bank at the powerhouse. The Federal Energy Regulatory Commission (FERC) license for the PVP expired in April 2022, and the PVP is currently operated under annual license issued by FERC. In July 2025, PG&E filed a license surrender application with FERC that proposes to decommission the project and remove the two dams that are part of the PVP: the Scott Dam and the Cape Horn Dam.

3. Building Resilience with a Watershed Network

3.1 Why a Network?

The Watershed Network serves a critical purpose of convening watershed stewards across water resource sectors and communities to acknowledge the effects of climate change and to collaborate on adaptation strategies to build resilience.

Figure 3-1. Watershed Network Paddle on the Russian River (September 17, 2025)

The Watershed Network is central to advancing the priorities of the Watershed Resilience Program, ensuring that resilience planning reflects the unique and diverse perspectives and knowledge of the communities within the Russian River watershed.

As described in Chapter 1, the Watershed Resilience Program nests within themes of the Water Plan Update 2023, addressing climate urgency, strengthening watershed resilience, and achieving equity in water management (California Department of Water Resources 2024a).

The Watershed Resilience Program principles advanced by DWR (California Department of Water Resources 2024b) articulate the purpose of convening a Watershed Network:

- Promote multi-sector, multi-benefit resilience strategies.
- Integrate and prioritize equity and social justice as part of the planning and implementation process.
- Focus on watersheds and interdependencies of water resource systems.
- Build and strengthen diverse watershed networks through collaboration, relationships, and trust.
- Apply best available science and promote best practices, approaches, and tools for climate resilience planning.
- Build a robust understanding of climate risks and embrace uncertainty by considering a range of plausible future conditions.
- Promote outcomes-based management with watershed performance indicators and a focus on implementation.

3.2 Building the Network

The Russian River Watershed Network brings together diverse perspectives and knowledge from across water sectors, communities, and the watershed. The Watershed Network is currently composed of 125 active individuals spanning a wide range of organizations including cities and towns, counties, federal and state agencies, groundwater sustainability agencies, Native American Tribes, non-governmental organizations, resource conservation districts, special districts, and watershed associations.

- *The Watershed Network brought together over 100 organizations across the watershed and across sectors to collaborate on understanding the risks of climate change to the Russian River watershed.*
- *Network members contributed local knowledge regarding vulnerabilities and risks to resources and systems and suggested hundreds of adaptation strategies to address those risks.*
- *There is broad agreement that the Watershed Network should continue to work together to implement the collaboratively developed WRP and advance identified adaptation strategies.*

Member organizations collectively represent the full breadth of the watershed's resource interests, including agriculture, economic development, hydropower, equity, flood management, groundwater, land use, recreation, TEK, and water quality. The Watershed Network was intentionally designed to include organizations with the capacity to implement or promote adaptation strategies, those with management responsibility for the resources of the Russian River watershed, advocates for frontline and under-represented communities, and Tribal community representatives. To advance equity and remove financial barriers to participation, compensation was made available to Watershed Network participants without institutional support. A full list of Watershed Network member organizations is available in Appendix A.

3.3 Network Governance

3.3.1 Network Charter

To establish clear roles and responsibilities, a Network Charter was developed and shared with all members. The charter outlined expectations for Watershed Network members, including:

- Participate and prepare for Watershed Network meetings by reviewing materials in advance and attending sessions to contribute insights from their agency, organization, or Tribal perspective
- Contribute to the development of the WRP through meeting discussions and online engagement opportunities
- Adhere to meeting guidelines that emphasize respect, understanding, and making space for diverse voices
- Collaborate with members from diverse backgrounds, perspectives, and water resource sectors

The complete Network Charter is included in Appendix A.

A significant product of the charter process was a collaboratively designed vision statement that captured the shared purpose of the Watershed Network:

Vision Statement

Actively steward the resources of the Russian River watershed to be increasingly climate resilient by working together across water resource sectors in collaboration with local and Tribal communities.

3.4 Network Activities

3.4.1 Engagements

The Watershed Network meeting schedule was designed to welcome collaboration and input at each major milestone of the WRP development. Meetings were structured with the intention of creating a two-way learning environment where Watershed Network members both contributed local knowledge and expertise and gain additional understanding of climate science, vulnerability assessment methods, and adaptation strategies. This approach aligns with the Watershed Resilience Program principles of applying best available science while building diverse networks through collaboration and trust.

Over the 18-month study period, six virtual Watershed Network meetings were held each corresponding to key project milestones as shown Table 3-1. Two additional technical deep dive meetings were added at the request of the Watershed Network. Across these eight scheduled events, 110 organizations participated in the Russian River Watershed Network.

Additional focused outreach efforts were conducted to key groups and agencies. A key feature of the outreach design was to encourage two-way information sharing among the project team and the Watershed Network.

Table 3-1. Meeting Schedule and Topics

Meeting Details	Study Milestones	Meeting Topics	Products for Review and Input
Virtual Network Meeting 1 February 26, 2025	Setting the Stage	▪ Watershed Resilience Pilot Process ▪ Network Charter ▪ Draft Goals and Vision ▪ Watershed Boundary	▪ Project fact sheet ▪ Network Charter ▪ Draft goals and vision ▪ GIS watershed boundary
Virtual Network Meeting 2 May 06, 2025	Explore Hazards/ Assess Vulnerabilities and Risks	▪ Historical Hazards and Impacts ▪ Future Hazards	▪ Historical hazard summary ▪ Projections of future hazards ▪ Gap analysis of studies needed for analysis ▪ Draft vulnerability metrics
Virtual Technical Call 1 July 19, 2025	Assess Vulnerabilities and Risks	▪ Indicators and Metrics	▪ Draft vulnerability metrics
Hybrid Network Meeting 3 September 16, 2025	Assess Vulnerabilities and Risks	▪ Vulnerability and Risk Assessment	▪ Draft vulnerability and risk assessment
Virtual Network Meeting 4 December 10, 2025	Assess Vulnerabilities and Risks/ Develop Adaptation Strategies	▪ Vulnerability and Risk Assessment (Revised) ▪ Initial Adaptation Strategies	▪ Refined vulnerability and risk assessment results ▪ Initial list of adaptation strategies
Virtual Technical Call 2 January 20, 2026	Assess Vulnerabilities and Risks	▪ Technical Details on Modeling Efforts Across Resource Areas	▪ Initial list of adaptation strategies
Virtual Network Meeting 5 February 24, 2026	Develop Adaptation Strategies	▪ Review Revised Adaptation Strategies	▪ List of draft adaptation strategies and evaluation
Virtual Network Meeting 6 March 24, 2026	Implement and Monitor	▪ Strategy Implementation Paths	▪ Draft implementation paths for strategies and recommendations for plan

3.4.2 Information Exchange

To maximize accessibility and engagement, multiple pathways were established for distributing information to Watershed Network members. Five meetings were held virtually to facilitate broad participation. One meeting was held in a hybrid format to encourage relationship building but still remain accessible for those who were not able to join in person. Materials were also made available through a dedicated project website (https://russianriverwatershedresilience.org/), which serves as a central repository for meeting agendas, presentation materials, draft work products, and supplementary resources.

- *110 communities and organizations*
- *Six Watershed Network workshops*
- *Two interactive mapping tools*
- *18 kayaks floating down the Russian River to visit key landmarks*
- *Two technical deep dives meetings*
- *16 meetings with key partners in the region*
- *Two meetings with Mendocino, Lake, Sonoma Tribal Environmental Professionals (MLSTEP)*
- *One vision and one plan*

Recognizing that different participants have varying preferences and capacities for providing input, the project team implemented multiple avenues for collecting feedback and ideas from Watershed Network members. Input was collected through interactive polling during meetings using Mentimeter, which allowed for real-time feedback and prioritization exercises. Meeting chat functions provided an opportunity for participants to share thoughts without interrupting discussions. Verbal input was welcomed and encouraged in real time during discussions. Written comments could be submitted via email after meetings, accommodating those who preferred to reflect on or consult with their organization or community before responding. Additionally, GIS tools were utilized to gather spatially specific input on vulnerability areas and potential adaptation strategy locations, enabling members to contribute to location-based knowledge and priorities.

3.4.3 Tribal Participation

Tribes remain active partners in ongoing watershed restoration, resource management, and climate adaptation efforts. Recognizing the critical importance of Tribal participation and sovereignty, Sonoma Water, as the project convenor, offered formal government-to-government consultation, participation in the Watershed Network, or both. With the assistance of the California Native American Heritage Commission, 29 Tribes were identified within the Russian River watershed boundary. A full list of Tribes is in Appendix A. Some Tribes requested formal consultation, some joined the network, and others did both. Sonoma Water, as convenor of the Pilot, continued to share Watershed Network meeting invitations, as well as notes, materials, and opportunities for feedback to the Tribes in the watershed throughout the duration of the Pilot.

To support Tribal engagement, the team consulted with members of the California Indian Environmental Alliance (CIEA), who kindly conducted additional outreach to Tribes within the watershed, attended and contributed insight regularly at Watershed Network meetings, and advised on options for receiving feedback from Tribal communities. These conversations helped bridge communication and approach efforts while incorporating learnings from previous joint management initiatives.

Several key considerations were identified, namely data sovereignty, diversity of Tribal interests, the incorporation of TEK, preservation of government-to-government consultation, direct consultation with Tribes outside of a network environment, and the timing of the Pilot grant cycle being a potential barrier to Tribal participation. The expedited timing of the Pilot did pose a challenge to establishing new, meaningful relationships with Tribes in the watershed, and to incorporating formal feedback at each milestone before moving to the next. However, Tribal participation perspectives were shared throughout the Watershed Network meetings. Tribes shared key insights on historical hydrologic conditions, fire management practices, ecosystem management, metrics and definitions for TBU, and land stewardship models.

The project team is appreciative of being able to attend two meetings convened by MLSTEP, which provided focused discussion opportunities for Tribal environmental staff working on climate and natural resource issues.

The project team would like to acknowledge that the scope, terms, and completeness of Tribal participation are determined by each Tribe, not by the Pilot or its administrators. Sonoma Water will continue conversations with Tribes for consultation and discussions beyond the study time period.

3.4.4 What Is Next for the Watershed Network?

The Watershed Network process has created a strong foundation for the implementation of adaptation strategies identified through the collaborative planning process. The Watershed Network established deep cross-sector knowledge, strengthened relationships among diverse parties, and deepened ongoing collaboration that will extend beyond the grant period.

To ensure the sustainability and longevity of the Watershed Network, several mechanisms have been put in place. The project website will continue to serve as a resource hub for watershed resilience information and a platform for ongoing engagement. While future funding and governance has yet to be established given the exploratory nature of the Pilot study, these investments in network infrastructure position the Russian River watershed to continue advancing climate resilience well into the future.

4. Climate Change in the Watershed

4.1 Introduction

The Russian River watershed is characterized by a climate with wet and dry seasons, with significant variations in the ecosystem from inland drier environments to coastal ecosystems with significant influence and cooling. Much of its annual precipitation occurs between late fall and early spring, with the remainder of the year experiencing drier conditions. A large portion of the surface water supplies received by the watershed are provided in the form of atmospheric rivers (ARs), or long, concentrated bands of moisture fueled by warming over the Pacific Ocean. While landfalling ARs can be beneficial for providing much-needed water supplies or alleviating drought conditions for the watershed, they can also create catastrophic flood events when too much precipitation is received in a short amount of time. Conversely, when drier conditions persist for too long in the absence of sufficient precipitation, the watershed can experience severe, sometimes multi-year droughts. These rapid shifts between extreme wet and dry periods have resulted in some of the most intense floods and droughts in California's history.

The hydrologic and ecological responses to climate-driven hazards reflect both natural watershed characteristics and the extensive human modification that has occurred over the 19th and 20th centuries. Construction of levees and channels, gravel mining, logging, and the expansion of agricultural and urban land have modified sediment transport, reduced floodplain connectivity, and altered flow regimes and many of the other natural buffers to extreme climate conditions to support human development in the watershed. Completion of Coyote Valley Dam in 1959 and Warm Springs Dam in 1983 provided additional flood control and water supply benefits for the watershed, while also influencing downstream geomorphic processes and cold-water conditions vital for fisheries. These watershed-scale modifications were intended to mitigate the effects of events induced by wet or dry climate conditions. However, as climate conditions change throughout the Russian River watershed, infrastructure and operational regimes must be reevaluated as well.

Understanding historical climate trends and how these conditions may evolve over the current century is vital to informing improvements to infrastructure, ecosystem needs, shifts in resource management, and subsequent planning efforts and analyses. This chapter explores historical climate conditions across the Russian River watershed and presents projected changes in temperature, precipitation, and associated watershed responses, including flooding, droughts, and wildfires. This work builds upon several previous efforts aimed at better understanding historical climate trends and future climate projections within the Russian River watershed, including the Sonoma Water Climate Adaptation Plan, North Coast IRWM Plan, DWR's California Watershed Resilience Assessment, local and multi-jurisdictional hazard mitigation plans, groundwater sustainability plans, and more.

4.2 Historical Climate

Historical climate conditions can be viewed from two perspectives: large-scale trends in climatic observations and event-based, climate-driven hazards. Historical observations demonstrate how climate conditions, such as temperature, precipitation, and streamflow, have changed over the last century and beyond. Historical hazards, such as floods, droughts, and wildfires, offering insight into the frequency and magnitude of these events alongside historical observations.

4.2.1 Long-term Historical Trends

Reconstruction of streamflow in the Russian River using tree-ring records allow the historical record of streamflow to be extended back to 1582, providing a long-term perspective on hydrologic variability prior to the stream gage measurements (beginning in 1911). These streamflow reconstructions are based on correlations between annual tree-ring-width patterns in moisture-sensitive tree species and observed streamflow, allowing for estimation of past droughts, wet periods, and multi-decadal trends. The resulting 423-year record (1582 through 2004) captures a wide range of hydrologic extremes and enhances understanding of natural climate variability relevant to water-resource planning and resilience assessments (Woodhouse and Griffin 2008). The paleo-reconstructed period for the Russian River at Healdsburg between 1582 and 2004 (Figure 4-1) exhibits a median annual flow of about 897 thousand acre-feet (TAF), with its wide range of annual flows between 0 to 2,188 TAF reflecting the natural historical climate variability in the watershed and episodes of both severe drought and major floods.

Historical measurements between 1911 and 2024 offer a more limited window into the history of the watershed but provide higher accuracy for evaluating trends in temperature, precipitation, and streamflow for the Russian River watershed over the last century. Historical temperature and precipitation trends are evaluated using gridded historical meteorological data developed from daily station data and monthly data from the Parameter-elevation Regressions on Independent Slopes Model (Daly et al. 2008). Spatially averaged historical temperatures over the Russian River hydrologic watershed demonstrate a long-term warming trend, despite considerable year-to-year variability (Figure 4-2). Annual average temperatures fluctuate between 55 and 60 degrees Fahrenheit (°F), with cooler periods noted in the early and mid-1900s. The warmest years appear clustered after 2000, indicating that the Russian River watershed has experienced more frequent and sustained warm temperature conditions in the beginning of the 21st century.

The spatially averaged historical precipitation record for the Russian River hydrologic watershed between 1911 and 2024 shows substantial interannual variability, which is characteristic of the highly dynamic climate within the region (Figure 4-3). Annual precipitation fluctuates widely for the watershed, with less than 20 inches of rainfall in extreme dry years and more than 70 inches in extreme wet years. Long-term trends highlight multi-decadal oscillations between wet and dry conditions, including a generally wetter period in the early 20th century that gradually transitions into drier conditions leading up to wetter years in the mid-century. In recent decades, precipitation trends show heightened variability rather than a clear trend, reflecting the increasing frequency of both very dry and very wet years.

The historical record of observed total flow for the Russian River at Healdsburg (Flint et al. 2014) between 1911 and 2024 shows substantial interannual variability, closely reflecting the watershed response to swings in precipitation (Figure 4-4). Annual flows demonstrate a wide range of fluctuations from extremely dry years with less than 200 TAF to exceptionally wet years exceeding 2,000 TAF. In more recent decades, the flows at Healdsburg exhibit notable variability but suggest no strong directional trend, mirroring the alternating patterns of severe drought and intense wet years that have characterized the early 21st century.

Figure 4-1. Paleo-Reconstructed Total Flow for the Russian River at Healdsburg Between 1582 and 2004

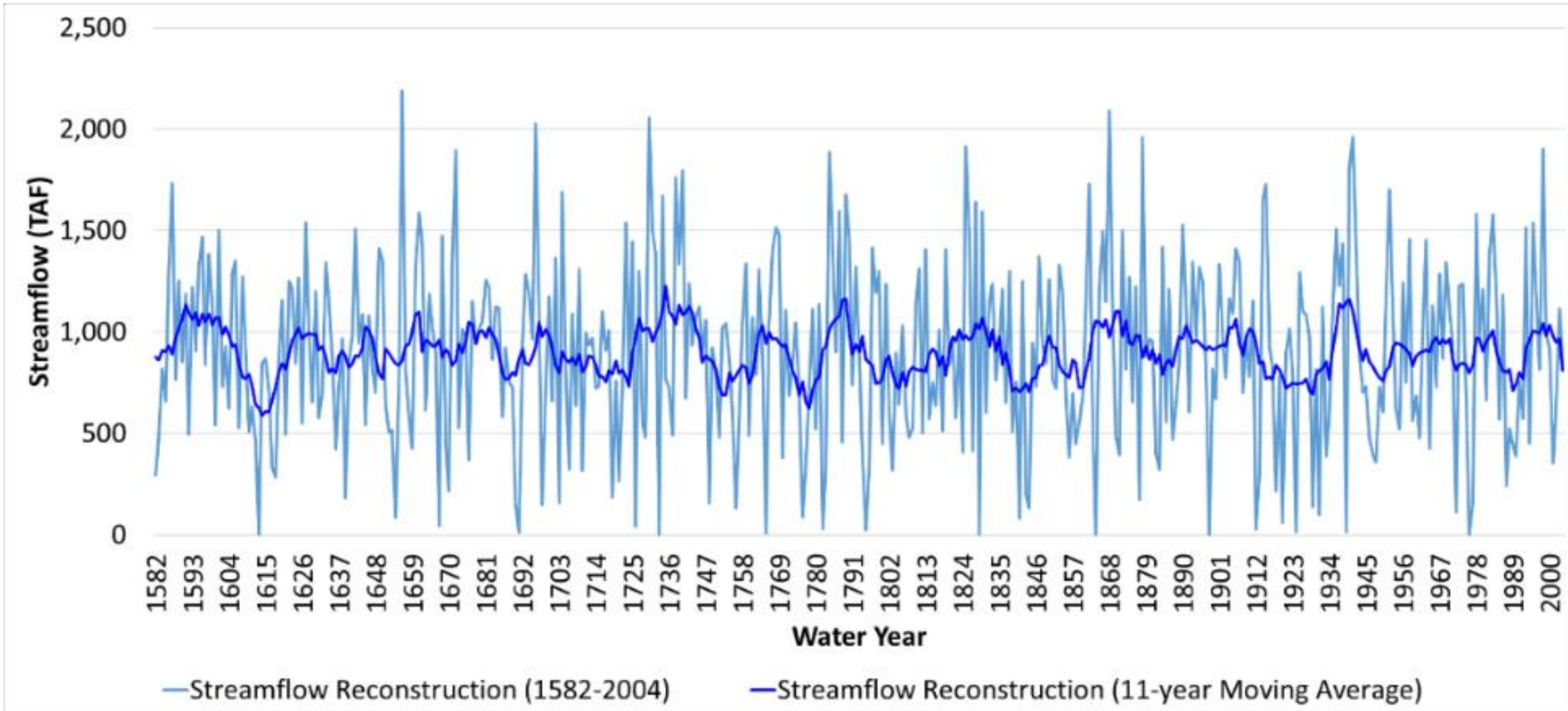


Figure 4-2. Spatially Averaged Historical Average Temperatures Between 1911 and 2024 over the Russian River Hydrologic Watershed

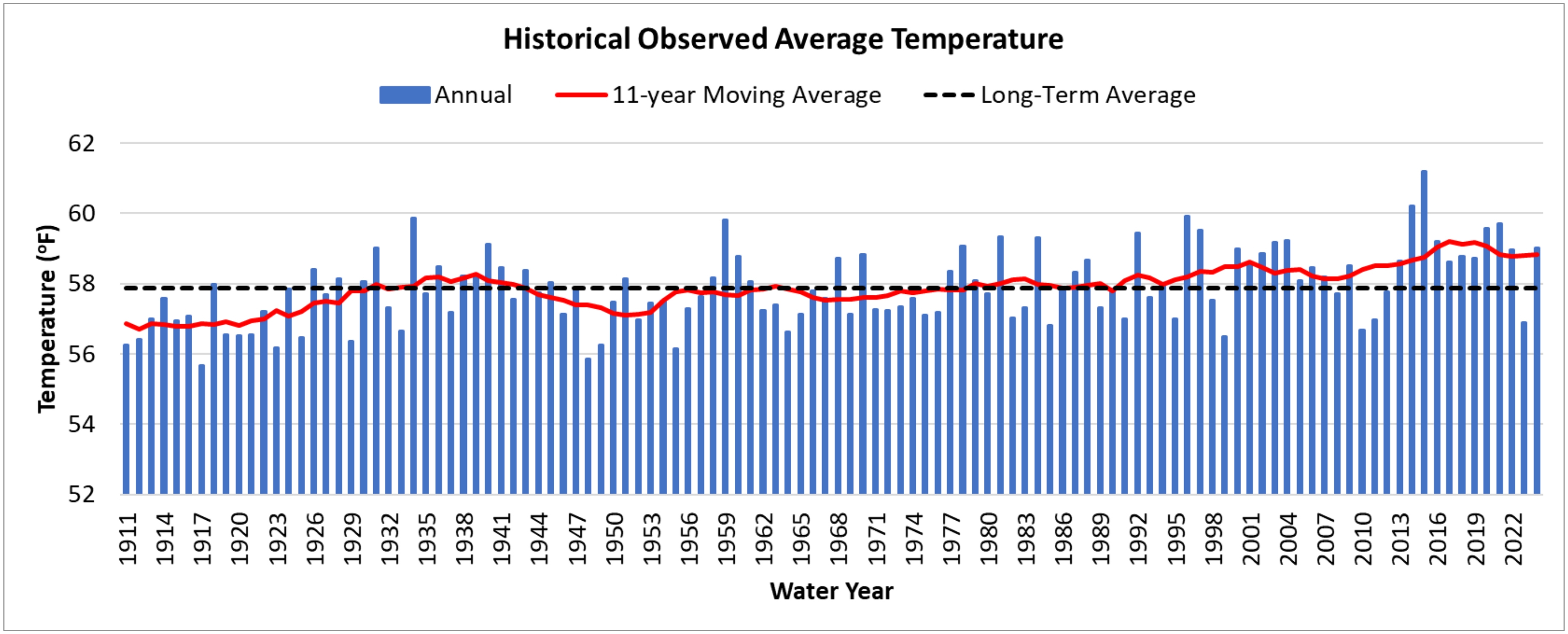


Figure 4-3. Spatially Averaged Historical Precipitation Between 1911 and 2024 over the Russian River Hydrologic Watershed

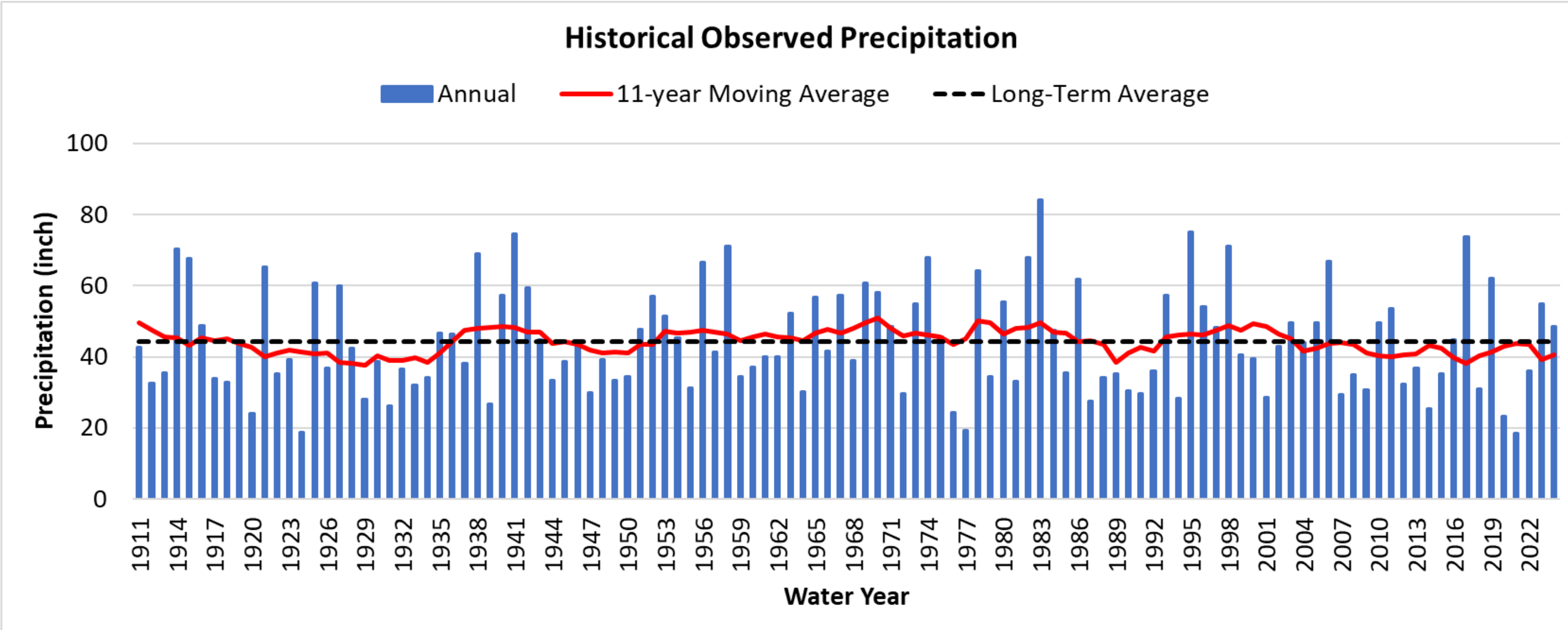
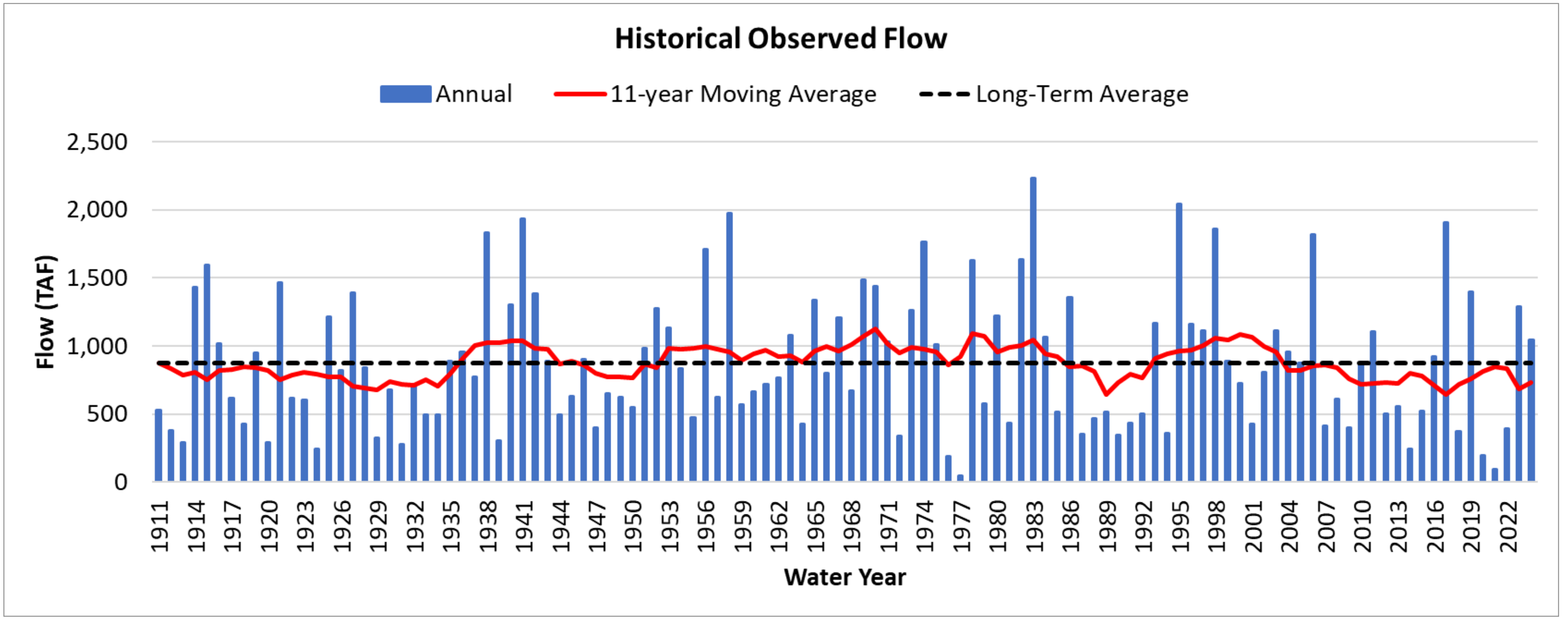


Figure 4-4. Historical Total Flow for the Russian River at Healdsburg Between 1911 and 2024



4.2.2 Historical Hazards

The Russian River watershed has experienced major weather-related events in recent decades. Rising temperatures and greater variability in precipitation have contributed to more frequent and intense floods and wildfires, prolonged droughts, and significant disruptions to water resources and ecosystems. Figure 4-5 provides a timeline of a selection of significant climate-driven weather events following 1976. It is important to note that this figure does not convey the full range of historical hazard events over the last 5 decades; additional information is provided in Appendix G. Understanding these historical patterns is essential for identifying current vulnerabilities and developing effective resilience strategies.

4.2.2.1 Extreme Temperatures and Drought

The Russian River watershed is susceptible to rising temperature extremes. In addition to acute heat waves, chronic warming trends are evident: the region now experiences more days above 100°F than in past decades, and the majority of the top 10 hottest periods on record between July and September have occurred within the last 20 years (California Department of Insurance 2024). These rising temperatures impact crop productivity, human health, water quality, and stream temperatures that are necessary for aquatic species survival.

The Russian River watershed is also highly vulnerable to extreme drought, which poses significant challenges to both water availability and quality. Droughts in this region develop gradually over multi-year periods, with recent severe events occurring from 2012 to 2016 and 2020 to 2022, and other historical droughts within the last 50 years recorded in 1976 to 1977, 1987 to 1992, and 2007 to 2009. These droughts resulted in reduced reservoir storage, impaired streamflows, increased groundwater reliance, and losses for both the agricultural community and ecosystems.

4.2.2.2 Wildfires

The Russian River watershed has also experienced several significant wildfires in recent years, including the Mendocino Complex Fire, Kincade Fire, Sonoma Complex Fires, Walbridge Fire, and Glass Fire. Fire regimes have intensified in recent years due to fuel accumulation, invasive vegetation, hotter summers, and expansion of development into fire-prone areas. These events have had profound impacts on regional communities and the watershed, including impairments to water quality, destruction of infrastructure, and degraded ecosystems.

4.2.2.3 Extreme Precipitation and Flooding

All major Russian River floods in recent decades, including the catastrophic events of 1986, 1995, 2006, and 2019, have been linked to AR conditions, which account for over 99% of flood damages in Sonoma County (Sonoma Countywide Flood Risk Management Assessment 2024; CW3E 2021). AR-driven flooding represents the majority of economic flood losses in Sonoma County, historically exceeding hundreds of millions of dollars per event in documented cases (Corringham et al. 2019). Channel confinement, urban development, and the loss of conveyance capacity from sediment buildup has further exacerbated flood risk in the watershed.

4.2.2.4 Frost Events

Spring frost events pose significant risks to frost sensitive crops and fish habitat. The 2008 frost season caused large simultaneous water withdrawals for frost protection, reducing river flows and resulting in salmonid stranding and mortality. Subsequent regulatory and technological interventions, including off-stream storage ponds, coordinated water demand management plans, and adoption of wind machines, have reduced, but not eliminated, frost-related hazards.

Figure 4-5. Timeline of Selection of Historical Hazard Events

		Sectors	Economic Damage
2020-2022	**Drought** Driest three-year period on record for California; record low reservoir levels in Sonoma County; severe water restrictions and 17% reduction in water use. Emergency drought regulations enacted, including curtailments of water diversions and modified reservoir releases to protect water supply for health, safety, and endangered fish species.	**Sectors**: Water supply, groundwater, agriculture, fisheries	Economic Damage: $148M crop revenue loss State/Federal Declarations issued
2020	**Glass Fire** Burned 67,484 acres across Napa and Sonoma counties. Destroyed 1,555 structures, including 334 homes in Sonoma County. Major impacts in eastern Santa Rosa and Sonoma Valley.	**Sectors**: Agriculture, water supply, public infrastructure, housing, air quality, water quality	Economic Damage: $3.1B in insured losses statewide Federal Declarations issued
2019	**Flood (February)** Russian River crested at 45.38 feet; widespread evacuations. Guerneville and Monte Rio were isolated due to flooding of transportation routes.	**Sectors**: Flood control, transportation, emergency response, housing, infrastructure	Economic Damage: $155M county-wide ($91.6M homes, $35M businesses, $23M infrastructure, $2.2M response) Federal Disaster Declaration issued
2018	**Mendocino Complex Fire (Ranch and River Fires)** Burned 459,123 acres, 280 structures and 1 fatality. Smoke impacts, evacuations, and air quality crisis region-wide.	**Sectors**: Forestry, agriculture, air quality, housing, public safety, vulnerable communities	Economic Damage: $56M insured property damage in Sonoma County Federal Disaster Declaration issued
2017	**Sonoma Complex Fires (Tubbs, Nuns, and Pocket Fires)** Burned over 110,000 acres; destroyed more than 6,900 structures and killed dozens of residents in Sonoma and Napa counties.	**Sectors**: Forestry, agriculture, air quality, housing, public safety, vulnerable communities	Economic Damage: $7.8B in damages across Sonoma and Napa counties State/Federal Declarations issued
2012-2016	**Drought** Driest four-year period on record for the watershed, with the two warmest years in state history.	**Sectors**: Agriculture, hydropower, forestry, recreation, ecosystems	Economic Damage: $1.6B-2B a year statewide Statewide drought emergency declared; multiple state and federal disaster declarations
2008	**Frost (Spring)** 2008 frost season was the worst in over 30 years, with freezing temperatures. Widespread use of water for frost protection in vineyards, led to drops in river flow. Combination of drought and frost led to fish stranding and death of juvenile coho and steelhead trout.	**Sectors**: Agriculture, water resources, ecosystems	Economic Damage: $156M in at-risk crops; up to $2.1B-$6.7B in lost business income if 10-30% crop loss region-wide State Frost Protection Regulation
1986	**Flood (February)** Record-breaking atmospheric river event caused Russian River to crest at 49.5 feet, the highest recorded level.	**Sectors**: Housing, recreation and tourism	Economic Damage: $89M in Sonoma County ($280M statewide) Federal Disaster Declaration issued
1976-1977	**Drought** The driest single year in California's measured hydrologic record occurred in 1977. Severe impacts to reservoirs and groundwater supplies; agricultural losses; increased reliance on emergency water sources.	**Sectors**: Agriculture, water utilities, rural communities, tourism	Economic Damage: $200M in Sonoma County ($3.5B statewide) Federal Disaster Declaration issued

4.3 Projected Climate Conditions

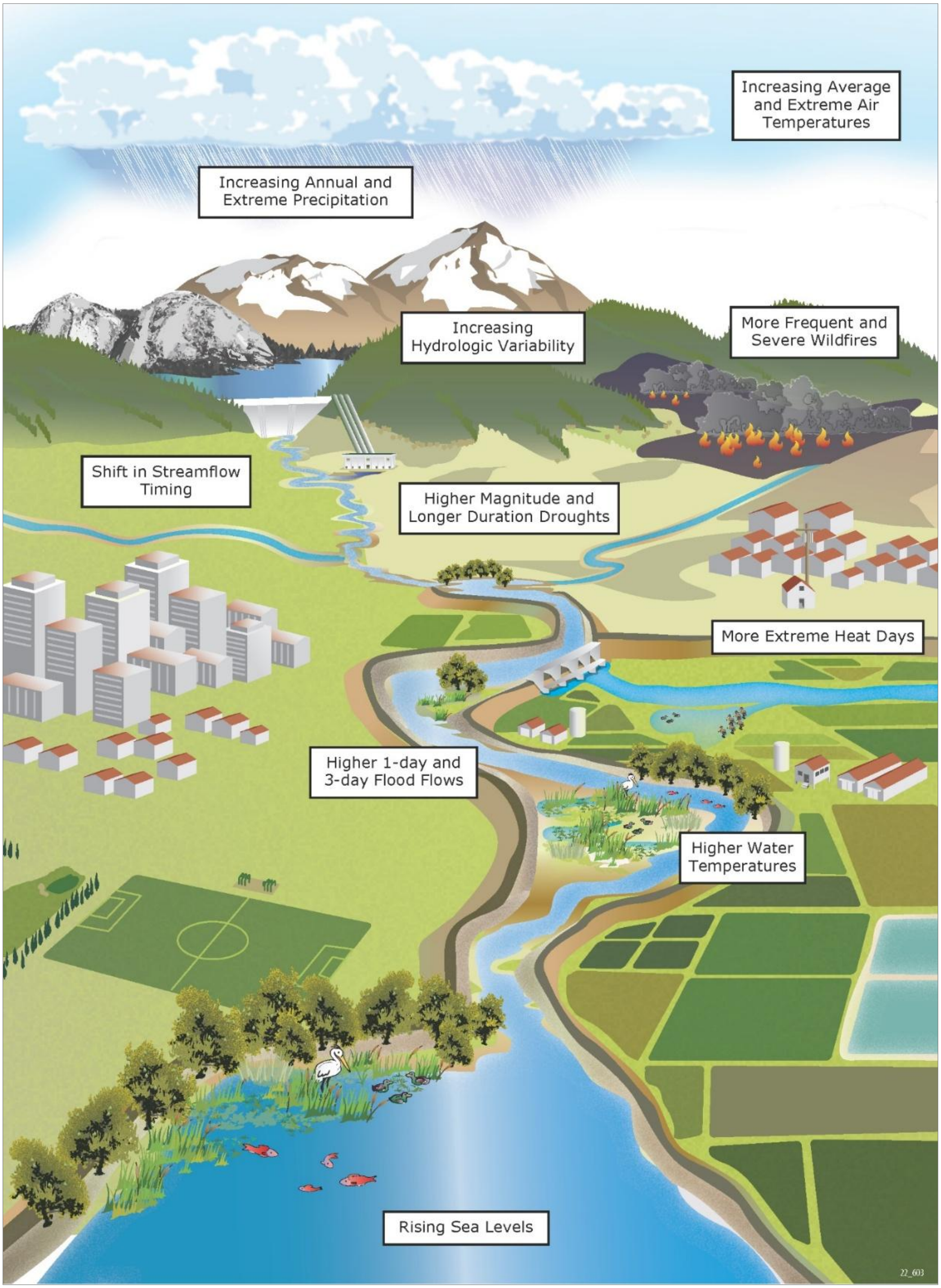
Future climate change is anticipated to affect the Russian River watershed in several ways, as shown in Figure 4-6. Climate projections indicate that the following significant changes are likely to occur:

- Average and extreme temperatures will increase.
- Extreme precipitation will increase.
- Hydrologic variability, both seasonally and interannually, will increase.
- Wildfire frequency will increase.
- The number of extreme heat days will increase.
- Extreme flood magnitudes will increase.
- Water temperatures will increase.
- Sea levels will rise.

This section provides a summary of the future climate projections and the main drivers for future climate vulnerability in the watershed.

Evaluation of future climate conditions relies on a suite of global climate models (GCMs), large-scale representations of the Earth's climate systems that are used to simulate future conditions. The Russian River Watershed Resilience Pilot leverages Coupled Model Intercomparison Project Phase 6 (CMIP6) GCMs from the Sixth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC 2021). CMIP6 also considers a set of shared socioeconomic pathways (SSPs), scenarios used to investigate how global societal trends (population growth, economic trends, policy considerations, etc.) might influence future greenhouse gas emissions and subsequent changes in climate. To translate the coarse resolution of GCMs into higher resolution for regional applications, the Localized Constructed Analogs Version 2 Hybrid (LOCA2-Hybrid) dataset from Scripps Institution of Oceanography was used (Pierce et al. 2023), offering a 3-kilometer resolution over California with temporal coverage between 1950 and 2100. For this dataset, downscaling is performed using a selection of GCMs that best capture the relevant characteristics of the climate in California. In total, 41 distinct climate projections were generated to assess future climate conditions over the Russian River watershed. Projected changes in temperature, precipitation, and watershed responses are highlighted for mid-future (2041 to 2070) and late-future (2071 to 2100) conditions relative to a historical (1981 to 2010) period. Additional details on methodologies for evaluating future climate metrics are discussed in Appendix B.

Figure 4-6. Overview of Projected Climate Changes in the Russian River Watershed



4.3.1 Temperature

Future climate projections for the Russian River watershed indicate a substantial and consistent rise in average temperatures relative to the historical record (Figure 4-7). This warming trend is evident across all climate projections, though the magnitude varies by individual climate model projection. Across the planning area, annual average temperatures are projected to increase by 3.7°F during the mid-future and 6°F during the late-future relative to the historical reference value of 57°F (Figure 4-8). Similarly, extreme heat days (days with maximum temperatures above 95°F) are projected to increase by 17 and 32 days per year under mid-future and late-future conditions, respectively, as compared to the 15 days per year for the historical reference period. Higher temperatures and a greater prevalence of extreme heat days are expected to directly affect surface water supplies, groundwater supplies, and ecosystems by intensifying evaporation, increasing water demand, and reducing dissolved oxygen. Warmer temperatures may also play a role in future coastal fog dynamics, an important phenomenon that provides moisture to coastal ecosystems and communities during summer months. However, more research is needed to fully understand the complexities between shifting atmospheric and oceanic processes that drive the occurrence and characteristics of coastal fog (Dye et al. 2024; Grantham 2018; Ackerly et al. 2018).

4.3.2 Precipitation

Future climate projections for precipitation over the Russian River watershed continue to show variability between wet and dry conditions that are characteristic of the instrumental period, with the magnitude and frequency of these swings increasing over time (Figure 4-9). Spatially, total annual precipitation is projected to increase by 2.9% during the mid-future and 5% during the late-future as compared to the historical reference value of 43 inches (Figure 4-10). While climate projections for most of the Russian River watershed indicate an increase in annual precipitation quantities across most of the planning area, localized areas may experience declines in precipitation, highlighting spatial variability in climate responses. Changes in extreme (99th percentile) daily precipitation demonstrate similar trends, with increases of 6% and 17% under mid-future and late-future conditions, respectively. Increases in extreme precipitation are likely to be driven by higher-magnitude ARs fueled by warmer temperatures and higher evaporation over the Pacific Ocean. These changes have implications for flood management, surface water supplies, groundwater recharge, hydropower production, recreation, and ecosystem health, each of which is sensitive to variability in annual and extreme precipitation patterns.

4.3.3 Sea Level Rise

Sea levels in the Pacific Ocean influence conditions in the lower Russian River watershed, altering the hydrology of the Russian River Estuary and the quantity of suitable habitat for aquatic species in this area. Since 1975, the Russian River watershed (measured at Point Reyes) has experienced 0.35 foot of sea level rise (NOAA 2026). Melting ice sheets and glaciers as well as the thermal expansion of seawater associated with increased global temperatures are the primary causes for increase in global mean sea levels in the past century. Development of sea level rise projections is typically performed by incorporating SSPs to model the physical processes associated with sea level rise. Under future conditions, the Russian River watershed (modeled at Point Reyes) could experience further rise in sea level of between 0.8 to 1.3 feet by 2050, and 3.1 to 6.6 feet by 2100 (California Ocean Protection Council 2024).

Figure 4-7. Trends in Future Temperature Projections Relative to the Observed Historical Record

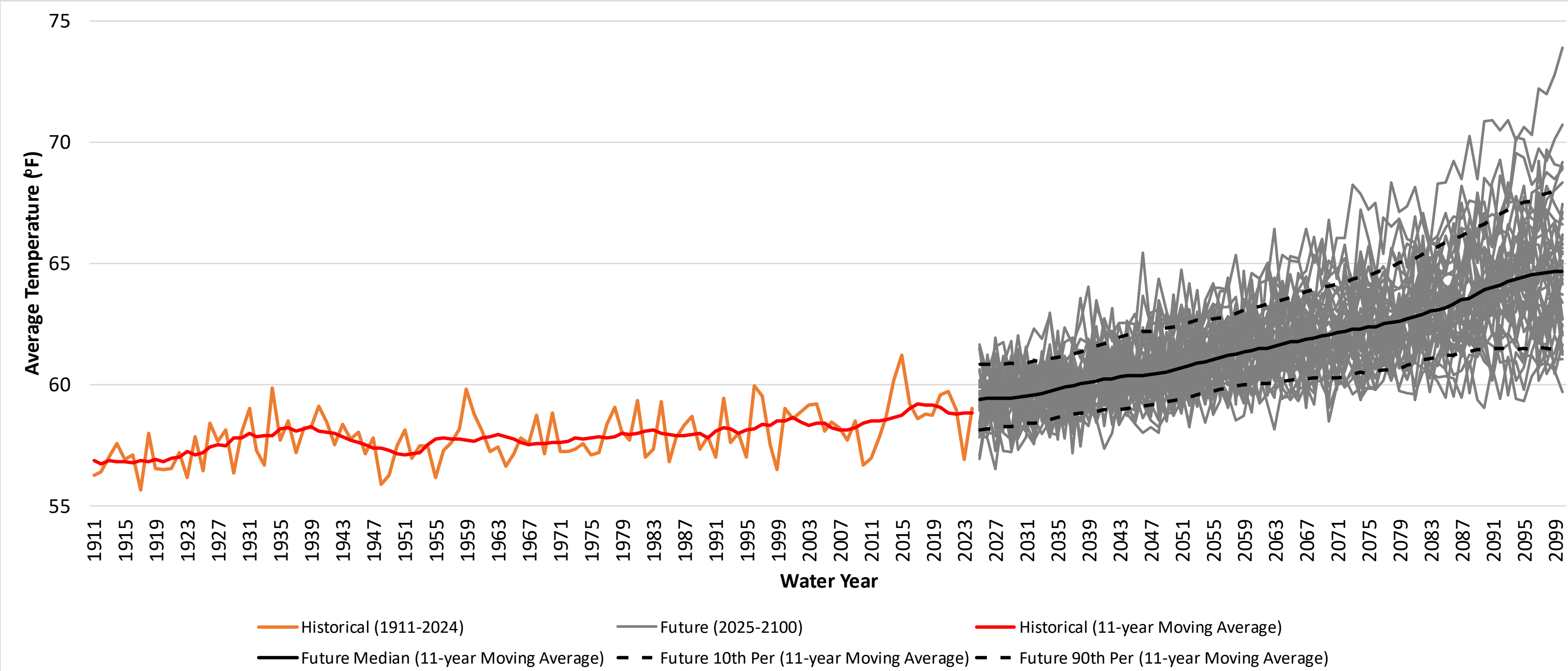


Figure 4-8. Change in Annual Average Temperature under Mid-Future (2041 to 2070) and Late-Future (2071 to 2100) Conditions Relative to a Historical Period (1981 to 2010)

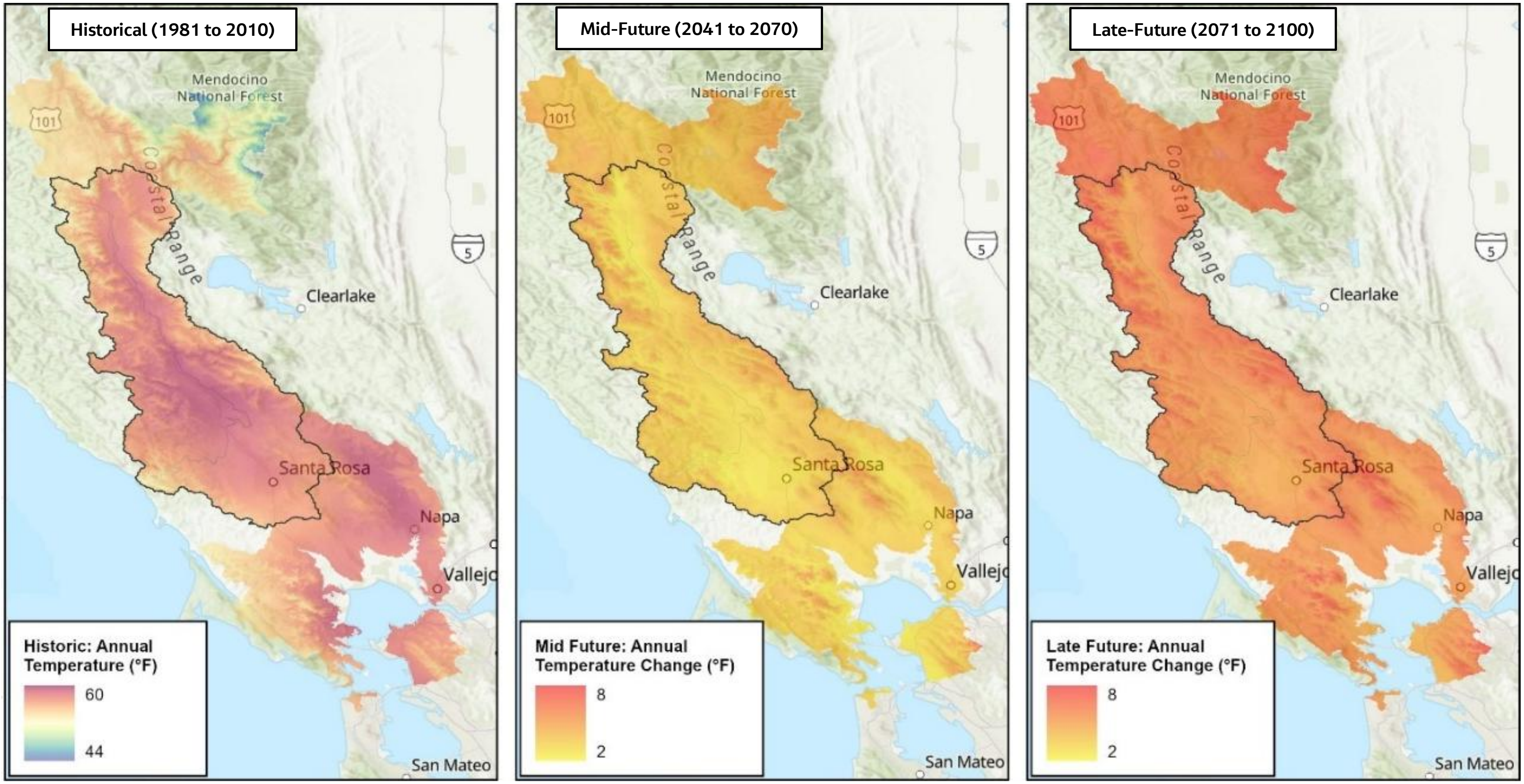


Figure 4-9. Trends in Future Precipitation Projections Relative to the Observed Historical Record

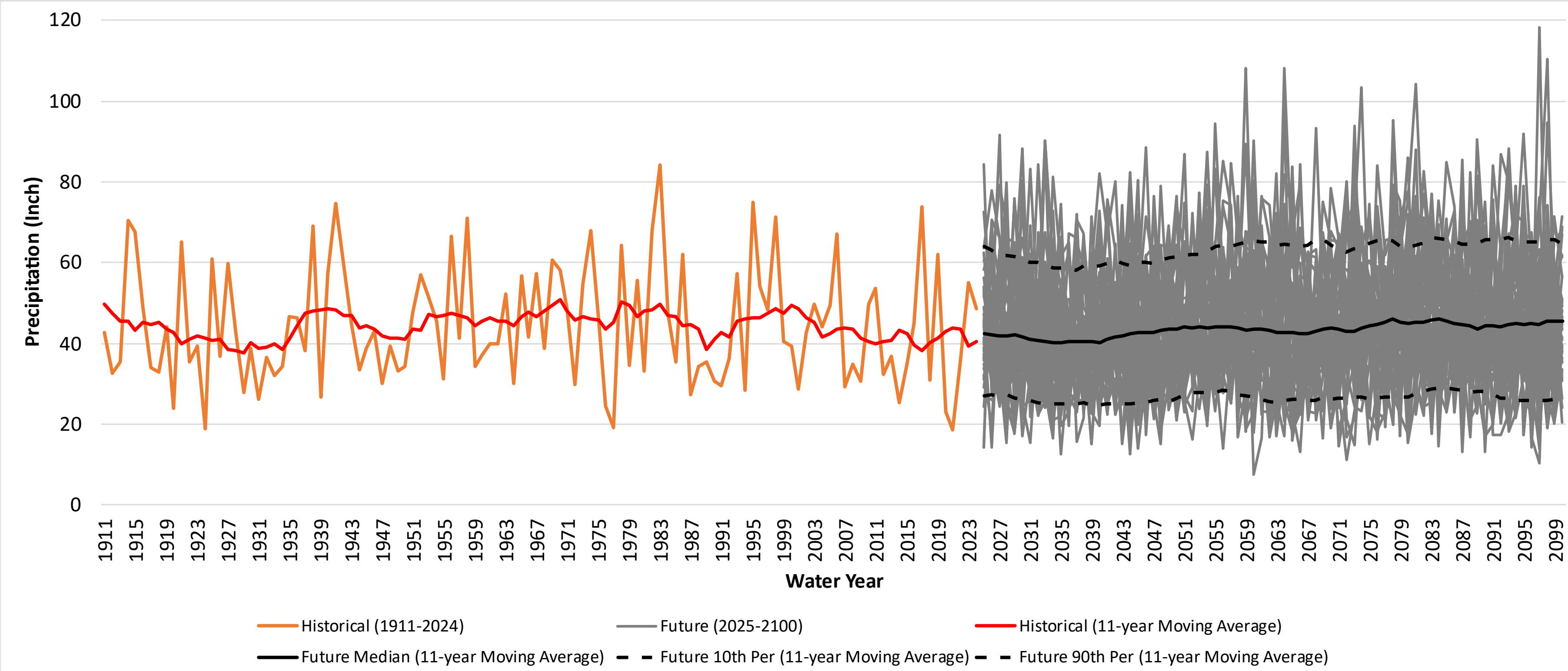
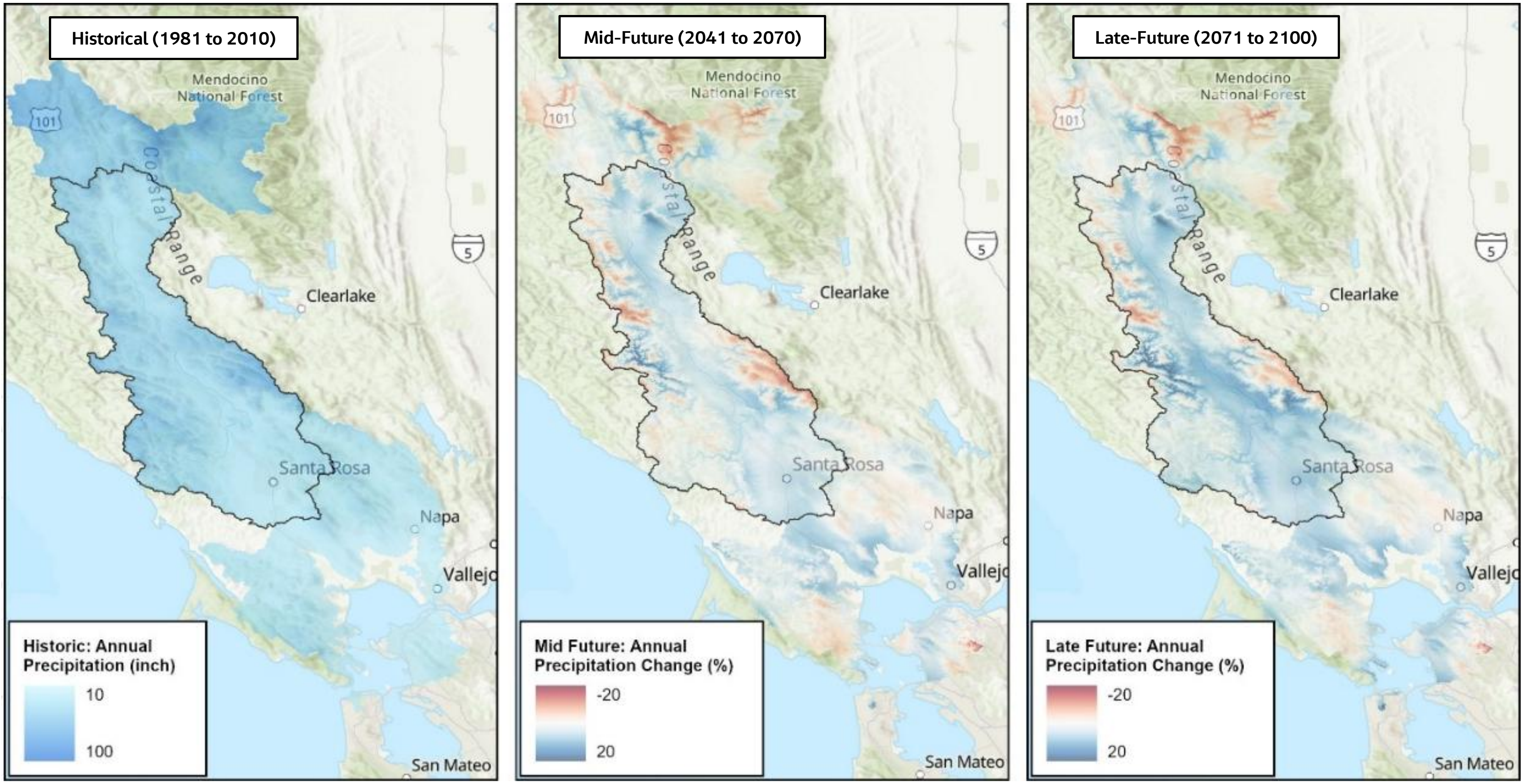


Figure 4-10. Change in Annual Average Precipitation under Mid-Future (2041 to 2070) and Late-Future (2071 to 2100) Conditions Relative to a Historical Period (1981 to 2010)



4.3.4 Watershed Responses

Climate projections represent trajectories of temperature and precipitation changes over the planning area, but do not characterize watershed-specific responses to climate change. As temperature and precipitation patterns evolve under future climate conditions, the Russian River watershed responds to these shifts through changes in runoff volumes, the timing of peak flows, evaporative demands, and more. To understand these considerations under future climate conditions, a hydrologic model must be used. The Russian River and Upper Eel River Basin Characterization Model (BCM) was developed by USGS in 2009 and serves as a regional water balance model that simulates unimpaired streamflows and evapotranspiration under historical and future climate conditions. Outputs from the BCM are discussed below; in some cases, alternative datasets are considered to characterize future conditions. Additional information on the BCM and other datasets utilized for this evaluation are provided in Appendix B and Appendix C.

Responses from the Russian River watershed to shifts in temperature and precipitation patterns vary spatially, temporally, and across individual simulations of future conditions. At a high level, the following watershed-scale conclusions have been identified through evaluation of these conditions:

- **Extreme Conditions:** Future projections for temperature and precipitation both indicate a higher frequency and magnitude of extreme conditions, with a rising number of annual extreme heat days and more severe occurrences of heavy rainfall. These shifts in extreme conditions are the primary drivers for several climate-induced hazards, including droughts, wildfires, and flooding, which have dramatic, potentially long-lasting impacts on the Russian River watershed and its communities. As such, the frequency of these events is likely to increase as future climate conditions worsen. Ecologically, these shifts result in warming of streams and loss of cold water fish habitat and the replacement of forest habitats with chaparral and oak woodland.
- **Soil Moisture:** As temperatures continue to rise across the Russian River watershed, soil moisture is projected to decrease and conditions become increasingly dry. Drier conditions have implications for ecosystem health, wildfire susceptibility, groundwater recharge, and soil stability, with drier soils reducing the resilience of vegetation and increasing the potential for erosion.
- **Climatic Water Deficit:** Climatic water deficit is a measure of unmet atmospheric evaporative demand. As conditions become warmer and drier, the atmospheric water demand increases and the availability of moisture to meet this demand decreases. As such, future trends indicate an increase in climatic water deficit, intensifying stress for species and habitats and elevating the potential for water supply and landscape drought conditions.
- **Runoff:** Despite increases in total annual precipitation, total annual runoff is projected to decrease slightly by mid-century relative to historical conditions. This discrepancy is primarily driven by increases in evaporative demand and reductions in soil moisture across the watershed, resulting in a greater quantity of losses to infiltration and evaporation. Reductions in runoff reduce the reliability of surface water supplies, opportunities for groundwater recharge, and sufficient flows for ecosystems. By the late-century, a small increase runoff is projected relative to historical conditions, potentially providing water supply benefits depending on the timing and magnitude of flows.
- **Streamflow Timing:** The timing of streamflow has important implications for water supply, flood management, and ecosystems. Shifts in precipitation patterns indicate a consolidation of streamflow to earlier in the year, with reductions in flows in the fall, spring, and summer. This results in higher peak flows and a greater overall volume of surface water during the wet season. Shifts in precipitation and peak flows to earlier in the season can also present challenges for reservoir operations within the watershed.

4.3.4.1 Drought

Paleo-reconstructed flows for the Russian River at Healdsburg show large natural variability characterized by repeated multi-decadal wet and dry periods and a long-term average that broadly resembles the modern historical record (Figure 4-11). The instrumental period captures most of this variability with improved precision and includes several occurrences of extreme drought and flood events. While future climate projections indicate a continuation of year-to-year variability, greater magnitudes for very wet and very dry years are noted. These trends suggest an increase in hydrologic volatility under a changing climate and a higher potential for more frequent extreme events, some of which may exceed the events highlighted in the historical variability over the last several centuries.

For drought events, paleo-hydrologic reconstructions reveal that the Russian River watershed has historically experienced droughts of both greater duration and magnitude than those captured in the instrumental record. While the 1976 to 1977, 1988 to 1992, and 2020 to 2022 droughts remain among the most severe short-duration droughts in recent history, the paleo record highlights longer, multi-decadal drought episodes, most notably the prolonged drought of 1610 to 1619, indicating that the watershed is climatically predisposed to extended dry periods (Figure 4-12). These reconstructed patterns broaden the understanding of natural variability and provide context for assessing future drought risk under climate change.

In comparison to future climate projections, an increase in both the severity and duration of drought events in the Russian River watershed relative to historical conditions is noted (Figure 4-13). Future droughts are expected to exceed historical events in terms of cumulative deficit, duration, and frequency, with more sustained multi-year droughts becoming increasingly common. These projected changes reflect the combined influence of higher ambient air temperatures, higher variability in precipitation patterns, and earlier seasonal drying. These findings underscore the increasing vulnerability of water supplies, ecosystems, and hydrologic reliability as drought conditions intensify over the 21st century.

4.3.4.2 Wildfires

While the historical record has shown both periods of extreme wet and dry conditions, assessment of the frequency and magnitude for potential weather-driven events is important for evaluating the inherent risk faced by the Russian River watershed and informing areas where improvements and strategies are needed. Beyond increases in drought severity and duration, rising temperatures, higher climatic water deficit, decreased soil moisture, and localized reductions in runoff intensify the prevalence of drier conditions across large swaths of the watershed, particularly in regions that do not display in increase in annual precipitation volumes. These conditions are projected to result in increases in both the frequency and severity of wildfire events. As such, the probability of a wildfire occurring each decade is projected to rise by 18% by the mid-future period and 22% by the late-future period relative to historical conditions (Figure 4-14). Decadal wildfire probability is representative of the probability that one or more fires occur in a given grid cell during a given decade. Heightened risks of wildfires pose threats to ecosystems, water quality, flooding, and regional communities.

Figure 4-11. Total Flow for the Russian River at Healdsburg for Paleo-reconstructed Records (1582 to 2004), Historical Observations (1911 to 2025), and Future Climate Projections (2026 to 2100)

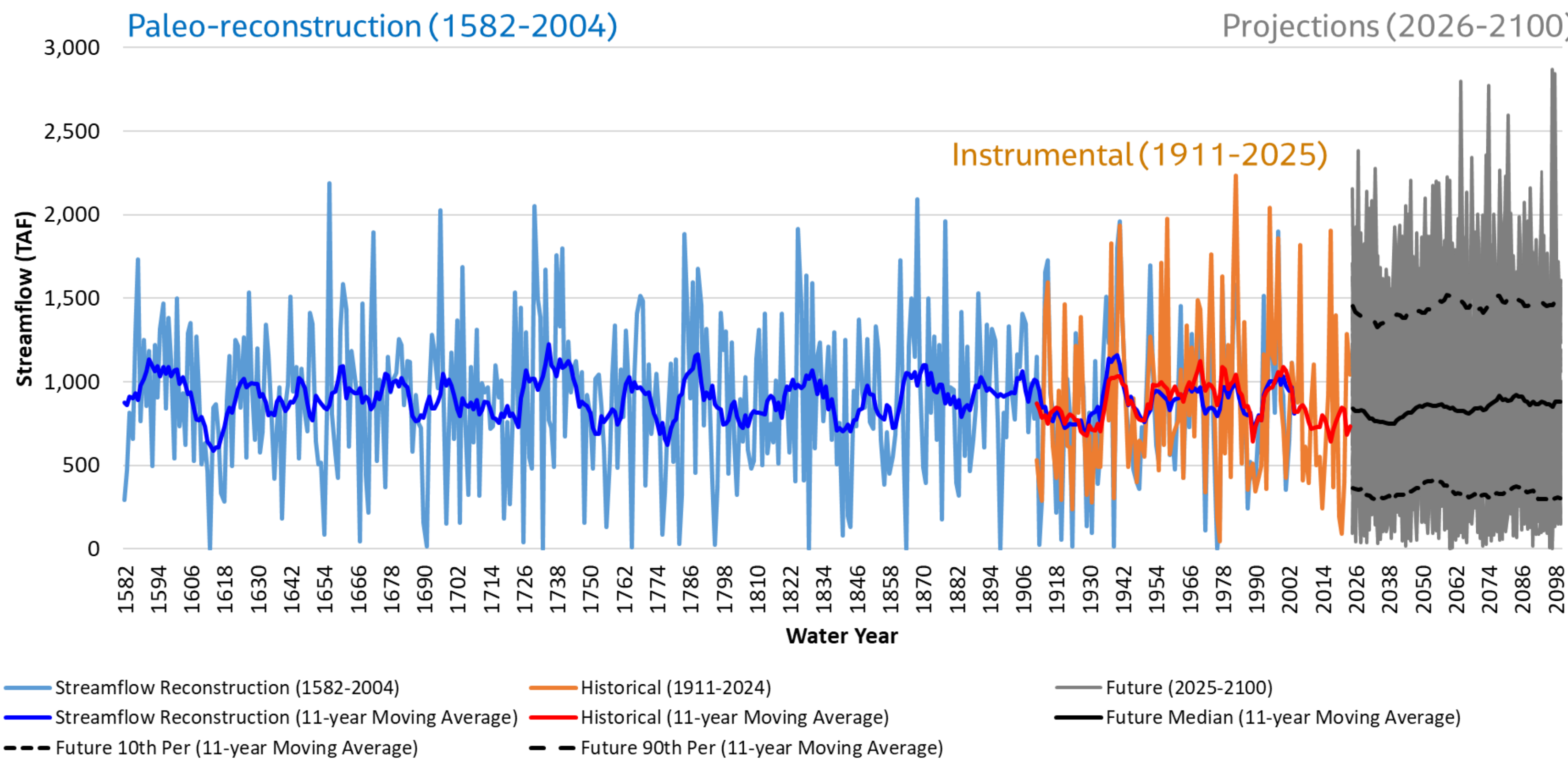


Figure 4-12. Drought Severity and Duration Estimated from Natural Flows for the Russian River at Healdsburg over the Paleo-reconstructed Period (1582 to 2025)

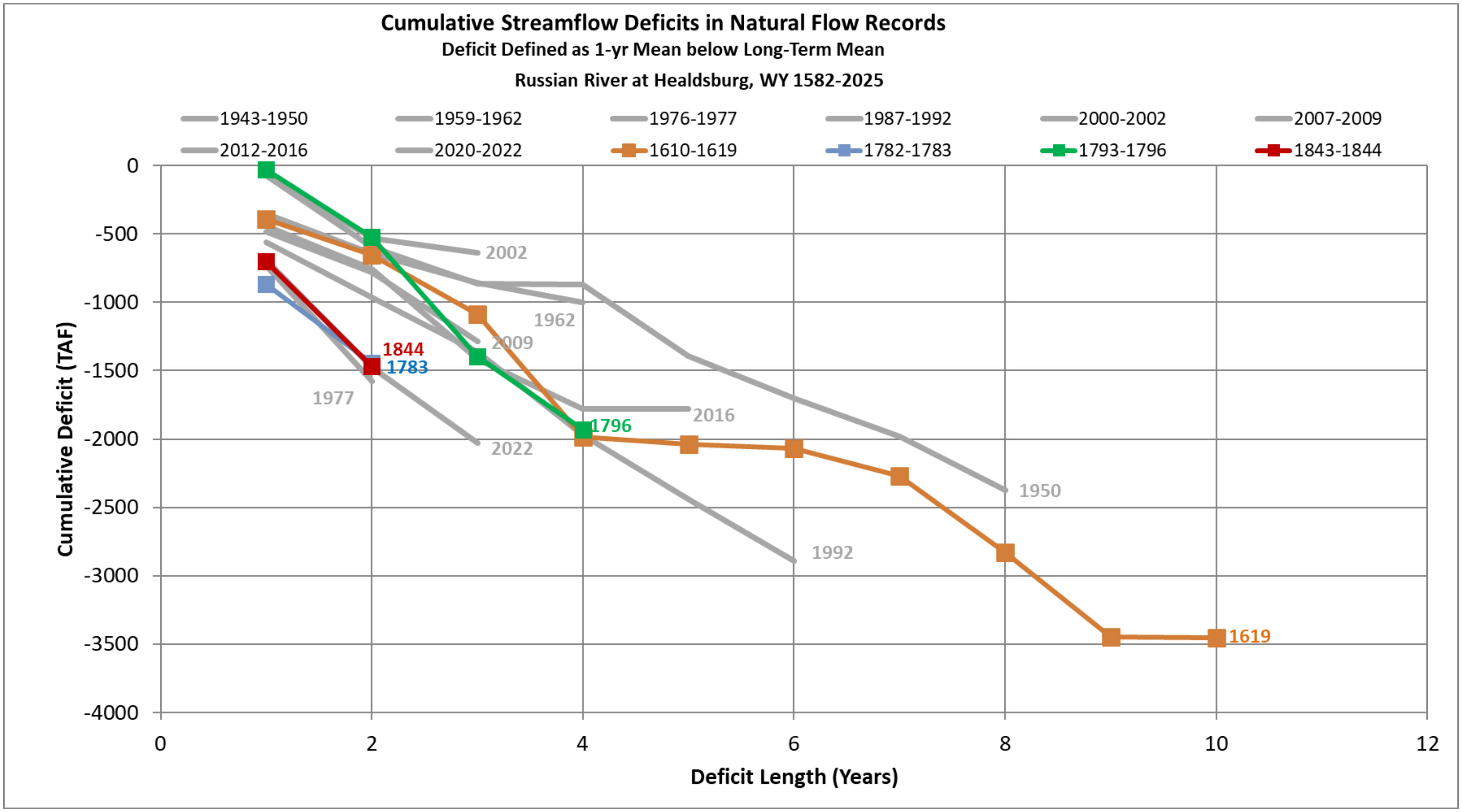


Figure 4-13. Drought Severity and Duration Estimated from Natural Flows for the Russian River at Healdsburg under Future Climate Projections (1941 to 2100)

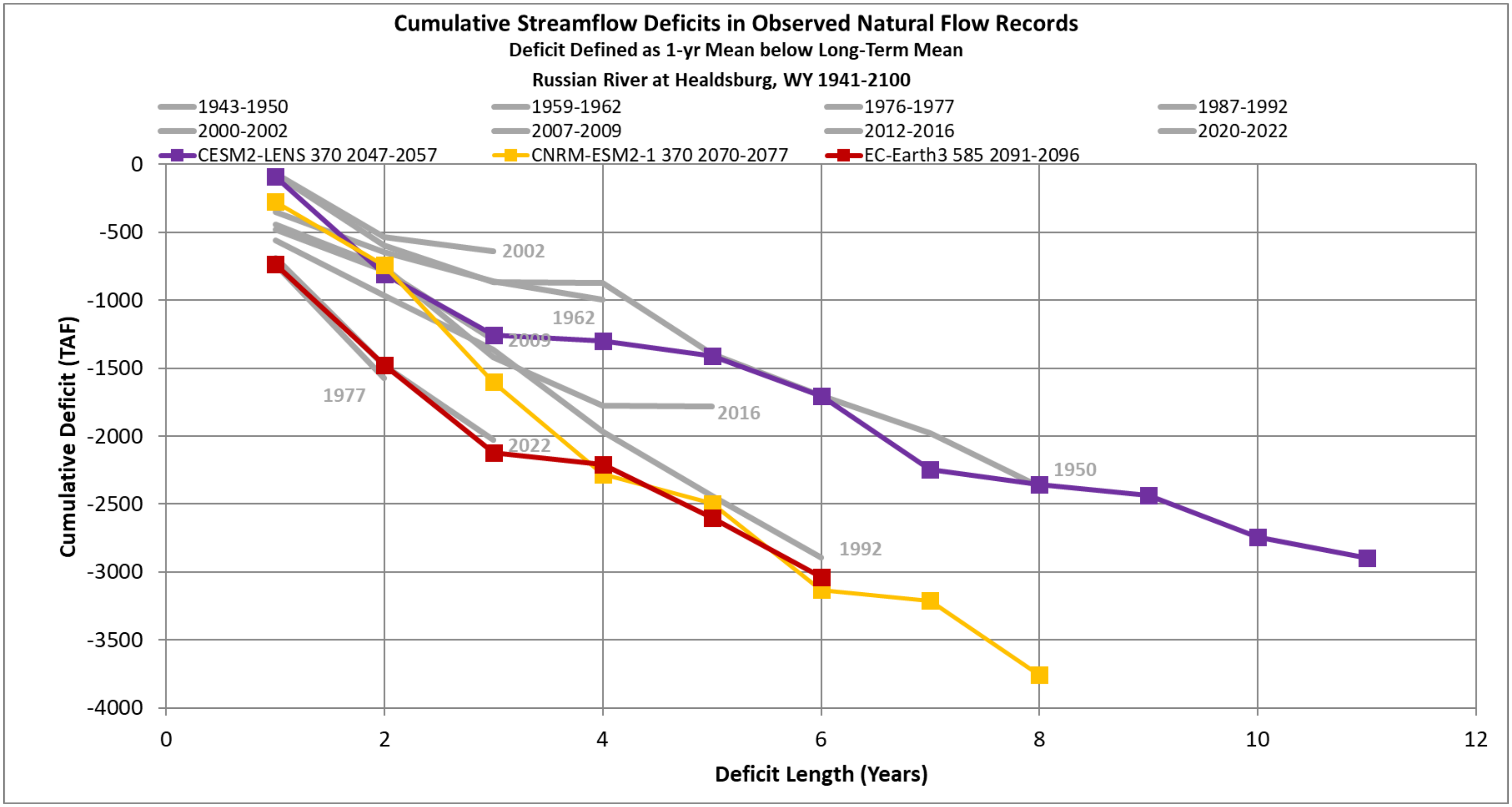
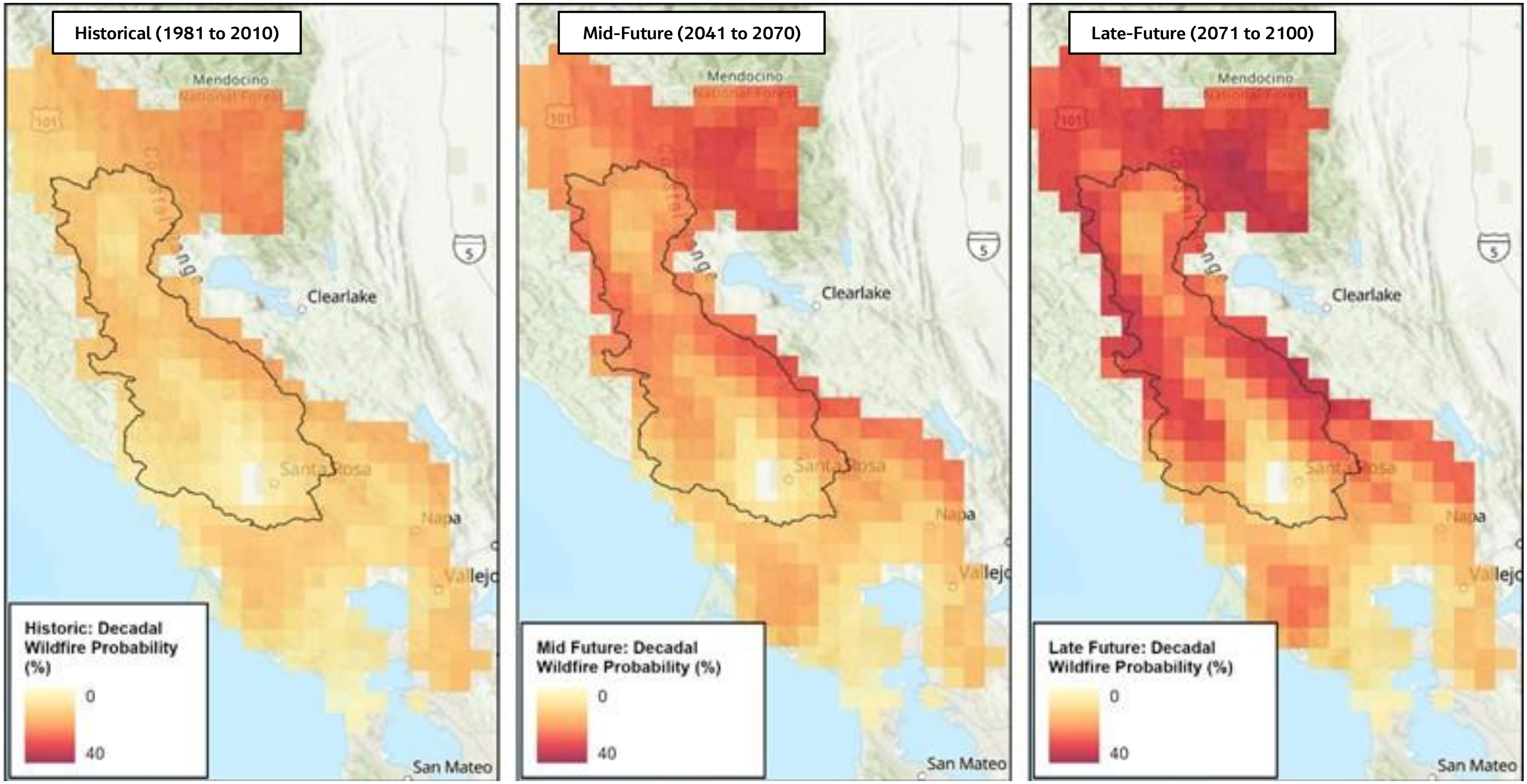


Figure 4-14. Change in Decadal Wildfire Probability under Mid-Future (2041 to 2070) and Late-Future (2071 to 2100) Conditions Relative to a Historical Period (1981 to 2010)



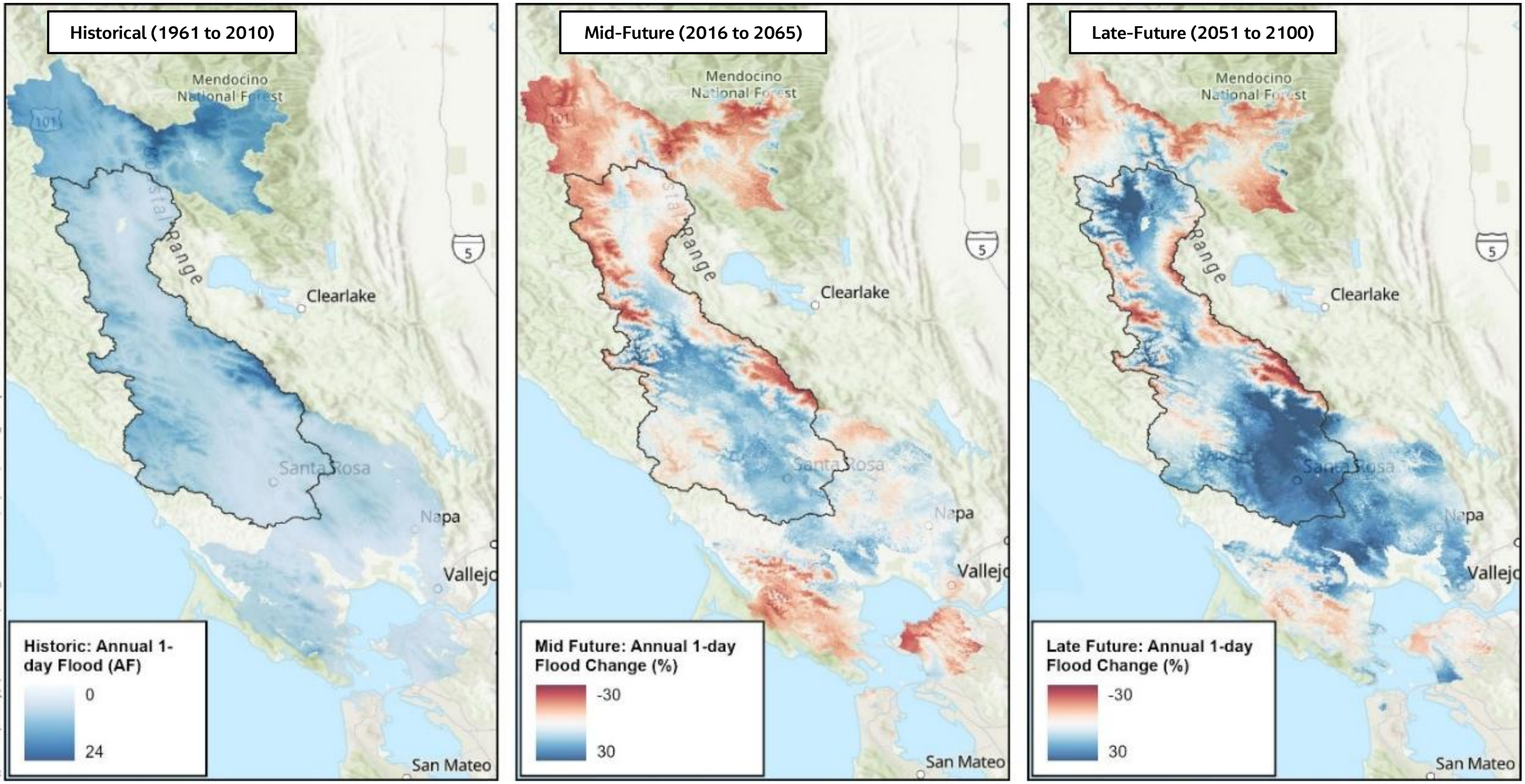
4.3.4.3 Flooding

Consistent with increases in extreme precipitation across the Russian River watershed, peak 1-day flood magnitudes are projected to increase by 1% under mid-future conditions and by 8.6% under late-future conditions (Figure 4-15). Projected changes for 3-day flood magnitudes are relatively similar, with estimated increases of 3.5% and 8.1% for the mid-future and late-future periods, respectively. Although 1-day and 3-day flood flows generally increase across the majority of Russian River watershed, several sub-regions, particularly on the western and eastern extents of the planning area, exhibit decreases in these metrics under future conditions. Changes in 1-day and 3-day flood magnitudes are largely driven by increases in extreme precipitation under future conditions. As such, spatial patterns of change resemble those of precipitation, with the most pronounced increases occurring in the southern portion of the watershed.

4.4 Summary

Over the coming decades, the Russian River watershed is projected to experience increases in average ambient air temperatures, a greater number of extreme heat days per year, and a higher frequency and magnitude of extreme precipitation events. Ultimately, hydrologic variability is anticipated to increase, with more frequent swings between dry and wet periods. These shifts are projected to alter conditions across the watershed and exacerbate many of the historical hazards that have affected the region over the last century, including droughts, wildfires, and flooding, resulting in more common and more severe occurrences of these events. Understanding the sensitivities and adaptive capacities and identifying the associated vulnerabilities to these changes for the built and natural systems throughout the Russian River watershed is vital to informing future strategies to adapt to and mitigate impacts.

Figure 4-15. Change in Annual 1-Day Flood Magnitudes under Mid-Future (2016 to 2065) and Late-Future (2051 to 2100) Conditions Relative to a Historical Period (1961 to 2010)



Note: Flood and other extreme metrics were evaluated using a 50-year period, whereas climate and hydrological metrics (e.g., temperature and precipitation) were estimated using the 30-year period.

5. Water Resource Vulnerabilities

5.1 Introduction

The Russian River Watershed Resilience Pilot employs an integrated vulnerability assessment to evaluate how evolving climate hazards are projected to impact a series of eight water-related sectors across the planning area. These sectors include surface water supply, groundwater supply, flood management, ecosystems, water quality, recreation, hydropower, and community and equity considerations. Evaluation of sector-specific vulnerabilities to climate change supports identification of key areas of climate sensitivity and characterization of projected impacts, informing areas where subsequent adaptation strategies should be developed and prioritized.

The vulnerability assessment is characterized by both qualitative and quantitative evaluations. The qualitative vulnerability assessment employs a scoring framework to characterize effects of climate hazards on individual components of water sectors throughout the planning area in terms of sensitivity, adaptive capacity, and vulnerability. The quantitative assessment builds on these qualitative findings to identify vulnerabilities through application of a projection-based modeling framework coupled with a series of indicators and metrics for each water-related sector. This chapter provides an overview of findings and results from these evaluations; additional details on the vulnerability assessment and relevant modeling assumptions are documented in Appendix C.

5.2 Summary of Key Vulnerabilities

In summary, nine water-related sectors across the Russian River watershed were evaluated through qualitative and quantitative methods to identify areas of high vulnerability to changing climate conditions. Table 5-1 provides an overview of key vulnerabilities that were identified through each sector-specific assessment. Brief descriptions are provided to highlight the primary drivers for these vulnerabilities. Results from these evaluations ultimately highlight areas where adaptation strategies are most needed to address the projected impacts of climate change and improve the overall resilience of the watershed to future conditions.

Table 5-1. Overview of Key Vulnerabilities Identified for Each Water-related Sector

Sector	Key Vulnerabilities
Surface Water Supply	▪ Impaired water supply resiliency for Upper Russian River water users due to a higher frequency of water shortages driven by the reduction in unimpaired base flow exacerbated by reductions in Eel River transfers. ▪ Lower Lake Mendocino annual storage due to more frequent and severe drought conditions exacerbated by reduced transfers from the Eel River. ▪ Impaired water supply resiliency for Lower Russian River water users and Lake Sonoma annual storage during periods of severe drought.
Groundwater Supply	▪ Temperature-driven increases in evapotranspiration, along with reductions in Lake Mendocino storage and releases reduce dry-season Russian River flows, which in turn, can reduce the total recharge of surface water to the alluvial groundwater system. ▪ Reduced groundwater storage and commensurate declines in groundwater levels during dry periods can induce a greater proportion of recharge of surface water to the alluvial aquifer system from already diminished surface water flows.

Sector	Key Vulnerabilities
Flood Management	▪ Increased flood risk for residential communities near Santa Rosa Creek due to increasing severity of extreme precipitation events under future conditions. ▪ Increased flood risk for populated areas of Cloverdale, Healdsburg, and Guerneville due to higher peak flows along the Russian River, as well as more rural areas like the Alexander Valley. ▪ Increased flood risk to structures and populations near Mark West Creek and Green Valley Creek due to backwater effects from increased stages along the Russian River and increased runoff; increased flood risk in the Laguna de Santa Rosa through Sebastopol.
Water Quality	▪ Reduced Lake Mendocino cold-water pool due to warmer reservoir inflows and decreased reservoir water surface elevations. ▪ Additional stress to fisheries due to lower flows, increased water temperatures, and reduced dissolved oxygen. ▪ Impacts to Coyote Valley Dam hatchery operations due to increases in water temperature from Lake Mendocino reservoir releases. ▪ Sea level rise and seawater intrusion in estuary and Petaluma Valley and Sonoma Valley groundwater basins. ▪ Higher likelihood of harmful algal blooms as a result of increased water temperatures.
Ecosystems	▪ Reduced mainstem Russian River juvenile rearing due to increased water temperatures, reduced dissolved oxygen, and decreased flows in the late spring. ▪ Lower tributary over-summer survival due to reduced flows and a higher frequency of seasonal drying, resulting in reduced availability of wetted habitat and degraded water quality. ▪ Risks to egg incubation during late winter and spring due to higher peak flows and increased water temperatures. ▪ Challenges for adult Chinook salmon migration due to the reduction of early fall flows. ▪ Decreased Russian River Estuary juvenile steelhead rearing and other salmonid life stages due to reductions in flows outside of the wet season, more frequent inlet closure events, and increased water temperatures.
Recreation	▪ Decreased boat ramp access for recreation at Lake Mendocino due to a higher frequency of periods with lower storage. ▪ Reduced opportunities for boating and fishing along the Russian River due to a higher frequency of flows below key recreation thresholds.
Hydropower	▪ Decreased hydropower production at Lake Mendocino due to more frequent lower minimum instream flow requirements.
Tribal	▪ For thousands of years, Tribal communities have stewarded and relied upon the water resources and ecosystems within the Russian River watershed. ▪ These resources have significant beneficial uses to the Tribes, including Native American Culture and Subsistence Fishing uses which may be vulnerable throughout the watershed

Sector	Key Vulnerabilities
Community and Equity	▪ Heightened risk for socially vulnerable communities in Santa Rosa, Ukiah Valley, the Cloverdale-Healdsburg-Windsor corridor, and surrounding Lake Mendocino due to increased floodplain inundation footprints, more frequent wildfires, extreme heat exposure, and longer and more severe drought events. ▪ Economic impacts stemming from reduced water availability and flooding to agriculture in dry and wet years, respectively.

5.3 Vulnerability Assessment Approach

The *qualitative* component of the vulnerability assessment utilizes a vulnerability matrix that provides a structured framework for evaluating climate-related risks across multiple sectors of the planning area. This matrix organizes individual components of the Russian River watershed (such as ecosystems, hydropower facilities, water supply infrastructure, flood management assets, water quality receptors, agricultural zones, and recreation/tourism resources) against key climate stressors of extreme heat, drought, extreme precipitation and flooding, wildfire, and sea level rise, where applicable. Each entry combines concise narrative descriptions of climate sensitivities and adaptive constraints with standardized numeric ratings for sensitivity, adaptive capacity, and vulnerability to climate stressors. These narratives were informed by the Watershed Network, existing watershed management plans, agency reports, and subject-matter expertise, ensuring that local context and sector-specific drivers of risk were captured.

The qualitative assessment evaluates components of each water-related sector based on three dimensions:

- **Sensitivity –** the degree to which changes in climate stressors influence the performance, function, and integrity of a given component
- **Adaptive capacity –** the ability to respond and recover to disruptions or impacts induced by climate stressors through operational flexibility, redundancy, or regulatory protections
- **Vulnerability –** a measure of the threat and susceptibility to the impacts of climate stressors given the qualities and state of individual components

Qualitative evaluations of assumed effects from climate hazards inform the subsequent ratings for sensitivity and adaptive capacity for components of each water resources sector. Once sensitivity and adaptive capacity scores are assigned, a vulnerability rating is determined for each component, with higher vulnerabilities associated with components that are both sensitive to climate impacts and have limited capacity to adapt or recover from disruptions. This approach allows for broader identification of high vulnerability components throughout the watershed, informing areas where deeper analyses through quantitative methods are most warranted.

The *quantitative* vulnerability assessment builds upon the findings of the qualitative evaluation of potential climate impacts to water-related sectors by employing a projection-based modeling framework to explore a range of future climate conditions. This framework allows for shifts in the timing and magnitude of impacts to be evaluated under a range of plausible future conditions. Because individual climate models represent changes in temperatures, precipitation, hydrologic variability, and sea level rise differently, the quantitative vulnerability assessment approach characterizes uncertainties in future climate trajectories by considering 41 different climate projections.

For each water-related sector, a series of metrics and indicators are used to inform and evaluate climate vulnerabilities under future conditions. Indicators represent observable aspects of a given sector that can be used to characterize that sector under historical and future conditions. Metrics incorporate quantitative measurements of certain components of a given indicator. As an example, an indicator for the recreation sector is recreational uses; metrics to evaluate this indicator include reservoir water levels and river flows that are sufficient for recreational activities.

To evaluate the set of indicators and metrics for each water-related sector, a variety of analytical tools have been employed for each vulnerability assessment. Many of these analytical tools leverage outputs from the BCM or other tools to simulate specific processes in the watershed, such as floodplain inundation, reservoir operations, and surface water-groundwater interactions. Table 5-2 provides an overview of each of these tools and application for relevant sector-specific assessments. For additional details related to assumptions, inputs, outputs, and limitations, please refer to the Attachment C-1: *Overview of Analytical Tools Used in the Russian River Watershed Resilience Analyses*. Quantitative analyses were performed specifically to support understanding of potential changes under a range of future climates and should not be viewed or used as definitive future outcomes.

Table 5-2. Overview of Analytical Tools by Water Sector

Tool	Use	Sector(s)[a]
BCM	Simulates historical and future climate unimpaired streamflows and evapotranspiration.	SW, FM, EC, RC
Russian River HEC-HMS	Simulates precipitation-runoff processes to support flood risk and reservoir operation studies for the Russian River and Santa Rosa Creek watersheds.	SW, FM
Santa Rosa Creek HEC-HMS	Simulates precipitation-runoff processes to support flood risk and reservoir operation studies for the Santa Rosa Creek watersheds.	SW, FM
Russian River HEC-ResSim	Simulates how water is stored and released from Lake Mendocino and Lake Sonoma, flows through the river system across various junctions and routing reaches, and is affected by human activities like water diversions and agricultural use.	SW, RC, HP, EC
Sonoma Water Decision Support Model	Simulates reservoir storage and releases, river diversions, aqueduct flows and capacity constraints, customer water demands, and alternative supply sources like groundwater and recycled water.	SW, RC, HP
RRIHM	An integrated surface water and groundwater hydrology and river operations model that represents surface-groundwater interactions and uses climate forcings to estimate dynamic water use demands.	GW
Potter Valley Integrated Groundwater-Surface Water Model	Simulates surface water flow, groundwater flow, groundwater-surface water interactions, evapotranspiration from shallow groundwater, and agricultural water use and irrigation dynamics for the Potter Valley Groundwater Basin.	GW
Groundwater Sustainability Plan Integrated Surface and Groundwater Computer Models	Integrated surface and groundwater computer models representing surface and subsurface movement of water supplies for the Petaluma Valley, Santa Rosa, Sonoma Valley, and Ukiah Valley groundwater basins.	GW

Tool	Use	Sector(s)[a]
Russian River Flood HEC-ResSim	Simulates reservoir operations for Lake Mendocino and Lake Sonoma.	FM
HEC-RAS	Simulates river hydraulics in the Russian River and Santa Rosa Creek watersheds.	FM
HEC-ResSim Water Quality Model	Simulates water quality conditions throughout the Russian River watershed using flow, biochemical processes, and meteorological inputs.	EC, WQ
QCM	Simulates the hydrologic and morphologic behavior of bar-built coastal lagoons.	EC, WQ
Suitable Habitat Acre-day Model	Estimates the amount of suitable water-quality based juvenile salmonid habitat available within the water column at different locations with the Russian River Estuary.	EC, WQ
Power Tools for Hydropower	Estimates hydroelectric power generation at Lake Mendocino and Lake Sonoma using daily reservoir storage elevation and release data.	HP
Vulnerable Communities Platform	Identifies areas of vulnerability to various climate hazards, including extreme heat, flooding, wildfire, and drought, and overlays information related to a range of socioeconomic factors.	CE

[a] CE = Community & Equity; EC= Ecosystem; FM = Flood Management; GW = Groundwater; HP = Hydropower; WQ = Water Quality; RC = Recreation; SW = Surface Water Supply

Notes:

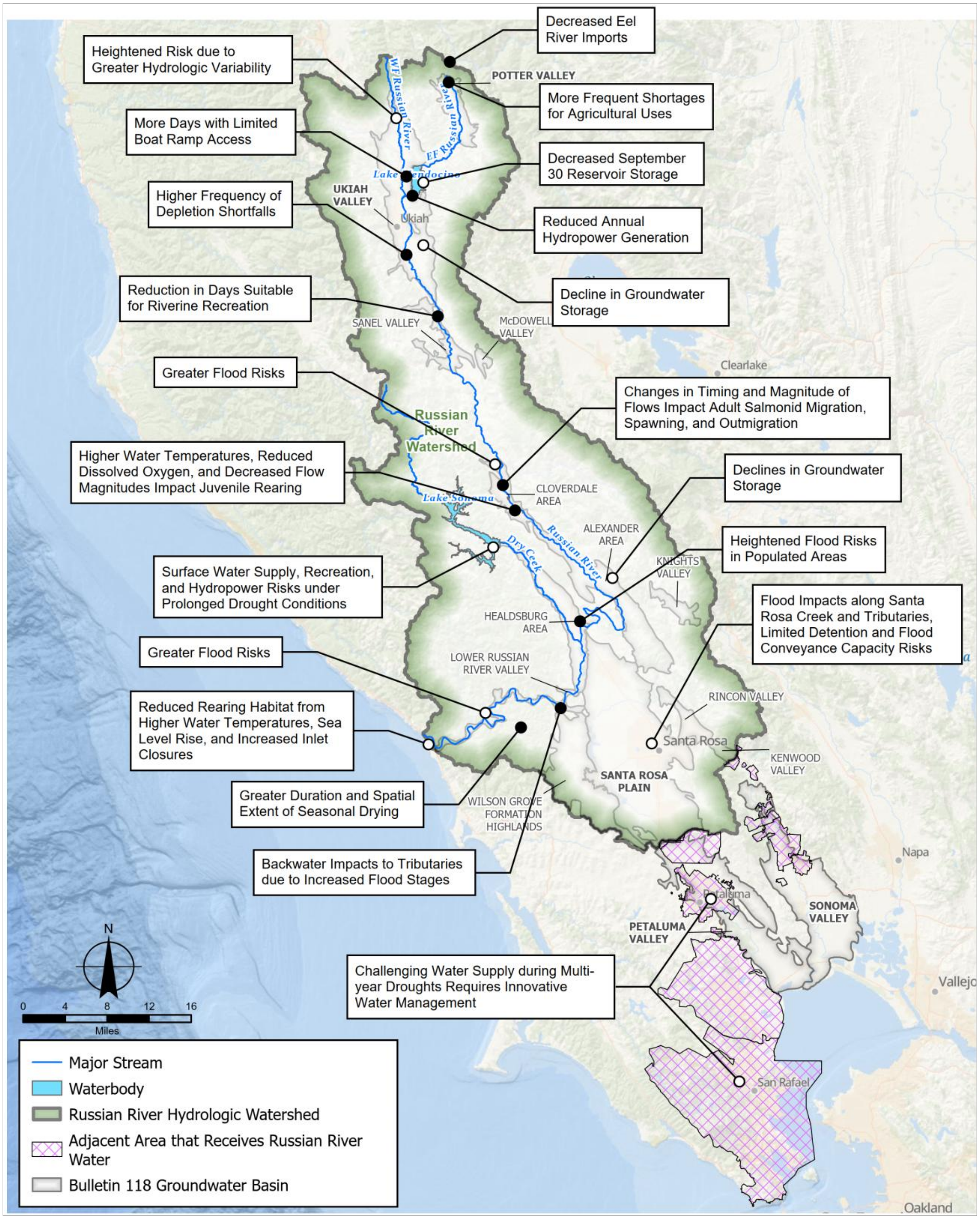
HEC = Hydrologic Engineering Center
HMS = Hydrologic Modeling System
QCM = Quantified Conceptual Model
RAS = River Analysis System
ResSim = Reservoir System Simulation
RRIHM = Russian River Integrated Hydrologic Model
USACE = U.S. Army Corps of Engineers

5.4 Vulnerability Assessment Findings

Changes in climate are characterized by increasing ambient temperatures across the planning area, more frequent and severe extreme precipitation events, and a consolidation of precipitation during the wet season. These changes drive several responses across the watershed, including reductions in fall, spring, and summer baseflows; higher peak flows in the winter; warmer water temperatures; increased wildfire risk; and more frequent and prolonged drought events and extreme heat days. Sector-specific vulnerabilities to these changes are varied and are often influenced by existing infrastructure and operations. Results from the quantitative assessment provide a detailed evaluation of vulnerabilities across the planning area, identifying areas where thresholds are projected to be exceeded, risks are evolving, and impacts are shared or cascading across individual sectors. Ultimately, these results provide a foundation for identifying and prioritizing adaptation strategies and subsequent planning efforts to address the impacts of climate change.

Findings across the planning area that have been identified through this vulnerability assessment are summarized on Figure 5-1. It is important to note that findings identified on this map are not limited to the specified locations; in some cases, changes and impacts under future climate conditions may be relevant to river reach, sub-watershed, and community scales. Summaries of results for each water-related sector are noted in the following subsections; further information is provided in Appendix C.

Figure 5-1. Summary of Vulnerability Assessment Findings in the Russian River Watershed



5.4.1 Surface Water Supply

The surface water supply assessment evaluates how the Russian River water supply system responds to a wide range of future hydrologic, operational, and climate conditions. Using coordinated Russian River HEC-ResSim and Sonoma Water Decision Support Model simulations, the analysis examines reservoir operations, Eel River transfers, retail system performance, and the relative vulnerability of the Upper and Lower Russian River. Results highlight growing challenges in maintaining reliable supplies, particularly in the Upper Russian River, where dependence on Eel River transfers and limited storage capacity increase sensitivity to climatic and operational change.

- ***Reduced Eel River summer flows and transfers to the Russian River watershed*** *are a major driver of vulnerability for water supply to agricultural and municipal users in the Upper Russian River that will be exacerbated by future climate impacts.*
- ***Lake Mendocino and the Upper Russian River will become increasingly stressed*** *due to longer and more severe droughts, reduced inflows, and greater transitional variability between wet and dry years.*
- ***Lower Russian River water users experience fewer direct impacts*** *but still face increasing pressures from longer and more severe drought conditions.*

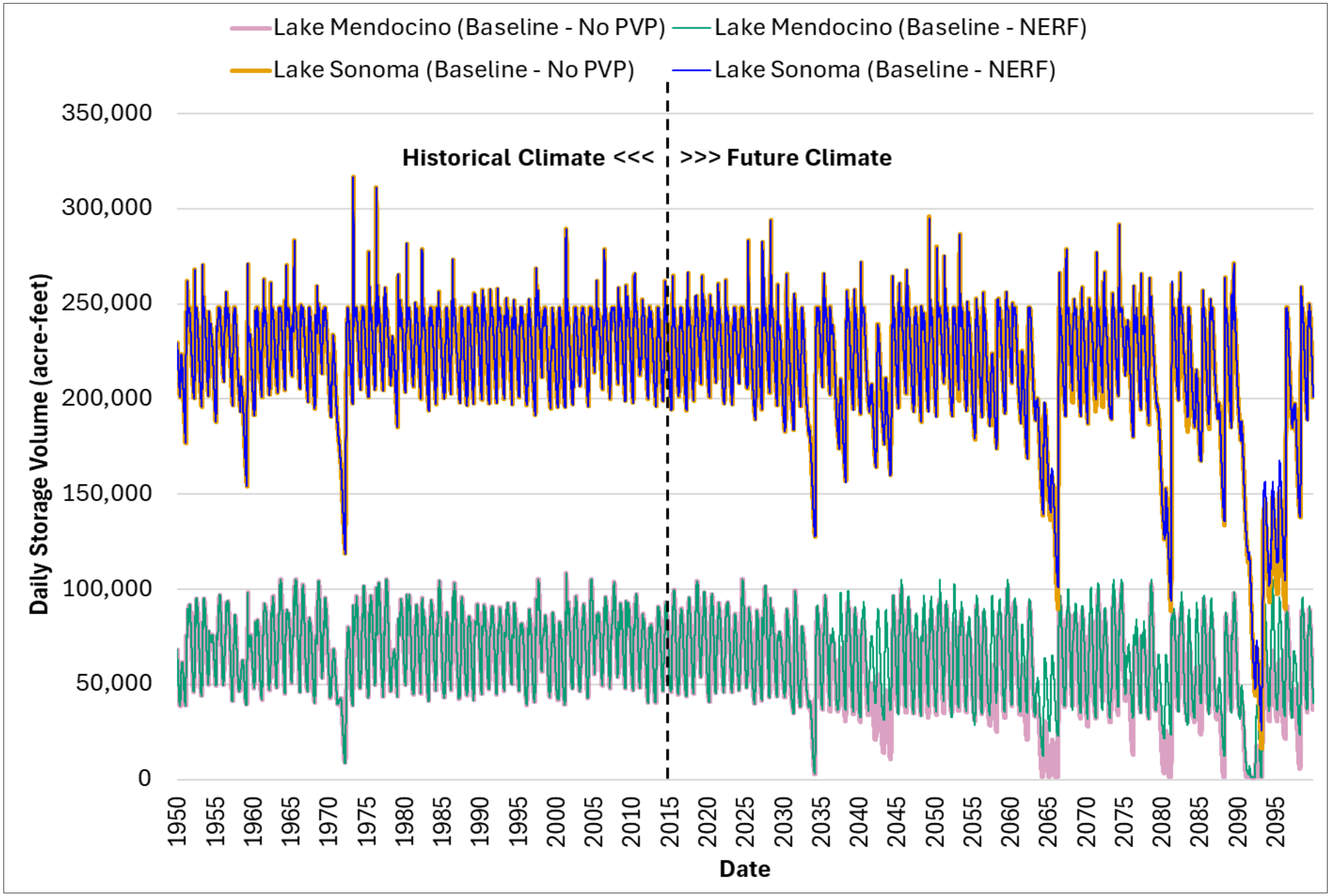
Reduced Eel River transfers are an existing and significant driver of Russian River water supply vulnerability, and they are amplified by the climate-related impacts assessed in this study. Because future Eel River transfer volumes are uncertain following the planned decommissioning of the PVP, climate impacts were evaluated under two plausible operational regimes: (1) No PVP, which includes full discontinuation of Eel River transfers after PVP decommissioning, and (2) New Eel-Russian Facility (NERF), which includes the transition to NERF.

Under future climate conditions, both Eel River transfer regimes result in many years with significantly lower transfer volumes than the historical period. Even with NERF in place, Eel River transfers are expected to remain lower than historical PVP operations, a condition that is further exacerbated by climate-driven loss of snowpack in the upper Eel River watershed and greater hydrologic variability. NERF operations also shift transfer timing earlier in the water year, reducing late-spring and summer water supply availability for Potter Valley agriculture and increases the frequency of unmet depletion and minimum instream flow requirements.

In addition to changes in transfer volumes and timing impacts to Potter Valley, the portion of the transferred water that can actually be captured and retained in Lake Mendocino is also an important factor influencing system performance under future climate scenarios. Eel River water availability is greatest during the wet season, when available storage capacity in Lake Mendocino is most constrained, limiting the ability to store imported water for later use. These operational vulnerabilities compound climate-driven reductions in watershed hydrology, both the loss of dry-season water availability and the increased intensity of winter storms that can constrain Lake Mendocino's storage capacity but are not climate impacts themselves.

Figure 5-2 shows the simulated storage for Lake Mendocino and Lake Sonoma under one climate model projection (EC-Earth3 5-8.5) for both the No PVP and NERF scenarios. This figure illustrates a particularly notable future climate trajectory for the Russian River system in that the model produces three severe, **multi-year droughts that each persist for roughly 2 to 7 years**, placing substantial strain on both Lake Mendocino and Lake Sonoma storage within only three decades.

Figure 5-2. Lake Mendocino and Lake Sonoma Storage Volume for Future Projection EC-Earth3 5-8.5 for Two Baseline Scenarios: (1) No PVP, which ends Eel River transfers starting in 2035, and (2) NERF Operations, in which PVP transitions to NERF beginning in 2035



Under the EC-Earth3 5-8.5 climate scenario, the No PVP operational scenario (PVP through 2034 and no transfers afterwards) generally produces lower Lake Mendocino storage for most of the period from 2035 to 2100; about 85% of days are lower than under the NERF scenario (PVP through 2034 and NERF from 2035). On average, Lake Mendocino storage under the NERF scenario is approximately 6.4 TAF higher than the no-transfer scenario. During late spring and summer, the storage under the NERF scenario averages about 7.2 TAF higher than the no-transfer scenario.

This effect is especially pronounced during multi-year droughts. In the 5-year drought occurring in the 2090s, storage under the no-transfer scenario never rebounds to greater than roughly 34 TAF, remaining substantially less than NERF throughout the entire drought sequence and limiting opportunities for recovery between dry years. Taken together, the sensitivity indicates that the absence of Eel River transfers can compound climate-driven stress by keeping storage lower for longer periods, reducing late-season availability, and dampening rebound potential between dry years—context for operations that sits alongside (but is distinct from) the climate-focused findings in this study.

While this scenario highlights one plausible climate pathway, it represents only a single realization within a much broader ensemble. Figures 5-3 and 5-4 summarize the maximum, median, and minimum projected storage conditions at Lake Mendocino and Lake Sonoma across all 41 climate scenarios to better reflect the full range of uncertainty in future hydrologic conditions.

Across the full ensemble, **Lake Mendocino is increasingly stressed** in future scenarios. Annual September 30 storage declines relative to the historical period, and the frequency of years falling below critical planning thresholds increases. Longer and more severe drought sequences also emerge, reducing the ability to recover storage between dry years. As storage declines become more frequent, the ability to maintain releases for downstream water users becomes more challenging in some years. Figure 5-4 presents results for the two baseline scenarios: (1) No PVP and (2) NERF Operations. Across these scenarios, reduced or highly variable Eel River transfers further amplify storage challenges. For example, under the No PVP scenario, median September 30 storage is approximately 2 TAF lower on average after 2035. The frequency of storage dropping below 10 TAF increases substantially from 44% under the NERF scenario to 83% under No PVP.

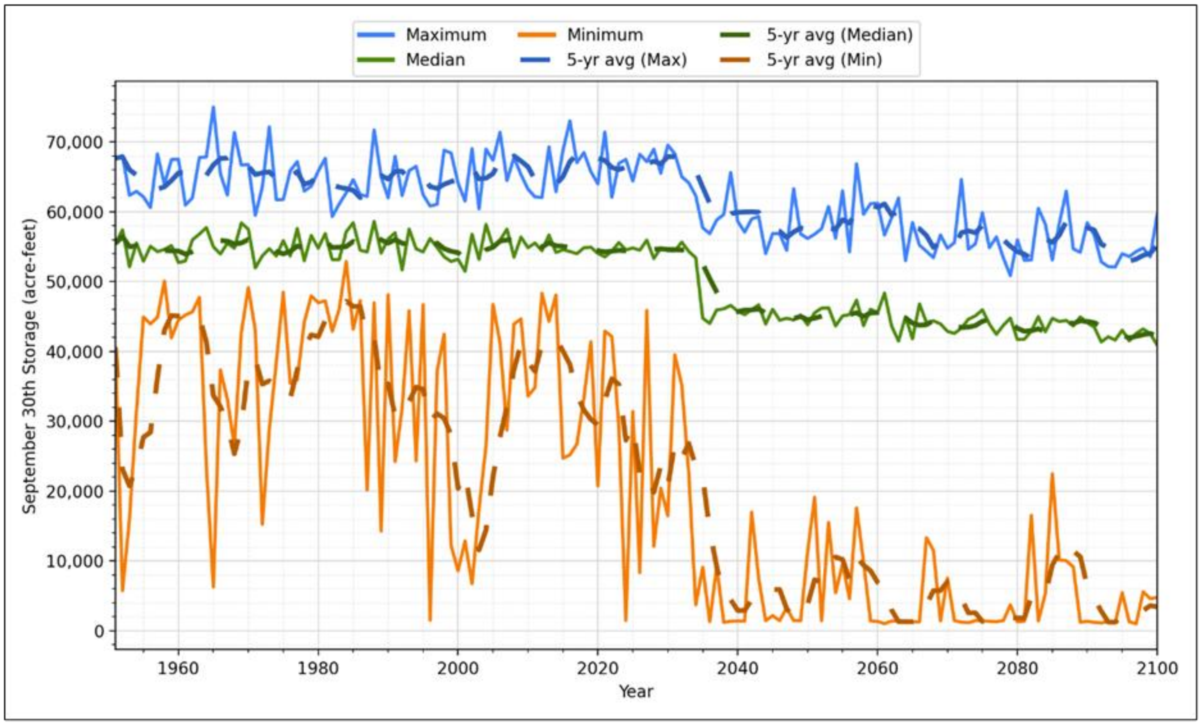
Upper Russian River water users face the greatest increases in water supply shortage risk. Shortfalls to meet full demands increase above historical levels in both mid-century and late-century periods, and the frequency and magnitude of shortfalls are highest under scenarios with reduced Eel River transfers. Potter Valley agricultural water supply is particularly vulnerable, with late spring and summer supplies unavailable in many future years unless significant adaptation measures are implemented.

Lower Russian River water users experience fewer direct impacts but still face increasing pressures from longer and more severe drought conditions. Lake Sonoma storage remains relatively stable across most climate and operational scenario simulations, yet several future projections include years with storage lower than historical lows. Although most model scenarios continue to meet Sonoma Water retail demands without shortages, increased shortfalls are predicted, particularly when local Marin County surface supplies experience multi-year drought conditions and Marin retail agency reliance on Russian River water increases.

Marin Water's and North Marin's reservoirs show relatively stable median conditions across historical and future periods, but with an expanding range of extreme outcomes. While average September 30 storage levels remain similar through mid- and late-century, the frequency of very low-storage years increases, particularly in the late-future period, signaling growing vulnerability during prolonged or severe drought sequences. These low-storage years are closely associated with simulated localized shortage events in Marin Water's service area.

Figure 5-3. Lake Mendocino September 30 Storage Statistics for Two Baseline Scenarios: (1) No PVP, which ends Eel River transfers starting in 2035, and (2) NERF Operations, in which PVP transitions to NERF beginning in 2035.

No Future Eel River Transfers (No PVP)



NERF Operations

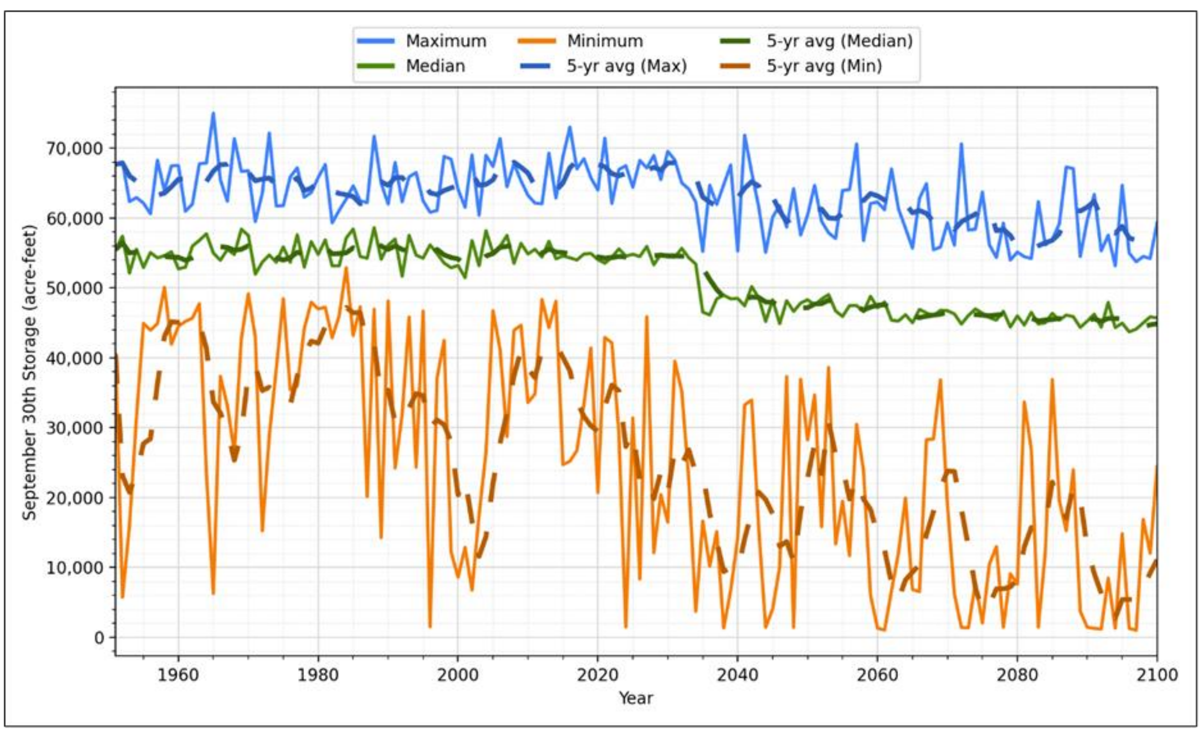
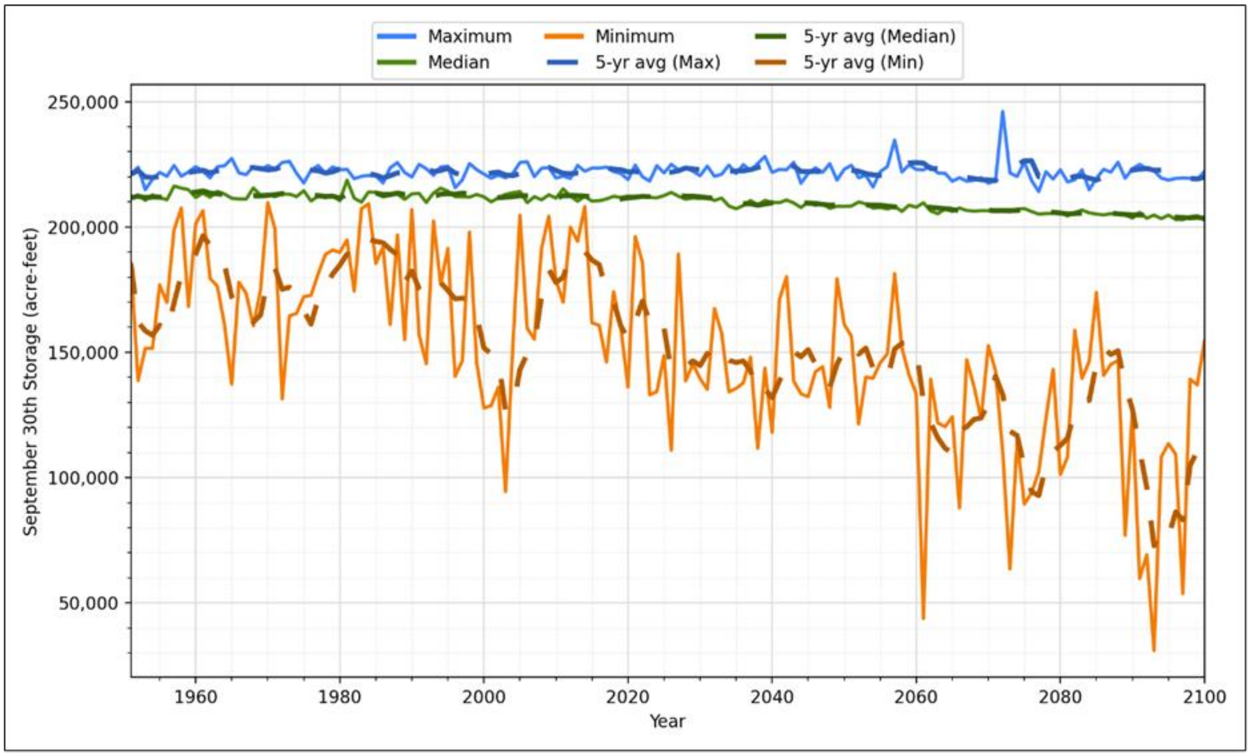
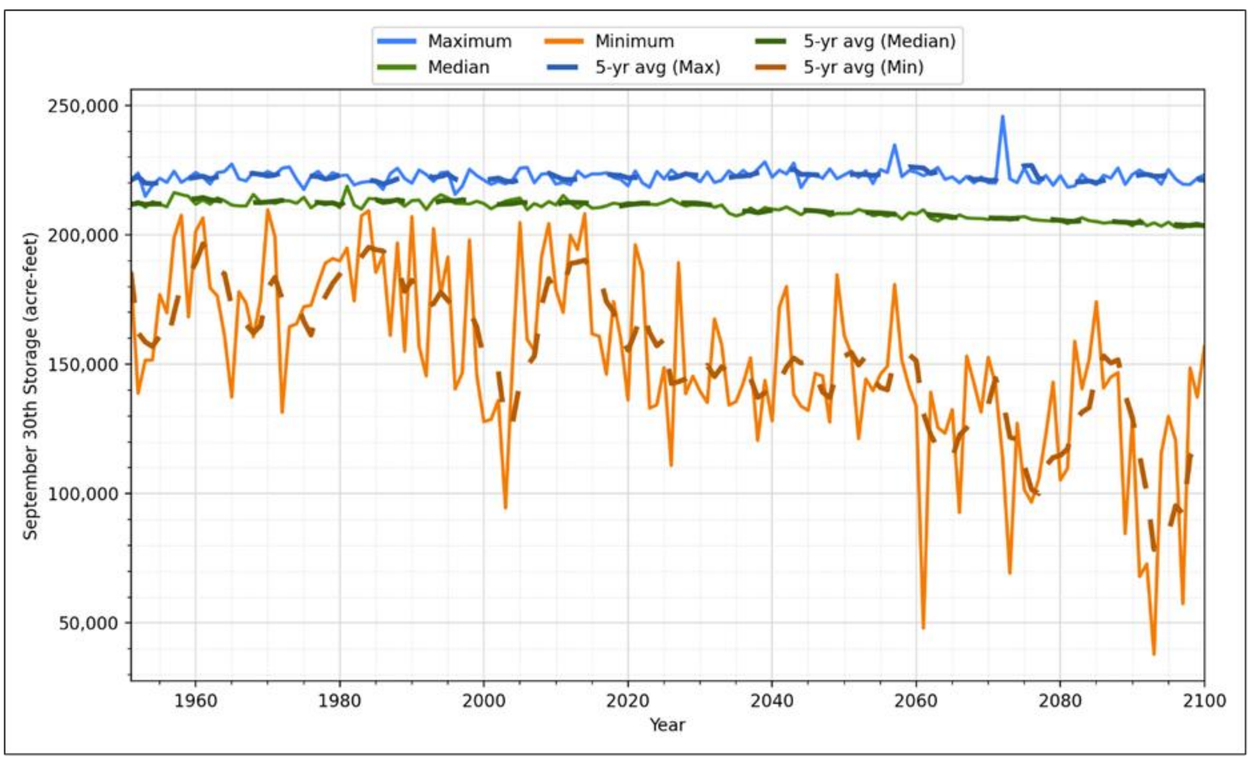


Figure 5-4. Lake Sonoma September 30 Storage Statistics

No Future Eel River Transfers (No PVP)



NERF Operations



Despite these challenges, the analysis indicates that operational adaptation and water management actions can reduce impacts. Opportunities include refining reservoir operating rules, strengthening demand management, expanding local supply strategies to transport and store surplus winter water, and improving coordination between upstream and downstream operational priorities. These strategies can help enhance system resilience and support long term water supply reliability for communities, agriculture, ecosystems, and regional partners.

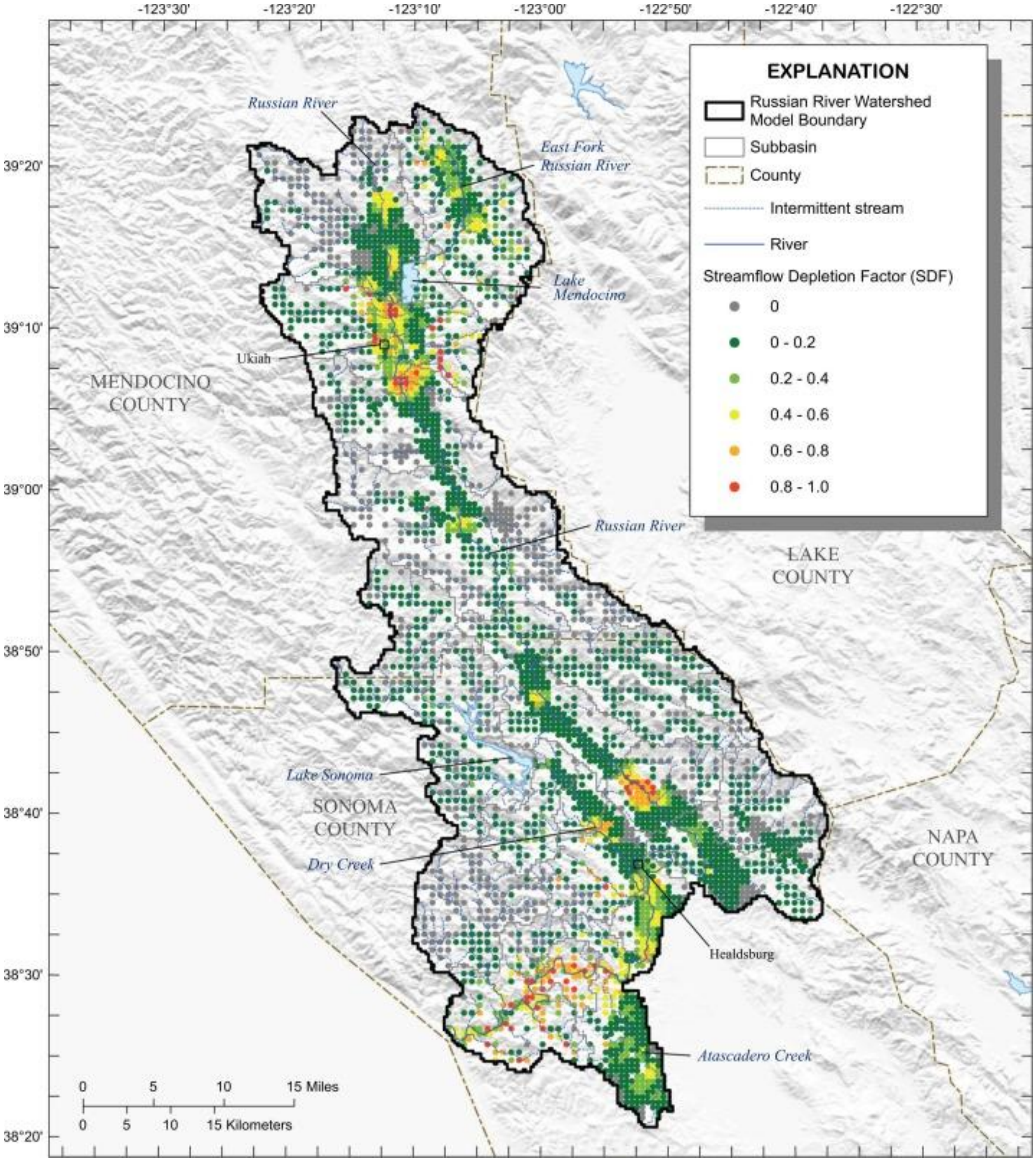
5.4.2 Groundwater Supply

- *Streamflow depletion "hot spots" in alluvial aquifers in portions of Ukiah Valley, Alexander Valley, and the Lower River are most vulnerable to changing Russian River flows.*
- *Amplified seasonal changes in groundwater storage (higher in wet seasons, but lower in dry seasons) will stress summer and fall conditions and sustainable groundwater supplies.*

Results from the RRIHM (Adera et al. 2026) show the close interconnection between surface water and the alluvial aquifer systems underlying and adjacent to the Russian River within the watershed. Appendix E presents and discusses historical water budget conditions, as simulated in the RRIHM, for the surface water, land, and groundwater systems in the Russian River watershed. Under historical conditions, model results suggest that aquifer systems along the Russian River have little interannual groundwater storage variability because seasonal groundwater storage losses accumulated during the dry season are typically replenished to capacity each winter season. However, seasonal declines in groundwater storage can result in depletions of streamflow along the Russian River. This can occur when groundwater storage declines and commensurate groundwater water-level declines induce surface water recharge from the Russian River into the alluvial aquifer system. In aggregate, net surface-groundwater exchange was from streams to aquifers, with 5% to 12% of total streamflow contributing to stream depletion to groundwater. The RRIHM also allows for estimation of stream depletion by groundwater pumping. This phenomenon is commonly represented with the concept of a stream depletion factor (SDF), which is the proportion of pumped groundwater derived from induced infiltration of surface water or groundwater that would have otherwise discharged to surface water. Model results also suggest that stream depletion by groundwater pumping is a significant component of the water budget for the alluvial aquifer systems along the Russian River, with an estimated 19% of pumped groundwater originating from stream depletion, with particular "hot spots" for streamflow depletion occurring in alluvial aquifers in portions of the Ukiah Valley, Alexander Valley, and the Lower River (Figure 5-5). These results demonstrate the close interdependence of surface water and groundwater in the watershed and highlight their shared vulnerabilities.

Future climate change simulations of the Russian River watershed show both greater seasonal and interannual hydrologic variability, with droughts occurring more frequently and with greater intensity. Given the close interconnection between the Russian River and the alluvial aquifer systems along the river's corridor, groundwater response follows these shifts, generally amplifying seasonal swings in storage, with greater increases in storage during the wet season and greater reductions in storage in wet-to-dry and dry seasons. Under the combined future stressors of intensified drought conditions and potential cessation of interbasin transfers of Eel River water, Lake Mendocino reliability is potentially reduced. Under conditions where Lake Mendocino drops below dead pool storage and releases cannot be made into the upper Russian River, groundwater replenishment from stream depletion is effectively cut off, amplifying dry-season groundwater storage declines and contributing to year-over-year storage declines in aquifer systems along the Upper Russian River. For aquifer systems along Dry Creek, where releases from the significantly more reliable Lake Sonoma sustain year-around flows, large year-over-year groundwater storage declines do not occur during the same simulated drought periods, highlighting the importance of surface water replenishment of groundwater in these systems.

Figure 5-5. Spatial Distribution of SDFs, Simulated for the 1990 to 2015 Period



Note: from Adera et al. 2026

Given the close interconnection between the Russian River and the alluvial aquifer systems along the river's corridor, increases in hydrologic volatility and attendant changes in streamflow response under climate change have follow-on impacts on groundwater resources. In general, groundwater response shows amplified seasonal swings in storage, with greater increases in storage during the wet season and greater reductions in storage in wet-to-dry and dry seasons (Figure 5-6). These larger-amplitude seasonal swings are driven by greater wet season stream leakage and greater groundwater discharge to streams in wet-to-dry and dry seasons.

Based on the evaluations performed to support Groundwater Sustainability Plan (GSP) development, changes in groundwater storage are sensitive to climate and hydrologic conditions where increases in groundwater storage occur during the wet periods when recharge from precipitation and streamflow tends to be higher. Decreases in groundwater storage tend to occur during drier periods when recharge from precipitation and streamflow tends to be lower and when groundwater pumping to meet agricultural demands is higher due to increased temperatures. In summary, groundwater inflows are generally larger during wet years and smaller during drier years, which has a larger influence on the change in groundwater storage over time. Additionally, increased temperature and decreased precipitation cause an increase in agricultural demand which can lead to increased groundwater pumping causing larger declines in groundwater storage during the drier periods. For the Petaluma Valley and Sonoma Valley, which are adjacent to San Pablo Bay, projected sea level rise assumptions were incorporated in the groundwater modeling used to support development of the GSP. Projected groundwater budgets for the Petaluma Valley and Sonoma Valley both suggest that inflow from the tidally influence Petaluma River and San Pablo Bay are projected to increase due to impacts of sea level rise. Increased inflow from San Pablo Bay could cause seawater to advance inland, however, available data do not indicate increasing trends in salinity at wells near San Pablo Bay.

5.4.3 Flood Management

Flood modeling was conducted to assess vulnerabilities associated with changing rainfall intensity and magnitudes suggested by future climate models. An integrated modeling suite comprised of hydrologic (HEC-HMS), reservoir operations (ResSim), and river hydraulic models (HEC-RAS) was applied to approximate potential future changes in flood risk. This suite of models is useful for approximating comparative changes in flood risk for historical and future climate. Spatial analyses of modeled future flood conditions (Figure 5-7) can inform our understanding of the relative shifts in flood risk from current to future climates and lead toward improved understanding of measures to reduce these risks. Simulations with the integrated modeling suite were conducted for current conditions and for future climate consisting of increased rainfall magnitude and intensity. It is important to note that the flood modeling was performed specifically to support understanding of potential changes under a range of future climates and should not be viewed or used as definitive future outcomes. This flood analysis did not include updates to base flood elevation mapping or refinements to models and should not be used to assess specific property risks. Flood risk management responsibilities are spread among multiple agencies in Mendocino and Sonoma Counties and many of these are coordinating to advance analysis and response.

Figure 5-6. Seasonal Changes in Groundwater Storage Volumes under a Hypothetical Drought for the HadGEM2-ES RCP 8.5 Future Climate Scenario for the Upper Russian River and Dry Creek Subwatersheds

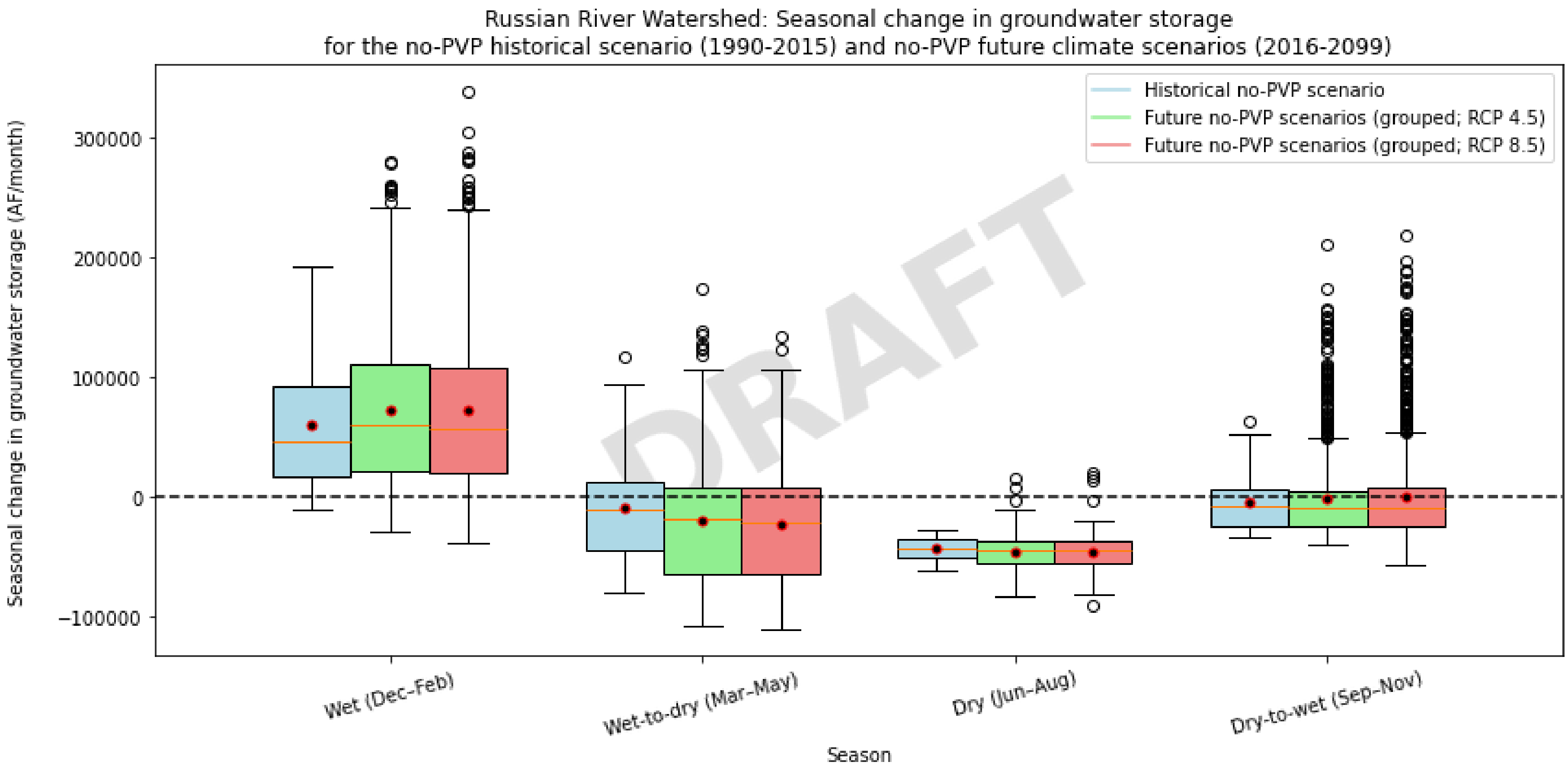
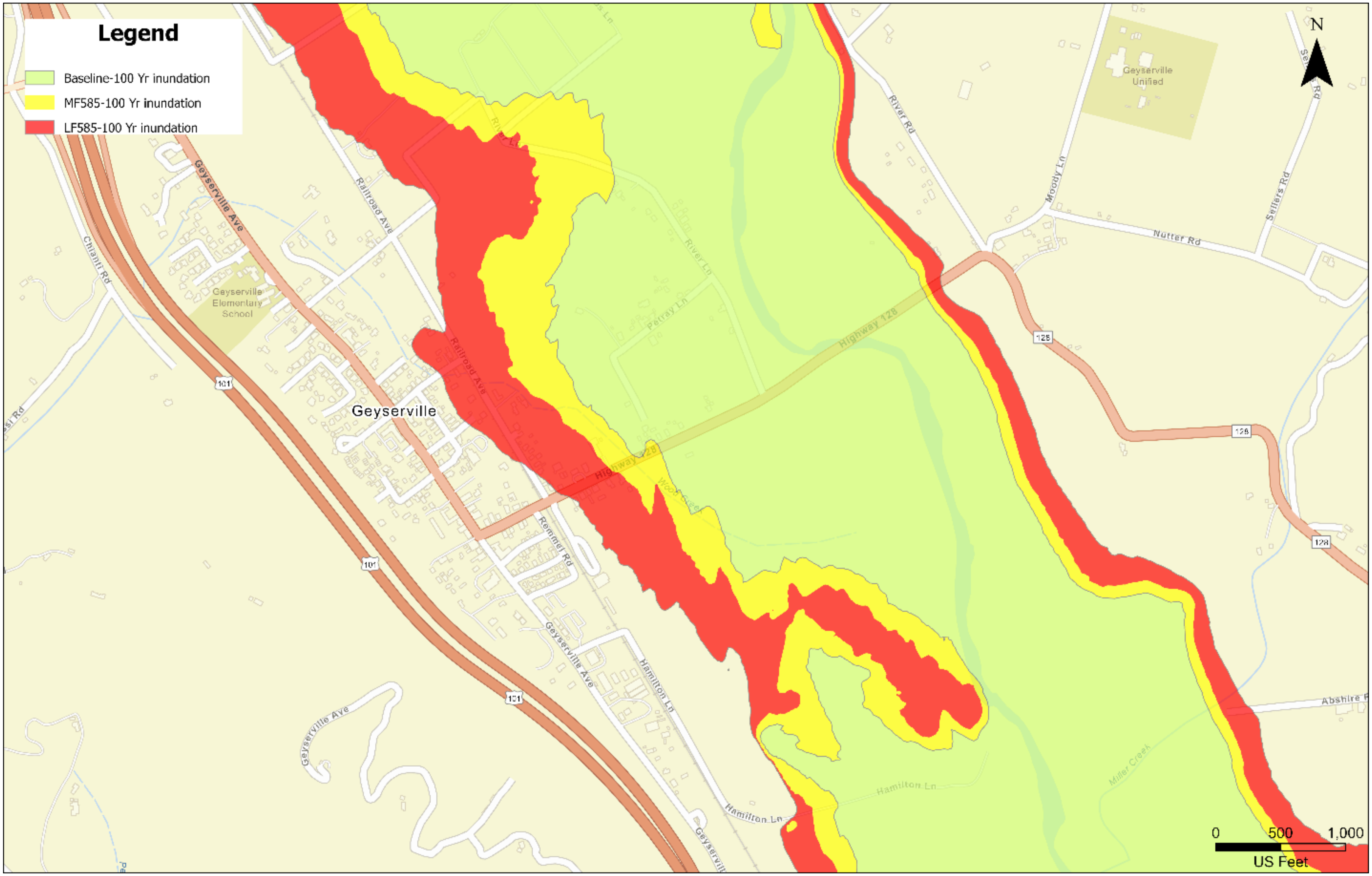
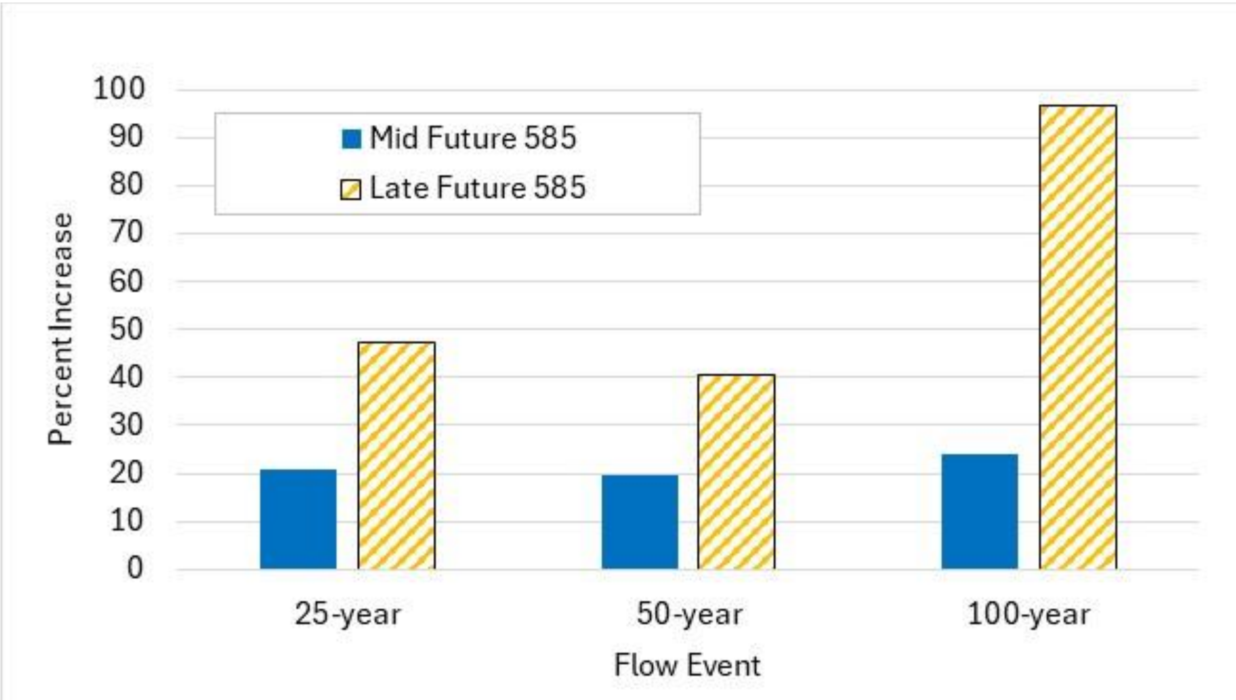


Figure 5-7. Sample of Structures at Risk with Modeled Increased Inundation under Future Climate (Baseline, Mid-Future, and Late-Future 100-year event)



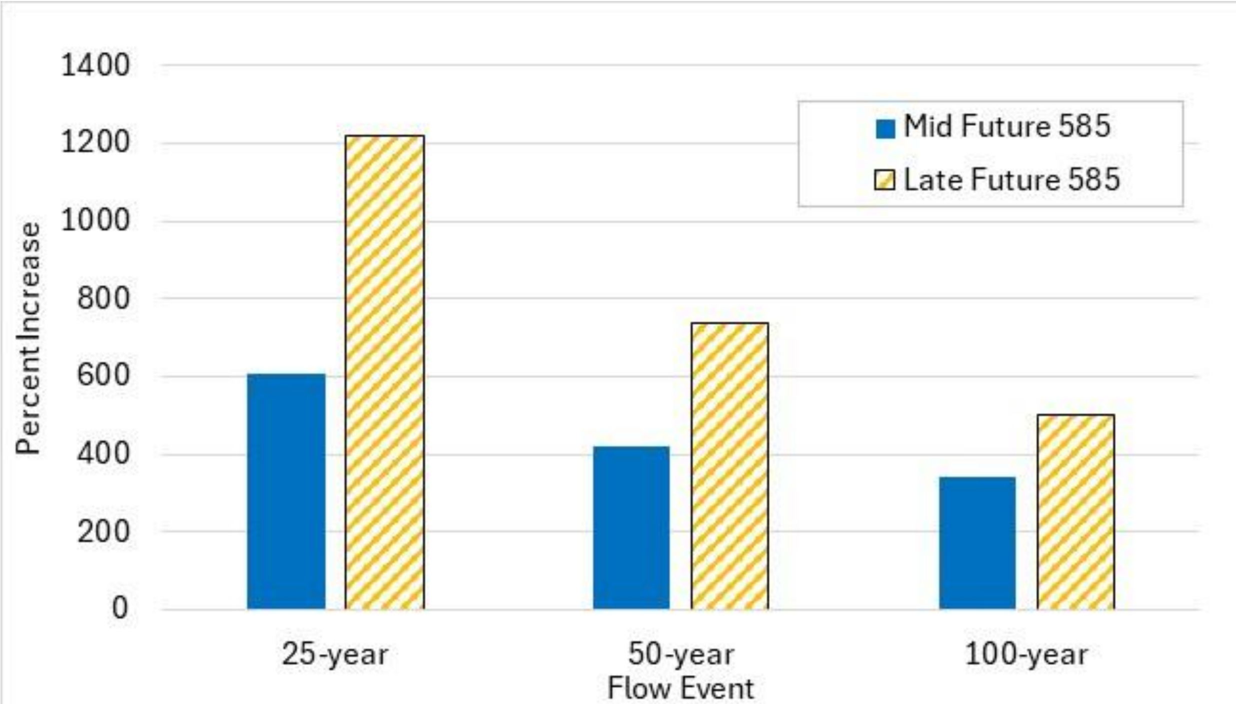
Along the Russian River, future climate is projected to nearly double the number of residences vulnerable to 100-year flood inundation. For the 100-year flood event, increases of inundated structures under future climate could reach 24% by mid-future and 97% by late future (Figure 5-8). For the 25-year flood event, model results indicate that approximately 20% more structures in the Russian River watershed may flood under the mid-future scenario and 47% more in the late-future scenarios. The majority of impacted residences are in the lower Russian River, where homes are situated closer to the river.

Figure 5-8. Simulated Increase in Residences at Risk in Russian River Watershed



Projected flood impacts to residences in the Santa Rosa Creek watershed are significantly higher as Santa Rosa Creek does not have the conveyance capacity required to transport even the current lower flood flows without overtopping its banks. In the mid-future, models predict a 600% increase in the number of structures flooded by the 25-year flood event. In late-future conditions, results show a 1,200% increase in residences impacted (Figure 5-9). At the 100-year flood level, the increases are smaller in percentage terms but larger in number of structures impacted, increasing from roughly 2,600 in the baseline to 11,600 in mid-future and 15,700 in late-future conditions. The Santa Rosa Creek watershed is more densely populated than the Russian River watershed, hence the large increases with increased flows under future climate scenarios. Backwater impacts of increased stages in the Russian River are also seen in Mark West Creek and Green Valley Creek.

Figure 5-9. Simulated Increases in Residences at Risk in the Santa Rosa Creek Watershed



Flood vulnerabilities under future climate are significant in residential areas near Santa Rosa Creek. While such residences are not within the current 100-year floodplain, increased runoff from projected future storm events is expected to result in a larger 100-year floodplain (Figure 5-7). Impacts are also seen in more populated areas along the Russian River, such as Guerneville and Healdsburg. Backwater impacts of increased stages in the Russian River are also seen in Mark West Creek and Green Valley Creek.

- ***Along the Russian River, future climate is projected to nearly double the number of residences vulnerable to 100-year flood inundation.***
- ***Projected flood impacts to residences in the Santa Rosa Creek watershed are significantly higher as Santa Rosa Creek does not have the conveyance capacity required to transport even the current lower flood flows without overtopping its banks.***
- *Backwater impacts of increased stages in the Russian River are also seen in Mark West Creek and Green Valley Creek.*

Numerical models provide useful estimates of future conditions, but results must be interpreted with an understanding of potential limitations of the modeling analysis, including those associated with assumptions adopted by the model. The full modeling suite has not been calibrated to historic events as part of this analysis, and a cursory comparison to larger historic events indicates that the model underestimates peak flows and stages. This would likely lead to an underestimation of the structures and population at risk under future climate. A full calibration of the HEC-HMS and HEC-RAS models should be incorporated into future studies.

5.4.4 Water Quality

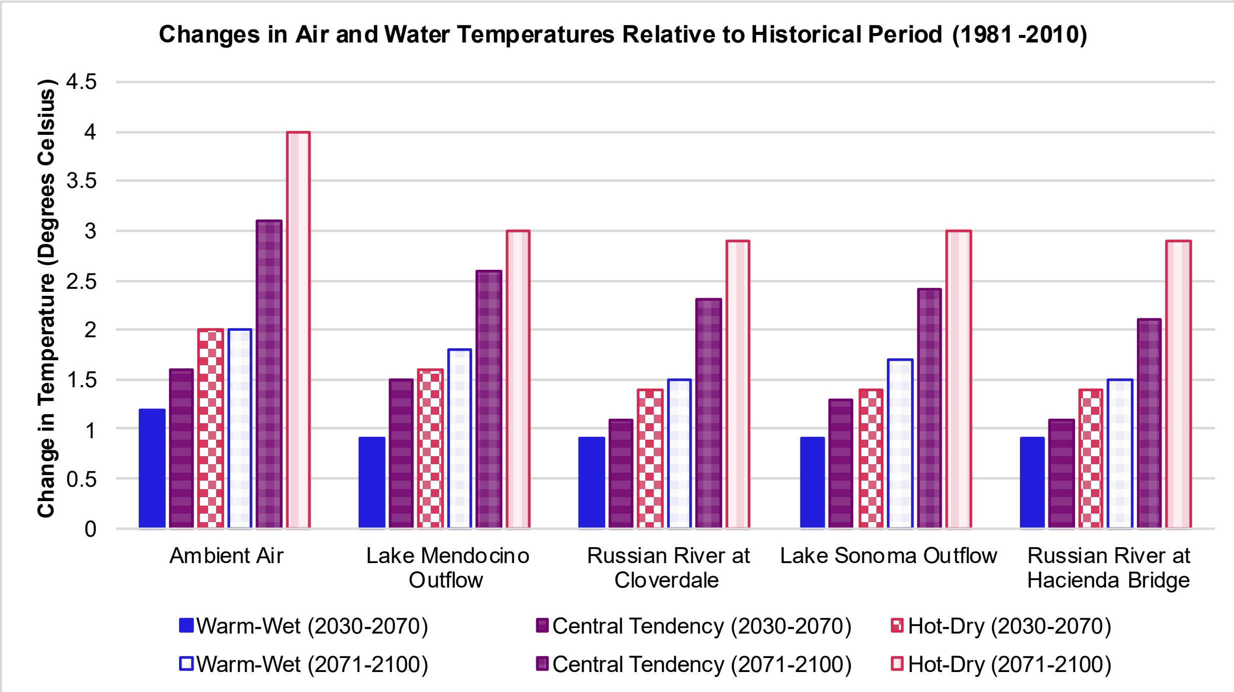
Water quality in the Russian River watershed is influenced by a variety of factors, including the introduction of contaminants and pollutants from a range of urban and agricultural sources, management of flows, the influence of air temperatures, and sediment dynamics. Each of these factors can have subsequent impacts to ecosystems (including habitat- and species-specific responses), recreation, and both existing and pending beneficial uses.

- ***Water temperatures are projected to increase along the Russian River, Dry Creek, and other tributaries due to increasing air temperatures, warmer reservoir releases, and greater heat absorption.***
- *The Russian River is expected to experience decreasing dissolved oxygen due to higher water temperatures and lower summer and fall river flows.*
- *Increasing water temperature and decreasing dissolved oxygen have the potential to impact salmon and steelhead rearing and spawning in the Russian River by decreasing the availability of suitable habitat*

The water quality vulnerability assessment evaluates projected changes in water quality, specifically changes to water temperatures and dissolved oxygen, under three future climate scenarios, representing a subset of the full suite of 41 climate projections: hot-dry, warm-wet, and central tendency. To estimate these changes, the Russian River HEC-ReSim Water Quality Model (RRWQM) was utilized to simulate different water quality parameters under varying hydrologic and meteorological inputs. For this assessment, water temperature and dissolved oxygen model outputs were analyzed at Lake Mendocino and Lake Sonoma reservoirs and along the mainstem of the Russian River to determine the water quality-related vulnerabilities of Russian River watershed. Supplementary water quality-related results are presented in Appendix C.

Results indicate that **under all evaluated future climate scenarios the water temperature being released from Lake Mendocino and Lake Sonoma is expected to increase due to warmer inflows from increased air temperature (Figure 5-10)**. Specifically for Lake Mendocino, there is projected increase in the frequency of fall water temperature spikes due to the depletion of the cold-water pool earlier in the season from lower reservoir storage. These increases in water temperature from reservoir releases may have an impact on Coyote Valley Dam hatchery operations as well as salmon and steelhead lifecycle stages downstream.

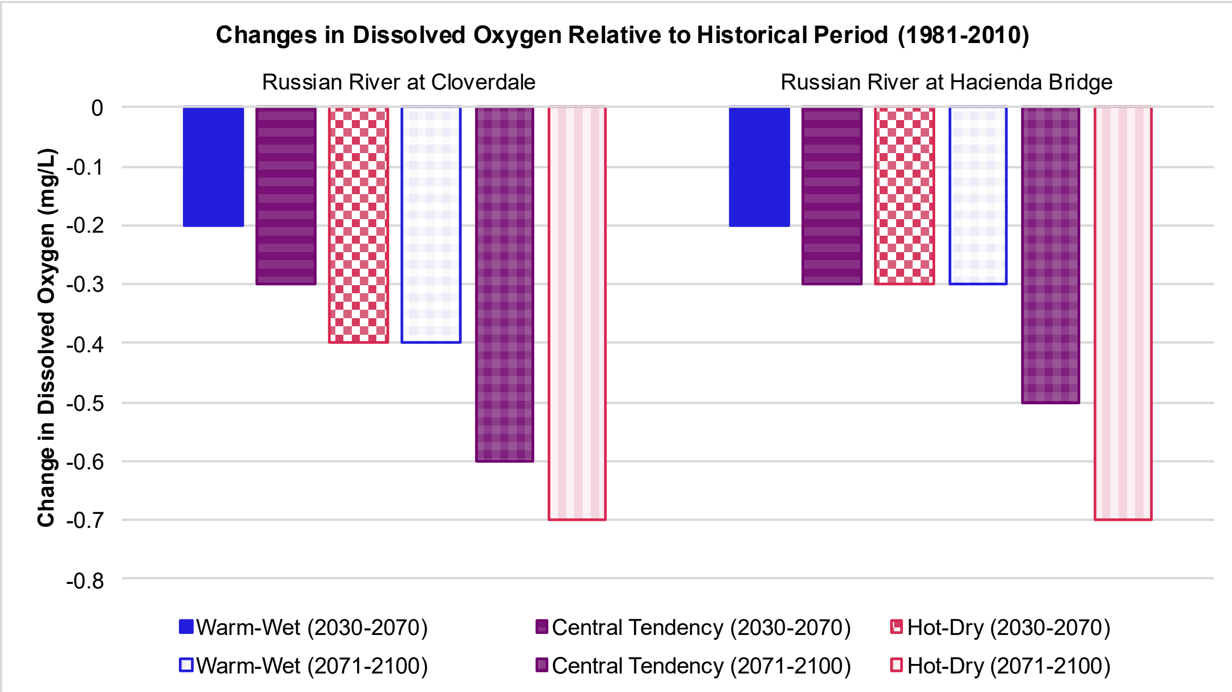
Figure 5-10. Change in Air and Water Temperature Results for Various Model Locations



For the Russian River, both Cloverdale in the Upper Russian River and Hacienda Bridge in the Lower Russian River are projected to experience an increase in water temperature through the whole year due to warmer local natural flow from increasing air temperatures, warmer reservoir releases, and greater heat absorption while flowing downstream from increasing air temperatures (Figure 5-10). Both locations are also expected to experience decreasing dissolved oxygen in the river due to higher water temperatures and lower river flows (Figure 5-11). These changes also have the potential to impact salmon and steelhead rearing and spawning in the Russian River by decreasing the availability of suitable habitat.

This analysis does not evaluate specific vulnerabilities to fisheries in the Russian River but instead provides general trends in water quality and an interpretation of the causes based on the RRWQM. The ecosystem vulnerability assessment explores associated water quality impacts to fisheries in more detail. Changes to other climate-influenced water quality constituents beyond water temperatures and dissolved oxygen, as well as impacts to recreation and existing and pending beneficial uses, will need to be explored in subsequent analyses under future efforts.

Figure 5-11. Changes in Daily Average Dissolved Oxygen Results for Cloverdale and Hacienda Bridge Model Locations



5.4.5 Ecosystems

The Russian River watershed contains a diverse range of aquatic and terrestrial ecosystems, characterized by distinct habitat types and species that both influence and are influenced by natural processes affected by climate change. Species that are threatened or endangered are of particular interest when evaluating climate-driven impacts due to existing vulnerabilities. For the purposes of the ecosystem assessment, vulnerabilities are explored for aquatic ecosystems and the following species: Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*) and coho salmon (*Oncorhynchus kisutch*). The ecosystem vulnerability assessment employs separate methodologies and analytical tools for the mainstem Russian River and its tributaries as well as the Russian River Estuary.

5.4.5.1 Mainstem Russian River and Tributaries

For the mainstem Russian River and its tributaries, the ecosystem vulnerability assessment evaluated projected climate-driven changes in hydrology, temperature, and dissolved oxygen in the mainstem Russian River and Dry Creek; total watershed averaged flow metrics for tributary watersheds to the Russian River and Dry Creek; and hydrologic connectivity in select tributaries of the Russian River watershed using ensemble climate simulations and literature-supported habitat relationships. Daily reservoir and river flows were modeled across historical (1981 to 2010), mid-future (2041 to 2070), and late-future (2071 to 2100) periods. Modeled discharge was interpreted qualitatively in relation to salmonid depth–velocity suitability preferences and migration thresholds at known passage for critical riffles at four locations in the HEC-ResSim model (Cloverdale, Healdsburg, Dry Creek at the Russian River, and Hacienda). Water temperature and dissolved oxygen projections were evaluated relative to species- and life stage-specific tolerance limits at a subset of these locations (Cloverdale, Dry Creek, Hacienda). Total watershed averaged flow outputs for identified tributary watersheds were generated using 41 simulations from the Russian River and Upper Eel River BCM. A complementary review of tributary wet–dry mapping and empirical survival studies was also conducted to assess sensitivity to seasonal flow disconnection.

Results indicate that **climate change is expected to intensify seasonal habitat constraints and increase vulnerability for multiple listed salmonid life stages**, particularly under late-future conditions. In the mainstem Russian River, projected reduced early fall flows increase the risk of delayed adult migration at critical riffles, especially for Chinook salmon (Figure 5-12). Higher and more variable winter peak flows elevate the likelihood of streambed and redd (spawning nests) scour for Chinook salmon, and to a lesser degree, steelhead and coho salmon. Warmer late winter and early spring temperatures advance incubation threshold exceedances, shortening the window of suitable egg development conditions at upstream locations, such as Cloverdale.

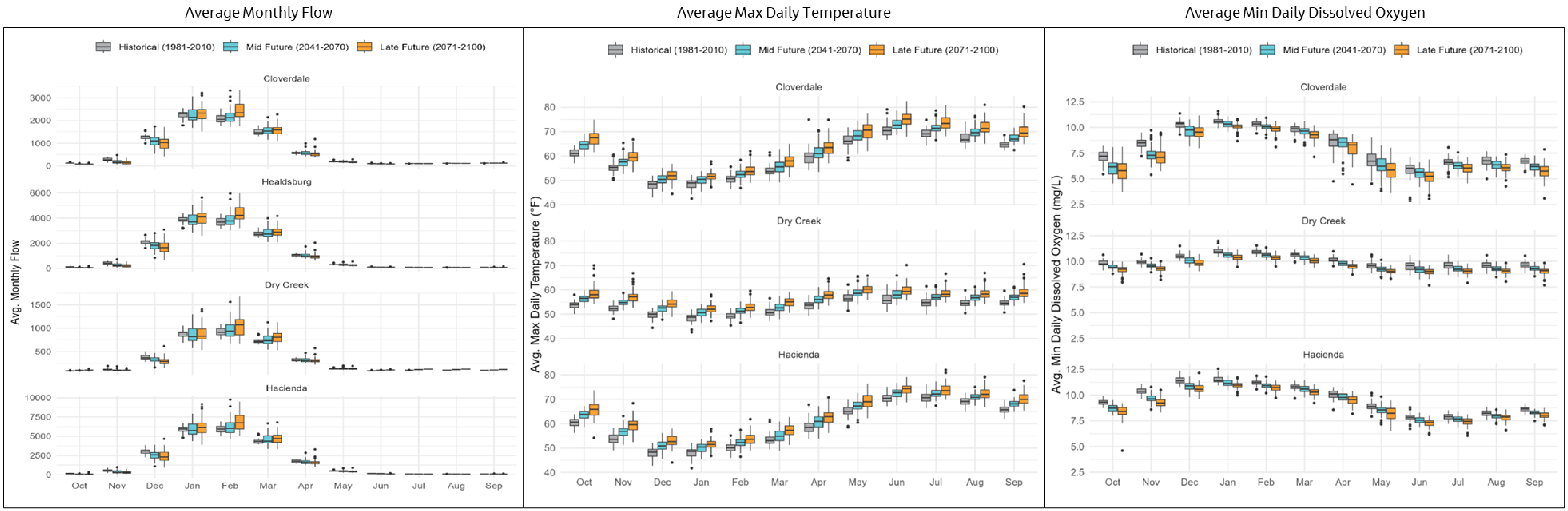
- ***Climate change is expected to intensify seasonal habitat constraints and increase vulnerability for multiple listed salmonid life stages***
- ***The most consistent and severe vulnerability is projected during juvenile rearing where mainstem summer temperatures already approach or exceed thermal thresholds under historical conditions and increase under future conditions.***
- *Projected warming and declining baseflows are expected to increase the duration and spatial extent of seasonal drying in tributaries, particularly in lower alluvial reaches*
- ***Seasonal thermal stress, low-flow passage constraints, and tributary connectivity loss are the dominant drivers of future climate vulnerability for listed salmonids in the watershed***
- ***Suitable habitat conditions for juvenile steelhead in the Russian River estuary are vulnerable*** *due to increased closure duration (sea level rise and river flows) and higher river temperatures are projected to reduce suitable juvenile steelhead rearing habitat during rearing months*

The most consistent and severe vulnerability is projected during juvenile rearing. Mainstem summer temperatures already approach or exceed thermal thresholds under historical conditions and increase under mid- and late-future conditions. At Cloverdale, projected late-future dissolved oxygen concentrations fall to less than 6 milligrams per liter beginning in early May and remain depressed through summer, compounding potential for thermal stress and associated impairment of multiple beneficial uses identified in the Water Quality Control Plan for the North Coast Region (California North Coast Regional Water Quality Control Board 2018). Additionally, reduced late-spring flows may further constrain juvenile outmigration and rearing habitat and associated survival to the Pacific Ocean.

Tributaries of the Russian River watershed represent an additional critical vulnerability. Empirical evidence identifies longitudinal disconnection and reduced wetted habitat as primary drivers of juvenile mortality, with “days of disconnection” strongly associated with survival. Projected warming and declining baseflows are expected to increase the duration and spatial extent of seasonal drying, particularly in lower alluvial reaches. Although groundwater-supported pools provide localized refugia, their persistence may diminish under intensified drought conditions. BCM-generated total watershed averaged flow results for tributary watersheds indicate a consolidation of flows into the winter season at the loss of total flow volumes in the fall and spring, signaling vulnerabilities for upstream migration in the fall and outmigration in the spring.

Overall, the most climate-sensitive components of the system are mainstem juvenile rearing, tributary over-summer survival, and egg incubation during late winter and spring. Adult Chinook salmon migration is vulnerable primarily during low-flow fall periods but is comparatively less constrained by temperature. These findings identify seasonal thermal stress, low-flow passage constraints, and tributary connectivity loss as the dominant drivers of future climate vulnerability for listed salmonids in the watershed. The predicted changes to aquatic habitat conditions are associated with different model scenarios and anticipated trends with climate change; it is difficult to predict specific timelines across future time periods.

Figure 5-12. Simulated Average Monthly Flow, Average Maximum Daily Temperature, and Average Minimum Daily Dissolved Oxygen at Various Locations along the Russian River and Dry Creek



5.4.5.2 Russian River Estuary

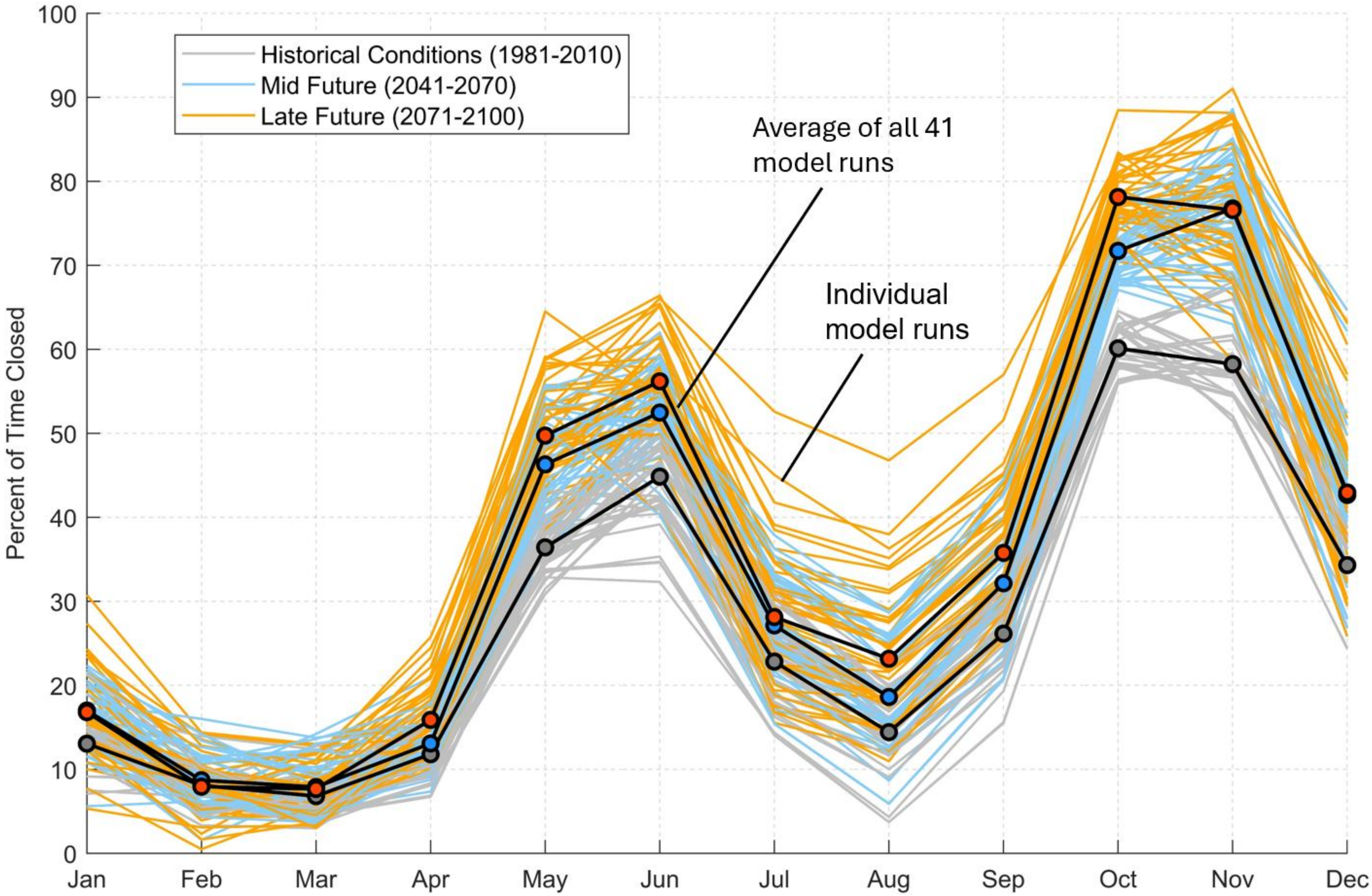
For the Russian River estuary, projected changes in hydrology and water quality were evaluated to determine how habitat conditions for federally listed salmonids in the estuary may be affected. Changes in suitable habitat availability were assessed across the historical, mid-future, and late-future periods. Separate lagoon hydrology and habitat models were integrated to simulate future conditions, taking into account changes in boundary conditions driven by climate change, including altered river temperature, sea level rise, ocean tides, and wave conditions. The QCM simulates river mouth closure dynamics, and the Suitable Habitat Acre-Day (SHAD) analysis quantifies spatial and temporal changes in juvenile steelhead rearing habitat under varying inlet conditions. River and reservoir operations were simulated separately using HEC-ResSim, and future tidal conditions follow State of California sea level rise guidance.

Vulnerability assessment results indicate that future climate conditions increase risk to multiple salmonid life stages. Both mid- and late-future conditions show reduced early fall, early winter, and spring flows and longer or more frequent inlet closure events. Late-future conditions also project higher winter peak flows. Projected increases in air temperature are expected to elevate river temperatures entering the estuary, and monitoring data confirm that estuary temperatures closely track upstream river conditions, particularly during closed-mouth periods. Increased closure duration and higher river temperatures are projected to reduce suitable juvenile steelhead rearing habitat during rearing months (May through November), as demonstrated on Figure 5-13.

Both mid-future and late-future conditions lead to net lower amounts of steelhead rearing habitat availability during the months of May through November (Figure 5-14). Overall, the change is relatively small (a loss of about 10% to 20% in the months of June and July). There is not a clear worsening trend from historical through mid-future and late-future conditions. This is because longer closure events can increase the volume of available habitat in the spring and late fall months when river temperatures are cooler and more suitable for rearing. Overall, both the mid-future and late-future scenarios are associated with less habitat than the historical scenario.

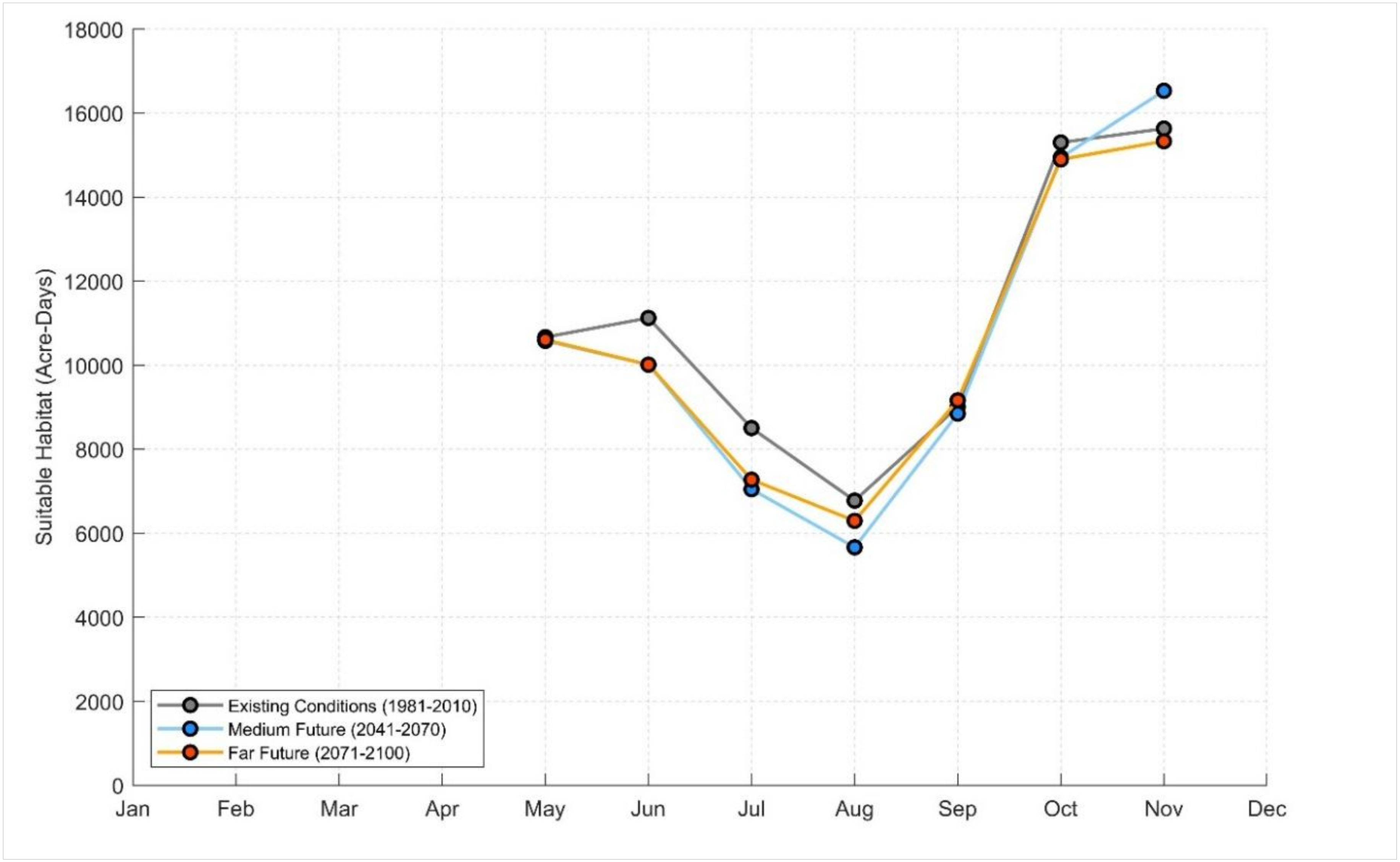
Overall, the estuary is expected to retain its typical seasonal open/closed dynamics, but with intensified drought sensitivity and temperature-related stress. These findings support continued use of adaptive management strategies that protect thermal refugia to sustain salmonid rearing and migration under future conditions.

Figure 5-13. Modeled Inlet Closure Seasonality Within Each Epoch (Historical [1981–2010], Mid-Future [2041–2070], and Late-Future [2071–2100])



Note: The thin lines in the background represent individual model runs, and show the percent of each month of the year that the Russian River inlet is predicted to be closed (e.g., 100% closed means that the river was closed for the full month). Different colors represent the different epochs. Thick lines in the foreground represent averages of all 41 model runs.

Figure 5-14. Suitable Steelhead Rearing Habitat Availability per Month



5.4.6 Recreation

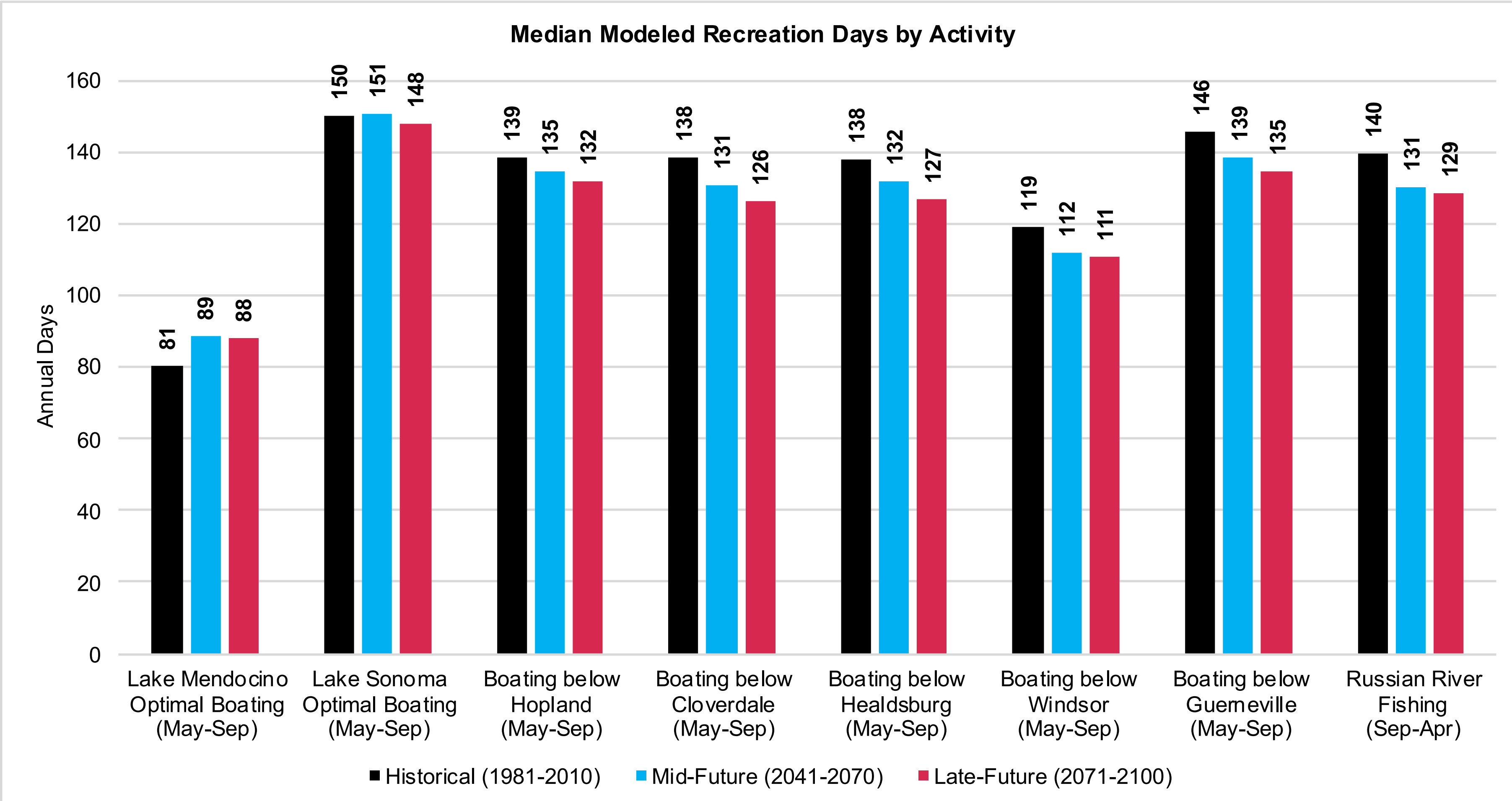
The Russian River, Lake Mendocino, and Lake Sonoma offer opportunities for recreation within the planning area. These opportunities are dependent on annual surface water supplies, reservoir management, and downstream diversions. Under future climate conditions, shifts in the timing and magnitude of unimpaired inflows to reservoirs and decreases in the total annual surface water supplies may affect the quality and availability of recreational activities, particularly in summer months. While not directly assessed, recreation in the Russian River watershed can also be affected by warmer water temperatures resulting in a higher likelihood of harmful algal blooms as well as post-fire and post-flood water quality impairments. Furthermore, management of flows for recreation may also have subsequent effects on water quality and ecosystems; these relationships require further investigation to fully quantify.

Vulnerabilities to climate change were assessed for both lake and riverine recreation using daily Sonoma Water Decision Support Model (DSM) outputs at Lake Sonoma, Lake Mendocino, and various locations along the Russian River. Key reservoir elevation and riverine flow thresholds identified in the *Fish Habitat Flows and Water Rights Project Draft EIR* (Sonoma Water 2016b) were utilized and supplemented with additional thresholds to expand coverage to upstream portions of the Russian River above Rio Linda Academy. Simulated reservoir elevation and Russian River flow timeseries under historical (1981 to 2010), mid-future (2041 to 2070), and late-future (2071 to 2100) conditions were compared to identified thresholds to estimate the number of annual days sufficient for the range of recreational activities considered. For Lake Sonoma and Lake Mendocino, changes in the availability of motorized boating, non-motorized boating, and camping were considered between May 1 and September 30. For the Russian River, non-motorized boating and public access were considered between the same time period. Fishing along the Russian River was also evaluated between September 1 and April 30.

- ***Optimal days for lake recreation at Lake Mendocino is projected to decrease with boating closures increased by up to 2 weeks under future climate.***
- ***Recreationally suitable days decreases by up to 12 days along the Upper Russian River, with smaller impacts along the Lower River.***

Findings from the analysis are summarized for median conditions on Figure 5-15. For Lake Mendocino, the number of days with optimal (i.e., no negative impact on any recreational activities) conditions for recreation increases by approximately 8 days (mid-future) and 7 days (late-future) annually relative to historical trends. However, the **annual frequency of closures that fully prohibit motorized boating increase by roughly 14 days each year for the mid-future and 17 days for the late-future** due to a higher prevalence of lower reservoir storage under future conditions. For Lake Sonoma, median conditions are relatively unchanged by future climate conditions, with only a 1-day increase to 2-day reduction in optimal reservoir elevations, depending on analysis period, which result in access limitations at only one of the three boat ramps. For both Lake Mendocino and Lake Sonoma, sufficient adaptive capacity exists to maintain the availability of recreational opportunities at these locations. While Lake Mendocino is more vulnerable to future climate conditions and displays a decreasing trend in annual storage, lightweight crafts can still be hand-launched to access the lake and the reduction in storage results in a decreased frequency of events that inundate surrounding campgrounds and parking lots. For Lake Sonoma, alternative boat ramps can still be utilized during periods of lower reservoir elevations to access the lake.

Figure 5-15. Summary of Recreation Vulnerability Assessment Findings



Along the Russian River, **the median frequency of recreationally suitable days decreases between 4 to 9 days for mid-future conditions and 7 to 12 days for late-future conditions**, depending on location and activity. The decrease in days that flows exceed identified thresholds at these locations is driven by reductions in storage at Lake Mendocino between May and February. The reduction in storage results in a decrease in surface water supplies that can be released downstream, resulting in a higher frequency of days with flows below thresholds suitable for recreation. Additionally, while Lake Sonoma storage appears to be more resilient to future climate conditions, this stability does not offset the impacts to flows caused by the reduction in Lake Mendocino storage in areas below the confluence with Dry Creek. **Along the Upper Russian River, riverine recreation is particularly vulnerable to the reduction in annual water supplies at Lake Mendocino as no infrastructure currently exists to manipulate water surface elevations.** For the Lower Russian River, where most of the recreation in the watershed is consolidated, operation of the instream summer dams has a greater impact on the prevalence of recreational activities in these areas. If instream dams continue to operate as normal and create sufficient water surface elevations for swimming, boating, and public access, the impacts of higher frequencies of low-flow occurrences can be partially mitigated.

5.4.7 Hydropower

Releases from Coyote Valley Dam at Lake Mendocino and Warm Springs Dam at Lake Sonoma are used to generate hydropower in the Russian River watershed. Changes in the magnitude and distribution of reservoir inflows throughout the year can influence the quantity of hydropower production and the reliability of these energy supplies for municipalities and residents within the watershed. Hydropower vulnerabilities at Lake Mendocino and Lake Sonoma were evaluated using daily turbine flow and hydropower generation timeseries between 1950 and 2100. These time series were generated by incorporating a python-based tool developed by Sonoma Water for estimating hydropower production into Sonoma Water DSM, a regional water supply model that simulates reservoir and diversion operations within Sonoma Water's service area. Historical trends between 1981 and 2010 were compared with mid-future (2041 to 2070) and late-future (2071 to 2100) climate conditions to evaluate vulnerabilities to hydropower generation at Lake Mendocino and Lake Sonoma.

Lake Mendocino annual total hydropower generation is projected to decrease by roughly 17% and 19% under median mid-future and late-future conditions, respectively (Figure 5-15). These changes are primarily driven by a significant reduction in reservoir releases to hydroelectric turbines in October through January. The reduction in turbine flow for these months is caused by a decrease in reservoir inflows to Lake Mendocino between spring and early winter as a result of reduced Eel River transfers. Given that Lake Mendocino hydroelectric supplies are primarily utilized by the City of Ukiah, alternative, local energy sources may need to be considered between October and January to compensate for the reduction in power production during these months.

- ***Lake Mendocino annual total hydropower generation is projected to decrease by roughly 17% and 19% under median mid-future and late-future conditions***
- *Lake Sonoma annual total hydropower generation demonstrates high resilience to future climate conditions, with only modest decreases under future climate.*

Lake Sonoma annual total hydropower generation demonstrates high resilience to future climate conditions, with a 2% decrease under median mid-future conditions and a 1% decrease under median late-future conditions relative to historical trends (Figure 5-16). Monthly trends are projected to vary slightly from month-to-month on average, but any decreases in some months are largely offset by increases in others, particularly under late-future conditions. Ultimately, shifts in reservoir inflows at Lake Sonoma have a relatively muted effect on annual reservoir storage, and reservoir operations appear to be capable of maintaining historical hydropower generation trends under future conditions. Between late spring and early fall under late-future conditions, Lake Sonoma hydropower production increases slightly relative to historical conditions, resulting in a minor overall increase in hydroelectric generation during this period. This change is driven by an increase in Lake Sonoma releases to compensate for the reduction in releases from Lake Mendocino during this period and ensure minimum instream flow requirements in the Russian River are being met.

5.5 Understanding Hazards with an Equity Lens

Advancing equity in climate and watershed planning requires an understanding of the current vulnerabilities and sensitivities of the existing population and understanding how projected future hazards will impact those populations.

Community vulnerability in the watershed is assessed by overlaying climate hazard information with social vulnerability indicators to determine if community members with higher sensitivity to hazards are disproportionately exposed. To understand current sensitivity, we leveraged the sensitivity indicators developed by the Vulnerable Communities Platform (VCP) (Office of Land Use and Climate Innovation). The VCP aggregates multiple demographic and access related indicators to develop four unique sets of sensitivity indicators for specific climate hazards: Water Supply, Wildfire, Extreme Heat and Flooding. Subsequently, the projected climate hazards specific to Russian River watershed were overlayed with the community sensitivity to understand who is impacted by the projected climate impacts.

- *Flood exposure increases by approximately 15% in the projected late-century, rising from approximately 13,000 residents to more than 15,000, with one third of exposed residents in the highest sensitivity tier.*
- *The risk of wildfire expands dramatically, with nearly the entire watershed exceeding a 15% decadal burn probability under late-century conditions, affecting many mid-valley communities that historically experienced lower risk.*
- *Extreme heat exposure intensifies most sharply, with up to over 40 additional days with temperatures greater than 95°F projected in inland areas by late century. Because 30% of residents, including outdoor workers and others with occupational heat exposure, are already in the highest heat sensitivity tier, exposure among heat sensitive populations increases by roughly 40% to 50% under future conditions.*
- *Future water supply vulnerability is similarly widespread, with roughly 50% of all residents expected to experience high water supply vulnerability.*

5.5.1 Existing Population Sensitivity to Climate Hazards

Figure 5-17 illustrates how current sensitivity to drought, wildfire, heat, and flood is distributed across the Russian River watershed, revealing clear north-south contrasts: clusters of higher sensitivity (shown in reds and blues) occur most prominently in the northern portion of the basin, while lower and moderate sensitivity populations (greens, yellows, and purples) appear more frequently in the south. Together, these patterns highlight the uneven distribution of climate-related burdens across the watershed and underscore the need for place-specific strategies that address both environmental exposure and underlying social vulnerability.

Figure 5-18 shows that, in the late-century climate scenario, the population sensitivity to climate hazards is unevenly distributed across the Russian River watershed, with 40% to 50% of residents falling into moderate to highest levels of sensitivity, depending on the hazard. Across all four hazard types, the northern watershed consistently displays extensive clusters of high sensitivity, reflected in the dominance of blue (highest) and red (second-highest) sensitivity tiers.

Figure 5-16. Summary of Hydropower Vulnerability Assessment Findings

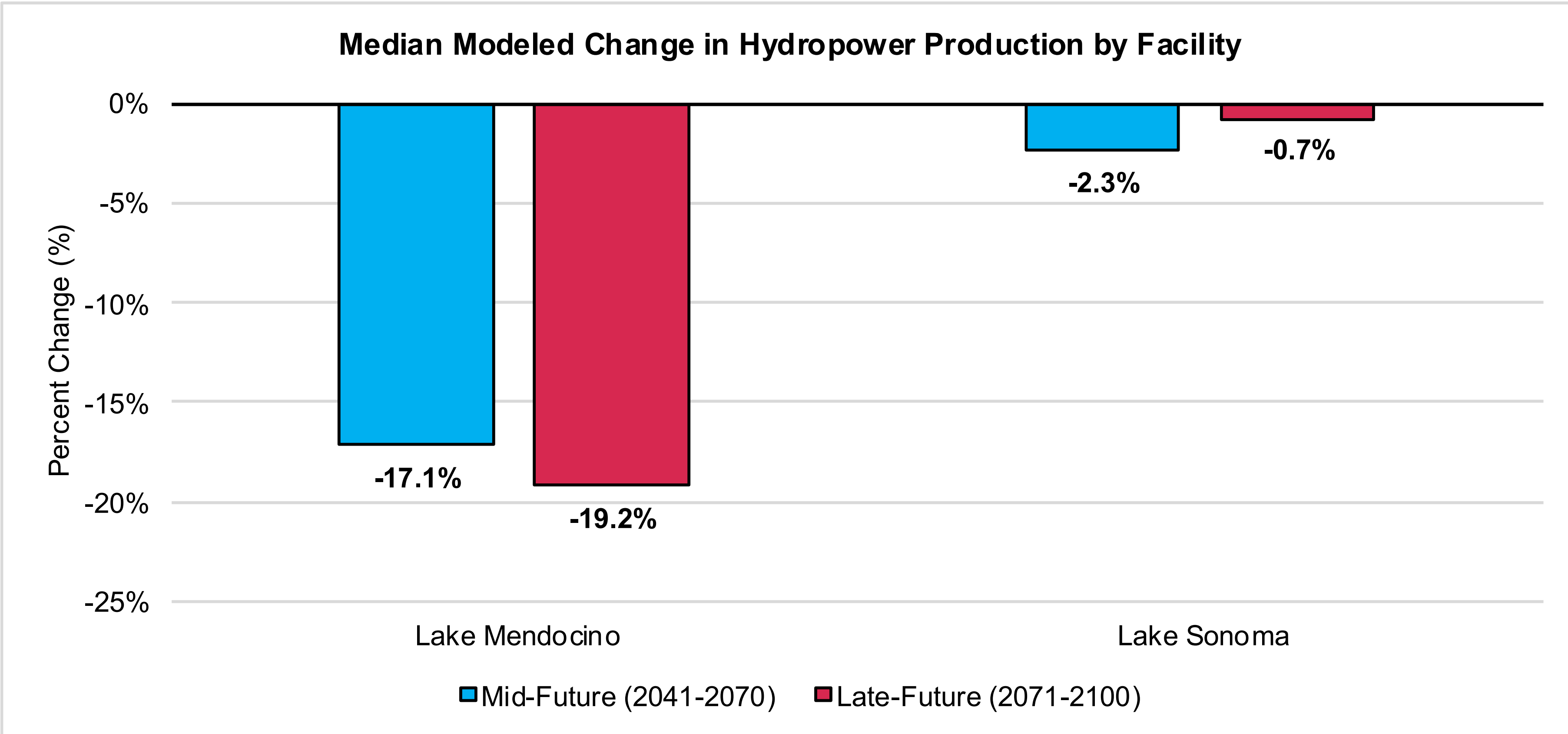


Figure 5-17. Distribution of Population Sensitivity to Climate-Related Impacts (Left to Right: Water Supply Vulnerability, Wildfire, Extreme Heat, Flooding)

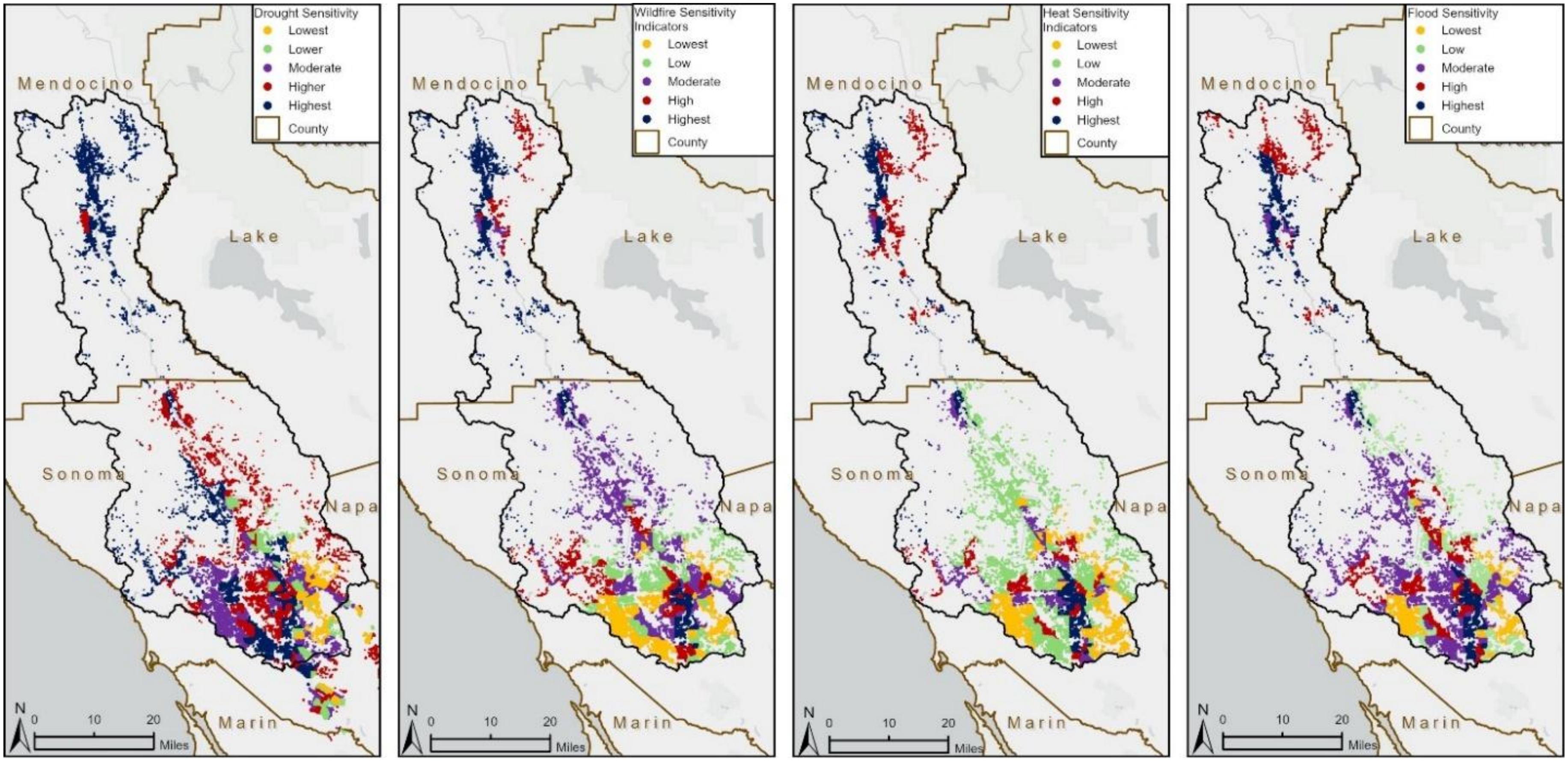
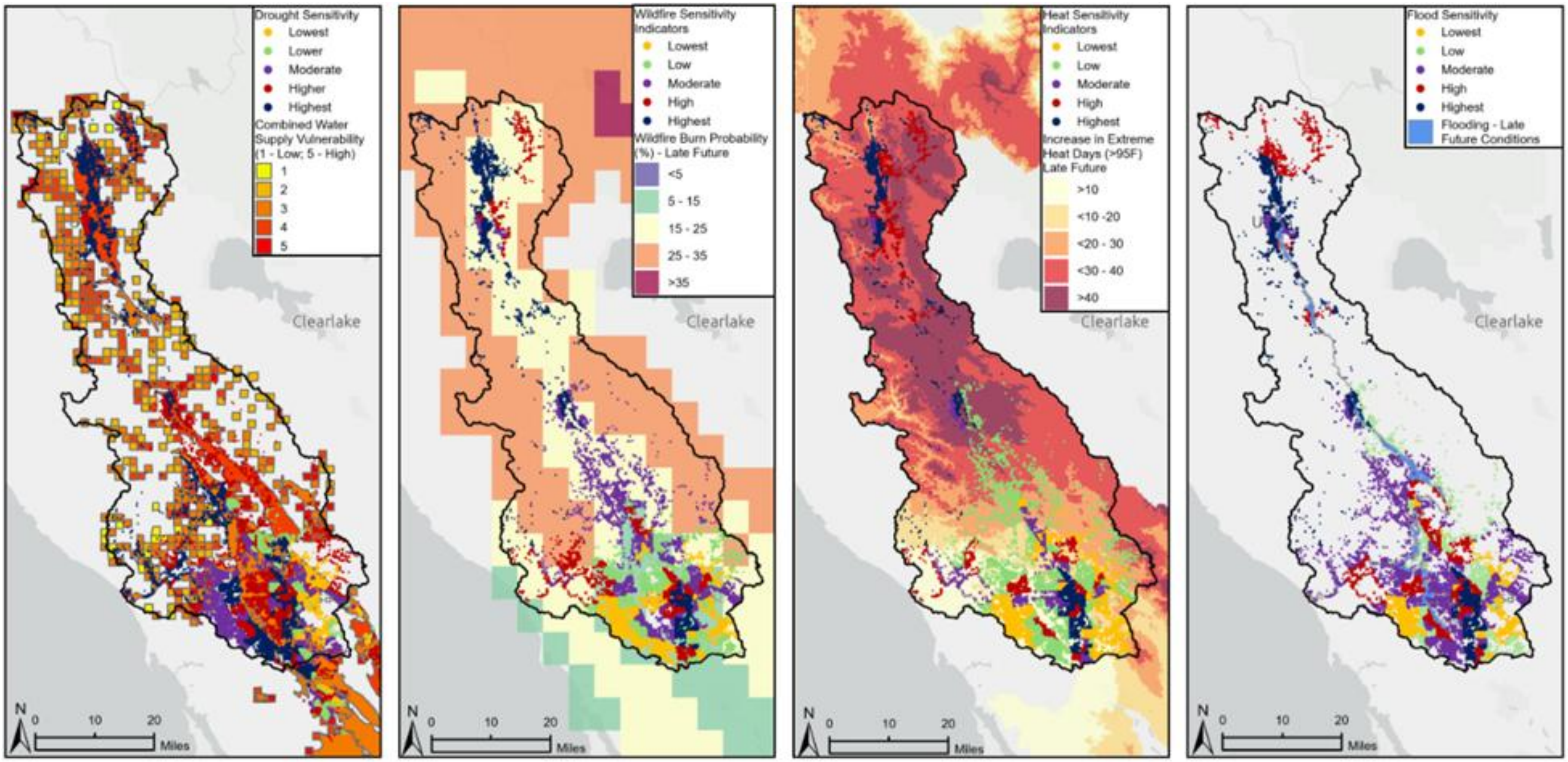


Figure 5-18. Late-Future Conditions Climate Impacts Mapping (Left to Right: Drought Sensitivity, Wildfire, Extreme Heat, Flooding)



Many of the people who are most socially vulnerable live in places that currently face the greatest climate hazards, which means they experience disproportionate exposure today and will experience greater exposure in the future. Findings from the community and equity vulnerability assessment include:

- Flood exposure increases by approximately 15% in the projected late-century scenario, rising from approximately 13,000 residents to more than 15,000, with one third of exposed residents in the highest sensitivity tier.
- In the late-future scenario, the risk of wildfire expands dramatically, with nearly the entire watershed exceeding a 15% decadal burn probability under late-century conditions, affecting many mid-valley communities that historically experienced lower risk. Currently, about 20% of all watershed residents fall within the highest wildfire sensitivity tier.
- Extreme heat exposure intensifies most sharply, with up to over 40 additional days with temperatures greater than 95°F projected in inland areas by late century. Because 30% of residents (including outdoor workers and others with occupational heat exposure) are already in the highest heat sensitivity tier, exposure among heat sensitive populations increases by roughly 40% to 50% under future conditions.
- Future water supply vulnerability is similarly widespread, with many residents expected to experience moderate to high water supply vulnerability.

Together, these findings underscore that hazard intensity, geographic reach, and exposure among high-sensitivity communities all increase substantially across future climate projections. Results of this assessment indicate that the people and neighborhoods of Santa Rosa, the Ukiah Valley, the Cloverdale-Healdsburg-Windsor corridor, the communities surrounding Lake Mendocino, and the lower Russian River corridor face the most significant and compounding climate pressures in the Russian River watershed.

5.6 Tribal Beneficial Uses

For thousands of years, Tribal communities have stewarded and relied upon the water resources and ecosystems within the Russian River watershed. These resources have significant beneficial uses to the Tribes and the vulnerabilities and risks described in this assessment directly impact Tribal communities throughout the watershed.

The Russian River watershed and adjacent waters are within the (Region1) North Coast Regional Water Board, which includes Del Norte, Glenn, Humboldt, Lake, Marin, Mendocino, Modoc, Siskiyou, Sonoma, and Trinity counties.

The Water Quality Control Plan for the North Coast Region (Basin Plan), adopted by the Water Board and as amended periodically, establishes the beneficial uses of water within the region; the water quality objectives necessary to protect those uses, including an Anti-degradation policy; the prohibitions, policies, and action plans, by which protections are implemented; and the monitoring, which is conducted to ensure attainment of water quality standards.

According to the Basin Plan, the basis for beneficial water uses and the protection and application of these uses is based on Section 13050(f) of California's Porter Cologne Water Quality Control Act, which states:

> "Beneficial uses" of the waters of the state that may be protected against water quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves."

An essential part of the development of the Basin Plan is an assessment of the beneficial uses which are to be designated and protected.

In 2003, the State Water Board approved the North Coast Regional Water Board's Native American Culture (CUL) definition that protects Native American culture, including subsistence fishing. This CUL definition was developed in partnership with tribes in the North Coast and predates the TBU definitions adopted by the State Water Board in 2017. The North Coast Region is currently collaborating with tribes to provide input and guidance on whether existing North Coast Regional Water Board or State Water Board definitions would better serve their needs. The 2023 Triennial Review Staff Report reaffirms the priority status of the Tribal beneficial uses project to reconcile these definitions.

The North Coast plan currently includes the following two beneficial uses of special significance to Russian River tribes:

- **Native American Culture (CUL)** Uses of water that support the cultural and/or traditional rights of indigenous people such as subsistence fishing and shellfish gathering, basket weaving and jewelry material collection, navigation to traditional ceremonial locations, and ceremonial uses.
- **Subsistence Fishing (FISH)** Uses of water that support subsistence fishing.

Once uses are defined they can be applied to specific water bodies through a designation process. A table with all beneficial use designations throughout the North Coast region can be found on Table 2-1 in the Basin Plan. It should be noted that there are currently no water bodies in the Russian River watershed that are designated for Tribal beneficial uses in the Basin Plan. They have been recommended and are under consideration through a lengthy process, but not yet designated.

(https://www.waterboards.ca.gov/northcoast/water_issues/programs/basin_plan/180710/BPChapter2BeneficialUses.pdf).

The Tribal CUL and FISH beneficial uses are distinct from the uses of Commercial and Sports Fishing (COMM) and Swimming and Wadable (REC1) due to the nature of the uses and the types and duration of exposure. Tribal CUL and FISH uses may be considered alongside other uses such as Cold Freshwater Habitat (COLD), Wildlife Habitat (WILD), Migration of Aquatic Organisms (MIGR), Spawning (SPWN), Reproduction, and/or Early Development Shellfish and other related uses to identify the most sensitive uses to be protected.

Tribal lifeways and uses are place-based, meaning that specific waters and locations of use have cultural and subsistence significance to specific Tribes and even to specific families within Tribal Nations.
Each Tribe speaks for themselves in relation to their usages and responsibility for the caretaking of their watersheds. Tribal advisory committees made up of all Tribes who have historical use of the watersheds can support the development of Tribal beneficial use designations and the development of narrative or numeric water quality objectives required to support designations. The source of this information is Sherri Norris of the CIEA on April 9, 2026.

6. Adaptation Strategies to Increase Resilience

The development of adaptation strategies to increase resilience across the Russian River watershed and adjacent areas that receive Russian River water involved several steps. The main steps involved in soliciting and organizing adaptation concepts included:

1. Identifying areas of highest vulnerability
2. Framing breadth of potential adaptation concepts
3. Reviewing existing planning documents for potential strategies
4. Soliciting input on potential adaptation concepts
5. Synthesizing input and developing adaptation strategies and actions

The sections that follow summarize these steps in the adaptation strategy development process.

6.1 Identifying Priority Areas Based on Vulnerability

As presented in Chapter 5, climate change vulnerabilities were identified throughout the watershed and across all water sectors. These vulnerabilities were characterized for the seven water resource sectors and organized into geographical areas of upper river, middle river, lower river, and adjacent or "plus" areas. Approximately 20 primary climate vulnerabilities were identified. A summary of these vulnerabilities is provided in Figure 6-1. Note that many of the vulnerabilities that are more distributed apply to broader areas that those shown on the map.

Most of these vulnerabilities have strong interdependencies across multiple water resource sectors. For example, many surface water supply vulnerabilities are also linked to vulnerabilities related to groundwater supply and recreation. And many flood management vulnerabilities are linked to ecosystem and water quality vulnerabilities. Due to these strong interdependencies of vulnerability, strategies may also provide multiple benefits for increasing the resilience in the watershed. For these reasons, a key has been developed to indicate which water resource vulnerabilities may be addressed by various strategies. This water resource vulnerability key is shown in Figure 6-2.

Figure 6-1. Summary of Vulnerability Assessment Findings in the Russian River Watershed

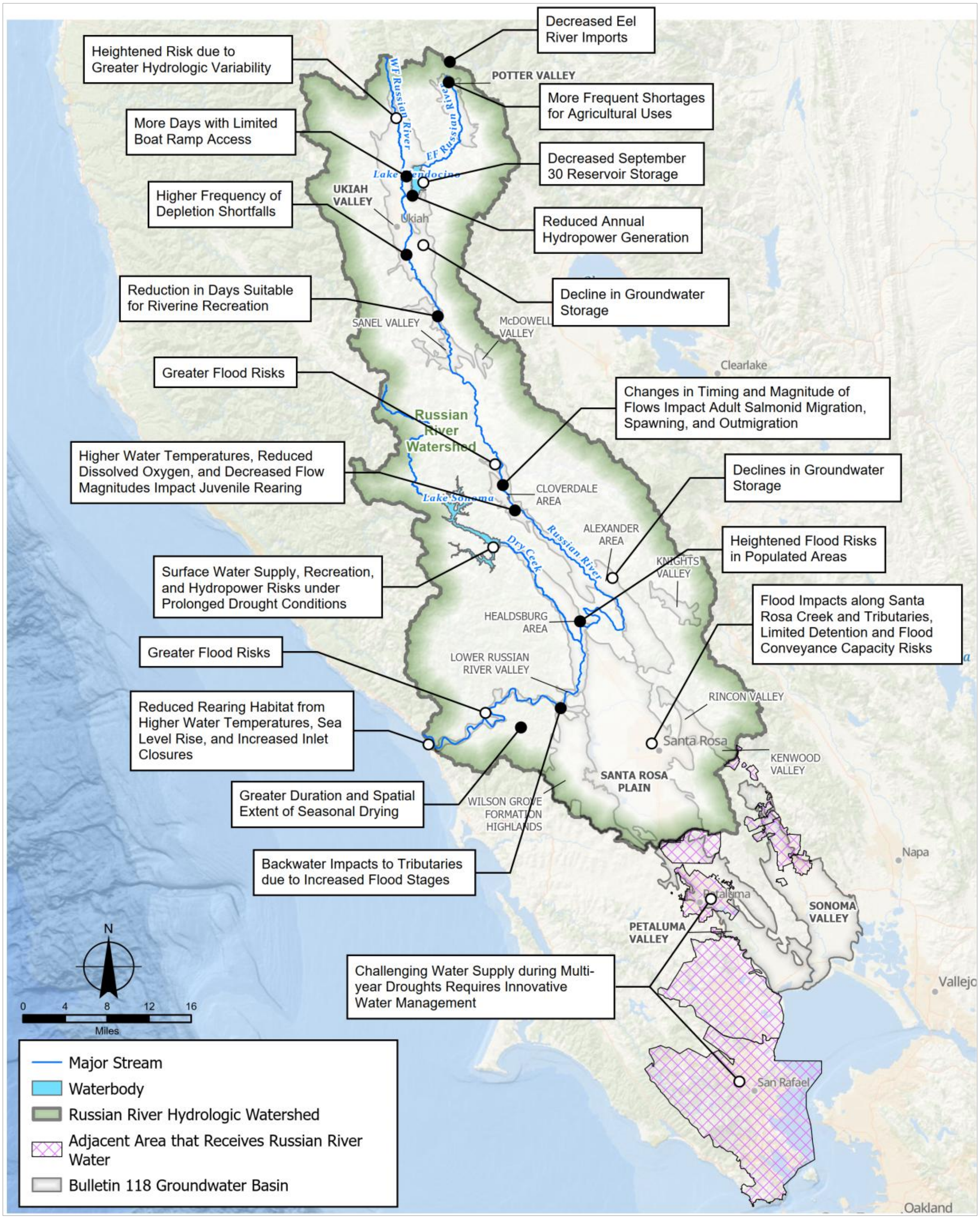
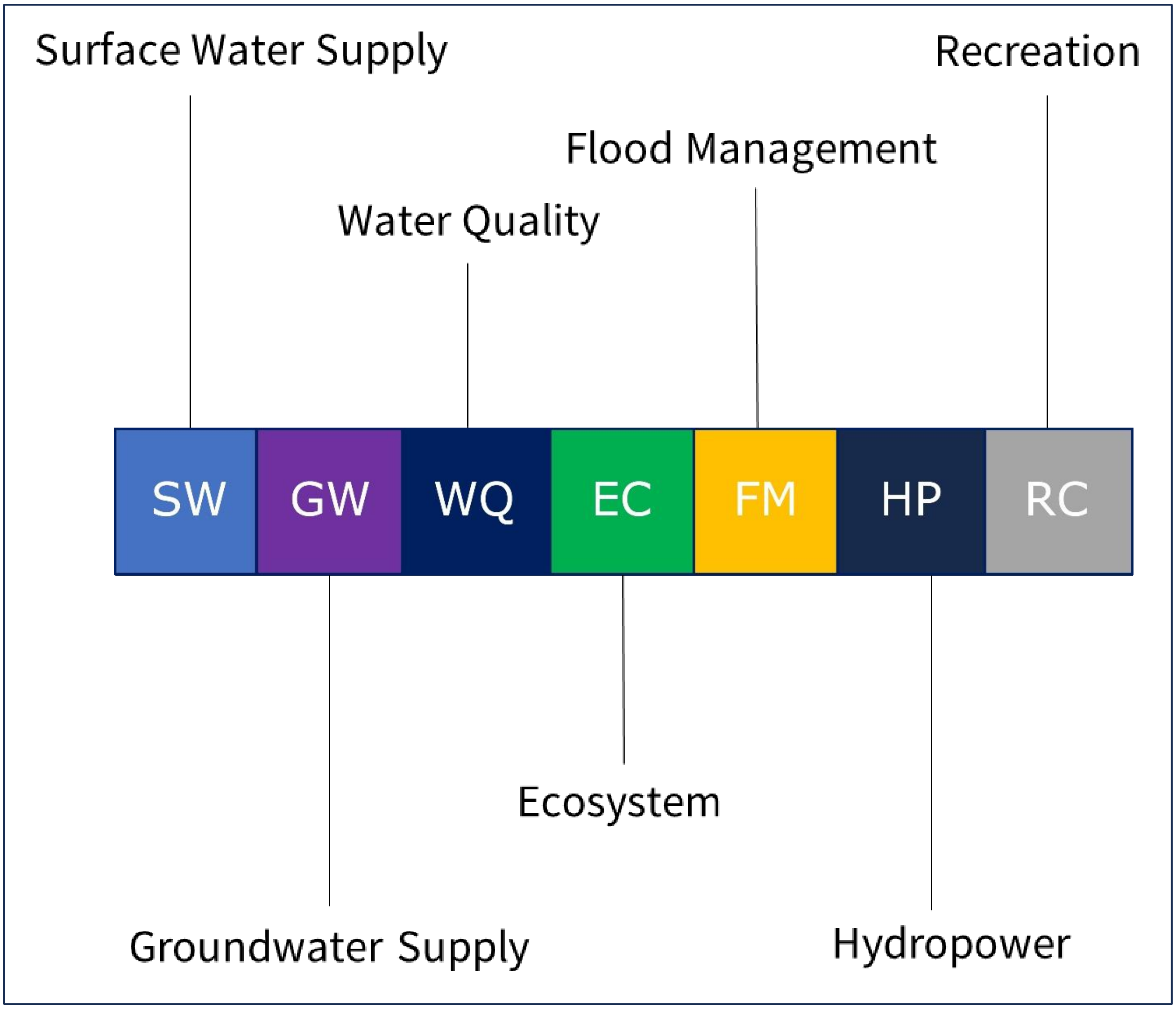


Figure 6-2. Key to Indicate Water Sector Vulnerabilities

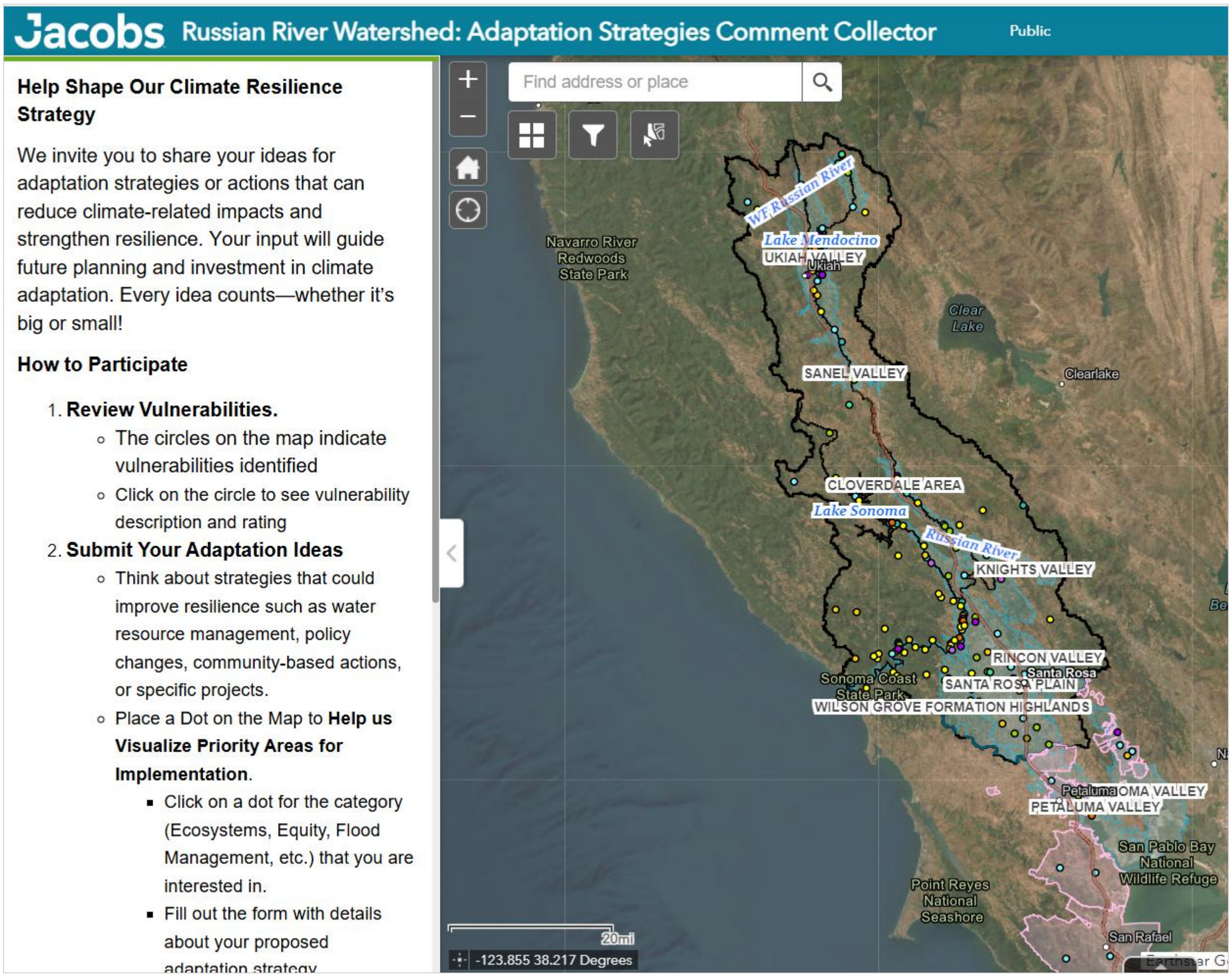


6.2 Development of Initial Ideas on Adaptation Concepts

After careful review of the primary climate vulnerabilities, initial ideas on adaptation strategies were compiled from the Watershed Network. The Network participants have a wealth of knowledge about various watershed conditions and potential adaptation approaches and were engaged to provide initial ideas on potential strategies.

Two Network meetings were dedicated, in part, to describe the adaptation strategy process and receive input on adaptation ideas. An interactive, online GIS portal was developed to allow participants to visualize vulnerabilities and indicate various strategy ideas on a map of the watershed (Figure 6-3). Over 200 ideas were compiled from participants in this manner.

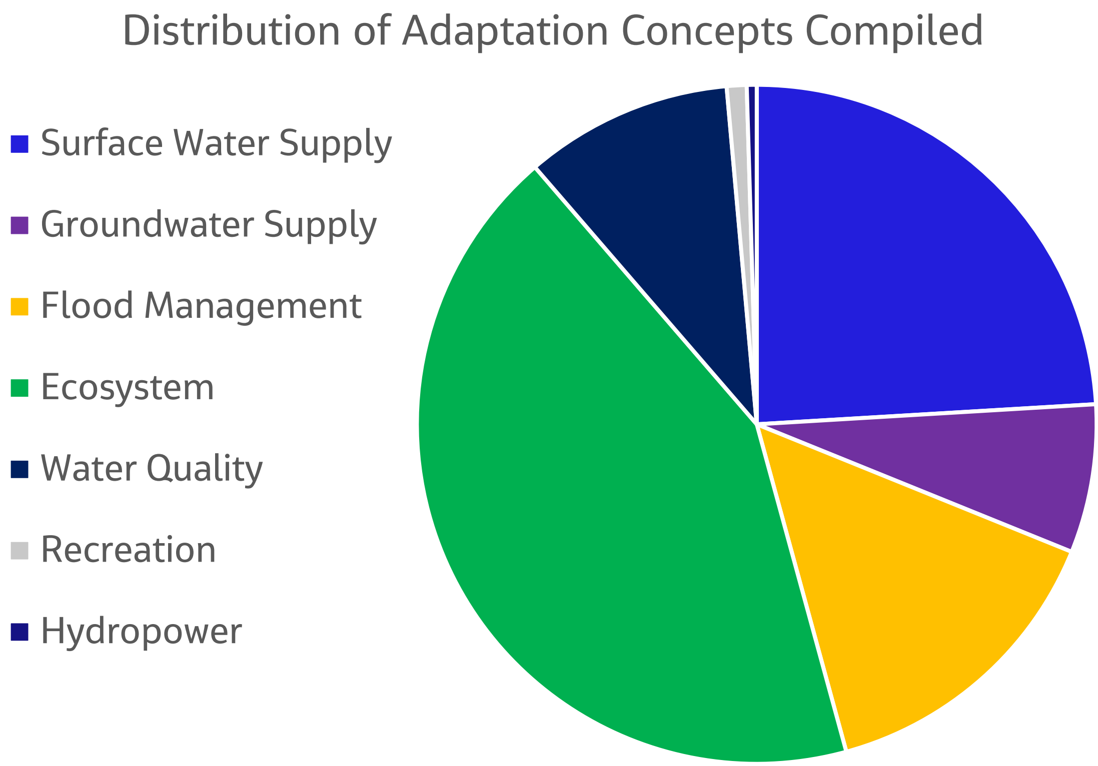
Figure 6-3. Interactive, Online GIS Portal for Collecting Adaptation Strategy Concepts



Approximately 10 additional meetings were also held with the Project Team and individual groups (agencies, trusts, Tribes, etc.) to gain additional insight into the potential adaptation strategies and alignment with programs that may amplify the ability to adapt.

In the end, over 250 adaptation concepts were compiled from direct Watershed Network input, review of existing report recommendations, and individual group input. Figure 6-4 shows a summary of the distribution of adaptation concepts compiled from the Watershed Network process. Adaptation concepts were compiled for all water resource sectors and in all regions of the watershed. A complete listing of the adaptation concepts that were compiled is included in Appendix D. The largest number of adaptation ideas or concepts were compiled for ecosystem, water supply (both surface and groundwater supply), flood management, and water quality – reflecting the most critical vulnerabilities and also the knowledge base and participant engagement distribution.

Figure 6-4. Summary of Distribution of Adaptation Concepts Compiled from the Watershed Network



6.3 Recent Accomplishments Toward Resilience

Many of the water and resource managers in the Russian River watershed have been active at driving climate adaptation actions over the past decade. Several examples illustrate the activity of this community and foresight to work toward resilience implementation:

- Forecast-Informed Reservoir Operations (FIRO) at Lake Mendocino and Lake Sonoma – FIRO refers to the use of advanced weather and hydrological forecasts and adaptive reservoir water control manuals to conserve water supply for potential dry years. To date, FIRO has resulted in additional water supplies of about 56,000 acre-feet (AF) for Lake Mendocino and 76,000 AF for Lake Sonoma, while providing climate adaptation benefits of improved flood risk management, water supply storage, and ecosystem conditions. Appendix H provides a comprehensive assessment of FIRO's climate adaptation benefits.
- Sonoma-Marin Saving Water Partnership – regional program to advance water conservation and water use efficiency resulting in award-winning savings.
- Sonoma Water Climate Adaptation Plan – The Climate Adaptation Plan (CAP) was originally developed in 2022 to address climate risks and resilience to Sonoma Water's facilities and operations. The implementation of the CAP priorities is in progress.
- Dry Creek Rancheria Fire Resilience Projects – demonstration projects to increase wildfire resilience through incorporation of TEK and cultural burn approaches.
- Ag + Open Space Vital Lands Initiative – initiative to protect vital lands for agricultural, water, communities, and wildlands through conservation easements.

- Sonoma Land Trust Conservation Program – program to focus conservation easements and acquisition on critical Coho streams.
- Sonoma County Groundwater Sustainability Projects and Actions – projects and actions led by GSAs and member agencies to improve groundwater sustainability, as identified in Groundwater Sustainability Plans.
- The Russian River Regional Monitoring Program – an independent regional science and monitoring program, governed by local and regional government, Tribal, and non-profit entities, to achieve and sustain watershed health through coordinated water quality and habitat monitoring, data management and standardization, and reporting.
- FireSmart Lake Sonoma – supporting private fire resilience action in the Lake Sonoma watershed.
- North Coast Water Board adoption of the Action Plan for Pathogens in the Russian River Watershed – a strategy aimed at minimizing huma exposure to pathogens and protection of the water contact recreation (REC-1) beneficial use.
- Sonoma County Groundwater Sustainability Projects – projects led by GSAs and member agencies to improve groundwater sustainability, as identified in the Groundwater Sustainability Plans.
- Marin Water's Strategic Water Supply Assessment – The roadmap integrates both demand reduction (through water efficiency) and new supply projects to meet Marin Water's goal of ensuring an additional 8,500 acre-feet per year (AFY) of resilient water supply, including new infrastructure to transport and store surplus winter water from the Russian River watershed.
- Climate Adaptation Certification of the California Land Stewardship Institute in partnership with the Sonoma Winegrowers Association certified over 10,000 acres of agricultural land using tier three carbon sequestration model and whole farm and wildland assessment of carbon sequestration and emissions.
- Fish Friendly Farming (FFF) Certification Program developed and administered by the California Land Stewardship Institute has certified over 100,000 acres in the Russian River watershed for stewardship practices that conserve water; reduce erosion from roads, vineyards, and other lands; revegetate creeks, and reduce toxic pesticide use. The FFF program provides regulatory compliance.

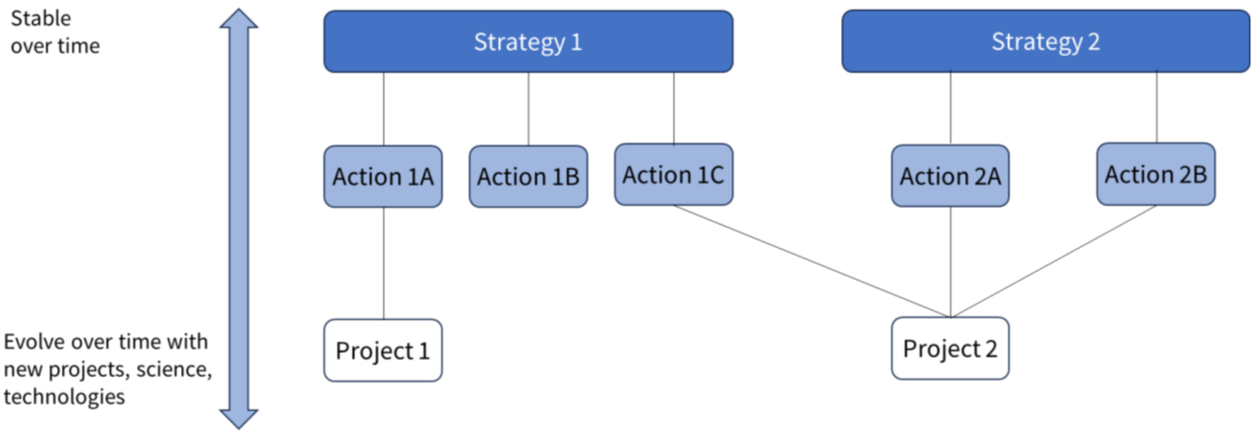
The Russian River Watershed Network members and community have a proven record of moving from planning to action. Some of these past actions were developed in partnerships, although in a less coordinated manner than that envisioned through the Watershed Network. The strategies and actions that are described in the next sections build from this good foundation and expand the types of adaptations considered.

6.4 Developing Adaptation Strategies and Actions

Adaptation strategy input received from the Watershed Network and those compiled through other sources and meetings varied in the level of detail and specificity. Some concepts reflected a broad strategy or objectives that could be applied to the entire watershed, while others were related to specific projects at specific locations on the river, tributaries, and adjacent areas. To organize the strategies into a more consistent presentation, the Project Team developed an approach to incorporate this input into a structured strategy template.

The structured strategy template organizes adaptation strategies into three elements of increasing level of specificity: strategies, actions, and projects. Strategies are high-level themes designed to achieve particular goals. These are thought of as "north star" themes that should be relatively stable over time. Actions are more specific methods in which parts of the strategy can be accomplished, and projects are the most specific and may address all or parts of actions or may align with several actions to varying degrees. The organization of adaptation strategies, actions, and projects is shown graphically in Figure 6-5.

Figure 6-5. Organization of Adaptation Strategies, Actions, and Projects



A total of 13 climate adaptation strategies were developed as part of this process as shown in Table 6-1. These strategies were developed to target one or more climate vulnerabilities and include elements related to water management infrastructure, operations, land and water stewardship and management, policy and governance, and science and technology. Each climate adaptation strategy has been developed to address one or more vulnerabilities. In many cases, the benefits derived from a strategy are anticipated to span several water resource sectors. Table 6-1 indicates the strategy and primary and secondary sectors that are expected to benefit.

Table 6-1. Climate Adaptation Strategies included in the Russian River Watershed Resilience Plan

Climate Adaptation Strategy	Water Resource Sectors[a]						
1. Increase Resilience to Changes in Upper River and Eel River Transfers	SW	GW	WQ	EC		HP	RC
2. Increase Water Supply Resilience to Drought	SW	GW	WQ	EC			RC
3. Increase Water Conservation, Water Use Efficiency, and Recycled Water Supply	SW	GW		EC			
4. Expand Conjunctive Use of Surface Water and Groundwater	SW	GW	WQ	EC			RC
5. Promote Land Stewardship Measures to Restore Watershed Function	SW	GW	WQ	EC	FM		RC
6. Restore Floodplains and Connectivity	SW	GW	WQ	EC	FM		RC
7. Restore Hydrological Function, Habitat, and Thermal Refugia in Tributaries	SW	GW	WQ	EC			
8. Adapt Russian River Estuary to Future Conditions			WQ	EC	FM		RC
9. Reduce Flood Risk to Communities and Infrastructure				EC	FM		
10. Manage Sustainable Headwaters and Support Wildfire Resilience	SW	GW	WQ	EC	FM		RC
11. Support Flexible and Adaptive Policy for Resilient Watershed Management	SW	GW	WQ	EC	FM	HP	RC
12. Enhance Tools, Monitoring, and Water Accounting Methods	SW	GW	WQ	EC	FM	HP	RC
13. Improve Forecasts and Forecast-Based Operations	SW	GW		EC	FM		

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, FM = flood management, HP = hydropower, RC = recreation

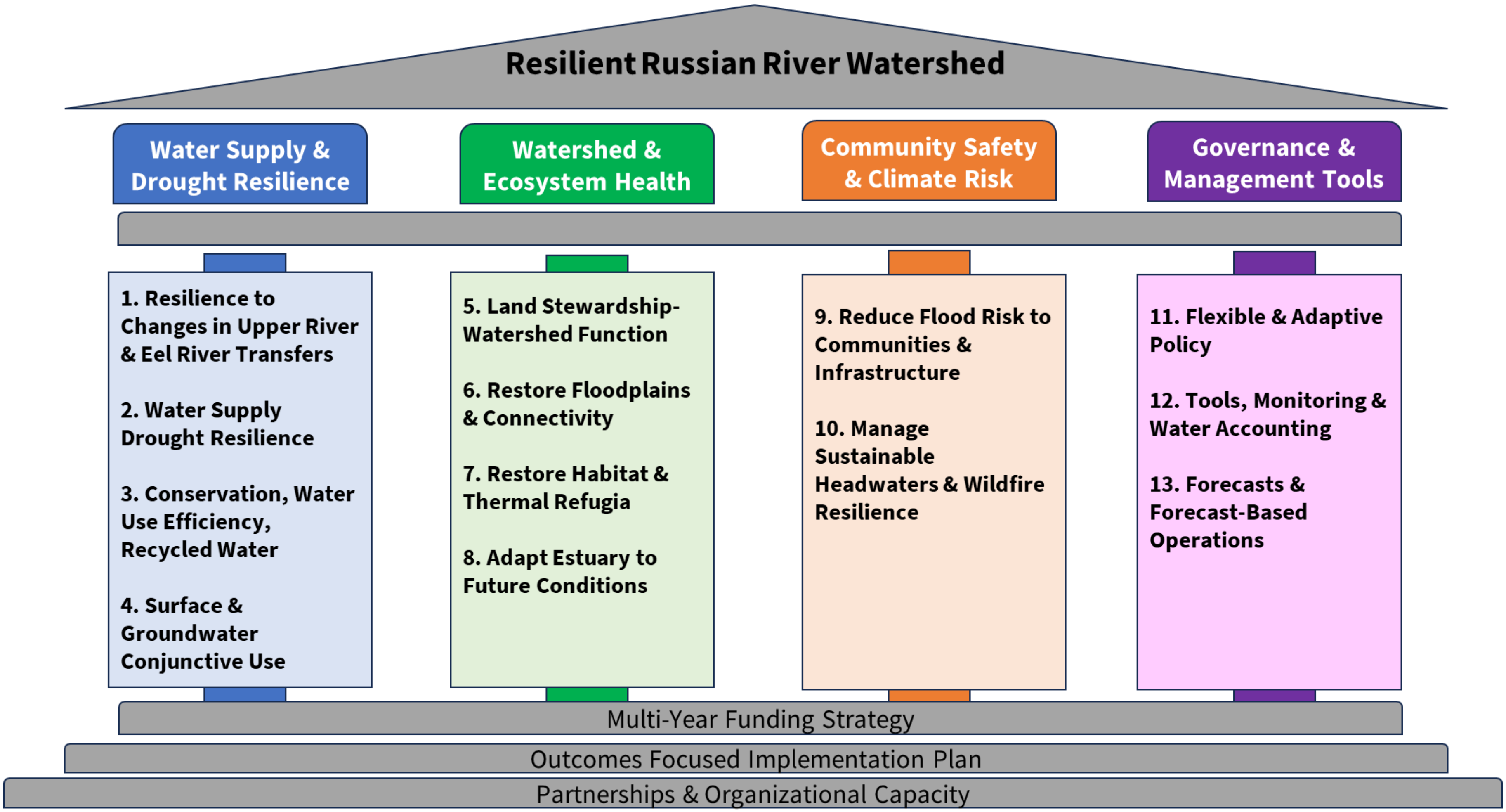
The overarching goal of the WRP is to help create a more resilient Russian River watershed to current and future climates. The WRP organizes the13 climate adaptation strategies around four main pillars as shown in Figure 6-6:

1. Water Supply & Drought Resilience
2. Watershed & Ecosystem Health
3. Community Safety & Climate Risk
4. Governance & Management Tools

Each of these pillars incorporates several related strategies that help to achieve similar outcomes. These pillars are supported by foundational implementation elements including multi-year funding, outcomes-focused implementation plan, and partnerships and organization capacity. These implementation elements are discussed in detail in Chapter 7.

Each of the strategies is presented in more detail in the following sections. These descriptions include strategy, related actions, and a project spotlight to demonstrate an example of a project level implementation. In subsequent work with the Watershed Network, projects will be better identified for each of the actions and a more comprehensive project database and tracking mechanism will be developed.

Figure 6-6. An Integrated Russian River Resilient Strategy



6.4.1 Strategy #1 – Increase Resilience to Changes in Upper River and Eel River Transfers

Actions	Vulnerabilities Addressed[a]						
Action 1 – Increase Surface and/or Groundwater Storage in Upper River	SW	GW	WQ	EC			RC
Action 2 – Improve Water Demand Management	SW	GW	WQ	EC			RC
Action 3 – Implement Managed Aquifer Recharge and Storage	SW	GW	WQ	EC			RC
Action 4 – Maximize Flexibility through Forecast-Informed Operations at Lake Mendocino	SW	GW	WQ	EC	FM		RC
Action 5 – Manage Immediate Risk due to Planned PVP Decommissioning	SW	GW		EC			RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, FM = flood management, RC = recreation

Project Spotlight: Implement Water Use Efficiency, Groundwater, and Storage Actions in Potter Valley

Several efforts are currently underway to address water reliability challenges in the Upper River and Potter Valley due to combined effects of climate change and Potter Valley Project decommissioning. The Potter Valley Water Supply Reliability Study (2025) contains recommendations to develop an integrated water supply strategy for the Potter Valley that includes:

- Accelerate Efforts to Reduce Water Demand in Potter Valley. Reduce Potter Valley water demands by 20 to 30% through irrigation delivery system improvements and on-farm irrigation demand management.
- Develop New In-Valley Pond Storage. Develop at least 2,500 AF of new in-valley pond storage.
- Develop New Groundwater Supply in Potter Valley. Develop a new groundwater supply of at least 3,500 AFY by constructing agricultural production wells to provide supplemental supply during June through September.
- Incentivize Storage and Well Development throughout Potter Valley. Due to the large number of small new ponds and new wells that will be required, it is likely that a decentralized approach toward reliability will be most effective. To provide an incentive to develop ponds and production wells as soon as possible, a Potter Valley water fund could be established to offer reduced costs (or rebates) to individuals who develop such projects.

6.4.2 Strategy #2 – Increase Water Supply Resilience to Drought

Actions	Vulnerabilities Addressed[a]						
Action 1 – Increase Drought and Emergency Water Storage	SW	GW	WQ	EC			RC
Action 2 – Improve and Integrate Regional Storage Operations	SW	GW	WQ	EC			RC
Action 3 – Increase Reliability of Conveyance and Interconnections	SW	GW					
Action 4 – Expand Use of Recycled Water Supply	SW	GW	WQ	EC			RC
Action 5 – Update and Expand Water Conservation	SW	GW	WQ	EC			RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, RC = recreation

Project Spotlight: Lower System Regional Water Bank

Sonoma Water and regional partners are currently studying the feasibility of a Regional Water Bank that would improve the drought and seismic water supply resilience in the lower system. The Regional Water Bank would integrate excess winter water diversion with the available groundwater storage in Santa Rosa Plain, Sonoma Valley, and Petaluma Valley groundwater basins and available surface storage in Lake Sonoma, Lake Stafford, and Marin Reservoirs. Through either direct movement of diverted water to storage pools or through indirect transfers through in-lieu exchanges, water could be stored during periods of high river flows and used as drought or emergency supply during dry conditions or abrupt disruptions on the aqueduct system.

The main components of the proposed Regional Water Bank include:

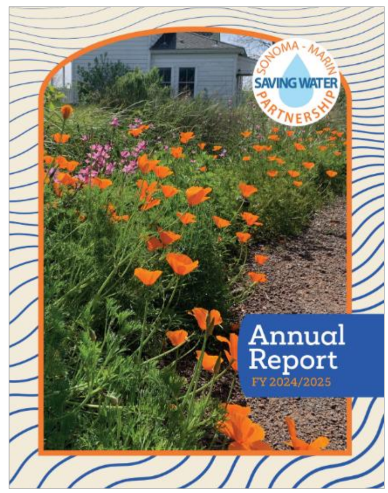
- Enhance Diversion of Available Winter Water at Wohler and Mirabel facilities.
- Evaluate expanding Groundwater Aquifer Storage and Recovery and/or In-Lieu Injection and Extraction Capacities in Santa Rosa Plain, Sonoma Valley, and Petaluma Valley groundwater basins.
- Develop Bank Storage and Water Bank Accounting Mechanisms. Integrate surface storage, groundwater storage, and transmission system conveyance to develop bank.
- Evaluate Opportunities to Augment Water Supply for Use During Droughts and Transmission System Interruptions.

6.4.3 Strategy #3 – Increase Water Conservation, Water Use Efficiency, and Recycled Water Supply

Actions	Vulnerabilities Addressed[a]						
Action 1 – Expand Water Conservation and Water Use Efficiency in Municipal and Industrial Sectors	SW	GW		EC			RC
Action 2 – Expand Water Conservation and Water Use Efficiency in Agricultural Sector	SW	GW		EC			RC
Action 3 – Expand Use of Recycled Water Supply	SW	GW	WQ	EC			RC
Action 4 – Adapt Rate Structures for Variability and Volatility of Sales	SW	GW					
Action 5 – Improve Measurement, Water Budget, and Accounting Systems	SW	GW		EC			RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, RC = recreation

Project Spotlight: Sonoma-Marin Saving Water Partnership



The Sonoma-Marin Saving Water Partnership (Partnership) represents 13 water utilities in Sonoma and Marin counties that have joined together to provide regional solutions for water use efficiency. The utilities include the Cities of Santa Rosa, Rohnert Park, Petaluma, Sonoma, Cotati, Cloverdale, and Healdsburg, North Marin and Valley of the Moon Water Districts, Marin Water, Town of Windsor, California American Water – Larkfield District and Sonoma Water (Partners). Each Partner offers water conservation programs that can assist customers in reducing their water use.

The Partnership was formed to identify and recommend implementation of water use efficiency projects and maximize the cost-effectiveness of water use efficiency programs in our region. The Partnership supports programs related to various water conservation programs such as water conservation rebates and incentives, Water Smart plant guides and labels, irrigation scheduling technology and tools, water education and water saving tips, and rainwater harvesting.

Through these actions, the reduction in regional per capita water use exceeded the targets set by the 20×2020 program. The Partnership continues its work to meet new water reduction goals such as the State Board's new water conservation framework, called Making Conservation a California Way of Life, and to secure a reliable water future for all our communities.

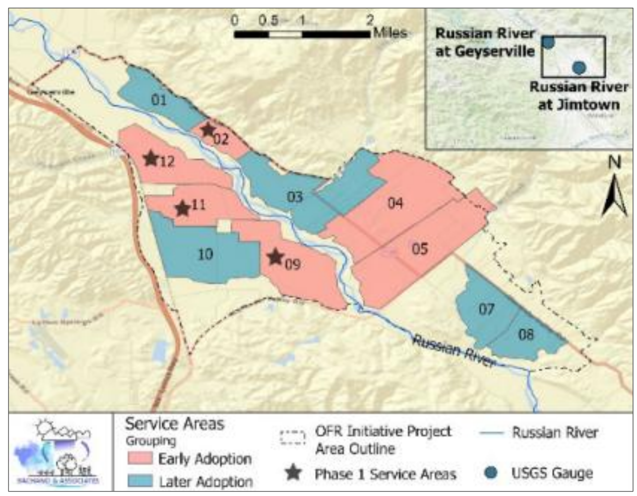
Continued and expanded investments in the Partnership and related water conservation programs throughout the Russian River watershed can contribute to future water supply resilience for the region.

6.4.4 Strategy #4 – Expand Conjunctive Use of Surface Water and Groundwater

Actions	Vulnerabilities Addressed[a]						
Action 1 – Integrate Managed Aquifer Recharge Projects	SW	GW	WQ	EC			RC
Action 2 – Evaluate Installation of New or Rehabilitate Existing Wells for Operable Production Wells	SW	GW	WQ	EC			RC
Action 3 – Improve Understanding of Surface Water-Groundwater Dependence in Alluvial Basins	SW	GW	WQ	EC			RC
Action 4 – Support GSAs to Maximize Watershed Infiltration and Groundwater Recharge	SW	GW	WQ	EC			RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, RC = recreation

Project Spotlight: Alexander Valley On-Farm Recharge Initiative



The Dry Creek Rancheria of Pomo Indians, in partnership with the Sonoma RCD and Alexander Valley landowners – Jackson Family Wines, Constellation, Foley Family Wines, Rodney Strong, Vino Farms, Silverado, Robert Young – are piloting an on-farm recharge project to create sustainable water resources with benefits to local fisheries, agriculture, and communities. The Alexander Valley On-Farm Recharge (OFR) Initiative's Pilot Phase envisions recharging across 3,000 acres of active and fallow vineyards with an annual 6,000–7,000 AF capacity, exceeding vineyard irrigation demands by an estimated 50%.

The initiative will "sip" diversion water during high flows in fall and winter months using shallow wells along the Russian River and distribute diversions to vineyard partners to apply to their fields as recharge. The initiative seeks to stabilize regional water resources and support the local community through current and future challenges (e.g., changing climate, threatened and endangered salmonid species, Potter Valley decommissioning, and contracting wine sales).

2025 WY and 2026 WY pilot studies are being conducted to refine OFR designs and operations. The 2025 WY pilot studies found that OFR did not degrade groundwater quality in the shallow aquifer below.

Phase 1 construction is expected to be completed in 2026 and will serve 1,000 vineyard acres and have an annual recharge capacity of 2,300 AF.

6.4.5 Strategy #5 – Promote Land Stewardship to Restore Watershed Function

Actions	Vulnerabilities Addressed[a]						
Action 1 – Protect Undeveloped Floodplains	SW	GW	WQ	EC	FM		RC
Action 2 – Integrate Tribal Traditional Ecological Knowledge	SW	GW	WQ	EC	FM		RC
Action 3 – Support Preservation of Riparian Buffers	SW	GW	WQ	EC	FM		RC
Action 4 – Acquire and Protect Properties in Key Fish Habitats	SW	GW	WQ	EC	FM		RC
Action 5 – Establish Resources and Education for Landowners for Grants and Permitting Support	SW	GW	WQ	EC	FM		RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, FM = flood management, RC = recreation

Project Spotlight: Sonoma Ag + Open Space Vital Lands Initiative

The mission of Ag + Open Space is to permanently protect the diverse agricultural, natural resource, and scenic open space lands of Sonoma County for future generations. In support of the Sonoma County community's vision, the Vital Lands Initiative is a long-range comprehensive plan to prioritize the land conservation activities of Ag + Open Space through 2031. The Vital Lands Initiative outlines five specific land conservation goals:

- Agricultural Lands: Protect lands that support diverse, sustainable, and productive agriculture.
- Community Identity: Protect open lands that surround and differentiate the county's urban areas and contribute to the unique scenic character of Sonoma County.
- Healthy Communities: Protect open space and publicly accessible lands in and near cities and communities and connect people with protected lands.
- Water: Protect natural lands and aquatic habitats that support sustainable aquatic ecosystems and water resources.
- Wildlands: Protect natural lands and terrestrial habitats that support plants, wildlife, and biodiversity.

The primary tool used to meet the initiative goals and objectives is the conservation easement. Conservation easements are legal agreements between a willing landowner and the agency that permanently limit uses of the land to protect its conservation values ensure that the terms of the conservation easement are being honored – specific agricultural, natural, scenic, or recreational attributes of the property that provide a public benefit. Since its formation, Ag + Open Space has protected and continues to perpetually steward over 118,000 acres of high priority open space lands, preserving productive agricultural land and local food, healthy watersheds, functional ecosystems and biodiversity, and scenic landscapes and greenbelts, as well as providing a wide variety of recreational opportunities for Sonoma County residents and visitors.

6.4.6 Strategy #6 – Restore Floodplains and Connectivity

Actions	Vulnerabilities Addressed[a]						
Action 1 – Implement Floodplain Restoration at Former Gravel Pits on Russian River	SW	GW	WQ	EC	FM		RC
Action 2 – Protect Instream Flows and Restoration Projects in Critical Coho Watersheds	SW	GW	WQ	EC	FM		RC
Action 3 – Implement Restoration Concepts from Laguna Restoration Plan	SW	GW	WQ	EC	FM		RC
Action 4 – Improve Modeling of Riparian, Floodplain, and Flood Dynamics	SW	GW	WQ	EC	FM		RC
Action 5 – Acquire and Protect Undeveloped Lands at Tributary Mouths	SW	GW	WQ	EC	FM		RC
Action 6 – Improve Understanding of Historical Geomorphology, Land Use, and Sediment	SW	GW	WQ	EC	FM	HP	RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, FM = flood management, HP = hydropower, RC = recreation

Project Spotlight: Laguna de Santa Rosa Restoration Plan

The Laguna de Santa Rosa is an expansive freshwater wetland complex that hosts a rich diversity of plant and wildlife species, and is also home to a thriving agricultural community. Since the mid-19th century, modifications to the Laguna and its surrounding landscape have degraded habitat conditions for both wildlife and people. Developed by Sonoma Water along with project partners at the San Francisco Estuary Institute, and the Laguna de Santa Rosa Foundation, and funded by Sonoma Water and the California Department of Fish and Wildlife, the goal of the Laguna de Santa Rosa Master Restoration Plan project is to develop a plan that supports ecosystem services in the Laguna—through the restoration and enhancement of landscape processes that form and sustain habitats and improve water quality—while considering flood management issues and the productivity of agricultural lands.

A restoration vision, plan, and framework have been developed for the Laguna de Santa Rosa. A series of reports describe a long-term vision for the landscape and a potential future Laguna. The Restoration Plan that was built from the vision identifies restoration opportunities and conceptual designs to support the establishment of implementable restoration projects. The Restoration Plan includes the following elements:

- A restoration framework that offers a planning structure for landscape scale restoration that can be further developed and refined over time.
- Restoration project concepts in the Laguna's 100-year floodplain developed from selected restoration opportunity areas shown in the vision.
- Criteria for prioritizing and sequencing restoration project concepts.

The utilization of the Restoration Plan and the ultimate success of restoration efforts in the Laguna will require local landowner support and adequate funding to implement the restoration and manage and sustain the benefits through long-term stewardship. It will also require coordination among all the agencies responsible for managing the land and water within the Laguna and its surrounding watershed.

6.4.7 Strategy #7 – Restore Hydrological Function, Habitat, and Thermal Refugia in Tributaries

Actions	Vulnerabilities Addressed[a]						
Action 1 – Protect Instream Flows in Critical Coho Watersheds	SW	GW	WQ	EC			RC
Action 2 – Support Riparian Restoration on Critical Tributaries	SW	GW	WQ	EC			RC
Action 3 – Identify Locations of Russian River Thermal Refugia	SW	GW	WQ	EC			
Action 4 – Support Enhanced Watershed Processes in Shallow Groundwater-Supplied Streams	SW	GW	WQ	EC			RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, RC = recreation

Project Spotlight: Studies on Importance of Flow-Related Variables on Thermal Refugia

Recent studies (Obedzinski et al. 2018) have established the importance of the relationships between survival of juvenile salmonids and flow-related variables in intermittent streams. With predictions for a higher frequency of drought conditions due to climate change and the associated increasing human demand for water during the dry season, understanding fish–flow relationships is becoming increasingly important for the protection of sensitive aquatic species. The study examined the effects of low streamflow on juvenile salmonids rearing in small intermittent streams, including Mill Creek, Green Valley Creek, and Dutch Bill Creek in the Russian River watershed from 2011 to 2013. Survival was positively associated with streamflow magnitude, wetted volume, and dissolved oxygen and negatively associated with days of disconnected surface flow (days of disconnection) and temperature. Days of disconnection best explained survival, though the relationship varied by geomorphic reach type. Survival was lower in alluvial reaches than in bedrock and clay reaches and showed a faster rate of decline with increasing days of disconnection and drought condition. In all reaches, the onset of pool disconnection represented a turning point at which water quality, water quantity, and survival declined. For this reason, the authors suggest that days of disconnection (or the flow magnitude at which pools become disconnected) is a useful metric for identifying flow-impaired reaches, informing streamflow protection strategies, and prioritizing streamflow enhancement efforts designed to benefit sensitive salmonid populations in intermittent streams.

6.4.8 Strategy #8 – Adapt Russian River Estuary to Future Conditions

Actions	Vulnerabilities Addressed[a]						
Action 1 – Develop Improved Understanding of Future Estuary Conditions			WQ	EC	FM		RC
Action 2 – Develop Adaptation Pathways for Estuary Management and Structure Protection	SW		WQ	EC	FM		RC
Action 3 – Promote Adaptive Regulatory Approaches for Evolving Estuary	SW		WQ	EC	FM		RC
Action 4 – Identify and Protect Critical Estuary Habitat and Refugia			WQ	EC			RC

[a] SW = surface water supply, WQ = water quality, EC = ecosystem, FM = flood management, RC = recreation

Project Spotlight: Russian River Estuary Management Project

The Russian River Estuary may close at any time of the year as a result of a sandbar forming at the mouth of the Russian River. The sandbar usually closes from the spring through the fall when river flows are relatively low and long period waves transport sand landward, rebuilding the beach that was removed by winter waves and river outflows.

Closures result in the formation of a lagoon in the Russian River behind the sandbar and water level increases in the estuary. Natural breaching events occur when estuary water surface levels exceed the sandbar height and overtop the sandbar, scouring an outlet channel, or when ocean wave conditions erode the barrier beach. Public agencies have been involved in breaching the sandbar since at least the 1960s. Sonoma Water became responsible for breaching activities in 1994.

Sonoma Water staff mechanically breach the sandbar to minimize the potential flood risk of low-lying shoreline properties along the estuary. As sea levels continue to rise, temperatures increase, and flow regimes change, the estuary will also change. Proactive study of the conditions likely in the future can inform the future management plans.

6.4.9 Strategy #9 – Reduce Flood Risk to Communities and Infrastructure

Actions	Vulnerabilities Addressed[a]						
Action 1 – Expand and Restore Russian River Floodplains			WQ	EC	FM		RC
Action 2 – Support Regional Coordinated Flood Planning and Policies			WQ	EC	FM		RC
Action 3 – Implement Stormwater and Watershed-Based Infiltration Programs	SW	GW	WQ	EC	FM		RC
Action 4 – Adapt or Relocate Critical Infrastructure in Floodplains			WQ	EC	FM		RC
Action 5 – Acquire or Develop Conservation Easements over Existing Floodplains			WQ	EC	FM		RC
Action 6 – Update Flood Management Design Guidance			WQ	EC	FM		RC
Action 7 – Enhance Flood Detention Capacity in Tributaries			WQ	EC	FM		RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, FM = flood management, RC = recreation

Project Spotlight: Laguna-Mark West Creek Watershed Planning Scoping Study

The Laguna-Mark West Watershed Planning Scoping Study encompasses an effort to identify the potential for projects within the watershed that provide flood protection and promote groundwater recharge and other watershed benefits, such as ecosystem, water quality, water supply, agricultural, open space, and other community benefits. The project is being led by Sonoma Water, San Francisco Estuary Institute, and Laguna de Santa Rosa Foundation.

The core project objectives are to reduce flood hazard and promote groundwater recharge within the watershed. Flood alleviation projects that provide flow and volume attenuation through storage and infiltration can also promote recharge. In contrast, in-stream hydraulic capacity projects such as floodwalls and pipeline bypasses may provide flood reduction benefits but are not generally effective in reducing overall flood flows or volumes or in promoting groundwater recharge. Examples of project types or elements that may be combined include swale or floodplain expansion, detention or retention, forest restoration, bypass channel, sediment removal or reduction, channel or bank modification, and existing reservoir expansion.

6.4.10 Strategy #10 – Manage Sustainable Headwaters and Support Wildfire Resilience

Actions	Vulnerabilities Addressed[a]						
Action 1 – Support Headwaters Conservation and Restoration	SW	GW	WQ	EC	FM	HP	RC
Action 2 – Implement Watershed Fuels Management	SW	GW	WQ	EC	FM	HP	RC
Action 3 – Develop Coordinated Post-Fire Remediation Plan	SW	GW	WQ	EC	FM	HP	RC
Action 4 – Integrate Traditional Ecological Knowledge	SW	GW	WQ	EC	FM	HP	RC
Action 5 – Remove Invasive Vegetation	SW	GW	WQ	EC	FM	HP	RC
Action 6 – Increase Forest Rehabilitation and Carbon Sequestration	SW	GW	WQ	EC	FM	HP	RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, FM = flood management, HP = hydropower, RC = recreation

Project Spotlight: Dry Creek Rancheria Fire Resilience Project

The Dry Creek Rancheria Band of Pomo Indians is actively enhancing its fire resilience through comprehensive vegetation management, dedicated emergency services, and climate adaptation planning, particularly in response to risks highlighted by the 2019 Kincade Fire. The Tribe has focused on expanding its fire-fuel reduction efforts across its 75-acre Rancheria and has taken steps to secure its infrastructure through renewable energy and improved fire services.

Key Fire Resilience Projects and Initiatives:

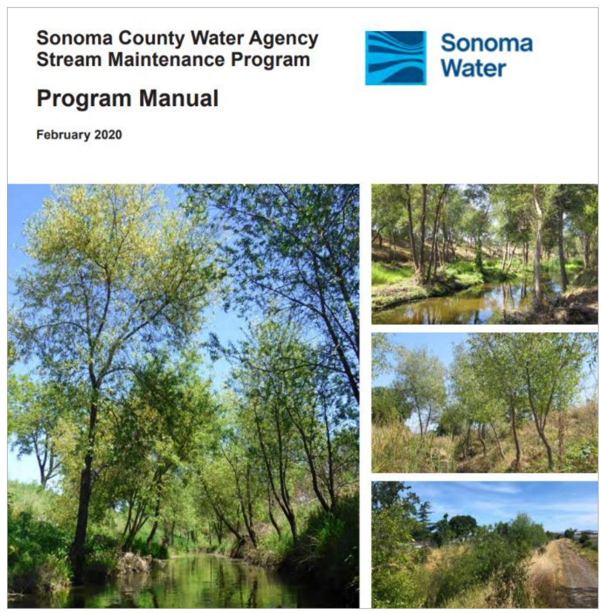
- Dry Creek Rancheria Fire Resilience Project: This project, supported by the State Coastal Conservancy, focuses on reducing fire fuels on approximately 57 acres of Tribal land, including areas damaged by the Kincade Fire and along Rancheria Creek. It includes vegetation management, forest thinning, and the development of long-term management strategies.
- Tribal Climate Adaptation Plan: The Tribe is integrating fire resilience with climate change adaptation by focusing on restoring Rancheria Creek, managing vegetation, and reducing the risk of catastrophic wildfire, which helps improve forest health and water quality.
- Traditional Ecological Knowledge (TEK): The Tribe is documenting and implementing TEK to guide forest management, focusing on historical landscape practices to improve climate resiliency.
- Broader application of lessons learned from these projects and incorporation of TEK can increase the wildfire resilience of the watershed.

6.4.11 Strategy #11 – Support Flexible and Adaptive Policy for Resilient Watershed Management

Actions	Vulnerabilities Addressed[a]						
Action 1 – Support Flexible and Adaptive Regulations	SW	GW	WQ	EC	FM	HP	RC
Action 2 – Acquire Conservation Easements to Support Watershed Resilience	SW	GW	WQ	EC	FM	HP	RC
Action 3 – Support Action Plan to Address Water Quality Impairments			WQ	EC			
Action 4 – Modify Russian River Hydrologic Index	SW	GW	WQ	EC			RC
Action 5 – Improve Integration of Flood and Land Management			WQ	EC	FM		RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, FM = flood management, HP = hydropower, RC = recreation

Project Spotlight: Sonoma Water Stream Maintenance Program



The Stream Maintenance Program (SMP or Program) was developed by Sonoma Water in 2006–2009 to improve and define the management and maintenance of flood control channels and streams under in many parts of the Russian River watershed. In the 2019 version, the SMP Manual reflects updates to in Program permits that demonstrate an adaptive approach to streamline program goals.

Over the years, Sonoma Water's stream management perspective expanded to include multiple objectives including resource protection and environmental sustainability in addition to just flood control and channel maintenance. Compliance with federal environmental laws and regulations such as the federal Endangered Species Act (ESA) and Clean Water Act (CWA), and state laws and regulations administered by the California Department of Fish and Wildlife (CDFW) and Regional Water Quality Control Boards (Regional Boards or RWQCBs) has required an increasingly extensive authorization process. Prior to the SMP, each individual maintenance project underwent separate permit approval that typically involved submitting between 5 to 15 individual permit applications to various regulatory agencies, and an annual permitting process of 10- to 18-month planning/application process for a work period that lasted only 3 to 4 months. By the early 2000s, the annual permitting process for routine and repeating maintenance activities had become inefficient for Sonoma Water and the regulatory agencies. The RWQCBs specifically requested that Sonoma Water develop a long-term plan to streamline and shorten this annual permitting process.

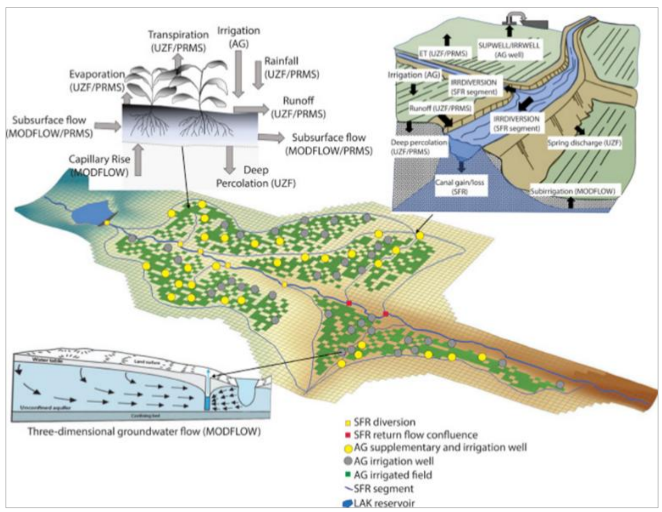
The SMP mitigation approach was also developed and evaluated over 3 years of interim permitting when proposed mitigation approaches were used and tested. During that period, individual maintenance projects were developed, submitted for agency review, permitted, and implemented. The interim permitting period was used to demonstrate and refine program maintenance activities, including the program's mitigation approaches. Since permits were originally issued for the Program in 2010 and 2011, Sonoma Water has met and communicated with representatives from USACE, RWQCBs, CDFW, USFWS, and NMFS regularly about the Program, including discussions on how to revise or adaptively manage elements of the Program to do things better.

6.4.12 Strategy #12 – Enhance Tools, Monitoring, and Water Accounting Methods

Actions	Vulnerabilities Addressed[a]						
Action 1 – Improve Modeling of Riparian, Floodplain, and Flood Dynamics	SW	GW	WQ	EC	FM		RC
Action 2 – Improve Monitoring Techniques to Inform Near Real-Time Modeling and Responses	SW	GW	WQ	EC	FM	HP	RC
Action 3 – Develop Fully Integrated Hydrologic, Hydraulic, and Water Quality Modeling Suite	SW	GW	WQ	EC	FM	HP	RC
Action 4 – Continue to Advance Climate and Weather Modeling and Forecasting	SW	GW	WQ	EC	FM	HP	RC
Action 5 – Expand Watershed Models to Incorporate Tributary Processes	SW	GW	WQ	EC	FM		RC
Action 6 – Improve Consistent Watershed-Scale Status and Trends Monitoring for Watershed Health	SW	GW	WQ	EC	FM		RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, FM = flood management, HP = hydropower, RC = recreation

Project Spotlight: Russian River Groundwater Surface Water Flow (GSFLOW) Model



The Russian River Integrated Hydrologic Model (RRIHM) is a computer-based simulation tool developed by the U.S. Geological Survey (USGS) in collaboration with Sonoma Water and the California State Water Resources Control Board. The RRIHM simulates stream-aquifer interactions using the Coupled Groundwater and Surface-Water Flow Model (GSFLOW). The model is coupled with MODSIM to represent coupled reservoir operations and priority-based water allocations. Agricultural water demands are simulated dynamically and are passed to MODSIM for determining reservoir operations and irrigation withdrawals. It is designed to better understand how groundwater and surface water interact across the Russian River watershed, and helps scientists and water managers evaluate water availability, movement, and quality in three dimensions.

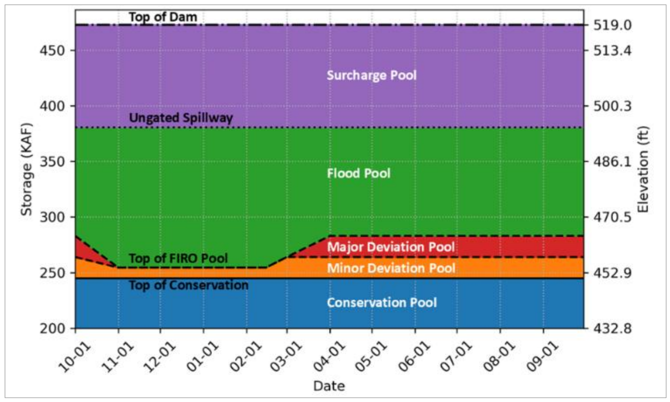
The model simulates movement and exchanges of water through the watershed, including rainfall-runoff processes, flow through the surface water system (in rivers and streams), in the groundwater system (in aquifers), and in response to human systems (agricultural and urban surface water and groundwater diversions). Dynamic simulation of these processes and feedbacks allows for characterization of impacts of future climate change and drought, as well as changes in land use and water management decision-making.

6.4.13 Strategy #13 – Improve Forecasts and Forecast-Informed Operations

Actions	Vulnerabilities Addressed[a]						
Action 1 – Operationalize FIRO at Lake Sonoma and Lake Mendocino	SW	GW	WQ	EC			RC
Action 2 – Operationalize Use of Advanced Quantitative Precipitation Information for Forecast-Informed Operations	SW	GW	WQ	EC	FM	HP	RC
Action 3 – Expand Transition to Applications and decision support tools for subseasonal to seasonal (S2S) and Decadal Climate Predictions	SW	GW	WQ	EC	FM	HP	RC
Action 4 – Expand Hydrometeorology and Stream Gaging Networks	SW	GW	WQ	EC	FM	HP	RC
Action 5 – Improve Understanding and Forecasts of Water Temperature	SW		WQ	EC			RC

[a] SW = surface water supply, GW = groundwater supply, WQ = water quality, EC = ecosystem, FM = flood management, HP = hydropower, RC = recreation

Project Spotlight: Lake Sonoma FIRO



FIRO is a reservoir operations strategy that better informs decisions to retain or release water by integrating additional flexibility in operation policies and rules with enhanced monitoring and improved weather and water forecasts (American Meteorological Society, 2020). FIRO was pioneered at Lake Mendocino and has been providing benefits for nearly 10 years at that facility, improving water supply, flood risk management, and ecological conditions.

The Russian River is expected to experience more hydrologic extremes – both droughts and floods – in the future due to climate change. FIRO was analyzed as a climate resilience strategy to mitigate these potential impacts. The results of this analysis show that FIRO is an effective strategy for improving water supply reliability, enhancing ecosystem conditions, and reducing flood risk under future climate scenarios.

FIRO leads to higher spring storage in Lake Mendocino and Lake Sonoma compared to the No-FIRO alternative, particularly in drought years. The water supply reliability benefits of FIRO are maintained under climate change when comparing historical and future climate periods. Higher storage in both reservoirs translates to increased flows during dry periods, which support salmonid and steelhead rearing and migration. At Lake Mendocino, higher storage also results in a longer lasting cold water pool that benefits salmonid spawning in the fall.

Under FIRO, pre-releasing water into the conservation pool before a storm reduces the frequency and volume of uncontrolled spills at Lake Mendocino and Lake Sonoma under climate change conditions. FIRO does not result in increased downstream flooding compared to the No FIRO alternative.

The upcoming major deviation for Lake Sonoma will establish guidelines and rules for USACE to retain water within the FIRO pool based on forecasted information and FIRO decision support tools. Sonoma Water intends to request this major deviation to be in place for up to 5 years, or until it is replaced with a updated Water Control Manual that formalizes FIRO procedures at Lake Sonoma, which is currently scheduled to be completed by 2028.

6.5 Linking Actions to Projects

As indicated previously, adaptation strategy input received from the Watershed Network and those compiled through other sources and meetings varied in the level of detail and specificity. Most input was not what could be described as "projects" in that it lacked definition, specific location, and detailed description. However, the next step in this adaptation strategy development process is to work with project proponents to compile and develop a more comprehensive, living database of projects aligned with each strategy and action. The database would also indicate the project proponent who would be expected to champion the effort. Chapter 7 provides further information on moving from strategies and actions to implementable projects.

7. Implementation Strategies

7.1 Requirements for Implementation

This Russian River WRP makes clear that there is much work to be done to build the resilience needed to withstand the expected impacts of climate change. As shown in Chapter 6, to meet the challenges of climate change, the Watershed Network has identified 13 strategies needed to address the risks associated with extreme heat, wildfire, flooding, water supply reliability, and water quality degradation. With its multiple jurisdictions, including three counties, multiple cities and towns, multiple watershed-wide organizations, and hundreds of identified adaptation concepts, the implementation of the WRP requires a thoughtful and deliberate approach. Successful implementation of a Plan of this scale requires the ongoing investment in, and cultivation of durable partnerships, organizational capacity, development and execution of a funding strategy and an outcomes focused implementation Plan. Together, these three elements set the foundation for skillful and effective program implementation (Figure 7-1).

Figure 7-1. Three Foundational Elements for Effective Program Implementation

7.2 Partnerships and Organizational Capacity – *Evolving the Network to be Purpose Built for Implementation*

The Russian River watershed communities have a long and strong legacy of collaboration and organizing across sectors and geographies to pursue common goals of watershed health. Tribes, agencies, jurisdictions, and watershed organizations joined the Watershed Network, with many strong relationships already in place.

Sonoma Water, with its major resource responsibilities, has cultivated durable partnerships with Mendocino and Marin counties, the cities and towns, Groundwater Sustainability Agencies (GSAs), and the Resource Conservation Districts (RCDs) within their service area, and the watershed. Together these entities collaborate to deliver a reliable water supply, manage groundwater resources, reduce flood risk, treat and recycle wastewater, and manage stormwater.

Additionally there are several organizations in the watershed, including the Russian River Watershed Association (RRWA), the Russian River Confluence, Russian River Regional Monitoring Program (R3MP), Russian Riverkeeper, the North Coast Resource Partnership (NCRP), the Laguna de Santa Rosa Foundation, Sonoma Land Trust, the CIEA, the Mendocino Lake Sonoma Tribal Environmental Professionals (MLSTEP) and many others that have woven a strong foundation of collaboration, science, planning and partnerships that will support successful implementation of the WRP.

Tribal Governments, communities, and organizations are critical partners in the watershed, leading conservation projects, including restoration, monitoring, and data collection. Enhancing partnerships with Tribal entities should be a priority throughout implementation to encourage integrating TEK across all efforts in the watershed and benefiting from Tribal understanding and skills. All these partnerships will be critical to the challenging tasks ahead to build resilience across the watershed.

Throughout the development of the Plan, the members of the Watershed Network have been successful in solidifying existing, and forging new, partnerships between its members. Co-creating an understanding of climate vulnerabilities and risks in the watershed and then collaboratively identifying adaptation strategies helped the Network members fully understand the issues facing different communities and different sectors.

The Network was designed with broad representation across the Watershed (see Chapter 3), with Sonoma Water as the convener to develop the WRP. Due to resource constraints, engagement was effective but limited to six main Watershed Network meetings and over a dozen additional targeted engagements. To move to the next steps toward implementation, additional organizational capacity and funding will be required.

7.2.1 Watershed Network 2.0

Whether the future implementing organization is an evolution of the existing Watershed Network, is housed in an existing organization, or is a brand-new organization it will need to have the ability to guide implementation partners through a complex process. For the purposes of this Plan, the next iteration of the Watershed Network will be referred to as the Watershed Network 2.0 (or Network 2.0).

To a certain degree, the configuration of Network 2.0 is dependent on how most project implementation funding will be provided. There is the potential that the funding available for watershed climate resilience through Proposition 4 will be delivered via a block-like grant mechanism, similar to how funding was provided historically to the IRWM Plan. In this scenario, Network 2.0 could be the recipient of a large block of funding and would work collaboratively with its members to develop a prioritization framework and fund projects. However, if funding is not offered through a block grant mechanism, individual jurisdictions could choose to pursue funding for their respective projects independently or choose to continue collectively within a Network 2.0.

Even without block funding, there is value in a continuation of Network 2.0 to collaborate on developing science, a shared prioritization approach, development of a funding strategy and ongoing partnership on funding proposals and project implementation.

To continue the work of the Plan and implement the identified adaptation strategies Network 2.0 will require additional organizational capacity including (but not limited to):

- An empowered decision-making body with diverse representation that includes Tribes, cities, counties, utilities, NGOs and interested parties in the watershed
- The ability to receive funds from multiple sources and redistribute them
- A robust and defensible planning framework that drives the prioritization of projects
- The technical and political capacity to manage a complex program from planning through to implementation
- Clarity on the approach to formal consultation with Tribal governments for implementation and project approvals
- A funding source to support ongoing Watershed Network 2.0 operations and membership participation

Additionally, it will be important that Watershed Network 2.0 avoid redundancy and align with existing watershed organizations.

7.2.2 The North Coast Resource Partnership As Partner and Model

The NCRP is a coalition of Tribes and counties working together on integrated regional planning and project implementation to enhance working and natural lands, built infrastructure, local economies, and community health in the north coast of California. Initially known as the North Coast IRWM Plan, the NCRP has been in existence since 2004 and has focused on verifying clean and reliable drinking water supplies, watershed health, energy independence, climate adaptation and economic vitality—especially in economically disadvantaged communities.

NCRP is both an excellent model and a critical partner for implementation of adaptation strategies in the Russian River.

The NCRP region covers over 19,000 square miles—12% of the California landscape—and includes the Tribal lands and the counties of Del Norte, Humboldt, Trinity, Siskiyou, Modoc, Mendocino, and Sonoma.

Through the receipt of block grants, NCRP has engaged in collaborative, integrated planning and project implementation, **investing over $85 million** in hundreds of projects that benefit the North Coast Region's communities and watersheds. Characteristics of the NCRP that have contributed to its success and are a model for the Russian River Watershed implementation efforts include:

- **Leadership Council:** Includes locally elected county and Tribal officials empowered to make funding decisions using their Implementation Framework. The Leadership Council sets direction, establishes criteria and investment targets, and makes all decisions for the NCRP.

- **Meaningful Tribal Representation.** The Leadership Council includes Tribal representatives from the Northern, Central and Southern districts of the NCRP region.
- **Stakeholder Driven Planning and Project Implementation Framework:** NCRP has developed a multi-benefit planning framework that is used collaboratively to prioritize projects and make funding decisions. It uses criteria and guidance from the Leadership Council.
- **Technical Peer Review Committee:** This committee acts as an advisory body to the Leadership Council, providing scientific and technical expertise.
- **Emphasis on Local Capacity Building**. Provides funding explicitly to support Tribes and historically disadvantaged communities in developing the capacity to lead on watershed health issues.
- **Efficient Expenditure of Funds toward on the Ground Outcomes.** NCRP closely tracks project goals and objectives and then measures impacts and performance metrics.

As Watershed Network 2.0 is formed, NCRP should be looked to as a model, a partner and a source for approaches to representation in decision-making, project prioritization and overall effectiveness in implementation of critical resilience actions in a diverse geography.

7.3 Project Implementation – *From Planning to Resilience Outcomes*

Over the last 2 years, the Watershed Network, through the WRP process, has made significant progress, identifying climate hazards, understanding how those hazards impact water resources sectors across the Watershed, and identifying Adaptation Strategies.

Now, the tasks ahead are focused on continuing current momentum on achieving resilience outcomes in the Watershed (Section 6.3). Figure 7-2 below lays out the four major next steps toward implementation for similar programs. As approaches to funding become more certain, an implementation plan specific to the Russian River watershed should be customized to fit the needs of the community and funding sources.

- **Phase 1: Plan –** Under Phase 1, additional planning is required to further define the projects required under each of the Adaptation Strategies and Actions discussed in Chapter 6. Under this phase, project proponents would have specific projects and would further develop each project and action (including their anticipated resilience outcomes, potential sponsors and partners, feasibility, regulatory requirements, and costs). This phase would also include initiation of public engagement that would continue throughout implementation. This phase should also include determination of the desired governance for Watershed Network 2.0, to the extent possible, depending on available funding and capacity. It should be noted that while this is Phase 1, Planning will be an ongoing and iterative process throughout Implementation. This Plan will be a 'living' document: it will be updated periodically to reflect new information on projects and, as needed, updated information on vulnerabilities and risks as new climate data becomes available.
- **Phase 2: Prioritize and Fund –** Under Phase 2, the list of projects defined under Phase 1 can be prioritized based on criteria developed by Watershed Network 2.0. Likely criteria may include measurable outcomes toward resilience, equity considerations, costs versus benefits, regulatory complexity, environmental impacts, public acceptance, or availability of funding for project type. Criteria used to select projects can also be translated into metrics for use in performance tracking. During Phase 2 a performance tracking framework can be established for use throughout the program. NCRP uses a multi-benefit planning framework to select and fund projects that can be a model for the WRP going forward and that includes a robust performance tracking approach. Under this phase, a long-term funding strategy can also be developed to start to match prioritized projects with available

funding sources and potentially develop funding sources. (More information on funding is found in Section 7.5).

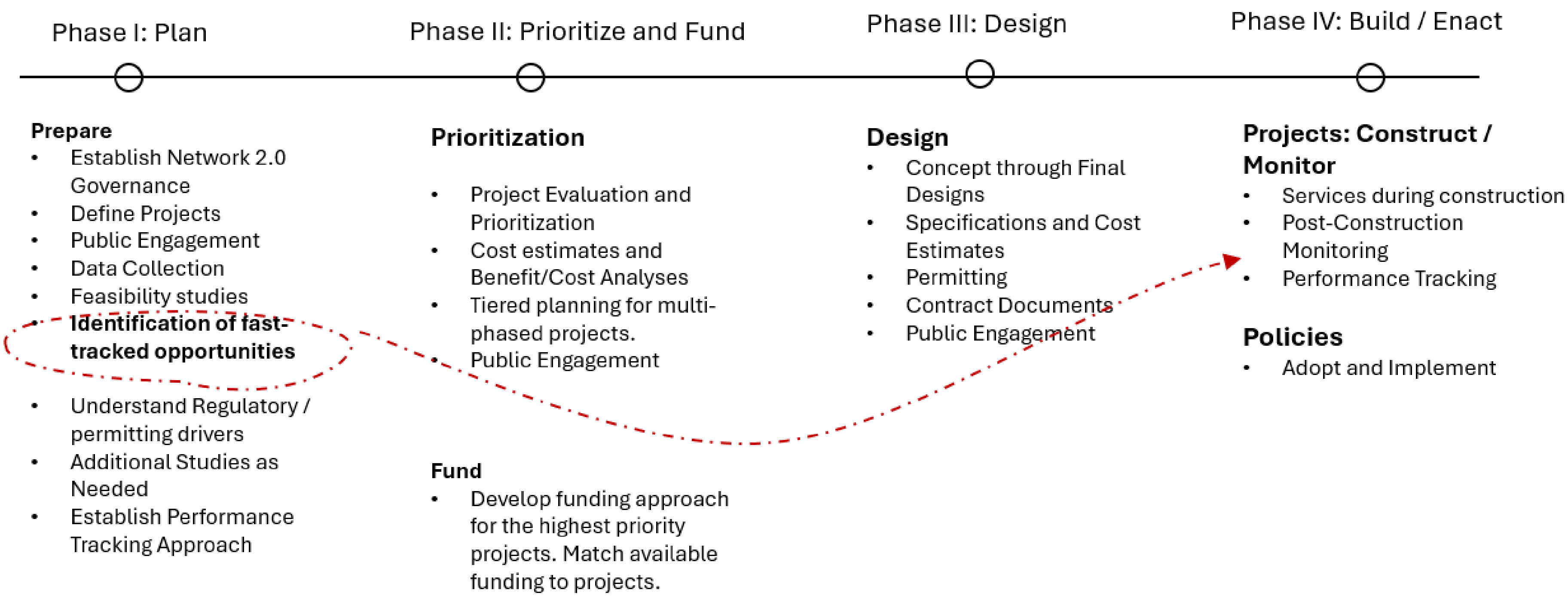
- **Phase 3: Design –** Under this phase, prioritized projects move through the design and permitting process, culminating in contract documents for bids if construction is required.
- **Phase 4: Build/Enact –** Under this phase, projects are constructed and post-construction monitoring is initiated and continued to confirm that project objectives are met. For adaptation strategies that involve policies rather than construction, this phase would see enactment of those policies. It is expected that implementation will be led by various entities and partnerships throughout the watershed (including Tribes, water agencies, cities and counties, RCDs, GSAs, and others). Note that projects will move iteratively through these phases as funding becomes available and as partners have capacity for driving projects.

Focus on Equity

Opportunities to strengthen the adaptive capacity of the most affected communities should be strongly considered at the outset of adaptation project development and throughout implementation, particularly in neighborhoods facing the highest combined sensitivity and hazard exposure—such as central and southwest Santa Rosa, the Ukiah-Cloverdale-Healdsburg-Windsor corridor, and drought-sensitive areas around Lake Mendocino and basin-margin wells. These areas represent the watershed's vulnerability hotspots for flooding, wildfire, extreme heat, and water-supply disruptions, and therefore should guide the phasing and prioritization of early and long-term resilience investments. These resilience projects might include distributed flood-storage and drainage upgrades, enhanced cooling access and heat-ready facilities, home-hardening and evacuation improvements, and water-supply reliability programs for small systems and drought-sensitive wells.

The State of California's current funding environment reinforces this equity-forward orientation—most notably Proposition 4, the State's $10 billion climate resilience bond approved in 2024, which requires that ***at least 40% of all funding directly benefit disadvantaged and vulnerable communities—*** positioning the watershed's most climate-burdened neighborhoods to effectively compete for State resources intended to accelerate resilience in frontline communities.

Figure 7-2. Outcomes Based Implementation Plan



7.4 Funding Strategy – *Matching and Developing Funding Mechanisms to Projects*

A successful funding approach for the WRP will need to leverage a portfolio of funding sources as well as develop a strategy that identifies the evolving funding needs over time while continuously matching needs and opportunistically acting on relevant funding sources. Funding will be needed for both project implementation and organizational capacity for Network 2.0 and its members to continue to work collaboratively to fulfill the intent of this Plan.

With 13 strategies and approximately 70 actions identified as needed to achieve resilience in the Russian River watershed, it is likely that this effort could span a period of 20 years or more. During that period, it is expected that funding availability from both State and Federal funds will fluctuate. In general, the State and Federal programs and funding vehicles may remain relatively constant, with funding amounts and availability varying based on economic and political factors. The magnitude and duration of this effort lend itself to looking at a broad and diverse portfolio of funding sources to be successful. This section provides a summary of the likely sources and mechanisms; however, these should be revisited regularly throughout the program to take advantage of new sources and approaches as they become available in future years.

7.4.1 State Funding Sources

California has historically seen a high commitment by the State administration, the legislature, and voters to consistently approve funding for planning, design, and construction of projects needed for water supply, water infrastructure, water quality, groundwater management, flood risk reduction, and ecosystem improvements. Over the last 40 years, California voters have approved more than $30 billion through California environmental and water bonds. (https://ballotpedia.org/List_of_statewide_bond_propositions_in_California)

7.4.1.1 Proposition 4 – The Climate Bond

The *Safe Drinking Water, Wildfire Prevention, Drought Preparedness, and Clean Air Bond Act* of 2024, known as the Climate Bond, approved $10 billion dollars for climate-related categories. Table 7-1 provides a summary of Proposition 4 funding most applicable to WRP adaptation strategies.

Table 7-1. Proposition 4: Climate Bond – Funding Categories

Category	Total Funding	Subcategories	Agencies	Summary
Safe Drinking Water, Drought, Flood, and Water Resilience	$3,800,000,000	Water quality, clean drinking water for tribes, water reuse/recycling, groundwater support	State Water Resources Control Board, Dept. of Water Resources	Supports safe drinking water, drought and flood resilience, groundwater, and water reuse
Wildfire and Forest Resilience	$1,500,000,000	Forest health, wildfire prevention (general)	CNRA, related conservancies	Funds wildfire prevention and forest resilience efforts
Coastal Resilience	$1,200,000,000	Sea-level rise, flooding, habitat restoration (general)	State Coastal Conservancy	Protects coastal communities from sea-level rise and flooding

Category	Total Funding	Subcategories	Agencies	Summary
Biodiversity & Nature-Based Solutions	$1,200,000,000	Habitat, ecosystem restoration (general)	Wildlife Conservation Board, CNRA	Supports biodiversity, habitat restoration, nature-based climate solutions
Clean Energy	$850,000,000	Grid reliability, storage, load flexibility	California Energy Commission	Funds clean energy and grid resilience projects
Park Creation & Outdoor Access	$700,000,000	Parks in underserved areas, improvements, access	Parks agencies, CNRA	Expands parks and outdoor access, especially in underserved areas
Extreme Heat Mitigation	$450,000,000	Urban greening, shading, cool pavements	CNRA Urban Greening Program	Mitigates extreme heat through greening and shading
Climate Smart Agriculture	$300,000,000	Support for small farmers, groundwater TA	Dept. of Water Resources	Supports climate-resilient agricultural practices

Note:

CNRA = California Natural Resources Agency

Proposition 4 Watershed Resilience Funding

The DWR announced that the new Proposition 4 Watershed Resilience Program—combining Sections 91019 (water conservation) and 91031 (IRWM and climate resilience)—will make approximately $152 million available for grants.

In addition to the $152 million explicitly identified for actions associated with the Watershed Resilience Program, many of the Proposition 4 funding mandates are in alignment with the adaptation strategies and actions identified in the Plan. This funding will primarily support project implementation; however, a portion may be available to support regional coordination and governance if there is a clear pathway to an eventual capital project.

Proposition 4 – 40% Requirement for Disadvantaged Communities

The statutory text of California's Proposition 4 Climate Bond includes an explicit equity mandate.

According to the California Natural Resources Agency's official bond accountability site, "At least 40% of the total funding made available pursuant to this division shall be invested in programs or projects that provide direct and meaningful benefits to disadvantaged communities, severely disadvantaged communities, and vulnerable populations." [bondaccountability.resources.ca.gov]

7.4.1.2 State Revolving Funds

Revolving funds provide low-interest loans and grants for projects that address water quality, safety, and supply.

- **Clean Water State Revolving Fund (CWSRF):** The program offers low-cost financing for a wide variety of water quality projects including publicly owned treatment facilities, nonpoint source projects, and estuary projects. The CWSRF interest rate is half of the most recent General Obligation Bond rate. More information, including the 2025–2026 intended use plan can be found on the program webpage: Clean Water State Revolving Fund | California State Water Resources Control Board.

- **Drinking Water State Revolving Fund (DWSRF):** Authorized by the Federal *Safe Drinking Water Act* (SDWA), this fund provides financing for public water systems to improve infrastructure and meet health standards. It prioritizes projects that reduce health risks, comply with regulations, and assist disadvantaged communities. The DWSRF assists public water systems in financing the cost of drinking water infrastructure projects needed to achieve or maintain compliance with SDWA requirements. Eligible project types include treatment systems, distribution systems, interconnections, consolidations, pipeline extensions, water sources, water meters, and water storage. Like CWSRF, the DWSRF interest rate is half of the most recent General Obligation Bond rate, and the most common construction financing term is 30 years. Further information can be found on the program webpage: Drinking Water State Revolving Fund | California State Water Resources Control Board

7.4.2 Federal Funding Sources

The Federal funding landscape for watershed and resilience projects has entered a period of uncertainty and transition. Under the Trump Administration, major agencies central to watershed conservation, including the U.S. Environmental Protection Agency (EPA), FEMA, and the National Oceanic and Atmospheric Administration (NOAA), have faced deep program cuts, staff reductions, and the rescission of unobligated *Inflation Reduction Act* funding. The *One Big Beautiful Bill Act* (OBBBA) eliminated dozens of climate and energy programs, including EPA's Environmental and Climate Justice Block Grants; in addition, the Fiscal Year 2026 (FY26) Budget Request proposes reductions of up to 90% for the CWSRF and DWSRF. NOAA's reductions in force and OBBBA-related rescissions are expected to limit habitat restoration investments, even if a narrower Transformational Habitat Restoration program returns. Despite these constraints, the FY26 appropriations process is advancing and will include reauthorizations for the CWA and surface transportation program.

- **Water Smart Drought Response Program | Bureau of Reclamation:** Supports a proactive approach to drought by providing assistance to water managers to develop and update comprehensive drought plans, and implement projects that will build long-term resiliency to drought, and implement projects that will build long term resiliency to drought. Program areas include Contingency Planning, Resiliency Projects and Emergency Response Actions.
- **FEMA Building Resilient Infrastructure and Communities | FEMA.gov:** Building Resilient Infrastructure and Communities (BRIC) is a Hazard Mitigation Assistance grant program that makes Federal funds available to States, U.S. territories, Federally recognized Tribal Nations, and local governments for hazard mitigation activities. It does so by recognizing the need to upgrade and modernize the nation's infrastructure against the growing risks to communities and the need for natural hazard risk mitigation activities that promote resilience with respect to natural hazards. In March 2026 FEMA announced the funding opportunity for Fiscal years 2024 and 2025 making $1 billion of funding available for community resilience projects that mitigate the impacts of disasters such as floods, wildfires, earthquakes, and hurricanes. This year's BRIC grant program gives preference to projects that are shovel-ready and that are located in States that have not won previous BRIC grants; since California has been awarded previous BRIC grants, California will not have preference in this BRIC round of funding.

7.4.3 Philanthropic Sources

Philanthropic dollars have the potential to accelerate watershed resilience work in California. Recent Statewide analyses, including the Resourcing Resilience report (2025) suggest that public and philanthropic funders must act together to fund climate adaptation efforts. Philanthropy is uniquely positioned to:

- Fund early-stage groundwork that public grants do not, such as coalition building, and feasibility studies.
- Remove access barriers for disadvantaged communities.

7.4.4 Other Funding Mechanisms

Beyond traditional State and Federal grants and loan programs, additional funding approaches may prove suitable to contribute to the long-term funding needs of the Russian River WRP. These local and regional tax measures and public private partnerships.

- **Local Funding Measures.** Local tax measures have been adopted throughout California to fill the funding gaps in resilience related efforts and are often used to fund infrastructure upgrades, public transit, and other societal needs. In the Bay Area, parcel taxes and sales taxes have been approved to cover wildfire prevention, emergency response, habitat restoration, and flood protection. Raising taxes is always politically challenging; however, with climate risks clearly arriving, the potential exists for local or regional tax measures to become publicly acceptable to fund a portion of the WRP and would be well suited to provide long-term sustainable base funding to support governance and operations. Beyond tax measures, local and regional bonds are also often used to fund hazard mitigation and resilience efforts.
- **Public Private Partnerships.** Public private partnerships are collaborative agreements between government agencies and private sector entities to finance, build, and operate public services or infrastructure; these partnerships allow risks, resources, and rewards to be shared over long-term contracts. Several innovative investment strategies are being developed and tested across California; the intention is to increase investment in natural infrastructure to support climate resilience, improve wildfire resilience, improve forest health, and protect water supplies. As these approaches are piloted across the State, they should be considered as an option providing needed funding for the Russian River WRP: https://www.bayareaeconomy.org/files/pdf/P3inCaliforniaWeb.pdf.

7.4.5 A Successful Funding Strategy

To fund the number of projects envisioned in the WRP over a decade or more will require continuous effort to identify and define the evolving priority projects and match them with available funding sources. At times, the availability of funding with a particular focus will drive priorities and it will be important to be opportunistic and flexible as the funding landscape changes over time. Development of a funding strategy is a critical next step. The key features of a successful funding strategy include the following:

- Develop and apply defensible prioritization tool to identify top priority projects.
- Continually push projects toward funding readiness by defining resilience outcomes, project scope, and budgets.
- Stay ahead of funding opportunities by tracking upcoming opportunities.
- Develop innovative funding mechanisms to supplement State and Federal grants.

7.5 Building Resilience Together with Intent

Climate change in the Russian River watershed is already posing significant challenges to the communities and ecosystems across the landscape. The analysis conducted for this Pilot show that these challenges will be considerably exacerbated in the near- and long-term future with increased fire risk, increased flooding, prolonged drought periods, increases in extreme heat events, and impacts to water quality and endangered species and their habitats and to Tribal Beneficial Uses.

This Watershed Resilience Pilot for the Russian River is a critical first step in addressing these current and future challenges, through collaboration, by building on existing partnerships and working together to understand the extent of the challenges across water resource sectors and across communities. Through the Pilot, the Watershed Network is working together to identify solutions through the development of adaptation strategies. This collaboration is essential to build collective intent to move forward together as a watershed community.

There are critical next steps ahead for this community to translate the substantial work completed through this Pilot into resilience outcomes. The first is to clarify the organizational structure for the Watershed Network that best suits the nature of the anticipated funding and the decisions ahead and creates a framework for ongoing collaboration. Next, the Network must develop a flexible and evolving implementation work plan that serves as a roadmap for implementing the hundreds of projects needed to protect the watershed and its communities. Finally, the Network must develop and execute a funding strategy to verify that the resources are available for this substantial and critical effort.

8. Performance Tracking

Performance tracking will be a critical element of the Russian River WRP as it moves from plan to implementation. Measuring and tracking performance is important to understand the progress, trends, and gaps towards watershed resilience, program implementation, watershed network engagement, and community and equity. Performance tracking for watershed resilience should strive to link measurable indicators and metrics to specific resilience and functional goals of the watershed network and program.

As part of the initiation of the Watershed Resilience Program, DWR has outlined the development of initial statewide indicators and metrics to support watershed resilience. These indicators relate primarily to watershed resilience measurements that could be tracked at statewide scale and functional statewide data sources. The purpose of this chapter is to outline the potential performance indicators that could be used for the Russian River watershed. Indicators will be further refined and updated as the program moves forward in 2026 and 2027.

8.1 Types of Indicators

Performance indicators are organized into four types that track different dimensions of implementation progress and outcomes:

- **Watershed Resilience Indicators:** The watershed resilience indicators focus on the state of the watershed system and whether implementation efforts are contributing to improved resilience capacity over time. These indicators may be quantitative or qualitative and may reflect system-level changes rather than site-specific performance. Given the long timeframes associated with many climate resilience benefits, these indicators are used to assess directional progress of the watershed towards resilience outcomes.
- **Program and Implementation Indicators:** Program and implementation indicators track whether specific resilience actions and projects are moving forward towards their respective goals. These indicators focus on activity and progress, rather than long-term outcomes, and are particularly useful in the near term. These indicators also indicate the progress of the portfolio of projects related to each of the resilience strategies.
- **Watershed Network Indicators:** Watershed Network indicators track the health of the network, the level of engagement, and support evaluation of partnerships throughout the watershed.
- **Community and Equity Indicators**: Community and Equity outcome indicators track where and how resilience benefits are delivered, verifying that implementation aligns with equity objectives identified in the Plan.

The specific indicators for each of these types are described in the following section.

8.2 Performance Indicator and Metrics

Performance tracking relies primarily on existing data sources and reporting mechanisms, consistent with guidance from DWR to minimize new reporting burdens on implementing partners. This approach emphasizes practicality, scalability, and efficient use of information already generated through project delivery and funding programs.

Data sources used for performance tracking may include the following:

- Project status and grant reporting
- Documentation of planning and implementation activities
- Monitoring and operational data
- Publicly available datasets and mapping tools

Rather than requiring continuous monitoring, performance tracking is conducted through periodic synthesis and review. Indicators are reviewed at defined intervals to assess implementation progress, identify emerging trends, and support adaptive management discussions. As implementation advances and new information becomes available, data sources and tracking methods may be refined to improve relevance, efficiency, and decision-making.

It is anticipated the Watershed Network will coordinate the acquisition of this necessary data and reporting in a shared performance tracking dashboard. This data will be developed as a shared responsibility amongst network members, specific project leaders, and watershed resource managers. This shared-responsibility approach reflects the collaborative nature of watershed resilience implementation and confirms that performance tracking supports learning, transparency, and coordinated action without imposing unnecessary administrative burdens. The exact structure of the performance tracking responsibilities will be examined further as organizational capacity of the future network is developed.

Watershed Resilience Indicators were developed based on review of measurements that were used to help support understanding sector-specific climate vulnerabilities. These indicators represent observable aspects of a given sector that can be used to characterize direction and trend of that sector over time. Draft metrics incorporate quantitative observational (or derived from observations) measurements of certain components of a given indicator.

The draft Watershed Resilience indicators and metrics aligned with each water resource sector is provided in Table 8-1. While the temporal frequency of the proposed metrics may vary from days to a full year, it is envisioned that these indicators would be updated annually and support tracking of the watershed resilience "vital signs" over multiple years.

Table 8-1. Watershed Resilience Indicators

Sector	Indicator	Metrics
Surface Water Supply	Water Supply Reliability	▪ Russian River Collector Diversions ▪ Sonoma Water Retail Customer Shortages
	Reservoir Condition	▪ Annual and Monthly Eel River Transfers ▪ Lake Mendocino Storage and Releases ▪ Lake Sonoma Storage and Releases ▪ Marin and North Marin Reservoir Storage
Groundwater Supply	Total Volume of Storage	▪ Groundwater-Surface Water Exchanges (estimated) ▪ Groundwater Storage
	GSP Sustainable Management Criteria	▪ Santa Rosa Plain GSP Sustainable Management Criteria ▪ Petaluma Valley GSP Sustainable Management Criteria ▪ Sonoma Valley GSP Sustainable Management Criteria
Flood Management	Flood Inundation	▪ Floodplain Inundation Extent
	Asset Exposure	▪ Number of Structures in Floodplain

Sector	Indicator	Metrics
Water Quality	Reservoir Condition	▪ Lake Mendocino Water Temperature Patterns (seasonal) ▪ Lake Sonoma Water Temperature Patterns (seasonal)
	River Condition	▪ Russian River Temperature and Dissolved Oxygen at Cloverdale (seasonal) ▪ Russian River Temperature and Dissolved Oxygen at Hacienda Bridge (seasonal)
Ecosystem	Ecological Flows & Geomorphic Processes	▪ Annual and Monthly Flows for Mainstem Russian River ▪ Annual and Monthly Flows for Russian River Tributaries ▪ Frequency of Tributary Drying ▪ Frequency and Duration of River mouth Closure
	Water Quality Impairments	▪ Daily Maximum Water Temperature Patterns ▪ Daily Minimum Dissolved Oxygen Patterns
	Salmonid Habitat Suitability	▪ Availability of Salmonid Habitat along Mainstem Russian River and Tributaries ▪ Availability of Salmonid Habitat in Russian River Estuary
Recreation	Recreational Uses	▪ Annual Days Suitable for Boating and Camping at Lake Mendocino ▪ Annual Days Suitable for Boating and Camping at Lake Sonoma ▪ Annual Days Suitable for Boating and Fishing along the River Russian
Hydropower	Hydropower Generation	▪ Annual and Monthly Hydropower Generation for Coyote Valley Dam ▪ Annual and Monthly Hydropower Generation for Warm Springs Dam
Community & Equity	Population Exposure to Risks	▪ Population Sensitivity to Floods, Wildfire, Drought, and Water Supply Disruptions (estimated)

The draft Program and Implementation, Watershed Network, and Community and Equity outcome indicators are provided in Table 8-2. These indicators are primarily used to track the progression and functionality of the Program over time. They help measure the types and progress of projects and portfolio implementation, funding, organization capacity, engagement and partnerships, and community and equity outcomes. It is anticipated that these indicators would be updated annually and support tracking of the program effectiveness over multiple years.

Table 8-2. Program and Implementation, Watershed Network, and Community and Equity Indicators

Indicator Type	Indicator	Metrics
Program and Implementation Indicators	Project Delivery and Implementation	▪ Number and type of projects initiative, advanced, or completed ▪ Progress compared to implementation phases
	Portfolio Implementation	▪ Balance of projects across climate hazards, sectors, and watershed geographies ▪ Distribution of projects aligned with resilience strategy and portfolio ▪ Degree of integration with existing programs, operations, and investments ▪ Alignment with regional and statewide resilience portfolios
	Project Pipeline	▪ Number and type of projects in the pipeline for implementation ▪ Distribution of projects associated
	Funding	▪ Total amount of funding received and dispersed by resilience strategy ▪ Contribution of funding by source and local match
Watershed Network Indicators	Organizational Capacity	▪ Assessment of functional organizational capacity to manage network, support development and prioritization of projects and portfolios, and acquire funds
	Engagement	▪ Number and type of network meetings ▪ Representation by membership type ▪ Self-assessment of network engagement
	Partnerships	▪ Coordination milestones achieved among watershed partners
Community & Equity Indicators	Equity Lens	▪ Distribution of implemented projects relative to areas of higher social vulnerability ▪ Access to resilience benefits for communities with limited adaptive capacity ▪ Integration of equity considerations into project phasing and sequencing

8.3 Application and Use of Indicators

Performance indicators are used to track resilience trends in the watershed and support adaptive management and informed implementation of a Russian River watershed resilience program. Periodic review of performance information provides a structured opportunity to apply indicator results to ongoing decision-making across the watershed. Specifically, performance indicators are used to complete the following:

- Adjust project sequencing and investment strategies in response to observed progress, readiness, and emerging conditions
- Refine evaluation criteria and implementation approaches based on lessons learned from project delivery
- Identify emerging risks, opportunities, or coordination needs that may not have been apparent during initial planning

Performance indicators must be applied and interpreted in the appropriate context. Their primary value lies in supporting adaptive management, improving coordination, and guiding future implementation decisions. In order to support transparency, watershed network coordination, and communicating program progress and effectiveness, it is recommended that an online performance tracking dashboard be developed for the Russian River WRP moving forward. In addition, the Russian River watershed network and DWR should continue to coordinate to evaluate integration with the draft California Watershed Resilience Hub tool managed by DWR.

9. Recommendations

The WRP incorporated a robust analysis of climate impacts on the water resources in the Russian River watershed; identified various resilience strategies and actions; and received input from an engaged Watershed Network on vulnerabilities, adaptation strategies, and engagement of the Watershed Network. It is recognized that the WRP was limited in time and scope, and that implementation actions are described generally. Based on the analysis, findings, and strategies, the following nine recommendations can help the WRP become more robust, implementation focused, and eventually successful in achieving resilience benefits for the Russian River watershed.

9.1 Maintain and Support the Collaborative Watershed Network to Adapt to a Programmatic and Implementation Focus

One of the major strengths of the WRP has been the robust and engaged Watershed Network. The WRP provides potential pathways for implementation, but fundamental to continuing the work is adapting the current Watershed Network to be able to manage a program and focus on implementing resilience projects and actions throughout the watershed. Moving forward, it is recommended to develop organizational capacity and a more formal structure for the Network to begin aligning various projects and actions with funding sources and implementation. Specifically, clarity is needed regarding the following aspects of next iteration of the Watershed Network:

- A durable funding source to support the ongoing operations of the Network
- An organizational structure that defines the framework for Network leadership, representation, membership, and decision-making around funding, prioritization of projects, and roles for implementation

9.2 Accelerate Project Definition and Project Prioritization

A high priority recommendation is to advance the WRP's strategies and actions in Chapter 6 by defining and developing specific projects. Many organizations within the watershed already have projects in development that address climate impacts and that can be incorporated into the evolving WRP. However, there is additional effort needed to further define projects aligned for each of the identified strategies and related actions. This work is expected to be done by individual project proponents and various partnerships through the Watershed Network. Project definition and development includes description of the project's goals and objectives including improvements to resilience and benefits to vulnerable communities, approach to incorporating TEK, regulatory requirements, potential partners, cost estimate, anticipated schedule, equity considerations, potential funding sources, and other project factors. A living databased of projects linked to strategies will be developed and maintained.

Alongside the development of project details, the Watershed Network should select and develop and prioritization framework to apply to projects to facilitate decision-making. As described in Chapter 7, the NCRP has a prioritization model that can serve as a foundation. The prioritization framework should include a range of criteria that reflect the values of decision-makers, regulatory requirements and funding and construction readiness.

9.3 Tackle the Most Pressing Climate Challenges Head-On

Significant climate vulnerabilities have been identified and evaluated through the WRP. The most challenging and geographically widespread vulnerabilities are as follows:

- **Drought and Water Supply Resilience –** Drought risks take different forms throughout the watershed depending on hydrologic characteristics and compounding stressors, but severe and extended droughts are a principal vulnerability that should be prioritized due to impacts to human health and safety, ecosystems, and the regional economy.
- **Flood Risk and Resilience –** Flood risks are significant along the mainstem Russian River and tributaries, particularly in the Central Sonoma Watershed Project located in the Santa Rosa Creek Watershed, and should be prioritized due to potential impacts on life safety and property.
- **Ecological Resilience –** Climate changes have large impacts on water temperature, dissolved oxygen, flow regimes, and estuary conditions that degrade aquatic ecosystems, and other watershed ecological resources, negatively affecting the species that rely upon this habitat.
- **Wildfire Resilience and Watershed Health –** Increasing risk associated with increased frequency and severity of wildfires and changing precipitation patterns necessitates taking watershed-scale actions in a holistic, systematic way.

To achieve significant, measurable benefits, the strategies and actions that address these most pressing challenges described in Chapter 6 should be prioritized.

9.4 Encourage a Portfolio Approach to Resilience Action

There is no single project or action that can resolve the climate challenges facing the water resources of the Russian River; rather, multiple actions at multiple scales will be required. Some actions will have larger resilience benefits than others, but it will take a strategic collection of coordinated actions to achieve real, measurable watershed resilience over time. This WRP encourages the use of a portfolio approach to addressing each of the 13 resilience strategies. Anchor projects—those that are core/foundational to the success of the strategy—should be combined with smaller projects that support resilience. Some projects may be ready for implementation, while others still need further development. This portfolio approach allows for a variety of projects to be implemented and integrated with a strategic focus.

9.5 Build Traditional Ecological Knowledge, Nature-Based Solutions, and Systems Thinking into Resilience Strategies and Actions

Tribal governments, communities, and organizations are critical partners in the watershed, leading on conservation projects including restoration, monitoring, and data collection. Enhancing partnerships with Tribals should be a priority throughout implementation to encourage integrating TEK across all efforts in the watershed and benefiting from Tribal understanding of the Russian River cultural and ecological landscape and stewardship skills. NBS are being implemented throughout California and are fully supported by the CNRA. NBS focus on using nature and nature-based processes to build resilience to climate-driven extremes. Expanding NBS will improve the likelihood of achieving multiple benefits compared to traditional projects, aligns with core state climate goals, and aligns with the strategies identified in the WRP. Traditional and ecological knowledge and NBS incorporate systems thinking approaches that show the integrated nature of watershed hydrological and ecological processes.

9.6 Ensure that Equity Priorities are Integral to Resilience Planning and Action

Advancing equity in climate and watershed planning is a major emphasis of the Watershed Resilience Program and this WRP. Significant climate vulnerabilities related to existing and future flooding, wildfire, extreme heat, and water supply were identified for Russian River communities that have compounding socioeconomic-related vulnerabilities. Prioritizing resilience actions that address equity challenges in the watershed should be ensured through a decision process that explicitly integrates and elevates actions that can reduce disproportionate impacts to these communities.

The State of California's current funding environment reinforces this equity-forward orientation. Most notably through Proposition 4, the state's $10 billion climate resilience bond approved in 2024, requires that at least 40% of all funding directly benefit disadvantaged and vulnerable communities. This funding environment positions the watershed's most climate-burdened neighborhoods to effectively compete for state resources intended to accelerate resilience in frontline communities.

9.7 Position the Russian River Watershed for Upcoming Funding

Implementation of on-the-ground resilience projects is the primary objective for the next phase of the program. However, implementation will require significant funding for the range of strategies and projects identified in the WRP. A successful funding approach for the WRP will need to leverage a portfolio of funding sources as well as develop a strategy that identifies the evolving funding needs over time while continuously matching needs and opportunistically acting on relevant funding sources.

In the near term, the Climate Bond (Proposition 4) is the state funding source in closest alignment with the goals of the Watershed Resilience Program. The Climate Bond approved $10 billion dollars for climate-related needs across water resource sectors. The DWR announced that it will make approximately $152 million available for grants for watershed resilience through the water conservation and IRWM and climate resilience sections of the Climate Bond. Within the strategies emphasized in this WRP, the projects will need to be prioritized and readied for expected grant funding opportunities in 2027.

In addition to the $152 million explicitly identified for actions associated with the Watershed Resilience Program, many other elements of the Proposition 4 funding are in alignment with the adaptation strategies and actions identified in the WRP, such as headwaters and wildfire resilience and coastal resilience. Each specific project within the resilience portfolios will need to be aligned with a potential funding source or sources and advanced to ensure timely readiness for upcoming funding.

9.8 Build a Program Tracking System and Key Performance Indicators to Guide and Monitor Watershed Resilience Implementation

As the WRP moves into the next phase with a focus on projects, funding, and implementation, a program structure will need to be developed. This program structure should include a detailed and evolving list of projects aligned with each resilience strategy and action, lead and co-lead entities for each project, project status and readiness for implementation, potential funding sources, and indicators and metrics that should be used to monitor performance during and after implementation. The indicators and metrics should include a mix of those related to system performance and those related to project implementation progress. The system performance indicators should build from those indicated in Chapter 7, while the implementation progress indicators should allow the Watershed Resilience Program to track status of individual projects, degree of strategy focus or breadth, and financial tracking. It is recommended that this tracking system be initiated in 2026 and a live, interactive version integrated into the Russian River Watershed Resilience website.

9.9 Encourage State to Fully Support and Fund the Watershed Resilience Program Throughout California

Based on the experience in the development of this Russian River Pilot and through discussions with other Pilot teams, the Watershed Resilience Program has demonstrated considerable value by providing state support to watersheds, allowing for the activation of collaborative watershed networks. With support and guidance, the state has encouraged the Pilot watersheds to engage in systems-based thinking around watershed climate resilience; identify major climate vulnerabilities; and develop strategies, actions, and projects to increase the resilience of the watersheds. Based on the successes of the pilots to date, it is recommended that the state expand the program to additional watersheds throughout the state to ensure that focused climate resilience planning and actions are implemented broadly in California's watersheds.

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