# Petaluma River Watershed Conservation and Enhancement Plan

Prepared by:

SONOMA RESOURCE CONSERVATION DISTRICT

Funding provided by:

BUREAU OF RECLAMATION

## Land Acknowledgement

The Petaluma River Watershed lies within the unceded lands of the Coast Miwok and Southern Pomo peoples. The Tribe regained acknowledgment of its sovereignty in 2000 through the United States Federal Government and is a federally recognized tribe known as the Federated Indians of Graton Rancheria.

We acknowledge the land, stewardship, and knowledge of the Coast Miwok peoples who have been connected to this land since time immemorial, and the impact removing traditional cultural practices has had on our landscapes. We recognize and respect the Tribe's relationship to the land not only in the past but also in the present and future.

Let this acknowledgment serve as a reminder of the lands and waters that we benefit from today and the importance of protecting and caring for them now and into the future. We will work alongside the people of the Coast Miwok and Southern Pomo in our ongoing restorative watershed efforts. This calls on each of us to be better stewards of the land while strengthening relationships with Indigenous peoples to elevate Native visibility in our community.

The partnership of the Federated Indians of the Graton Rancheria is critical to the success of our collective work in the Petaluma River Watershed and expedites the return and integration of Indigenous land stewardship practices to the local ecosystems and resources we all depend upon.

## CREDITS

Formerly known as the Draft Petaluma Watershed Enhancement Plan, the 2022 update yields the current Petaluma River Watershed Conservation and Enhancement Plan (Plan). The first version of the Enhancement Plan, completed in 1998, included valuable input from a Landowner Advisory Committee and concerned residents of the Petaluma River Watershed. The USDA Natural Resources Conservation Service (NRCS) and the Sonoma Resource Conservation District (RCD) provided project support and technical assistance throughout the planning process. Prunuske Chatham, Inc. was instrumental in providing consultation services, scientific studies, and meeting facilitation which effectively identified community concerns during the project.

The 2015 revision to the Plan was completed by Sonoma RCD and included an update of technical information and the reformatting of the original plan to the Environmental Protection Agency's (EPA) format for the 9 Elements of a Watershed Plan.

The updated 2022 Plan has been accomplished by Sonoma RCD in collaboration with the Petaluma Watershed Collaborative, a group of local stakeholders building institutional capacity to carry out sustainable watershed management and restoration within the Petaluma Watershed. Reza Environmental provided editorial and technical support during the development process. The Tribal Heritage Preservation Office (THPO) of the Federated Indians of Graton Rancheria provided review and editorial support of cultural resource information. Most notable, this update incorporates data and information from recent regional and watershed-specific efforts including the March 2018 *Petaluma Valley Historical Hydrology and Ecology Study* prepared by San Francisco Estuary Institute and Sonoma RCD.

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## LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ADU | Accessory dwelling unit |
| BMP | Best management practice |
| BOR | Bureau of Reclamation |
| CAL FIRE | California Department of Forestry and Fire Protection |
| CASGEM | California Statewide Groundwater Elevation Monitoring |
| CCC | Central California Coast |
| CDFW | California Department of Fish and Wildlife |
| CNDDB | California Natural Diversity Database |
| CNPS | California Natural Plant Society |
| CERCLA | Comprehensive Env. Response, Compensation, and Liability Act |
| CPC | Climate Protection Campaign |
| CWA | Clean Water Act |
| DO | Dissolved oxygen |
| DWR | California Department of Water Resources |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| GHG | Greenhouse gas |
| GSA | Groundwater Sustainability Agency |
| IPCC | Intergovernmental Panel on Climate Change |
| LOP | Sonoma County Local Oversight Program |
| MALT | Marin Agricultural Land Trust |
| MS4 | Municipal Separate Stormwater Sewer System |
| MWELO | Model Water Efficient Landscape Ordinance |
| NMFS | National Marine Fisheries Service |
| NOAA | National Ocean and Atmospheric Administration |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resource Conservation Service |
| PCI | Prunuske Chatham, Inc. |
| Point Blue | Point Blue Conservation Science |
| PWA | Petaluma Watershed Alliance |
| RCPA | Regional Climate Protection Authority |
| RCRA | Resource Conservation and Recovery Act |
| RETU | Redwood Empire Trout Unlimited |
| RMP | Regional Monitoring Program, San Francisco Estuary Institute |
| SFB RWQCB | San Francisco Bay Regional Water Quality Control Board |
| SFEI | San Francisco Estuary Institute |
| SGMA | Sustainable Groundwater Management Act |

| | |
|---|---|
| SLT | Sonoma Land Trust |
| Sonoma Ag + Open Space | Sonoma Agricultural Preservation and Open Space District |
| Sonoma Water | formerly Sonoma County Water Agency |
| SRCD | Sonoma Resource Conservation District |
| SSC | Species of Special Concern |
| SWAMP | Surface Water Ambient Monitoring Program |
| SWPPP | Stormwater Pollution Prevention Plan |
| TMDL | Total Maximum Daily Load |
| UCCE | University of California Cooperative Extension |
| UGB | Urban growth boundary |
| USACE | United States United States Army Corps of Engineers |
| USFWS | United States Fish and Wildlife Service |
| USTPO | Underground Storage Tanks Program Office |
| UWMP | Urban Water Management Plan |
| WUI | Wildland-urban interface |

# Section One: Introduction and Background

**This section covers Chapters 1-3 encompassing the Petaluma River Watershed description and history, cultural resources, geology and soils, climate and precipitation, water re-sources, and a watershed land use overview.**

Map credit Petaluma Historical Hydrology and Ecology Study cover desinged by SFEI

# CHAPTER 1. INTRODUCTION

Watershed plans are intended to be living documents that continue to change and improve over time. The first Petaluma Watershed Enhancement Plan was developed in 1998 to determine how to manage the watershed more effectively. This Plan was updated in 2013 and 2015, replacing each previous Plan with current information in the watershed and new recommendations for watershed management strategies. This 2022 Plan focuses on including new technical information from recent studies (including the 2018 *Historical Hydrology and Ecology Study*), social and resource related recommendations for improved water quality and quantity, current climate change information, saltwater intrusion concerns, and land development. The objective of the 2022 Plan update is to reflect the latest conditions, goals, and regulatory requirements associated with the watershed, to review natural resource issues concerning residents, and to recommend a course of action to maintain and improve those resources.

In conducting this update of the Plan, a group of Petaluma Watershed stakeholders (Petaluma Watershed Collaborative) cooperatively reviewed existing information, identified data gaps, and recommended additional data collection activities. Outreach efforts to solicit community-wide feedback were conducted to incorporate goals and objectives from citizens and interested community members. The feedback generated through the cooperation of the Petaluma Collaborative and community was integrated into this update as a consensus for Petaluma Watershed needs. Through complementary efforts to this 2022 update, an Action Plan for the watershed has been developed to prioritize the most critical projects for watershed sustainability and guide the investment of collective resources to address the watershed needs identified in this Enhancement Plan.

## PURPOSE OF THE PETALUMA RIVER WATERSHED RESTORATION AND ENHANCEMENT PLAN

The overall purpose of the Watershed Enhancement Plan is to identify ways in which to protect, conserve, and enhance the watershed. The watershed plan goals listed below are an expansion of the original 1998 plan goals.

### Goals

a. Maintain long-term, local control of watershed planning and enhancement to establish integrated watershed management.

b. Conserve and improve the natural resources of the watershed including the protection of water quality and quantity.

c. Maintain streams to maximize beneficial uses.

d. Encourage responsible stewardship of urban, rural, agricultural, and park lands.

e. Educate the community about the natural features of the watershed including its people, ecology, and economy and actions they can take to enhance and maintain watershed function.

f. Support diverse agriculture that responsibly manages the landscape and contributes to the watershed's economic vitality.

## Sovereign Nations

**Federated Indians of Graton Rancheria**

The Federated Indians of Graton Rancheria is a federally recognized tribe by the U.S. Congress. The Coast Miwok and Southern Pomo communities are the original stewards of the present-day Petaluma River Watershed. The ancestral territory spans areas known today as Marin and Sonoma counties. The Tribe remains culturally affiliated with ancestral lands and continues its stewardship role with a commitment to applying Traditional Ecological Knowledge and traditional practices such as burning and material gathering. Graton Rancheria is a sovereign nation in the region and provides support for the protection and sustainable management of lands throughout and beyond the Petaluma Watershed boundary.

## Stakeholder Groups

Local stakeholder engagement and community outreach is an important part of the development and implementation of any watershed management plan. Sonoma RCD is an advocate of coordinated watershed management by agencies, local organizations, watershed groups, landowners, and community members to meet common watershed goals. Continued collaboration amongst stakeholders and local entities is expected to maintain the forward progress of actions resulting from and provide updates to this living planning document. Below are many of the stakeholder groups actively working on conservation concerns in the Petaluma River Watershed.

**Sonoma Resource Conservation District (SRCD)**

The Sonoma RCD works with landowners in the watershed to provide technical, educational, and financial assistance to protect natural resources and improve the viability of agricultural and rural lands. In existence since 1946, the RCD serves multiple watersheds covering 85 percent of Sonoma County. A Board of Directors composed of local landowners oversees the management of the District. The RCD works with landowners on water quantity and quality, soil health, fish and wildlife habitat, climate protection, adaptation, and resilience, forest health and fire preparedness. The RCD is active in community education, outreach, and collaboration, and is currently leading and coordinating efforts amongst the Petaluma Watershed Collaborative. The RCD is an important bridge between landowners and government agencies; it helps landowners achieve regulatory compliance and carries out state and federal conservation initiatives by assisting local landowners with the development, funding, and implementation of on-the-ground projects.

**California Department of Fish and Wildlife (CDFW)**

Historically, the CDFW (formerly known as the CA Department of Fish and Game) conducted stream surveys in parts of the watershed in 1957. The CDFW is actively engaged in determining restoration measures for native salmonid species within Sonoma County watersheds and throughout the state, developing the Coastal Watershed Planning and Assessment Program (CWPAP) that focuses on fishery-based watershed assessments throughout the California Coast. Other fishery-focused planning efforts undertaken by CDFW include the Coho Recovery Plan and the Steelhead Recovery Plan, which identifies watersheds that provide suitable habitat and aids in the selection of basins for further study. CDFW provides funding for local entities and stakeholders to implement vital salmonid habitat recovery and habitat enhancement projects.

**California Department of Forestry and Fire Protection (CAL FIRE)**

CAL FIRE is dedicated to the fire protection and stewardship of over 31 million acres of California's privately-owned wildlands. In addition, CAL FIRE provides emergency services in 36 of the State's 58 counties via contracts with local governments. CAL FIRE's mission emphasizes the management and protection of California's natural resources, a goal that is accomplished through ongoing assessment and study of the State's natural resources and an extensive Resource Management Program. CAL FIRE oversees enforcement of California's forest practice regulations, which guide timber harvesting on private lands.

**California Department of Parks and Recreation (State Parks)**

The State Parks mission is to provide for the health, inspiration, and education of the people of California by helping to preserve the state's extraordinary biological diversity, protecting its most valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. There are 280 park units throughout the state, including state natural reserves, state beaches, state desert parks, and other designations.

Petaluma Adobe State Historic Park is located in the Petaluma watershed along Adobe Creek, both north and south of Adobe Road. The park unit contains the ruins of General Vallejo's adobe mansion, as well as undeveloped land along the creek, and the State Parks Bay Area District Office. The Bay Area District is comprised of 16 park units in inland Sonoma County, as well as Marin, Napa, and San Francisco Counties.

**City of Petaluma**

The City of Petaluma's Public Works & Utilities Department provides a comprehensive and integrated approach to water conservation and water resources planning within the watershed. The City has representation on the Petaluma Valley Groundwater Sustainability (GSA) Board of Directors and appoints one community member to serve on the Petaluma Valley GSA Advisory Committee which serves to provide input and recommendations to the Board of Directors on the groundwater sustainability plan, implementation and policies. The GSA Board on the City's interest in groundwater planning and actions. For a more comprehensive description of the Petaluma Valley GSA and the groundwater sustainability plan, please see below. Please see Ellis Creek Water Recycling Facility below

for information on the City's water treatment facility. The City of Petaluma is recognized as a climate adaptation pioneer (Chapter 6. Climate Change Impacts and Adaptation).

**Ellis Creek Water Recycling Facility**

Petaluma's Ellis Creek Water Recycling Facility (Ellis Creek) collects, treats, and reuses wastewater from the City's sewer system. An average of 4.6 million gallons of wastewater from the community is treated each day by leading-edge technology and natural processes. High-quality recycled water is used on-site at Ellis Creek for landscape irrigation, fire protection, plant-process-water, and toilet flushing. Recycled water is used within the City for landscape irrigation at parks, schools, public landscape areas, and other landscape irrigation. Recycled water is also used outside City limits for agricultural and vineyard irrigation. Methane gas produced in the treatment plant is captured and utilized to fuel local solid waste trucking in place of fossil fuel energy. Treated wastewater that is not immediately used for irrigation flows through a series of oxidation ponds and constructed wetlands for additional biological treatment. In additional wastewater treatment, Ellis Creek provides wildlife habitat and public access walking trails around the treatment wetlands that connect to Shollenberger Park.

**Friends of the Petaluma River**

The Friends of the Petaluma River is a non-profit organization dedicated to both celebrating and conserving the Petaluma River Watershed system. Through education, providing river access, and conservation initiatives, the group is committed to long-term sustainable stewardship to protect the River.

**Madrone Audubon Society, Sonoma County**

Madrone Audubon Society is a nonprofit conservation organization as well as the Sonoma County Chapter of the National Audubon Society. The mission of Madrone Audubon includes support for appreciation and protection of birds and their habitats. With a long history of support for citizen science and conservation in Petaluma, Madrone Audubon also engages in local and regional issues to protect habitat, species and the environment.

**Marin Agriculture Land Trust (MALT)**

Founded in 1980, MALT advances farmland protection and supports sustainable agriculture practices throughout West Marin. With the protection of farmland, MALT strengthens the agricultural community, supports a robust local food system, restores, and protects ecological health of the protected lands, and promotes climate-resilient landscapes.

**National Marine Fisheries Service (NMFS)**

National Oceanic and Atmospheric Administration's NMFS is responsible for implementing the Endangered Species Act and managing the recovery and conservation of federally threatened and endangered marine species in the United States. The Petaluma Watershed is considered habitat for Central California Coast (CCC) steelhead and Chinook salmon. NMFS listed CCC steelhead as threatened on August 18, 1997 and designated the Petaluma River and its tributaries as critical habitat

on September 2, 2005. The Petaluma Watershed is classified as Essential Fish Habitat in the Pacific Coast Salmon Fisheries Management Plan (PFMC 2014) under the Magnuson-Stevens Fishery Conservation and Management Act. Leading recovery efforts throughout California, NMFS works diligently with local stakeholders to restore salmonid populations to sustainable levels.

**Natural Resources Conservation Service (NRCS)**

NRCS is the federal agency that helps landowners implement conservation projects on agricultural lands through the Conservation title of the Farm Bill. Resource Conservation Districts work with NRCS to help leverage funding and implement projects throughout the county, state, and country. Through programs such as the Environmental Quality Incentives program (EQIP), NRCS works to promote agricultural production, forest management, and environmental quality as compatible goals. With funding and technical assistance through EQIP, farmers and ranchers can optimize agricultural production while meeting federal, state, and local environmental regulations.

**Paula Lane Action Network (PLAN)**

PLAN is a nonprofit conservation organization based in Petaluma, incorporated in 2004. PLAN supports open space preservation, protection of habitat and wildlife corridors, and American Badger conservation and education. PLAN formulated the High Use-Low Impact (HULI) project design for open space land where sensitive habitat and wildlife exist and public access is desired, to balance and prioritize the environment and encourage appreciation of nature with minimal to no impacts. PLAN consults throughout California on American Badger protection and conservation.

**Petaluma River Flood Control Zone 2A Advisory Committee**

The Zone 2A Advisory Committee represents agricultural, residential, municipal, and commercial interests, providing leadership regarding flood control in this Petaluma flood control zone. The committee is comprised of seven members, six appointed by the Second District; meetings are intermittently held to discuss needs within the Zone 2A boundary.

**Petaluma River Park Foundation**

The Petaluma River Park Foundation (PRPF) is a nonprofit organization founded in 2019 by Petaluma residents to create a new 24-acre riverfront park on the McNear Peninsula, located in the heart of the City of Petaluma, California. The mission of the Petaluma River Park Foundation is to meet our vital need for shared space that connects people, art, and nature. PRPF envisions that the Petaluma River Park will be a vibrant, welcoming park that fosters a love of nature, sparks creativity, and unifies the community for generations to come.

**Petaluma Valley Groundwater Sustainability Agency (GSA)**

The Petaluma Valley Groundwater Sustainability Agency (GSA) is a public agency formed to sustainably manage groundwater in the Petaluma Valley groundwater basin. The agency was formed in June 2017 in compliance with California's Sustainable Groundwater Management Act (SGMA). The Petaluma Valley groundwater basin was identified as a medium-priority basin according to Department of Water

Resources criteria. A Board of Directors, Administrator, Plan Manager, and Advisory Committee make up the GSA with the charge of developing and implementing a 20-year Groundwater Sustainability Plan (GSP) to ensure sustainability of groundwater in the basin. The six main sustainability indicators tracked by the GSP are lowering groundwater levels, seawater intrusion, storage capacity, land subsidence, groundwater quality, and surface water depletion.

**Petaluma Wetlands Alliance (PWA)**

PWA, a local all-volunteer nonprofit organization, is committed to education about and stewardship of Petaluma public wetlands. PWA teaches local 3rd grade students in the classroom and in the field through traditional and experiential learning, reaching over 700 students per year with no fees or charges. Other services include public nature walks, research in bird biology, and assisting the city with maintaining trails, benches, kiosks, and vegetation. Efforts are focused in Shollenberger Park, Alman Marsh, and the Ellis Creek Water Recycling Facility.

**Point Blue Conservation Science (Point Blue)**

Working across the globe, Point Blue (formerly Point Reyes Bird Observatory) works closely with partners to reduce the impacts of climate change, habitat loss, and other environmental threats while developing nature-based solutions to benefit both wildlife and people. Point Blue works towards Climate-Smart Conservation through restoration, education, and data collection for knowledge-based conservation action.

**San Francisco Bay Regional Water Quality Control Board**

The San Francisco Bay Regional Water Quality Control Board is one of California's nine regional water boards, responsible for developing and enforcing water quality objectives and implementation plans that will best protect the beneficial uses of the State's waters, recognizing local differences in climate, topography, geology and hydrology.

**Sonoma County Agricultural Preservation and Open Space District (Sonoma Ag + Open Space)**

Sonoma Ag + Open Space permanently protects the diverse agricultural, natural resources, and open space properties of Sonoma County. They are one of the first districts in the country to strive for the preservation of valued agricultural lands. Since their establishment the district has preserved over 122,000 acres of open space and agricultural lands throughout the county and continues to educate the public and manage lands for future generations.

**Sonoma Water**

Sonoma Water (formerly Sonoma County Water Agency) oversees and manages water resources throughout the county and plays a significant role in caring for the people and the environment through resource and environmental stewardship and technical innovation. The services provided by the agency are wide-ranging and include providing water to nine cities and special districts through a water transmission system that distributes water to more than 600,000 individuals. Sonoma Water is also responsible for managing the county sanitation zones and districts, providing flood protection services

and steam maintenance, partnering with local water suppliers to support water conservation efforts, providing environmental services related to environmental laws and regulations, and supporting community outreach and education through their Water and Energy Education Program.

**Sonoma County Farm Bureau**
The Farm Bureau is comprised of farm and ranch families. It is an independent, non-governmental, not-for-profit organization dedicated to protecting water resources, actively participating in legislation, electing government officials with agricultural interests, protecting land, environmental conservation, promoting healthy and safe farms, supporting safe labor programs, food safety initiatives, and promoting agricultural interests in local communities and government.

**Sonoma Land Trust (SLT)**
SLT is a local, non-governmental, non-profit organization that works closely with private landowners, Sonoma Ag + Open Space, and an array of public agencies and government. They conserve scenic, natural, agricultural, and open space land through development of long-term land protection strategies, active stewardship, and conservation easements while also providing educational opportunities. SLT has protected more than 58,000 acres of land in Sonoma County since its establishment in 1976.

**Redwood Empire Trout Unlimited (RETU)**
RETU's mission is to conserve, protect, and restore the Redwood Empire's (Coastal Northern California) coldwater fisheries and their watersheds. Volunteers, members, and leaders organize and participate in conservation, policy, education, and outreach efforts throughout Northern California with the goal of conservation of coldwater stream ecosystems and fisheries.

**United Anglers of Casa Grande High School (United Anglers)**
The United Anglers of Casa Grande High School is a non-profit organization established in 1983 on the Casa Grande High School campus in Petaluma. The United Anglers' mission is to promote environmental awareness and activism through education and hands-on experience. They seek to revive salmon species from extinction through habitat restoration and the operation and maintenance of a state-of-the-art fish hatchery. The program allows students to actively engage with their environment while restoring suitable instream habitat for threatened and endangered salmonids.

**University of California Cooperative Extension (UCCE)**
UCCE holds 64 cooperative offices throughout California that function as local problem-solving centers. UCCE connects local issues with the latest UC research, collaborating with federal, state and local entities. They advocate for healthy landscapes and communities, help farmers become more efficient, provide education about stewardship, promote water-wise solutions and irrigation efficiencies, support 4H Youth Development, and help preserve natural areas.

**US United States Army Corps of Engineers (USACE)**
USACE is a federal entity that acts as the nation's environmental engineer to manage constructing sustainable facilities, regulating waterways, managing natural resources, restoring degraded ecosystems, and cleaning up contaminated sites from past military activities. USACE works in partnership with local and regional stakeholders to develop solutions to challenges affecting all including climate change, ecosystem restoration, sustainability, and more.

## Petaluma River Watershed Collaborative

Funded by the Bureau of Reclamation's WaterSMART program, Sonoma RCD has led efforts to build the institutional capacity among local stakeholder groups to carry out sustainable watershed management and restoration in the Petaluma River Watershed by creating and sustaining the Petaluma River Watershed Collaborative. The Collaborative has held stakeholder meetings to revise this Plan and created an *Action Plan* to identify and advance restoration projects and priorities. Local landowners, residents, business owners, interested individuals, and natural resource-focused nonprofits, agencies, and organizations have all been invited and encouraged to participate in the process of determining goals, plan development, and prioritization of projects and needs of the watershed and surrounding community. The following entities have been active in all or parts of this collective process:

California Department of Fish and Wildlife
California State Parks
California State Senate, Third District
City of Petaluma
County of Sonoma, Second District
Daily Acts
Dry Creek Rancheria Band of Pomo Indians
Environmental Science Associates
Environmental Protection Agency
Federated Indians of Graton Rancheria
Friends of Petaluma River
Madrone Audubon Society, Sonoma County
Marin Agriculture Land Trust
National Marine Fisheries Service
Natural Resource Conservation Service
Paula Lane Action Network
Petaluma River Council
Petaluma Wetlands Alliance
Point Blue Conservation Science
Redwood Empire Trout Unlimited
San Francisco Estuary Institute
Sonoma County Farm Bureau
Sonoma Land Trust
Sonoma County Regional Parks
Sonoma Resource Conservation District
Sonoma Water
United Anglers of Casa Grande, Inc.

## ORGANIZATION OF THE PLAN

The organization of this plan is based upon the US Environmental Protection Agency's Steps to Effective Watershed Management, as described in "A Quick Guide to Developing Watershed Plans to Restore and Protect our Waters" (2013). This Plan follows the framework of the EPA's six steps of watershed planning.

Step 1: Build partnerships

Step 2: Characterize your watershed

Step 3: Finalize goals and identify solutions

Step 4: Design an implementation program

Step 5: Implement watershed plan

Step 6: Measure progress and make adjustments

# CHAPTER 2. WATERSHED DESCRIPTION AND HISTORY

The Petaluma Watershed maintains a complex and evolving relationship between human uses and biodiversity; this chapter details those interactions.

## OVERVIEW

Located in southern Sonoma County and northeastern Marin County, California, the Petaluma River Watershed encompasses a 146 square mile, pear-shaped basin. The watershed is approximately 19 miles long and 13 miles wide with the City of Petaluma near its center. U.S. Highway 101 bisects the watershed valley. Mountainous or hilly upland areas comprise 56% of the watershed, 33% percent of the watershed is valley, and the lower 11% is salt marsh. Sonoma Mountain at 2,295 feet is the highest point in the watershed.

The Petaluma Watershed has been a vital system for Tribal communities, agriculture, commerce, and social cohesion. Providing transportation of goods and services to growing communities, the Petaluma River, including its headwaters and smaller tributaries, gave life to the developing North Bay area. The Petaluma River has historically been referred to as both Petaluma Slough and Petaluma Creek (Petaluma Valley Historical Hydrology and Ecology Study, 2018). By the mid-19$^{th}$ century, as the City of Petaluma increasingly depended on the waterway for commercial shipping, routine dredging and other channel modifications became necessary to ensure navigability. In 1959, the Petaluma River was officially declared as such by an Act of Congress, qualifying it to receive federal funding for continued maintenance.

The watershed encompasses a biologically diverse ecosystem with unique features supporting rich habitats for species of special concern and endemic plant populations. With increasing European and American colonization, the area has grown to encompass an array of land uses including vineyards, croplands, ranches, state and regional parks, and urban development. Through this process, riparian corridors have become fragmented and channeled, and polluted by silt from erosion of streambanks and pollutants from urban and rural regions. Habitats have also become fragmented, making wildlife movement challenging. Activities within the watershed have a direct impact on the San Pablo Bay where the lower reaches of the river undergo a constant tidal exchange with bay water.

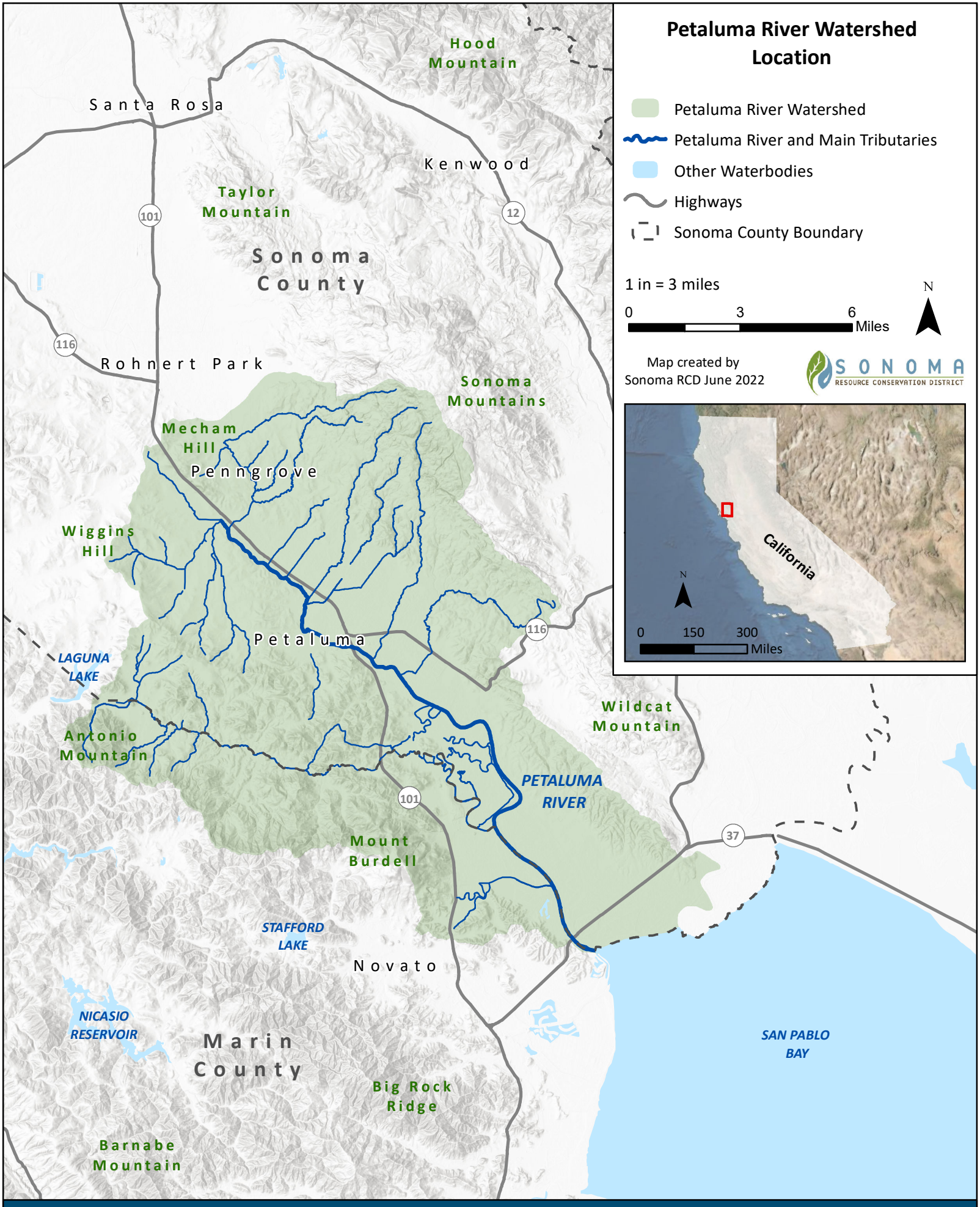


**Fig 2.1. Location of the Petaluma River Watershed.**

Data: California Interagency Watershed Map (CALWATER 2.2.1)

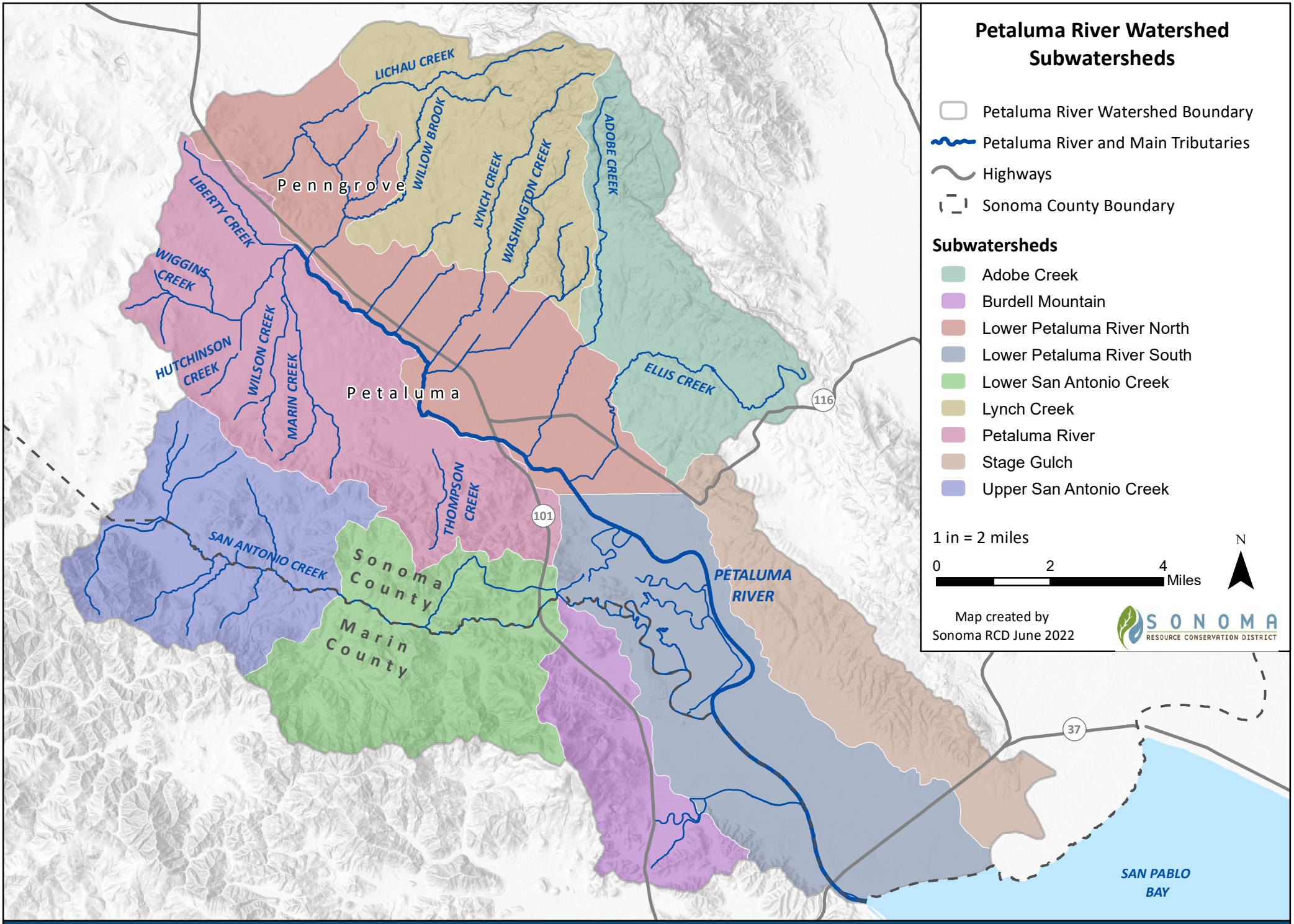


**Fig 2.2. Subwatersheds in the Petaluma River Watershed.**

Data: California Interagency Watershed Map (CALWATER 2.2.1)

## HISTORY AND CULTURAL RESOURCES

The history and cultural resources of the Petaluma River Watershed illustrate an evolution of land use, economic development, and resource exploitation. Cultural resources are defined as tangible remains of past human activity that include Prehistoric or ethno-historic Native American sites, historic buildings, archaeological sites, objects or collection, earthworks, as well as areas of the natural world which hold cultural value. These resources are important in understanding the present landscape.

Tribal Cultural Resources have been lost due to settlement, development, and land management focused on singular approaches rather than thoughtful, holistic strategies. Loss of access to traditionally used gathering and sacred sites are just a few of the many impacts that local Tribes have endured. Tribes have invested in monitoring and restoration efforts and have a significant amount of experience and traditional knowledge that can contribute to co-management of resources (OEHHA 2021).

As described in the April 2023, *Petaluma River Baylands Strategy* co-authored by Sonoma Land Trust, San Francisco Estuary Institute, Point Blue, and Sonoma RCD:

*Encroachment of European settlement culminated in a series of acts and bills removing land and political status from tribal governments. As a result, native Californians were left landless and legally powerless, often making their way as itinerant farm workers or commercial fishermen. Legal land entitlement remained out of reach until 1920, when the Bureau of Indian Affairs purchased a 15.45-acre tract of land in Graton to create a "village home" for dispersed people of Marshall, Bodega, Tomales, and Sebastopol (Federated Indians of Graton Rancheria 2023). This home consolidated neighboring, traditionally interactive groups into a single entity—Graton Rancheria—thus establishing them, temporarily, as a Federally Recognized Tribe of American Indians.*

*In 1958, Congress passed the California Rancheria Act, terminating all 41 Rancherias, extinguishing the recognition of their residents as American Indians, and removing the land from Federal Trust. As with many other California Tribes, federal recognition for the Coast Miwok was not restored until decades later, after tribal members raised money to travel to Washington to campaign for restoration of federal status and rights. For the Graton Rancheria, campaigning began in 1990, with recognition restored in 1997, and a tribal constitution ratified by the Bureau of Indian affairs in 2002, allowing the tribe to re-establish a land base, provide funding for cultural preservation, and establish tribally owned businesses capable of achieving self-sufficiency (Graton Rancheria 2019).*

*Today, the Graton Rancheria community encompasses "a federation of Coast Miwok and Southern Pomo groups recognized as a tribe by the United States Congress. The Miwok of west Marin County have, through the years, been referred to as Marshall Indians, Marin Miwok, Tomales, Tomales Bay, and Hookooeko. The Tribe opened the Graton Resort and Casino in 2013, which now funds various programs and services for its tribal membership, including environmental and cultural preservation, elder care, childcare, housing, legal support, emergency financial support, education, and employment.*

*Graton Rancheria has developed a Tribal Heritage Preservation Office program with a designated Tribal Heritage Preservation Officer and Sacred Site Protection Committee responsible for protecting the Tribe's tribal cultural resources.*

## GEOLOGY AND SOILS

The Petaluma River Basin lies within the southern portion of the northern Coast Ranges of California. The basement rock is the Jurassic – Cretaceous Franciscan assemblage, overlain by thick, discontinuous sequences of Tertiary and Quaternary deposits. Prior to the general rise in sea level that occurred in recent geological time, Petaluma Valley was filled with older alluvium consisting of gravels, sands, and clays that were deposited by aggradations along the stream course traversing the area and by sheet wash and other colluvial processes in interstream areas. Well logs indicate these deposits are thin in the upper Petaluma Valley but thicken to over 300 feet in the southern parts of the watershed near the San Pablo Bay. The rise in sea level and the subsequent encroachment of the waters of San Pablo Bay resulted in the filling of the lower portion of the valley as far as the City of Petaluma with bay mud, comprised of younger alluvium and soft marine silts and clays.

Five faults or fault systems have been identified in the Petaluma groundwater sub-basin. The Rodgers Creek fault zone, which has been linked by some to the active Hayward fault, runs along the easterly ridge of the watershed. The Tolay fault extends along the valley east of the City of Petaluma, while the Bloomfield fault is located on the westerly side. A trace of the Meacham Hill fault has been documented crossing the southwestern side of Meacham Hill. Folding and faulting which occurred in the basin during the late Pliocene and Quaternary periods produced the main structural and topographic features of the area. These processes have continued into recent times. Information on the geological units in the Petaluma Valley and their characteristics is contained in the State Department of Water Resources' Evaluation of Groundwater Resources in Petaluma Valley (Volume 3, Bulletin 118-4) published in June 1982 (DWR 1982).

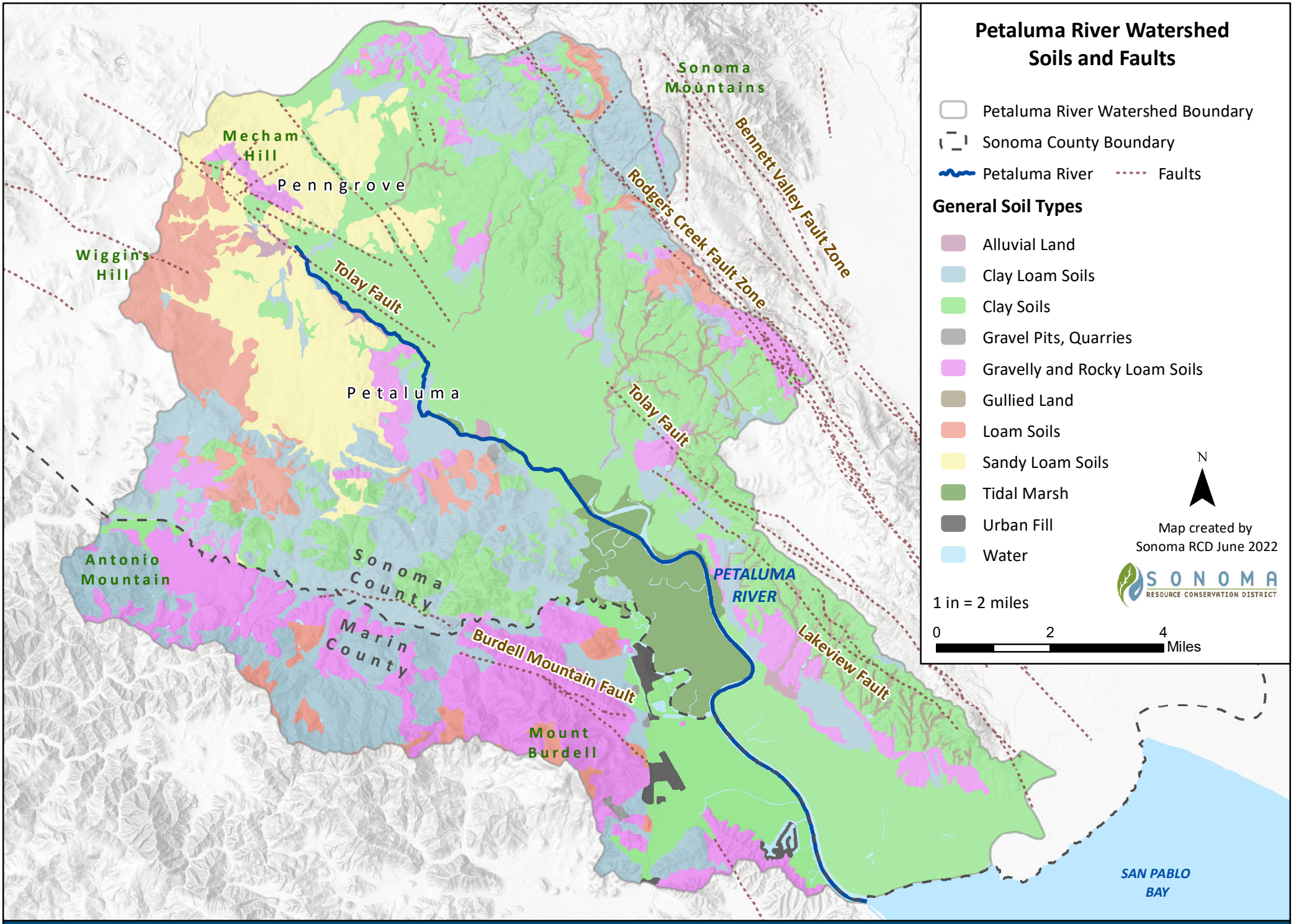


**Fig 2.3. Soils and quaternary faults in the Petaluma River Watershed.**

Data: NRCS Soil Survey Geographic (SSURGO) Database,
USGS Quaternary Fault and Fold Database for the United States

## CLIMATE AND PRECIPITATION

The Mediterranean climate of the Petaluma River basin is generally characterized as a marine west-coast type with cool, wet winters and warm, dry summers with some fog and wind. Localized climatic conditions are strongly affected by the topography, and it is not unusual to have wide variations in climate at locations separated by only a few miles. Historical annual temperature means in the watershed range from roughly 70.6° F maximum and 44.7° F minimum resulting in an average annual temperature of 58.5° F. Extreme recorded temperatures are 17° F and 109° F. Average annual rainfall over the basin ranges from about 20 inches at the mouth of the Petaluma River to about 50 inches at the highest elevations in the drainage basin. While the values mentioned above represent historical averages, temperatures will likely increase, and rainfall events will become more variable and intense according to climate models (Cornwall et al. 2014). Petaluma is currently in a three-year drought as is most of California with the lowest Jan-Feb rainfall in over 100 years. Long-term climate projections include longer more frequent periods of drought, increased temperatures, and short-duration precipitation events with a shift to more intense individual storms with fewer weak storms (see Chapter 4, Climate Change) (Collins et al. 2013).

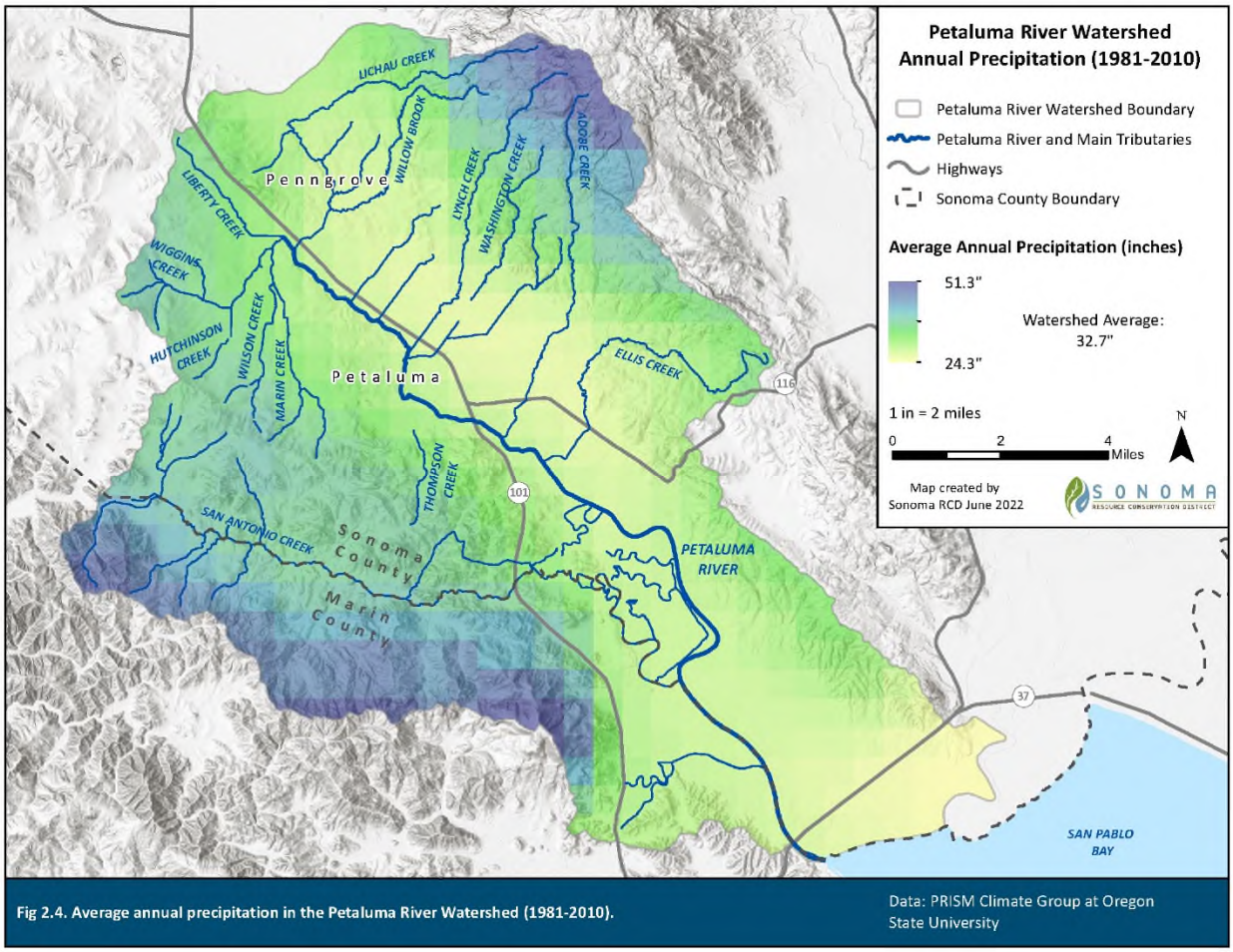


Fig 2.4. Average annual precipitation in the Petaluma River Watershed (1981-2010).

Data: PRISM Climate Group at Oregon State University

## HYDROLOGY

The headwaters and ephemeral tributaries of the Petaluma River begin on the steep southwest slopes of Sonoma Mountain, the southern slopes of Mecham Hill, and the eastern slopes of Wiggins Hill and Mt. Burdell. The confluence of Willow Brook, Liberty Creek, and Wiggins Creek form the headwaters of the Petaluma Watershed just upstream of Rainsville Road and Stony Point Road. The Petaluma River itself flows across the Denman Flat area and through the City of Petaluma. Tidal influence extends upstream of the confluence with Lynch Creek (beyond the railroad crossing). See Map 2.2, depicting the Petaluma River Watershed.

The lower twelve miles of the Petaluma River flow through the Petaluma Marsh, the largest remaining salt marsh in San Pablo Bay. The marsh covers 4,191 acres and is surrounded by approximately 7,000 acres of “reclaimed” wetlands, land which was drained for agricultural use. Prior to reclamation, marshland elevations ranged from mean sea level to 3 feet above mean sea level.

Major tributaries in the eastern portion of the watershed include Lichau Creek, which flows into Willow Brook and feeds into the Denman Flat area near Stony Point Road and Rainsville Road, Lynch Creek, Adobe Creek, and Ellis Creek. Tributaries flow through unincorporated land and land within the City of Petaluma limits before joining the Petaluma River.

Three major creeks are located on the western side of the watershed. Wiggins Creek and Marin Creek flow into Liberty Creek, which also feeds into Denman Flat. The largest sub-watershed is San Antonio Creek, which is located in the western portion of the watershed south of Petaluma. San Antonio Creek flows from near Laguna Lake in Chileno Valley to the Petaluma Marsh and divides Marin and Sonoma Counties. In the lower watershed, small tributaries drain into the river and marsh areas.

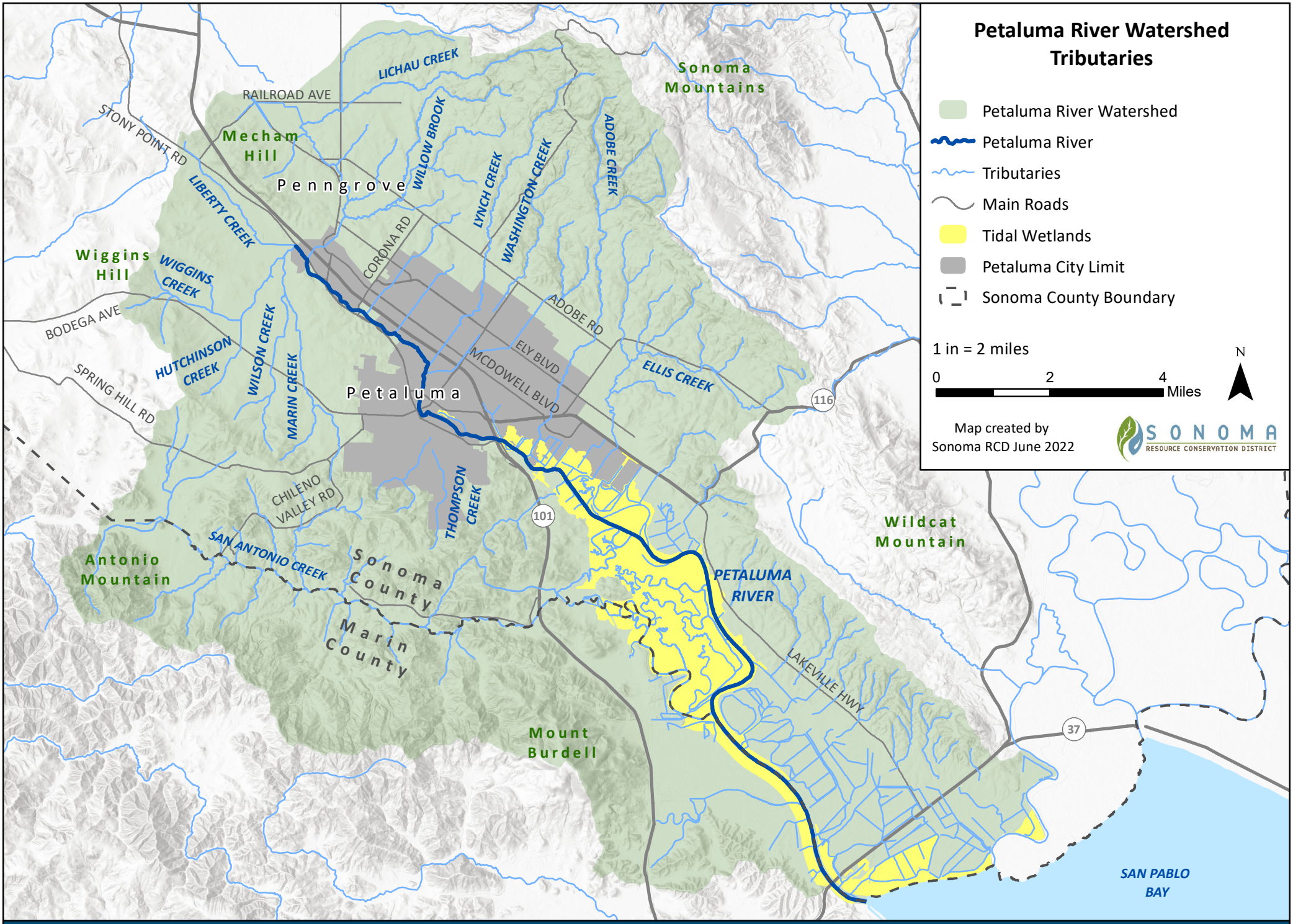


**Fig 2.5. Tributaries in the Petaluma River Watershed.**

Data: City of Petaluma GIS Division, Sonoma County Vegetation Mapping and LiDAR Program

## WATER RESOURCES

Water resources are categorized as surface and groundwater in this document. These resources constitute the foundation of ecological processes, community life, and agriculture. Described below are physical features creating tributaries and aquifers, uses including natural and human based interactions, and impacts on these resources within the watershed.

### Surface Water

Surface water is defined as all the water that is naturally open to the atmosphere such as lakes, rivers, and reservoirs. The surface water resources of the Petaluma Watershed are defined by the topography and drainage systems throughout the landscape. Situated in Sonoma and Marin Counties, just northwest of the San Pablo Bay, the Petaluma River and its tributaries drain an area of 146 square miles. According to the Petaluma General Plan 2025 these systems include: the Petaluma River, open creek channels, conduits, culverts, bridge openings, detention ponds, and control structures such as weirs. These elements are vital to direct stormwater runoff into the Petaluma River and out to the San Pablo Bay.

The headwaters and ephemeral tributaries of the Petaluma Watershed begin on the slopes of Sonoma Mountain and southern slopes of Meacham Hill, and the eastern slopes of Wiggins Hill and Mt. Burdell. The confluence of Liberty, Willow Brook, and Wiggins Creeks form the headwaters of the Petaluma River as they flow in a southeasterly direction. The river itself flows across the Denman Flat area and through the City of Petaluma; the lower 12 miles of the river flows directly into the Petaluma Marsh. To date the Petaluma Marsh is the largest remaining marsh in the San Pablo Bay encompassing 5,000 acres.

Major portions of the Petaluma River Watershed lie outside of Petaluma's urban boundary and marshes are used for livestock grazing, urban residences, and viticulture. The Petaluma River system supports a variety of marine, estuarine, and freshwater fish species. Salmonids in particular use the Petaluma River and its tributaries as habitat for spawning, rearing, and migration. These systems are significant in providing habitat for fisheries, wildlife, and riparian plant communities.

### Groundwater

The 46,000-acre Petaluma Valley Groundwater Basin is located within the larger 93,440-acre Petaluma Valley watershed (Petaluma Valley GSA 2021). The main geologic units which form the primary aquifers in the Petaluma Valley are sedimentary deposits of the recent Alluvium, the Wilson Grove Formation, and the Petaluma Formation. Five faults or fault systems are documented within Petaluma Valley which may have an influence on groundwater movement and water quality. Aquifers are generally discontinuous vertically and horizontally, creating partitions of variable water quality and aquifer properties. In general, groundwater flows from recharge areas in the mountains surrounding the Petaluma Valley toward the valley axis and in a generally southern direction towards San Pablo Bay.

Groundwater resources are vital in serving the water supply needs of Petaluma area citizens, commerce, industry, and agriculture. Groundwater is defined as water that infiltrates and collects underground where it is held in either an upper saturated zone or a lower saturated zone (Petaluma Valley

Groundwater Sustainability Agency 2021). Amply filled aquifers and good groundwater quality are vital to the health of the watershed. Groundwater is a limited and valuable resource; although it is technically a renewable resource, on the timescale of decades it must be treated as finite. There are many stakeholders involved in the use and management of groundwater including: local agriculture including dairies, government, local water purveyors, business, and environmental interests.

Groundwater resources have long played a significant role in the development, growth, and sustainability of the Petaluma Valley (Petaluma Valley Groundwater Conditions 2021). These groundwater resources are relied upon to varying degrees by rural and urban residents, agricultural users, golf courses and other businesses and support the rich ecosystems present in Petaluma Valley. Assuring sustainable groundwater supplies in the Petaluma Valley is critical to the environmental health and economic vitality of the basin.

Groundwater levels near the city of Petaluma dropped from the mid-1950s until the early 1960s, allowing greater intrusion of salt water into the aquifers along the lower Petaluma River. Delivery of Russian River Project water to the City of Petaluma began in 1962 with completion of Sonoma Water's Petaluma Aqueduct. This allowed reduction in the volume of municipal groundwater pumped and recovery of ground water levels. Groundwater levels have remained relatively steady since that time except during the drought of 1976-77, and no appreciable change appears to have occurred in the last 20 years with respect to the volume of groundwater affected by saltwater intrusion. If groundwater pumping near the tidal portion of the Petaluma River does not substantially increase, the volume of affected groundwater should not increase.

A computer analysis completed by the California Department of Water Resources (DWR) in 1982 indicated that the total groundwater storage capacity of the Petaluma Valley Groundwater Basin was 1,697,000-acre feet. Based on fall 1980 ground water levels, total water in storage was 1,420,000-acre feet – about 84% of the total capacity. However, the Petaluma Valley Groundwater Basin as defined in DWR (1982) encompassed an area of 60,000 acres. Parts of the study area are now in the Wilson Grove Formation Highlands Groundwater Basin and the Napa Sonoma Volcanic Groundwater Basin. At its updated area of 46,000-acres, the Petaluma Valley Groundwater Basin has a lower storage capacity than was estimated in DWR (1982).

Groundwater is the primary source of supply for domestic and agricultural use by rural property owners in the basin and while urban water supply to the city of Petaluma is primarily imported Russian River surface water, groundwater is a vital supplemental and backup source. Recent modeling conducted by USGS indicates that long-term groundwater levels in the Petaluma Valley were relatively stable between 1960-2015. Levels varied up to 20 feet seasonally and declined during multi-year droughts but recovered during wet periods. The average annual decline in groundwater storage for the Petaluma Valley between 1960-2015 was 400 acre-feet per year, which was less than 1% of average groundwater recharge. Wells that showed declines were in the northeast part of the valley (Traum et al. 2022).

Historical occurrences of serious nitrate contamination have been documented in the western portion of the basin due to past agricultural, industrial, and urban land use practices (DWR 1982). However, recent analyses by USGS, Sonoma Water, and the City of Petaluma indicate that instances of high nitrate

concentrations have decreased. Where they occur, they tend to be localized, small scale, and limited to shallow or mixed-depth wells near the land surface (Traum et al. 2022).

DWR found that saltwater intrusion from the tidally influenced portion of the Petaluma River affected shallow aquifers prior to 1962, but that there had been no further incursions after that time. The lack of further saltwater intrusion was attributed to substitution of groundwater with surface water (DWR 1982). More recently, a USGS study found that some wells located in the southern extent and along the axis of the Petaluma Valley were salinity-affected. In addition, high concentrations of dissolved ions were measured in some deep wells sampled, which was attributed to water-rock reactions rather than t idally influenced river water (Traum et al. 2022).

### Sustainable Groundwater Management Act

In 2009 the State Legislature amended the Water Code with SBx7-6, a statewide groundwater elevation monitoring program. This program was designed to track both seasonal and long-term trends in groundwater basin elevations throughout California. DWR developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program with the purpose of establishing long-term, locally managed groundwater basin monitoring. Local entities must work in collaboration with DWR to collect and maintain groundwater elevation data.

In 2014, the State of California enacted the Sustainable Groundwater Management Act (SGMA), which substantially changes the way groundwater is managed in California (Sonoma Water 2021). SGMA requires that California groundwater basins identified as high or medium priority establish a Groundwater Sustainability Agency by June 30, 2017 and develop a plan for sustainable management by January 31, 2022. The Petaluma Valley Groundwater Basin (Basin), designated as basin number 2-1 in DWR's Bulletin No. 118 (DWR 2016a), and shown on Figure 1-1, is categorized as a medium-priority basin by DWR (DWR 2020) and is, therefore, required to comply with SGMA.

To satisfy the requirements of SGMA, local agencies must do the following: 1. Form one or more Groundwater Sustainability Agencies (GSAs) to fully cover the SGMA high- or medium-priority basin/subbasin 2. Develop one or multiple Groundwater Sustainability Plans (GSPs) that fully cover the SGMA high- or medium-priority basin/subbasin 3. Implement the GSP and manage to achieve quantifiable objectives and sustainability within 20 years of GSP adoption 4. Report data and GSP progress to the DWR. The City of Petaluma was the initial monitoring entity for CASGEM compliance in the basin. With the formation of the Petaluma Valley GSA, responsibility for CASGEM monitoring has been transferred to the GSA. Data is submitted to DWR semiannually as required by CASGEM, and can be viewed via the CASGEM Public Portal.

## FLOODPLAINS

A "floodplain" is any land area susceptible to being inundated by floodwaters from any source (City of Petaluma 2021). Over the years, the City of Petaluma has invested significant time and resources into creating a more flood-safe environment for the community. In addition to creating strategic maps, the

city has completed projects to contain, channelize, and manage the flow of water through local rivers and creeks. The city has also updated floodplain maps using upgraded technology which allows for a greater understanding of flood risks in Petaluma. Additionally, investing in generating sea level rise scenarios has provided insight on sea level rise, particularly in the areas of Petaluma affected by incoming tide levels.

Sonoma Water's Master Drainage Plan details the climatic, hydrologic, and topographic factors which contribute to the delineation of floodplains or flood prone areas. Specifically, the floodplain delineation closely approximates the base (100-year) flood elevation lines developed by the USACE for the National Insurance Administration, Federal Emergency Management Agency's Flood Insurance Rate Maps for the City of Petaluma and Sonoma County.

The term "100-year flood" is often used inconsistently and misunderstood by many people. It is a measure of water level rather than rate of occurrence; therefore it can happen any time. The misinterpretation can foster a belief that if a 100-year flood occurs in any one year, then it cannot occur for another 100 years. This belief is false because it implies that floods occur deterministically rather than randomly. Because periods of heavy rainfall and floods occur randomly and sometimes unpredictably, there is a small probability that the 100-year flood could occur in any year, regardless of when the last "100-year flood" occurred.

As noted in the Southern Sonoma County Stormwater Resources Plan, future climate scenarios are likely to result in increased seasonal variability of precipitation, runoff, and stream flows for Sonoma County, along with increased likelihood of "extreme" precipitation and drought events that were rare or unprecedented in the historic past (Sonoma Water 2019). However, the precise risk of flood events is difficult to predict. Much of Sonoma County's wintertime precipitation comes in the form of "atmospheric rivers" from the Pacific Ocean. An atmospheric river is a relatively narrow ribbon in the atmosphere with ample moisture and strong winds. These atmospheric phenomena can produce very high precipitation in relatively focused areas. The amount and intensity of precipitation therefore depends greatly on where these atmospheric rivers make landfall, something climate and atmospheric researchers cannot yet fully predict.

Land use, specifically developed lands, is an important topographic factor influencing surface runoff of stormwater. The watershed's decrease in water quality, susceptibility to erosion and flooding is directly linked to increased urbanization and accompanying pavement (Sonoma Water 1986). Using "green infrastructure," to capture and store excess stormwater and floodwater by increasing the capacity of watersheds, stream corridors, floodplains, and wetlands to catch and retain rain and runoff is recommended to ameliorate flooding caused by extreme precipitation events (Sonoma Water 2019). This would include protecting, expanding, and enhancing the natural water supply system, including wetlands, upper watersheds, groundwater recharge areas, streamside areas, and flood-prone areas, with the result of spending less on "hard" engineering approaches such as levees.

## BIODIVERSITY

More than 90% of California's original marshland has been degraded, destroyed, or "reclaimed" by urbanization, agriculture, and commercial salt operations. In the San Francisco Bay, less than 15% of original tidal marshland remains – much of it highly fragmented or altered. The North San Francisco Bay tidelands provide food and shelter for millions of shorebirds and hundreds of thousands of waterfowl that migrate through or winter every year. Only 27% of the historic tidal marshes in San Pablo Bay remain. The Petaluma Marsh is the largest remaining salt marsh in San Pablo Bay, totaling an estimated 5,000 acres. Less than 3,000 acres of the marshland is still naturally tidal, and this tidal marsh is under severe threat from sea level rise. The marsh has three zones: low marsh of cordgrass or tulles, which receives maximum submergence; a middle marsh of pickleweed *(Salicornia virginica*), alkali bullrush, or cattails; and a high marsh, which is rarely, if ever, covered by tidal action. During extreme high tides, the surrounding uplands are a refuge for many marsh animals.

The upper Petaluma watershed is comprised primarily of grassland habitat, extending from the northern river riparian areas west, east, north and south. The lower Petaluma watershed is comprised of riparian areas, wetland, and salt marsh. Higher elevations of the watershed along the northeast and south to southwest borders include forested areas. Multiple special status species, including American Badger, California Red-legged Frog, and avian species reside in the watershed. According to a 2021 search of the California Natural Diversity Database, six wildlife species are listed as federally endangered and four as federally threatened. The California Native Plant Society (CNPS) identifies 53 plant species in the watershed. Fragmented habitat areas present a challenge for natural movement patterns, which are critically important to support biodiversity. Use of grassland for agriculture, ranching, development, and infrastructure can, at times, present conflicts with wildlife if not properly managed.

# CHAPTER 3. OVERVIEW OF WATERSHED LAND USE

The Petaluma River Watershed is located in the ancestral territory of the Coast Miwok; archaeological evidence indicates that human occupation in the Sonoma County region began over 10,000 years ago, and over that time Native people developed a deeply sophisticated understanding of and relationship with the environment, including activities that are now considered to be land management and production practices. Today, the watershed is a mostly agricultural landscape dominated by grassland and pasture for grazing cattle and sheep; it was historically a production center for poultry and dairy products (see Chapter 2, History and Cultural Resources Section). In the past three decades, agricultural production has diversified to include vineyards, flowers, olive groves, and other specialty crops. The remainder of watershed land use is rural and urban residential with some industrial, institutional, and commercial use in the City of Petaluma, salt marsh and wetlands along the Petaluma River in the south, and grassland and forested areas in the hills along the western, southwestern, northwestern, and northeastern watershed borders. This chapter describes predominant land uses, impacts and opportunities within the Petaluma Watershed.

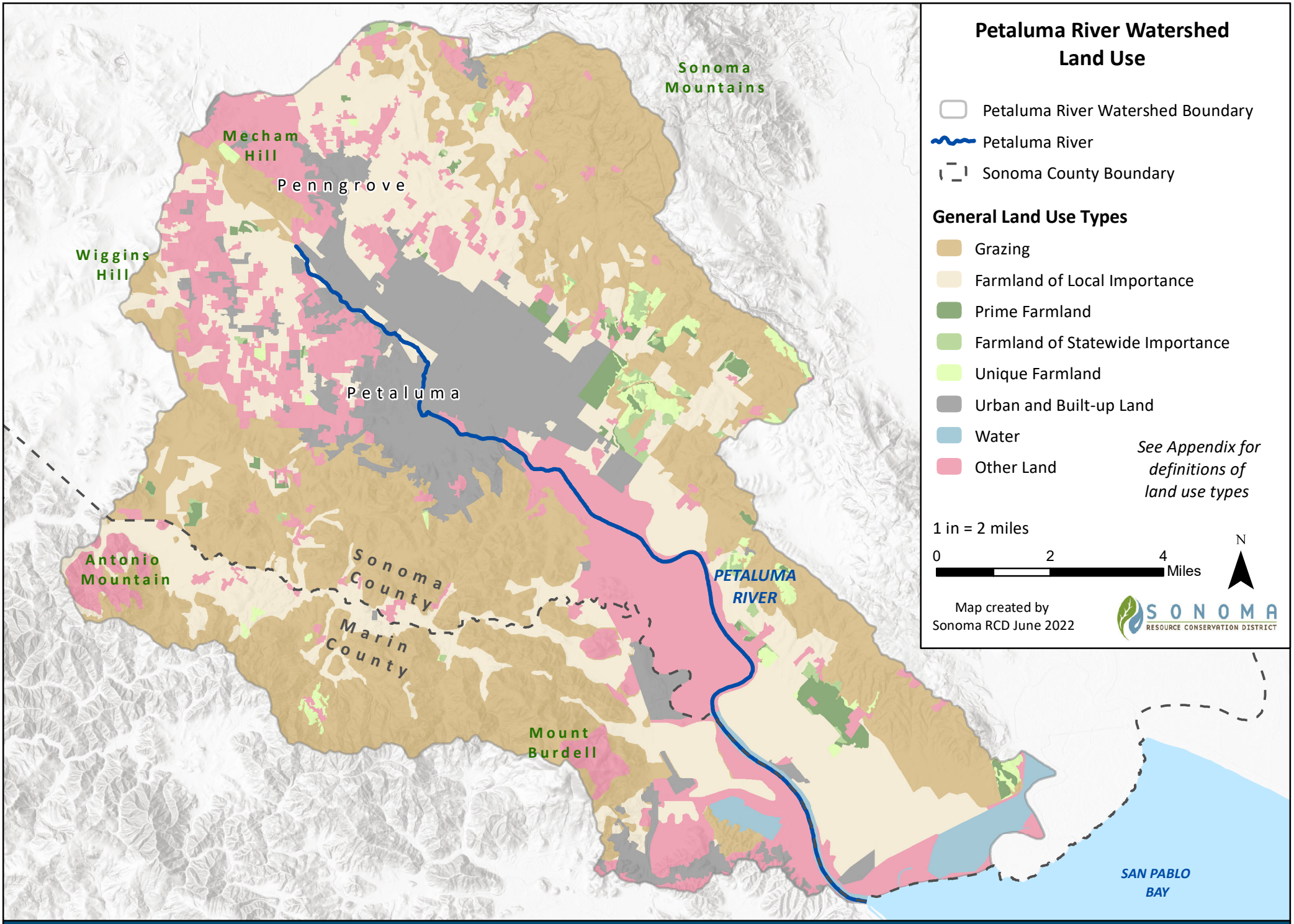


**Fig 3.1. Land use in the Petaluma River Watershed (data updated 2022).**

Data: Farmland Mapping and Monitoring Program, Division of Land Resource Protection, California Department of Conservation

## DEMOGRAPHIC CHARACTERISTICS

According to the 2020 Census data, the total population of the City of Petaluma was 59,776; it experienced a growth rate of 5.4% between 2010 and 2018, with an average of 0.7% annually, the fourth highest in Sonoma County. Although the growth rate is expected to decline, current estimates show the population increasing to 61,736 by 2023 (Sonoma County EDB 2019). The 2021 population of Penngrove was estimated to be about 2,800 (World Population Review 2021). These figures do not account for residents living in rural parts of the watershed, which we estimate to number about 5,000. Including this estimate, the total population living within the Petaluma Watershed as of 2021 was approximately 68,000.

The Sonoma County General Plan 2020 projects total population for the Petaluma planning area by the year 2020 at 76,300, which is an overestimate. A 2020 Sonoma County Indicators Report (Sonoma County EDB 2020) shows that the county's population as a whole "continues to age and shrink," while Petaluma's population is rising at a declining rate (Sonoma County EDB 2019). Although population trends are hard to predict due to the COVID-19 pandemic and California and Sonoma County's recent severe wildfire events, housing demand in the watershed is likely to remain high for the foreseeable future because of the proximity to San Francisco and enhanced quality of life.

Petaluma's population is aging; about 32% is 55 or older, and the number of children and number of households with children have decreased in the past two decades. By 2023, nearly 20% of the population is expected to be in the 65+ age bracket. While White residents continue to represent most of Petaluma's population, the Latino population grew by 7.3% from 2000 to 2019 (Raimi + Associates 2021), and that trend is expected to continue throughout the watershed as well as the county and state (Sonoma County EDB 2019).

Four disadvantaged community blocks are located within the watershed in the City of Petaluma. Two are located along the Petaluma River at North McDowell and are listed on the Department of Water Resources (DWR) Disadvantaged Community Map as severely disadvantaged with a high social vulnerability ranking according to the Agency for Toxic Substances and Diseases Registry's Social Vulnerability Index. A third tract is located across from the Sonoma Marin Fairgrounds and the fourth is near Petaluma High School. These areas contain many mobile homes, residents 65 and older, and households with low median income, suggesting that these areas' mobilization and disaster response capabilities, especially with respect to flooding, may be insufficient.

## URBAN AREAS

Urban land uses and the continued expansion of urbanization in the watershed have a pronounced influence on the health of the watershed. Existing and continued urbanization is a significant contributor to water quality impacts and degradation or loss of valuable riparian habitat. The City of Petaluma established an Urban Growth Boundary in 1972 in order to limit the expansion of urbanization and focus additional development within city limits. Land at the urban edges in proximity to the Urban Growth

Boundary comprise both habitat and movement areas for wildlife along with an urban to rural transition zone.

Urban areas in the Petaluma River Watershed are limited to the City of Petaluma, which is located north of center in the watershed (Figure 3.2, Residential Density in the Petaluma River Watershed). The city is in the process of updating its General Plan, which was last updated in 2012. The update is a multi-year process that began in the summer of 2020 and is expected to be completed in 2023. Petaluma has experienced a great deal of change since the adoption of the current General Plan. High priority concerns include prioritizing the natural environment, preserving open space and green space, climate change impacts and actions, availability and affordability of housing, public health, safe streets and roads, multi-modal transportation, and sustainability.

The City is committed to climate readiness, striving for greenhouse gas carbon neutrality by 2030 and in early 2021, approving its *Climate Emergency Framework*. The framework outlines principles to guide the City's ongoing response to the climate crisis and is intended to guide and inform climate policies and implementation strategies. Some of the City's climate-smart actions include: LED streetlight conversions, solar installation at city facilities, subscription to Sonoma Clean Power's EverGreen 100% Renewable Energy Program, building codes that eliminate the use of natural gas in new construction, and energy efficiency and renewable energy retrofits.

Petaluma has an ongoing commitment to sustainable development and preservation of the agricultural lands and open space surrounding the city. In 1972 the City Council of Petaluma passed a controversial ordinance limiting growth to 500 housing units per year and in 1998, the city adopted an urban growth boundary to concentrate development and ensure efficient and compact growth patterns. The General Plan ensures that all future growth results from infill and that land outside of the Urban Growth Boundary (UGB) is maintained primarily for agricultural, rural, and open space land uses. Urban growth boundaries (UGBs) are considered a necessary pro-active growth management technique to separate urban growth from adjacent greenbelt lands: farms, ranches, open lands, and parks. A significant goal of these boundaries particularly in areas such as Sonoma County with highly valued productive farmlands and other resource bearing land areas, is to protect them from development in addition to providing habitat for wildlife and securing healthy watersheds. UGBs allow communities to preserve their identity, prevent urban sprawls from merging, provide open space for recreation, aesthetic purposes, and encourages cities to acknowledge future land-use planning. In 1998, the residents of Petaluma voted in Measure I, which would create a 20-year UGB (City of Petaluma undated). Voters chose to renew the measure in 2010 to extend the UGB timeline through the year 2025. Petaluma was the first to address extending their UGB in Sonoma County.

Housing Availability is a recurring issue for the City of Petaluma. Between 2010 and 2017, housing vacancy rates declined, reaching 3.4% (Sonoma County EDB 2019). The city's current goal is to develop environmentally responsible denser infill housing close to transit that includes a range of affordability. The housing stock has grown at a rate of about 260 units per year since 2015 and the city has been directed to develop an additional 1,910 units by 2031 to meet projected demand and comply with state housing requirements (Association of Bay Area Governments 2021).

The city has seen a significant increase in accessory dwelling unit (ADU) development, issuing about 100 permits for ADUs between 2014 – 2019. The majority of ADU development has been in the western part of the city. However, recent legislation will likely result in ADU development in the eastern part of the city, which is characterized by many planned unit developments where ADUs were not previously allowed. The passage of SB 9 in the 2021 California legislative session allows property owners to split parcels over 2,400 square feet into two lots, each having up to two housing units (duplexes) (Linch and Baral 2021). Infill development is recommended to be concentrated in three areas: Downtown, East Washington, and Corona SMART Station (Urban Land Institute 2021). ADU options are permitted in several of the development projects listed on the City's website.

For a complete list of development projects see the City of Petaluma's website on the "Major Development Projects" page: https://cityofpetaluma.org/planning-major-developments/

The City has a stated interest in areas beyond the City's formal sphere of influence; Petaluma's Planning Referral Area encompasses the entire 113 square-mile Petaluma River Watershed. Sonoma County refers all projects within the Planning Referral Area to the City for comment. Likewise, City projects that may affect the County or are near the urban boundaries are referred to the County. The City and County planning staff and public representatives also have working relationships and less formal means of cooperation, such as meetings on topics related to planning.

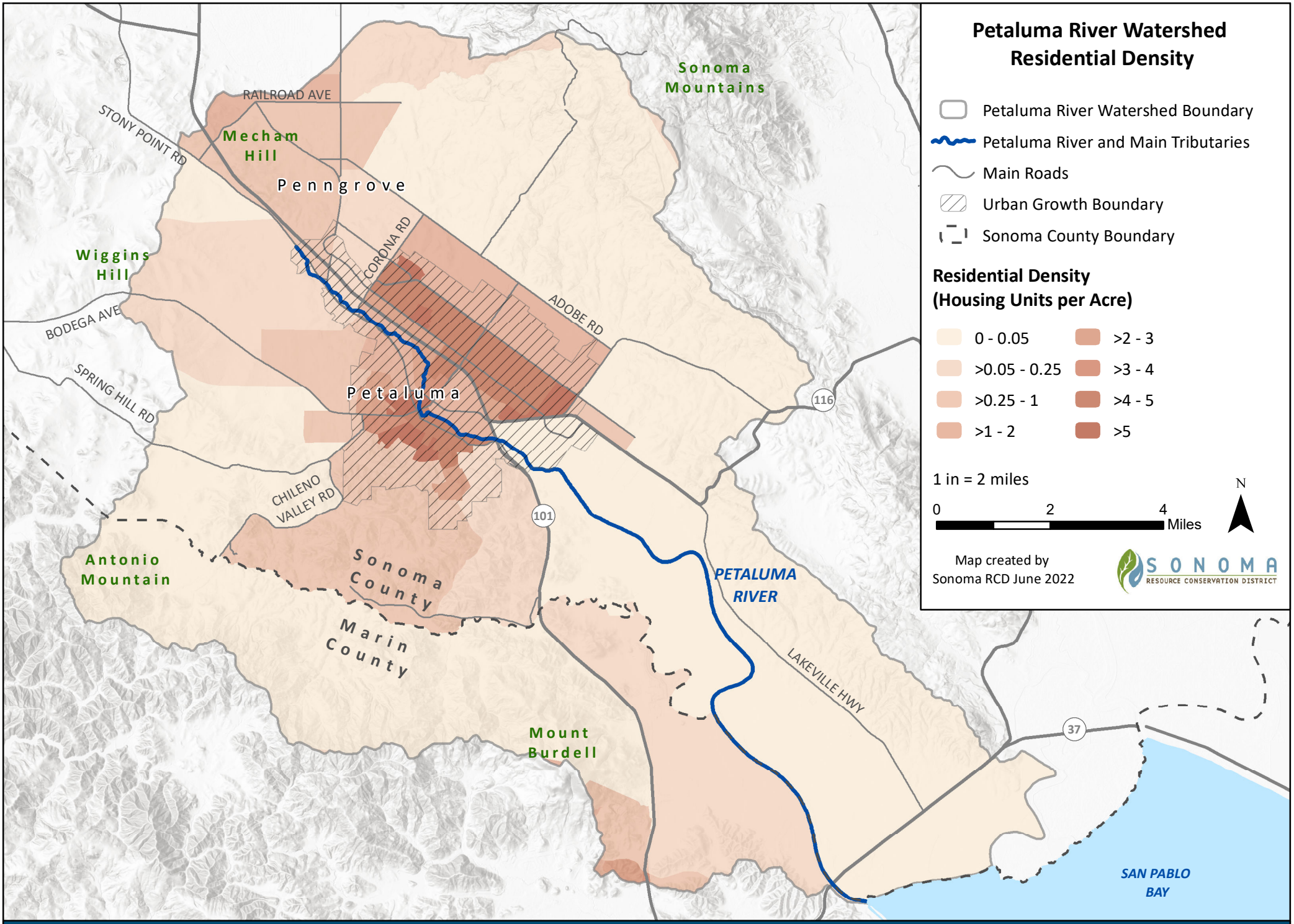


**Fig 3.2. Residential density (housing units per acre) in the Petaluma River Watershed.**

Data: U.S. EPA EnviroAtlas

## RURAL RESIDENTIAL

Rural residential housing (from 1 unit / 160 acres to 2 units/ acre) comprises about 55% of the watershed. It occurs mainly in the north to north-central and southwest portions of the watershed. The community of Penngrove is a Census Designated Place in the north part of the watershed that contains limited commercial and significant rural residential development. Sonoma County's General Plan limits new commercial and industrial development around Penngrove to the "Urban Service Area" of Penngrove and further specifies that the development specifically serves the service, employment or agricultural processing needs of planning area residents (Sonoma County PRMD 2008).

## OPEN SPACE

Open spaces and parks are integral to Petaluma's character, comprising a substantial portion of land, nearly 2,000 acres, or 20 percent of acreage—within the Urban Growth Boundary (UGB) (Map XX, Parks and Open Space, and Urban Separators). Petaluma owns and maintains a full range of open space and recreational resources, including regional, community, neighborhood, and pocket parks in addition to surrounding rural lands, which allows for the preservation of its unique identity. Policies continue to focus on the city's greatest natural resource, the Petaluma River, to expand land conservation and preservation.

The City of Petaluma owns Lafferty Ranch on Sonoma Mountain, small parcels related to water supply on Manor Road, Petaluma River Marina, oxidation ponds and related facilities near Lakeville, Shollenberger Park, Rocky Memorial Dog Park (on an old landfill), Alman Marsh near the marina, a portion of the McNear Peninsula near downtown, and 160 acres of marsh and oxidation ponds near Shollenberger Park. The River Park Foundation, a nonprofit, recently purchased the main section of McNear Peninsula which will be combined with city owned Steamer Landing Park so the whole Peninsula will become a city park. On the eastern side of its boundaries, Petaluma owns a municipal airport on East Washington Street, Prince Park, Wiseman Park, Lucchesi Park, and a golf course. The largest community parks in Petaluma are Lucchesi (30 acres), Wiseman (21 acres), and Prince (22 acres) parks. Helen Putnam Regional Park, encompassing 256 acres in the southwestern portion of Petaluma, is a County Regional Park.

Shollenberger Park was originally a 165-acre ranch along the Petaluma River purchased as a dredge disposal site. A decant channel constructed to allow site drainage morphed into a freshwater marsh while continuing to function as intended. In 1996, the parking lot, restroom, and walkway to the pier were declared a community park. Several hundred people walk the 2.2 mile circle daily. In 2002, Alman Marsh became an extension of Shollenberger Park; it is a brackish tidal wetland that provides habitat for several threatened and endangered species, including Salt Marsh Harvest Mouse and Black Rail. The Ellis Creek Water Recycling Facility was opened for public recreation in 2009. The 270-acre site contains 30-acres of polishing wetlands that complete the water filtration process, seasonal wetlands, and over 100-acres of brackish tidal wetlands that are connected to the Petaluma River at high tides. The site provides important bird and wildlife habitat and is considered a wildlife sanctuary. It is connected to

Shollenberger Park by a one-mile trail. Over 230 bird species have been surveyed by Petaluma Wetland Alliance in these three locations.

The city also owns urban separator lands. Urban separators create boundaries between adjacent Urban Growth Boundaries (UGBs), for instance, between Petaluma and Novato UGBs. They are designed to buffer open and green space, and agricultural lands from urban development and offer areas for wildlife movement and public recreation while preventing swaths of urbanization and habitat fragmentation, retaining separate and easily identifiable cities. There are currently about 157 acres acting as urban separators around urban development in Petaluma. Urban separators between Petaluma and Novato amount to approximately 2,755 acres and serve as a gateway between Sonoma and Marin Counties. Additionally, roughly 3,360 acres of open space, farmland, and foothills to the northeast buffer Petaluma from the City of Rohnert Park.

CDFW manages the 1,950-acre Petaluma Marsh Wildlife Area. It is located approximately six miles southeast of the City of Petaluma and bordered by the Petaluma River on the east, San Antonio Creek on the south, private property (Neils Island) on the west, and Schultz Slough on the north. The 300-acre Rush Creek Marsh managed by Marin County Parks and Open Space District is located south of Basalt Creek and north of Novato, the northernmost city in Marin County. The State Coastal Conservancy and U.S. Fish and Wildlife Service own and manage approximately 430 acres of marsh as part of the Baylands Project, located in the southwest corner of Lakeville Highway and Highway 37.

West of Lakeville Highway and Reclamation Road, SLT owns and manages over 1,000 acres, about half in oat hay, half grazed (in combination with seasonal wetlands) and 528 acres in agricultural easement. East of Lakeville Highway and Reclamation Road, SLT manages 1,800 acres, of which around 1,000 are grazed and 100 are farmed. About 1,000 of SLT's total acreage in the watershed are planned to be restored to tidal marsh. Sonoma Ag + Open Space has numerous conservation easements on rural and agricultural properties in the watershed that include hay, sheep, dairy, and grazing use in addition to easements on open space land providing habitat for multiple species and preserving wildlife corridors.

The open and green spaces at the City's outer edges offer public access opportunities, including Helen Putnam Regional Park. The Paula Lane Nature Preserve in West Petaluma, reflects a new project model of public access, combining volunteering and education on land with sensitive habitat and protected species. The project model, High Use-Low Impact (HULI), is included in the City of Petaluma's Climate Action Framework, to be considered for future parks and open spaces in Petaluma. Other open space land in the watershed includes: Tolay Lake Regional Park (Sonoma County Regional Parks), the Burdell Ranch (CDFW), and Petaluma Adobe and Olompali State Historic Parks (both owned by California Department of Parks and Recreation). These lands offer habitat preservation as well as an array of activities for residents and visitors such as hiking, mountain biking, horse-back-riding, picnicking and wildlife viewing.

The Tolay Lake Regional Park illustrates a long presence of Coast Miwok cultural history throughout the landscape; it includes 3,400 acres of ecologically and historically rich lands. The preservation of such areas has been vital to the Federated Indians of Graton Rancheria, community, cultural histories, and natural resources that support several threatened species. The land has been identified by the Federated Indians of

Graton Rancheria as an area of spiritual significance. It is currently open daily for recreation and provides habitat for a variety of wildlife, including Golden Eagles, Burrowing Owls, and other birds of prey and passerines.

## AGRICULTURAL LANDS

For over a century, agriculture has been the dominant land use throughout the Petaluma Watershed (see Chapter 2, History and Cultural Resources Section). Historically, the area has been a production center for poultry and dairy products and although the poultry industry has declined, dairy continues to be one of the watershed's leading agricultural commodities. Dairy operations are found throughout the watershed, particularly in the San Antonio Creek and Adobe Creek watersheds. Vineyard development has increased, particularly near Lakeville, along Highway 101, and in the San Antonio Creek watershed. Other agricultural uses include livestock (beef and sheep), horses (including about five boarding and training facilities), oats (for silage, hay, or straw and seed), olives, truck crops, Christmas trees, poultry production (turkeys, chickens, ducks, and eggs), emus, llamas, greenhouses, and floral nurseries (Map 3.4, Agricultural lands in the Petaluma River Watershed). Sonoma County's General Plan reflects the desire of residents to manage growth and protect agriculture. The County has reinforced its limited growth patterns with strong policies protecting agriculture and Petaluma's General Plan 2025 seeks to preserve its "setting as an urban place surrounded largely by rural land uses and densities, agriculture and open space (City of Petaluma 2008)."

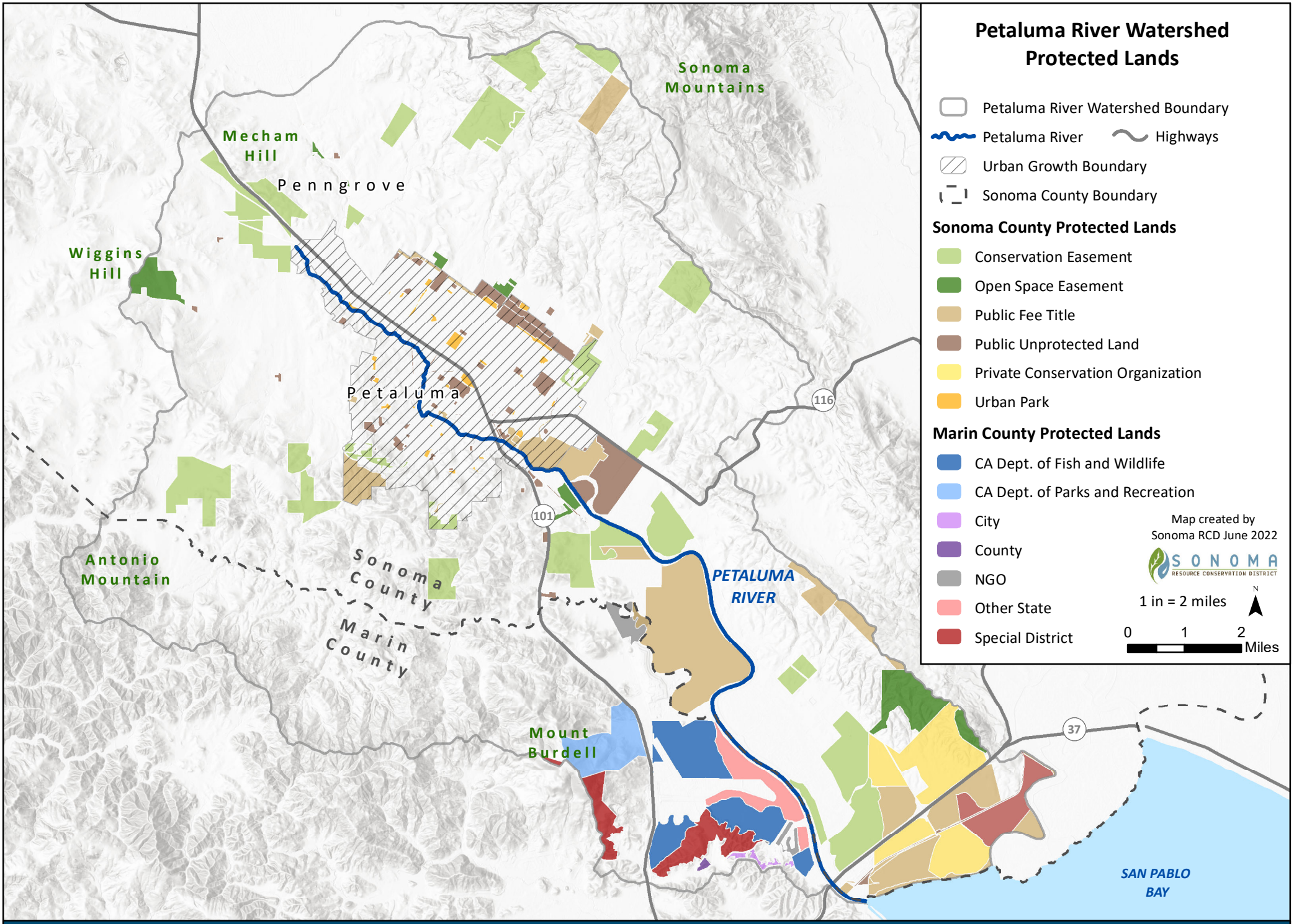


**Fig 3.3. Protected lands in the Petaluma River Watershed.**

Data: Sonoma County Public and Protected Areas Database, California Protected Areas Database

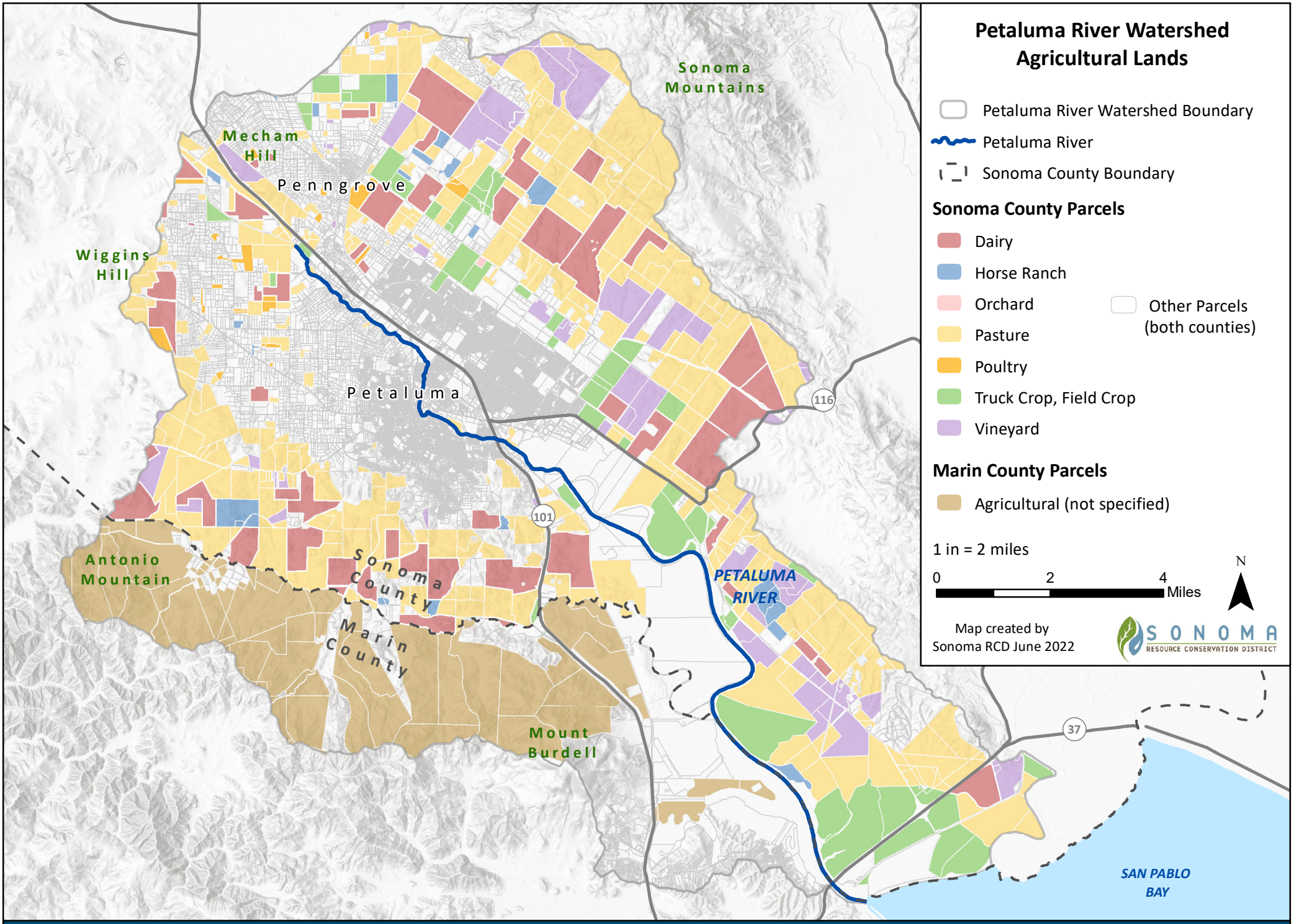


**Fig 3.4. Agricultural lands in the Petaluma River Watershed.**
Data updated 2021 (Sonoma County) and 2020 (Marin County).

Data: County of Sonoma Clerk-Recorder-Accessor Office, Marin County GeoHub

## LEVEES

During the late 1800s the tidelands bordering San Pablo Bay were “reclaimed” for farmland. Many miles of levee were constructed in the watershed to keep out the bay waters and the lands were drained and allowed to dry out; rainwater flushed out the salts from the land and crops were planted. Currently, these lands support local agricultural operations, infrastructure (i.e. roads) and important habitat and the levees require ongoing maintenance to prevent them from flooding. The USACE is not responsible for the many levees throughout the Petaluma Watershed and private landowners must maintain them at their own expense.

To maintain the levees, landowners are required to obtain permits from some, or all, of the following regulatory agencies: USACE (with consultation from the NMFS and USFWS), County of Sonoma, CDFW, Regional Water Quality Control Board, Bay Conservation and Development Commission, and the State Lands Commission. Often, obtaining permits can be a lengthy and costly process. Currently the Sonoma RCD administers permits issued by each regulatory agency for levee maintenance activities being completed by numerous landowners in the Petaluma River Watershed.

## RECREATION

In addition to the wealth of land-based conservation and recreational opportunities provided by the parks and open space described above, the Petaluma River and its adjacent park and open space network provides for an array of recreational and educational opportunities.

In November 2020, the Petaluma River Park Foundation purchased 20 acres of wild waterfront property on the McNear Peninsula surrounded by the Petaluma River. The site is located just off D Street through Haystack landing and is adjacent to land where the Friends of the Petaluma have their headquarters. The nascent Petaluma River Park will consist of three main sites – the Northwest, Northeast, and Southeast sites, each of which will make use of existing features to provide pedestrian, picnicking, and other park-related activities. The Park is envisioned to be accessible from both land and water and received a $1M matching grant from Sonoma County Ag + Open Space in March 2021 to begin Master Design, Plan Development, and Phase 1 construction (Petaluma River Park Foundation undated).

Draft plans for the River Park fulfill a major component of the City's Petaluma River Access and Enhancement Plan and matches the priorities of Petaluma residents. The Petaluma River Park proposal would augment existing park space, add over 1 mile of public access trails, and protect and enhance tidal wetland habitat, seasonal wetlands, and upland habitat.

The project is adjacent to Steamer Landing Park and the David Yearsley River Heritage Center, which is centrally located next to the Petaluma Bus Terminal, SMART Train station and walking paths, and would create a destination park for the surrounding community, employment centers, and visitors to Petaluma. This project will strengthen access to open space and to the River for the underserved in our community, many of whom live in the areas next to the Park property and who do not currently have adequate access to parks or open space and who suffer from disproportionate impacts of climate change. The proposed development of Petaluma River Park will provide the critical mental and physical health benefits of regular engagement with nature to these communities and beyond.

While the development of the Petaluma River Park delivers important public access and conservation value, the associated increase in tourism presents a challenge with respect to visitor impacts, such as

increased traffic congestion, possible strain on a limited water supply, and the risks of community displacement as the River Park increases local property values. For these reasons, it's essential that the River Park be developed in concert with the community to ensure that the economic benefits of the Park's creation are shared directly with local residents, and in collaboration with local conservation and environmental experts to create a unique park plan that simultaneously supports recreation and public use while employing the highest standards of environmental stewardship.

As residents and visitors make use of the watershed's stunning array of natural wealth, they are likely to become appreciative of, and hopefully protective of, these sensitive and valuable resources.

The Petaluma River Access and Enhancement Plan (1996) prepared by the City of Petaluma contains over 30 projects to improve recreational opportunities along and within the river, including the development of the McNear Peninsula as a park, described above. Other projects that would enhance the watershed's recreational opportunities include Class 1 multi-use paths to close gaps along the river in several locations, as identified in this Plan and will be further defined in the City of Petaluma's Active Transportation Plan and the General Plan Update, both currently being developed.

The Petaluma River is a unique feature that offers aesthetic value, significant ecological function, and recreational opportunity. The Petaluma Small Craft Center Coalition is a local organization bringing human-powered boaters together to improve river access. Vessels solely powered and operated by human fitness create little impact on river ecology and function when compared to motor powered crafts. Through an assortment of trainings and events it has been the Petaluma Small Craft Center Coalition's mission to better connect the community with the city's river heritage. The Coalition's plans to develop a Small Craft Center boathouse along the river will increase the use of the river for fitness, recreation, and education. The center will encourage active participation in events on the Petaluma River.

## PETALUMA RIVER NAVIGATIONAL CHANNEL

The Petaluma River has been significantly altered by land use changes in the past 140 years. Although it is referred to as a "river," geomorphologically, it is a tidal slough; its lower reaches experience regular tidal exchange from San Pablo Bay (Southern Sonoma RCD undated). In 1880, the river was dredged and straightened to a channel 50 feet wide and three feet deep at high tide to create a navigable waterway to transport goods. In 1931, sediment accumulation in the channel led to the USACE reshaping it to 100 feet wide and eight feet deep (Sonoma Water 2019). In 1987, the Petaluma Marina was built; it has 198 berths and accommodates small transferable vessels under 35 feet in length. The marina is at the southern edge of the city and is bound by US 101 to the west, Lakeville Highway to the north, and Alman Marsh to the east (Colin 2015).

The river continues to be dredged to keep it navigable by gravel barges and recreational craft; the most recent dredging occurred in September and October 2020 with funding received from USACE. The channel was dredged using hydraulic technology, which is not suitable for the Marina, which requires a mechanical approach. In 2021, the city is working to secure the necessary funding to go out to bid to dredge the Marina (pers. Comm. J. Sanglerat, City of Petaluma, September 2021).

The dredging project provided a deeper river which accommodates a wide variety of boats, providing more recreational opportunities and the possibility for the return of river events and a revitalized riverfront economy and experience. Additionally, the dredging improves the capacity of the river to

withstand periods of extreme precipitation, offering enhanced flood protection for low-lying areas. Future dredging is expected to occur on a 10-year maintenance schedule; the City of Petaluma has obtained the necessary permits and is identifying funding to finance it (City of Petaluma PW&U undated).

Petaluma River Access Partners is a citizen, nonprofit, and city group developing an implementation and funding strategy for the 1996 Petaluma River Access and Enhancement Plan. They refer to their effort as Petaluma Water Ways, a vision to provide "more miles of riverfront pedestrian and bike greenspaces and parks, a water trail with more access points for hand-carried small craft, and connections to other regional trails (Petaluma Small Craft Center 2018)."

## TERRESTRIAL TRANSPORTATION

According to 2013 planning documents, the preferred future for Central Petaluma is "one of pedestrian-oriented public streets, plazas, squares, and riverfront walks, lined with mixed-use, pedestrian-oriented buildings (OPTICOS 2013).

Maintaining a strong transportation network is a critical issue in Petaluma and surrounding areas. Historically the reliance on the Petaluma River and the Northwestern Pacific Railroad were the lifelines of the city. As the population grew so did the demand for efficient travel between cities along Highway 101 and alternative routes became vital for the development of Petaluma. Caltrans is widening Highway 101 in Petaluma between Lakeville Highway (Route 116) and Corona Road by adding a carpool lane in each direction, making the highway three lanes in each direction. The project is the eleventh and final project in Sonoma County of a larger project known as the Marin-Sonoma Narrows, which will add lanes from State Route 37 in Novato to Old Redwood Highway in Petaluma. The highway widening project through Petaluma is expected to be completed by the end of 2022. Improving the ease of commuting will likely increase development pressure on Petaluma as more San Francisco-Oakland-Berkeley Metropolitan Statistical Area (MSA) residents migrate north to enjoy North Bay amenities and lifestyle and escape the congestion of the MSA.

According to the 2021 Community Socioeconomic Profile, based on the US census, slightly over half of employed residents in Petaluma commute to work beyond city boundaries. Despite a high proportion of local commuters, as of 2019 about 73% of Petaluma commuters drove to work alone. The share of residents using public transportation to commute decreased from 5% in 2000 to 3% in 2019 and during the same period, the number of Petaluma residents telecommuting nearly doubled – from 4.7 to 8.7%.

The city's primary transportation priorities include improved mobility for all modes of travel, providing cross-town mobility enhancements for residents crossing Highway 101, constructing safe and attractive pedestrian walkways, creation of an efficient bicycle network to schools and major city destinations, as well as a focus on enhancing commuter rail and improving already existing bus transit routes. The Sonoma Marin Area Rail Transportation (SMART) District was established in 2003 to develop and implement the passenger rail system slated to run on the Northwestern Pacific Railroad corridor between the Marin and Sonoma counties. The system includes a bicycle and pedestrian pathway along the rail corridor. It is currently 45 miles, extending from the Sonoma County Airport south to Larkspur in Marin County. Future expansions are planned for Windsor, Healdsburg and Cloverdale, providing 70 miles of passenger rail upon completion. The SMART Area Rail Transit District oversees the engineering, planning, evaluations, and necessary assessments to properly enable the passenger train service. A SMART station is

located adjacent to the Petaluma Transit Mall on Copeland Street; the transit mall is served by Golden Gate Transit, Petaluma Transit, and Sonoma County Transit. A second SMART station is planned for the north end of Petaluma when funding becomes available.

For over two decades, the City of Petaluma has been working on its pedestrian improvement priorities to remove barriers limiting foot traffic and mobility throughout the City of Petaluma. To establish a strong pedestrian network, the city has been implementing sidewalk renovations and construction, street crossings, and trails. As written in the Petaluma General Plan 2025, improvements for pedestrian networks are to preserve and enhance connectivity in existing neighborhoods, while planning for linkages between new developments and surrounding land uses. The Bicycle & Pedestrian Plan (2008) outlined a bikeway system that includes establishment of Class II bike lanes on all new arterial and collector streets and bicycle and pedestrian friendly design for all new and redesigned streets. Class II bikeways are bike lanes established along streets and are defined by pavement striping and signage to delineate a portion of a roadway for bicycle travel. Implementing the Bicycle & Pedestrian Plan to promote the use of bicycle and pedestrian corridors would reduce vehicle use on local roadways.

The Petaluma River Access and Enhancement Plan promotes public access points to the water to facilitate crossings and travel by ferry or private boat as well as connections from the existing and planned river trail system to the Bay Area Ridge and San Francisco Bay Trails (City of Petaluma 1996).

# Section Two: Management and Recommendations

This section covers Chapters 4-12 covering climate and adaptation, urban land use, agricultural and rural sus-tainability, riparian and wetland ecology, fish and wildlife, water supply and quality, stormwater, data gaps, and education and community outreach.

Photo credit Sonoma Resource Conservation District

# CHAPTER 4. CLIMATE CHANGE IMPACTS AND ADAPTATION

Climate change refers to any significant change in the measures of climate – such as temperature, precipitation, or wind patterns – lasting for several decades or longer. Increases in the Earth's temperature and associated changes to climate patterns over the past century are caused by increased levels of carbon dioxide and other greenhouse gases in the Earth's atmosphere (EPA 2013). This chapter includes a description of the effects of climate change on a larger scale and in Sonoma County as well as adaptation recommendations.

## GLOBAL CLIMATE CHANGE

The Intergovernmental Panel on Climate Change (IPCC) Climate Change 2021 Summary for Policymakers (SPM) presents key findings of Working Group 1 contributions to the IPCC Sixth Assessment Report (AR6) on the physical science basis of climate change, building on previous years' reports and incorporating subsequent new evidence from climate science (IPCC 2021). Some of the high level and key findings formulated as statements from the IPCC SPM 2021 report relating to climate change as it impacts watershed health are provided below.

- It is unequivocal that human influence has warmed the atmosphere, ocean, and land and that widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred.

- Human influence has warmed the climate at a rate that is unprecedented in at least the last 2,000 years.

- The scale of recent changes across the climate system as a whole – and the present state of many aspects of the climate system – are unprecedented over many centuries to many thousands of years.

- Global surface temperature will continue to increase until at least mid-century under all emissions scenarios considered. Global warming of 1.5°C – 2°C will be exceeded during the 21$^{st}$ century unless deep reductions in CO2 and other greenhouse gas emissions occur in the coming decades.

- Many changes in the climate system are projected to become larger in direct relation to increasing warming. They include increases in the frequency and intensity of heatwaves, marine heatwaves, heavy precipitation, and, in some regions, agricultural and ecological droughts. Other projections include an increase in the proportion of intense tropical cyclones and reductions in Arctic sea ice, snow cover and permafrost.

- With every increment of global warming, predicted changes get larger in regional mean temperature, precipitation, and soil moisture.

- Projected changes in extremes are larger in frequency and intensity with every additional increment of temperature increase.

- Continued warming is projected to further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events.

- With further warming, every region is projected to increasingly experience concurrent and multiple changes in climatic impact-drivers. Changes in multiple climatic impact-drivers would be more widespread at 2°C compared to 1.5°C warming and even more widespread and/or pronounced for higher warming levels.

## CLIMATE CHANGE IN CALIFORNIA AND SONOMA COUNTY

The consequences of climate change are projected to be substantial in California and to have far-reaching impacts on many ecosystems, agriculture, and infrastructure. California is already experiencing the effects of climate change including increased temperatures, rising sea levels, longer and more severe fire seasons, and shifts in precipitation leading to extended and more severe droughts and intensified less-frequent storm systems.

Regarding agriculture alone, a 2018 study by a team of researchers from the University of California documented that climate change will pose many challenges for the agricultural sector of California, which produces more than 400 types of commodities including over one third of the United States' vegetables and two-thirds of its fruits and nuts. California is the largest and most diverse agricultural state in the United States and is highly sensitive to climate change. Changes in climate that affect agriculture – such as reduced winter chill hours, reduced water availability, and increased and intensified heat waves – will impact the agriculture industry, potentially leading to job loss and economic decline coupled with local, regional, and national food insecurity. These findings highlight the vulnerability of agriculture to changes in climate (Pathak et al. 2018). At the same time, increasing organic matter in agricultural soils have the potential to reduce atmospheric greenhouse gases while helping agriculture adapt to the impacts of climate change (Flint et al. 2018).

Overall, the projected changes of greatest regional concern are sea level rise, salinity shifts, temperature increases, hydrological changes (timing, quantity, and quality) and an increase in the severity of storms. On their own, each carries specific implications, but also of concern is the cumulative effect of any combination of these factors. Other stressors include the development and fragmentation of open spaces, decreased water quantity and water quality impairments, invasive species, pest vectors and related diseases.

Changing temperatures have already started impacting our communities in terms of personal health, energy, water, and land use. The climate dictates almost all factors of life, including:

- The quantity and quality of our water supply, and patterns of water demand

- Rates, patterns, and production of commercial and residential energy use

- Where, when, and how agriculture can produce crops supplying food and materials to meet basic needs

- Health risks for vulnerable populations including the very young and elderly

The impacts of climate change on biodiversity, agriculture, and infrastructure are far reaching, requiring coordinated and targeted local efforts to protect native species, their ecosystems, and ecosystem services. Local and regional groups including the Regional Climate Protection Authority (RCPA), The Climate Center, North Bay Climate Adaptation Initiative, California Climate and Agriculture Network and their many partners provide education and resources to communities in Sonoma County and beyond about the likely impacts of climate change on our economy and environment, and adaptation strategies to mitigate them. In 2021 RCPA adopted a Sonoma Climate Mobilization Strategy, in 2021 Petaluma adopted a Climate Emergency Framework, and many other cities in the county have adopted climate action plans and policies including green building programs and Land Use and Community Design Programs to address climate change.

## Predicted Conditions

### Floods

One of the projected impacts of climate change is the increased likelihood of extreme floods capable of destroying streambanks and nearby uplands, infrastructure, roads, and crops. Flooding can be especially severe near the coast and the Baylands shoreline, where high tide combined with an increased high-water level caused by sea level rise can push flood levels higher than previously experienced.

Sonoma County is one of the top recipients of repetitive federal flood damage payments and, in fact, has losses greater than those of the next nine top recipient communities combined, making it the county with the highest number of properties suffering repetitive flood losses west of the Rockies. The frequency and magnitude of atmospheric river events, during which high volumes of rain fall in a short period of time, are predicted to increase due to climate change (Dettinger et al. 2009). This will likely increase flood risk and damage to public and private property.

### Sea Level Rise

Sea level has risen approximately 7 inches over the last 100 years. Recent data from the IPCC predicts a 20-inch rise in sea level over the next 50 years and the San Francisco Estuary and Watershed Science journal predicts a sea level rise of 16 inches by mid-century and 50 inches by the end of the century. Areas of southern Sonoma County that were tidal before diking and leveeing, such as the lower Petaluma River, are most at risk of flooding under low and moderate increases in sea level rise (Figure 4.1). The sea level rise anticipated from climate change has the potential to submerge historic wetlands and existing agricultural properties and threaten public infrastructure, including Highway 37 and the railroad, unless flood protection infrastructure (levees, ditches, and pumps) is maintained.

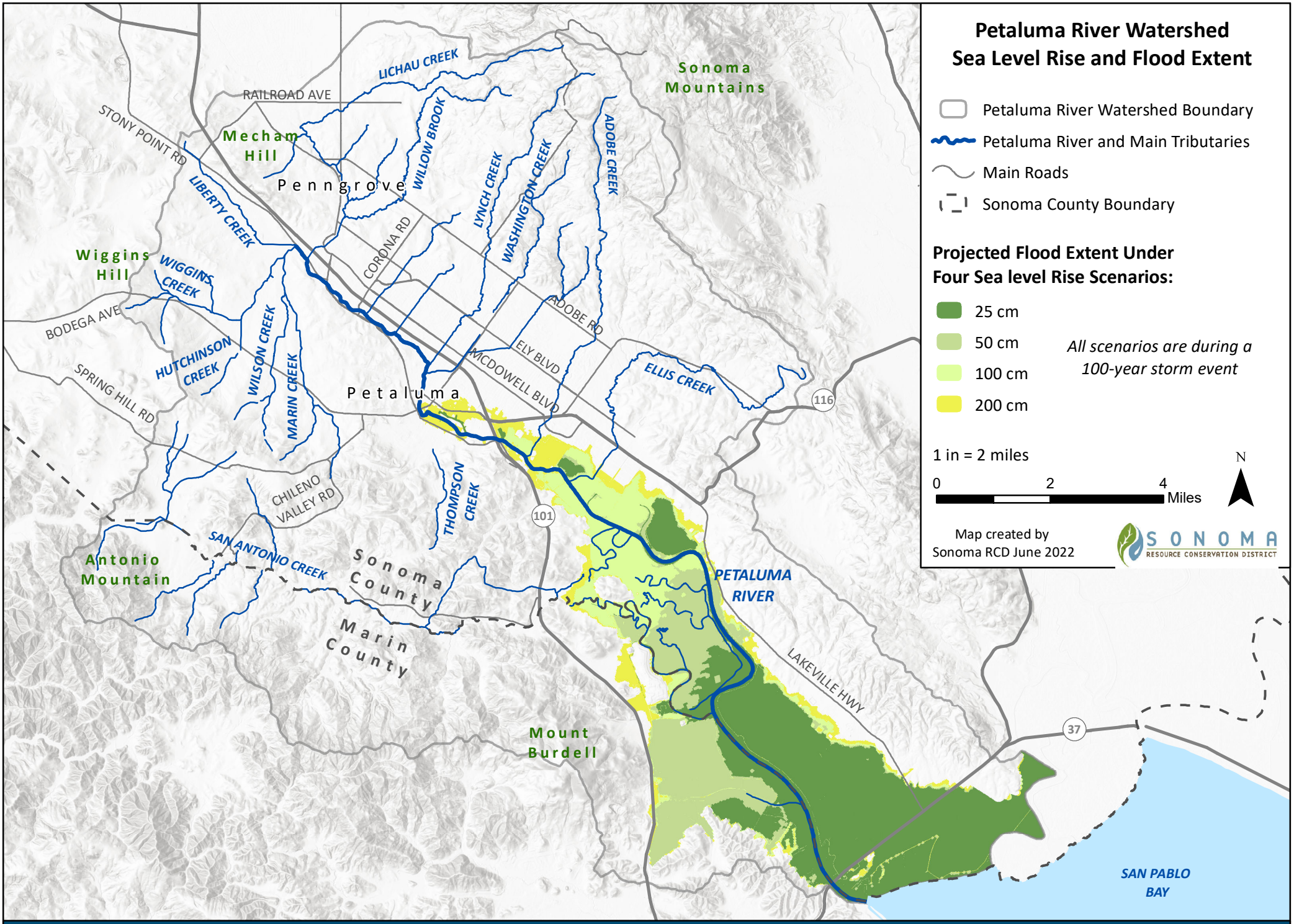


**Fig 4.1 Projected flood extent in the Petaluma River Watershed under four sea level rise scenarios during a 100-year storm event.**

Data: Our Coast Our Future, USGS Coastal Storm Modeling System (CoSMos)

**Heat**

In Sonoma County, average summer high temperatures have increased by about 1° F and winter low temperatures have increased by about 1.7° F since 1900. Such increases tend to be more pronounced in low-lying valleys than in mountainous areas, and continued temperature increases as well as increased periods of extreme heat are expected (Cornwall et al. 2014). Under a high greenhouse gas emissions scenario, average summer high temperatures in Sonoma County could increase by 9 to 11° F before 2100 and the average number of days per year with extreme heat (above 98° F) could reach 18 days in the Petaluma area (Cal-Adapt data). The impacts of extreme heat may include increased heat-related illnesses and deaths, increased urban heat island effects, reduced surface and groundwater supplies, strains on power grids, loss of agricultural productivity, and increased tree mortality.

**Water Supply**

Climate models suggest that the timing and amount of rainfall in Sonoma County will become increasingly variable. Coupled with rising temperatures and more extreme heat days, irregular precipitation patterns will place a strain on the region's water supply. Drier soils will contribute less runoff to surface waters such as the Russian River, which provides nearly all water for the City of Petaluma. Longer and more frequent droughts may accelerate the pumping of groundwater, which could diminish aquifers, increase saltwater intrusion, place stress on water supply infrastructure, and reduce water quality (Cornwall et al. 2014). Reducing water use and carefully managing surface and groundwater resources will be key to sustaining an adequate, long-term supply, particularly in the dry summer months during peak water demand.

**Fire**

Climate change is a dominant driver behind major wildfires that have burned in California recently (Williams et al. 2019). While California's forests, woodlands, and grasslands evolved with wildfire and depend on the benefits of "good fire," climate change allows fires to burn hotter, spread faster, and cover more area. Increased temperatures, reduced rainfall, and arid conditions cause vegetation to dry out earlier in the year and lengthen the state's wildfire season. California statewide has experienced an increase in the number of large-scale, climate-driven wildfires leading to the devastating loss of life and property. In Sonoma County alone, it is estimated that over 200,000 acres burned in just the 2017, 2019, and 2020 wildfire seasons (CAL FIRE 2019, CAL FIRE undated). These wildfires destroyed thousands of structures, forced hundreds of thousands of community members to evacuate their homes, created prolonged power shut-offs, exposed people to smoky air, and placed stress on many people including children, the elderly, and individuals with health conditions. Additionally, thousands of acres of habitat was lost and presumably resulted in the loss and displacement of wildlife across the region.

While wildfire hazards tend to be highest in the northern and eastern parts of Sonoma County, there are areas of concern within the Petaluma River Watershed (Figure9 4.2). Modeling conducted by CAL FIRE indicates that the annual probability of wildfire occurrence between 2026 and 2050 is relatively low for the City of Petaluma, but moderate or high in the surrounding wildland-urban interface (WUI) and elevated areas (Figure 4.3). Coupled with high fuel loading and new development in the WUI, wildfire

risk presents numerous challenges in the watershed. Losses due to catastrophic wildfire could include human lives, homes and structures, natural and cultural resources, farms and rangelands, timber, and public and private infrastructure. In recently burned areas, landslides and significant sediment loss during or after a winter storm event could impair water quality and water supply in streams and creeks vital to fish, wildlife, and people.

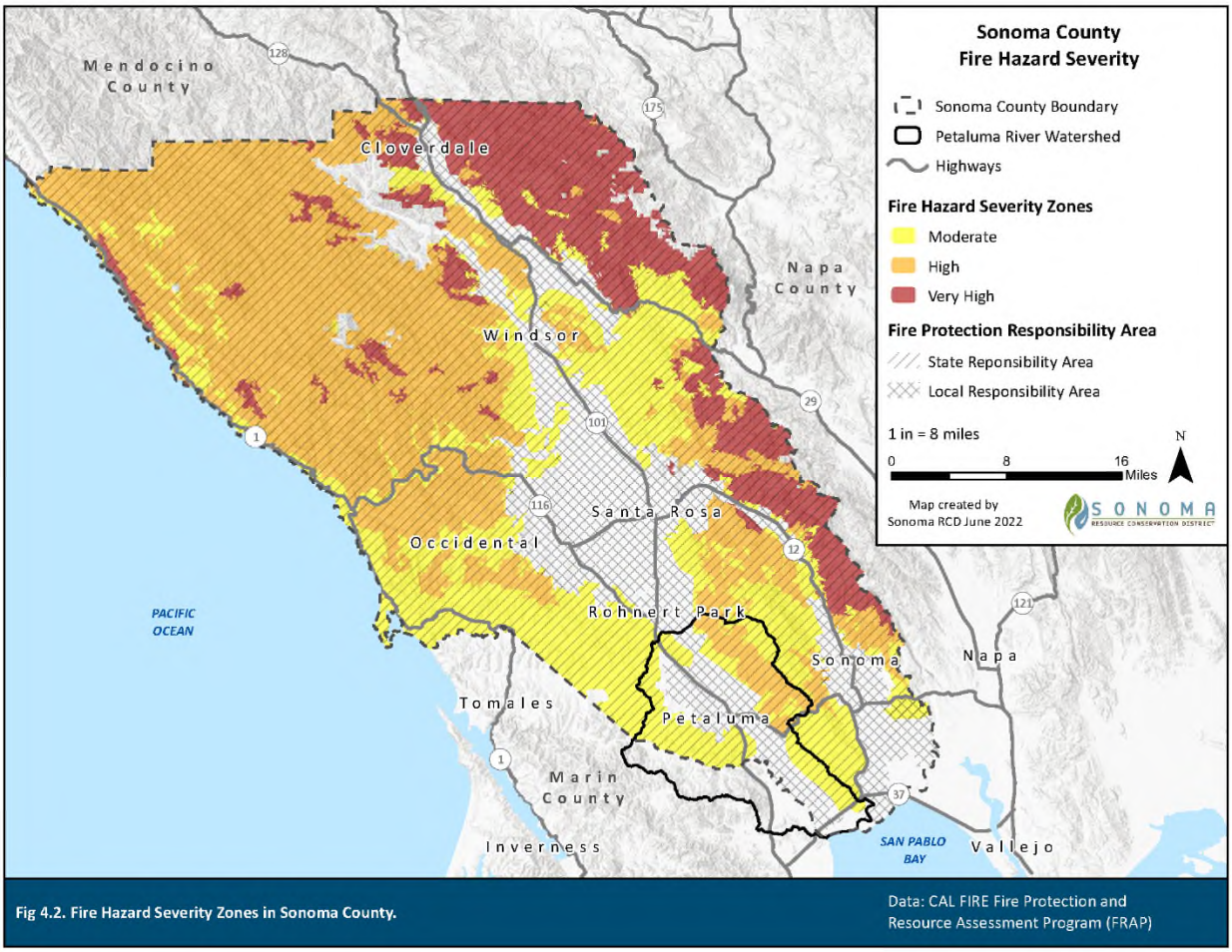


Fig 4.2. Fire Hazard Severity Zones in Sonoma County.

Data: CAL FIRE Fire Protection and Resource Assessment Program (FRAP)

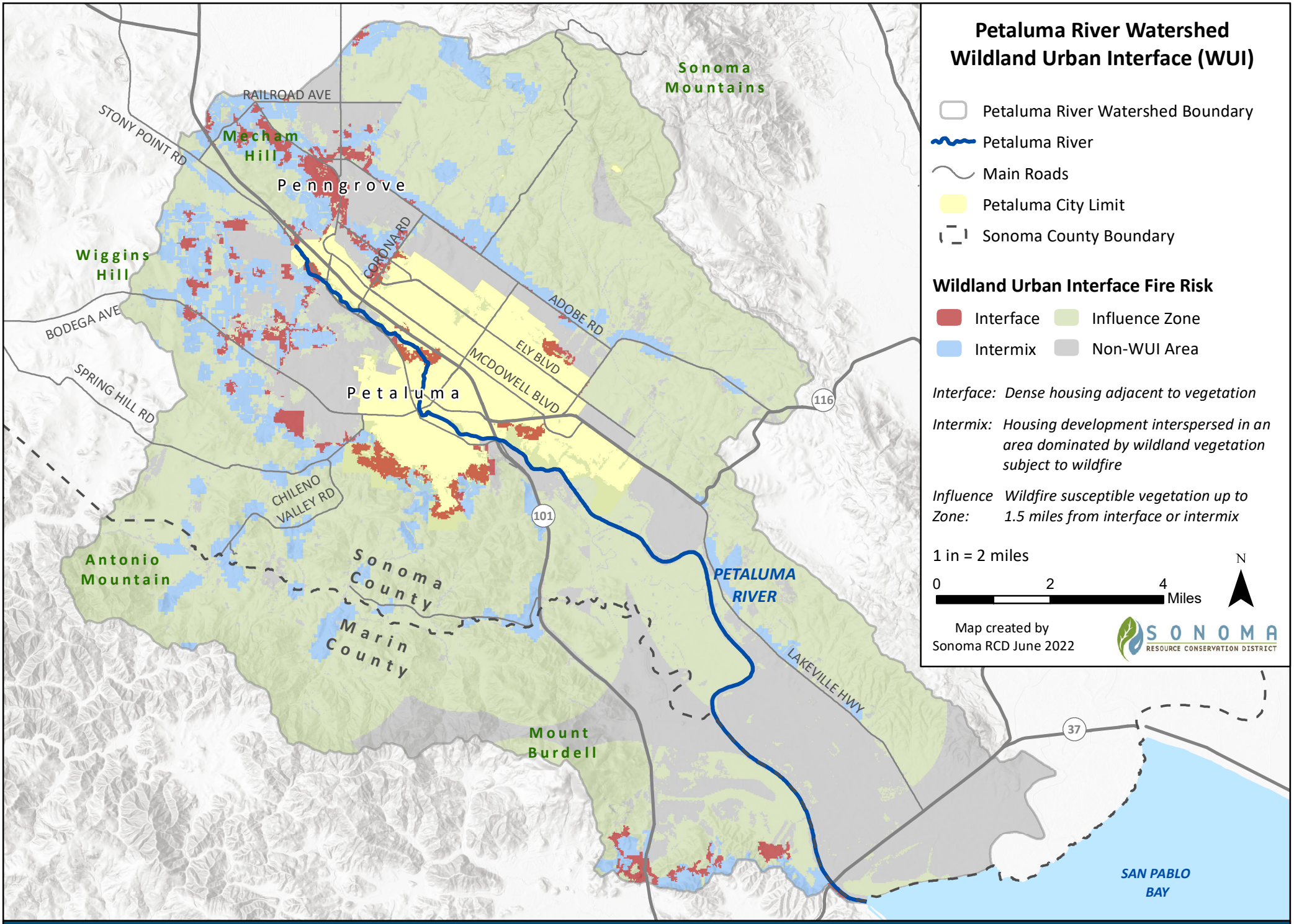


**Fig 4.3. Wildland-urban interface (WUI) fire risk in the Petaluma River Watershed.**

Data: CAL FIRE Fire Protection and Resource Assessment Program (FRAP)

## Potential Impacts

### Human Society and Health

Across California and in Sonoma County, the systems that provide food, water, housing, transportation, and healthcare are vulnerable to climate change. Increased flooding may cause injury or loss of life in low-lying areas, disrupted movement of people and goods, and economic losses in agriculture and other sectors. Extreme heat may lead to increases in heat-related illness, higher prices for food and water, added stress on emergency services and hospitals, and strain on the electrical grid. More frequent and intense wildfires may cause the loss of buildings and infrastructure, displacement of people, health problems associated with smoke inhalation, injuries or death, and reduced accessibility to energy, food, and water supplies (Sonoma County RCPA 2016).

The impacts of climate change will not be distributed equally. For example, extreme heat events are most likely to cause hardship for the very young and old, outdoor workers, individuals in poor health, people living in urban heat islands, and the homeless. Disparities in health, education, income level, and access to resources make certain communities more vulnerable than others. This includes low-income communities and communities of color, which are disproportionately burdened with climate-related impacts. Policies and programs that address climate adaptation need to actively engage and uplift communities that have historically been excluded from planning efforts. California's Climate Change Adaptation Strategy 2018 Update has a climate justice chapter that includes five goals for promoting equity and inclusivity in climate adaptation (California Natural Resources Agency 2018):

1. Actively engage, educate, and partner with communities to enable early, continuous, and meaningful participation in adaptation initiatives.

2. Identify the most vulnerable communities to climate change to prioritize initiatives and build grassroots capacity.

3. Support and coordinate adaptation efforts across jurisdictions and policy areas to maximize community resilience.

4. Promote holistic approaches to climate adaptation that maximize co-benefits and economic development.

5. Make equity an integral consideration for climate research.

### Agriculture and Local Economy

Agriculture is uniquely vulnerable to climate change. Rising temperatures, constrained water resources, magnitude and persistence of droughts, and increased pest and disease pressure are among the climate change impacts that threaten to fundamentally challenge California agriculture in the coming years and decades. Models also predict pressures from weeds, disease and pest shifts, and decreased crop yields, loss of chill hours for crops, and changing intensity and number of storms. Warmer temperatures will create conditions unfavorable for the cultivation of many wine grape varieties and may necessitate farmers changing the cultivars they plant or moving their vineyards northward and/or to higher elevations (CalCAN 2011).

Lands in the southern portion of Sonoma County along the Highway 37 corridor contain agricultural lands in hay and grain, pasture for livestock grazing, and open space lands that support working

landscapes. Grassland pasture and grain produced in the corridor are purchased by local dairies and meat producers. Hay producers grow specialty crops and produce high quality grain to meet local demands for horse and livestock feed and to ensure high value milk, cheese, and meat products. This locally produced seed and grain feedstock contributes to closing the local agricultural supply loop by providing feed for local dairy cows and finishing grains and pasture for grazing livestock. Local cultivation minimizes the carbon and ecological footprint that would be more significant if the grain products were mostly shipped out of the region or needed to be imported. There is concern that increasing costs of doing business coupled with the climate-related challenge of maintaining levees to protect against sea level rise in the vicinity will take this important agricultural acreage out of production.

Agriculture has been identified by the State as having a vital role in adaptation to and mitigation of impacts from climate change. There are many ways that agriculture can mitigate climate change and numerous farming practices that could contribute to reducing future impacts. In addition to providing crops, farmland provides numerous additional benefits, including carbon sequestration, open space preservation, water absorption and filtration, and wildlife habitat connectivity. Agriculture and forestry offer the most readily available commercial terrestrial 'sinks' of carbon dioxide. Soil management practices that have the greatest potential to sequester carbon include cover crops, perennial cropping, reduced synthetic fertilizer inputs, and conservation tillage. Composting and adding organic amendments also increase carbon storage in soils.

Increasing agricultural waste composting through anaerobic digesters and implementing methane digesters and/or alternative manure management strategies on dairies are sustainable farming practices that can both sequester carbon and reduce GHGs. Incorporating trees, shrubs or hedgerows into rangeland or farm landscapes also sequesters significant quantities of carbon. Restoring forested lands along creeks, rivers, and farm and ranch edges dramatically increases carbon stocks. When appropriate stocking rates are observed, cattle grazing can increase aboveground species richness and productivity of vegetation, which is frequently correlated with increased soil carbon. Rotational grazing, a practice of intensively grazing and rotating livestock through paddocks, and converting from conventionally raised feedstock to perennial grasslands, has been shown to increase soil carbon. Lastly, research has shown that significantly more carbon is sequestered in organic soils that are cultivated with animal manures and cover crops rather than conventional soils cultivated with synthetic fertilizers. These practices, when marketed effectively, can also increase a crop's consumer value, increasing local and regional agriculture sustainability.

**Biodiversity and Habitat**

While climate change models have generated a wide range of projections, there is consensus that some habitats, particularly tidal wetlands, will be impacted more than others. Increases in sea level rise could account for losses of up to 30% of the world's remaining tidal wetlands by 2100 unless humans can accommodate wetlands moving inland (Schuerch et al. 2018). According to a recent study by Climate Central (2022), wetlands could increase in area by 25% or decline by 97% by 2100 depending on the pace of sea level rise, how fast wetlands can grow vertically, and especially how much land is conserved for wetlands migration. Wetlands are likely to be particularly vulnerable to climate change impacts through shifts in salinity and inundation patterns (Callaway et al. 2007). However, wetlands are also important in combating climate change. Wetlands serve as carbon sinks, storing 20-30% of the world's soil carbon (Nahlik and Fennessy 2016). They buffer against winter floods and summer droughts by

acting as sponges that trap stormwater and release it slowly over time. The threats to wetlands and their importance for climate change adaptation underscore the need to maintain the wetland health along the lower Petaluma River. The tidal wetlands from Petaluma to the San Pablo Bay provide important habitat for birds, fish, reptiles, amphibians, mammals, and invertebrates that depend on brackish water environments. Unless land is acquired for gradual migration, sea level rise over the next 50-100 years could turn much of our current marshland into tidal mudflats, decreasing carbon storage as well as drastically changing habitat and ecosystems in our Petaluma Marsh.

Many species in Sonoma County and the Petaluma River Watershed will likely be affected by climate change. The rate of change from current human generated causes is expected to be much faster than natural geotime changes so many species may not be able to adapt and evolve quickly enough to survive. Biodiversity is declining globally. Those species with low genetic diversity are most vulnerable, while those with high genetic diversity are more likely to survive and adapt to altered environmental conditions. Plant and animal ranges are likely to shift, with new associations and interactions among species. The Sonoma County Biodiversity Action Plan provides a framework for conserving the region's biodiversity in the face of climate change and other threats (Community Foundation of Sonoma County 2010). Recommended actions in this plan include connecting fragmented habitats to maintain species migration patterns and allow for potential range shifts within the region. The Petaluma River Watershed contains a critical linkage located just south of the City of Petaluma along which conservation and restoration actions will be essential to maintaining habitat connectivity and wildlife movement in a changing climate (Figure 4.4).

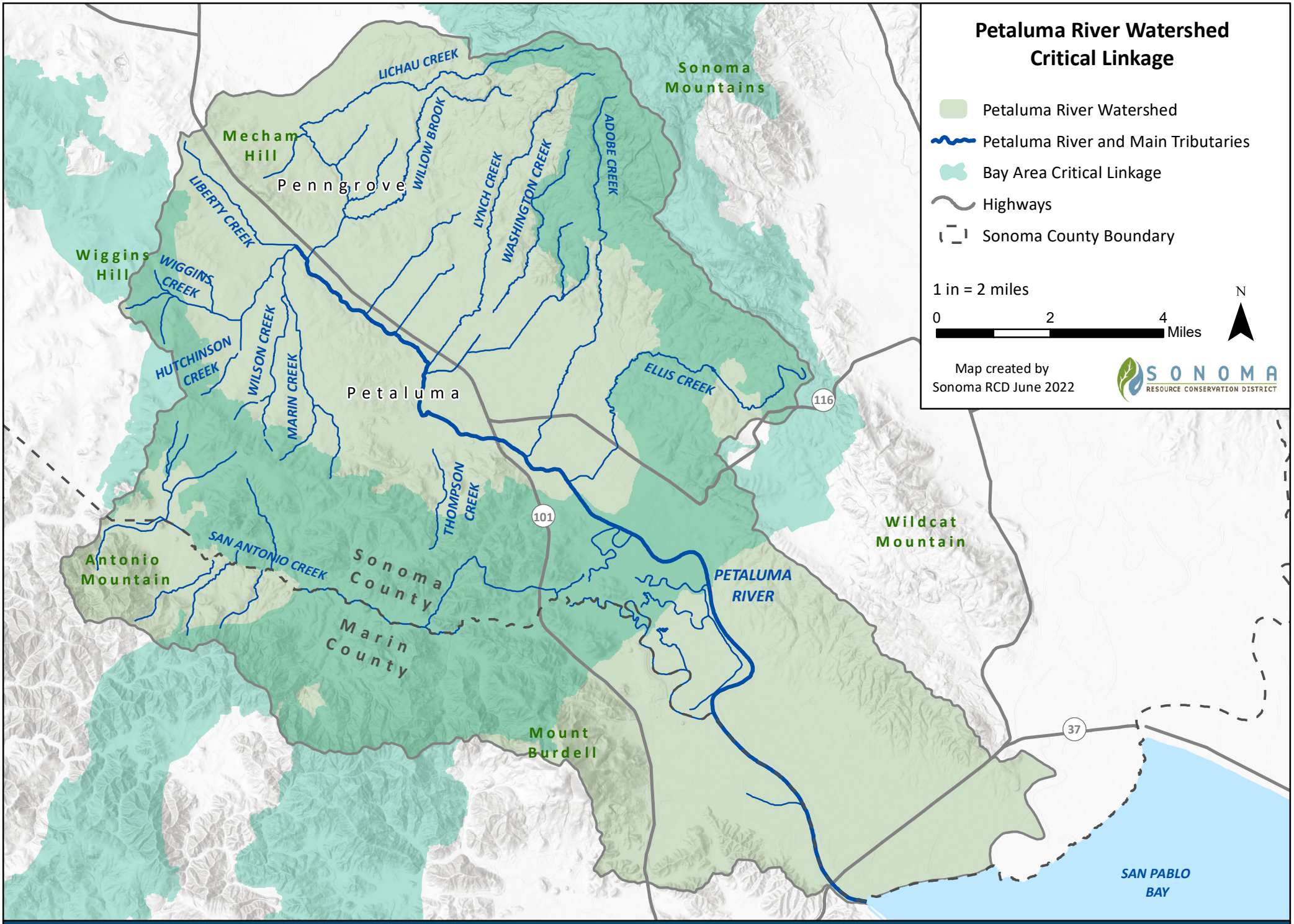


**Fig 4.4. Bay Area Critical Linkage in the Petaluma River Watershed.**

Data: Conservation Lands Network, SC Wildlands, and Bay Area Open Space Council

## CLIMATE INITIATIVES

### State

California's climate goals set the state apart as a leader in climate change resiliency. California's first major initiative was the Global Warming Solutions Act of 2006 (AB32), which set limits on greenhouse gas emissions and outlined commitments to creating a sustainable, clean energy economy. California strengthened its limits on GHG emissions with the adoption of SB 32 in 2016, which required GHG emissions reductions of 40% below 1990 levels by 2020. In 2018, Governor Jerry Brown signed SB-100, which set California on a path toward zero greenhouse gas emissions by 2045. California's advancements in renewable energy, energy efficiency, and cap-and-trade programs have allowed its economy to grow while reducing its carbon footprint (Environmental Defense Fund, undated).

In 2020, California's Governor advanced 30 x 30, an executive order that enlisted natural and working lands in climate mitigation. California was the first state in the US to join 38 countries in this effort; the order pledged conservation of 30 percent of California's land and coastal water by 2030 and directs state agencies to deploy multiple strategies to store carbon in the state's natural and working lands through:

- Healthy soils management, including cover crops, hedgerows, and compost
- Wetlands restoration to protect coastal areas
- Active forest management to reduce catastrophic risk and restore forest health, boosting green infrastructure in urban areas like trees and parks

The 30 x 30 initiative calls for "science-driven, nature-based approaches, both traditional and western," to be "expanded across the state to protect California from the effects of climate change. Such approaches must be dynamic and adaptive, and wherever possible, achieve multiple benefits (Administration of Governor 2022)." The core commitments of the initiative are: 1) advance justice, equity, diversity, and inclusion; 2) strengthen tribal partnerships; and 3) sustain economic prosperity, clean energy resources, and food supply. A related effort released simultaneously with the 30x30 initiative is the Natural and Working Lands Climate Smart Strategy (California Natural Resources Agency 2022). This document contains regional profiles and priorities identified for the San Francisco Bay region include:

- Regenerative agriculture – practices that focus on the health of the ecological system in which crops are produced
- Green communities – urban parks, green schoolyards, green infrastructure, community forests, residential composting
- Living shorelines and levees, saltmarsh restoration
- Wetland and riparian area protection and restoration

- Prescribed and cultural burning, agroforestry, reforestation
- Grazing, native plant restoration
- Corridor protection to facilitate range shifts
- Expanding the use of community greening to reduce impacts of pollution
- Increasing land access for historically marginalized groups
- Increase tribal capacity to scale climate smart land management
- Support nature-based curriculum and experiences in underserved schools
- Build workforce development capacity through climate smart land management job training, apprenticeships, and California Conservation Corps

### County

Actions to address the current and future impacts of climate change within Sonoma County have made notable progress in recent decades. The Sonoma County Board of Supervisors has become increasingly committed to finding solutions to reduce greenhouse gases and effectively steward the environment. In 2009, Sonoma County became the first in the nation to create a Regional Climate Protection Authority (RCPA), a move that recognized both the magnitude and cross-sectoral and multi-jurisdictional nature of the climate crisis. The RCPA is a unique agency governed by a Board of elected officials from all nine cities and the county to guide and coordinate climate change actions with the goals of climate mitigation and adaptation.

RCPA's most recent guidance document, the Sonoma Climate Mobilization Strategy (2021), identifies GHG reduction, carbon sequestration, and adaptation as vital components of the strategy to reduce emissions to 80 percent below 1990 levels by 2030. GHG reduction, or "decarbonization" strategies include all-electric buildings, carbon-free electricity, a drive less campaign, and zero waste. Carbon sequestration relies on maintaining and increasing the carbon currently held in soil and plants through forest management to reduce catastrophic wildfire risk and agricultural protection, stewardship actions to increase carbon sequestration on working and natural lands, and municipal practices to draw down carbon and increase urban forest cover, and implement regenerative land management. Adaptation strategies include increasing the resilience of the electrical grid through community and municipal microgrids and strengthening economic, social, and community resilience to expected impacts.

The County continues to build and maintain partnerships with the Regional Climate Protection Authority, the North Bay Climate Adaptation Initiative, and others to increase climate resiliency and adaptation initiatives.

### Local

The City of Petaluma established a Climate Action Commission in 2019 to coordinate climate action policies and advise the City on climate-related matters. The Climate Action Commission consists of nine

members, including two youth members. In collaboration with city staff and volunteers, the Petaluma Climate Action Committee developed the Climate Emergency Framework. This framework outlines the City's response to the climate crisis and can be used to inform decision-making about climate policies and implementation strategies. It consists of four sections: Equity and Climate Justice, Mitigation and Sequestration, Adaptation and Social Resilience, and Community Engagement. The framework focuses on the need to significantly reduce GHG emissions from all sectors of the local economy, reduce GHG emissions from goods and services purchased or consumed in Petaluma, and sequester carbon from the atmosphere through regenerative land management practices (City of Petaluma 2021).

Following the adoption of the Climate Emergency Framework, the Petaluma Equitable Climate Action Committee (PECAC) was established. The PECAC is composed of six members that provide a voice for Black, Latinx, Asian-American and other underrepresented communities during the implementation process of the Framework. Serving on the committee for six months, the members participate in listening circles with community members to understand their climate-related concerns and provide input to the City of Petaluma and the Climate Action Commission on how to move the Framework forward to promote climate justice. PECAC represents a new model for incorporating the knowledge and lived experiences of community members that have historically been left out of decisions on climate change planning and adaptation (Daily Acts, 2021).

In 2021, the City of Petaluma was awarded a $1 million grant called the "Cool City Challenge" which supports the City's plans to become carbon neutral by 2030 without carbon offsets. In an applicant pool of over 40 California cities, Petaluma was one of three to be awarded the grant from the Empowerment Institute. This program involves building social networks across neighborhoods to achieve community-wide carbon neutrality goals. With the support of 25 community partners and a dedicated volunteer team, Petaluma has already recruited 300 "Cool Block" leaders to take action on emission reductions, disaster resilience, water stewardship, neighborhood livability, and empowerment. The strategy for this program is based on Petaluma's Climate Emergency Framework Plan and demonstrates the city's commitment to increasing representation and participation from historically underserved and marginalized communities (Point Blue Conservation Science, 2021).

The Health Care District recently received a grant to work with Blue Zones – an organization helping people live longer and better by improving their surroundings – to improve health and prolong life in Petaluma. Blue Zone has studied the longest living communities in the world and now promotes key factors to longer life, which include a high proportion of plant-based nutrition, daily light exercise, family centered living, social hour with a long-time circle of friends, and a relationship with Nature. Blue Zones promote forest bathing, taking quiet hikes in forests and natural open spaces as a best practice for long life. Gardening and walking outdoors are highly recommended. Biking and human powered watercraft would also be highly recommended exercise routines. Access to our open spaces, tree lined streets, and river paths are critical to the overall health of our citizens.

## RECOMMENDED ACTIONS – CHAPTER 4. CLIMATE CHANGE IMPACTS AND ADAPTATION

**Recommendation 4.1** – Follow recommendations in California's Climate Change Adaptation Strategy 2018 Climate Justice Chapter:

a) Actively engage, educate, and partner with communities to enable early, continuous, and meaningful participation in adaptation initiatives.

b) Identify the most vulnerable communities to climate change to prioritize initiatives and build grassroots capacity.

c) Support and coordinate adaptation efforts across jurisdictions and policy areas to maximize community resilience.

d) Promote holistic approaches to climate adaptation that maximize co-benefits and economic development.

e) Make equity an integral consideration for climate research.

**Recommendation 4.2** – In riparian areas:

a) Encourage a patchwork of habitats, such as a small grassy area near a dense shrubby area near a group of tall trees.

b) Encourage multi-story native vegetation: groundcover, shrubs, and trees.

c) Leave old and dead trees in place if they do not threaten infrastructure.

**Recommendation 4.3 –** Where feasible, allow natural hydrologic processes, such as flooding and laying down new layers of sediment.

**Recommendation 4.4 –** In forestlands monitor for pest insects and pathogens, invasive species, and dying trees. If you have questions, contact University of California Cooperative Extension Master Gardeners or a private arborist.

**Recommendation 4.5** – Support improvement of the Urban Forest to increase biodiversity, reduce urban heat, sequester carbon, improve quality of life, and provide multiple other benefits.

**Recommendation 4.6** – Improve and beautify the downtown ecosystem with planting native trees, restoring riverbanks with native vegetation, and creating larger park settings in community areas such as the River Park, Outlet Mall flood area, and Fairgrounds which improve living standards for the local underserved communities.

**Recommendation 4.7 –** Assist landowners to eradicate non-native pest insects, pathogens, and invasive weeds.

**Recommendation 4.8** – For wetlands:

a) Complete large wetland restoration projects to serve as buffers to tidal flooding as well as sea level rise.

b) Reduce development in low-lying areas, behind levees, or adjacent to the bay/coast and prevent and reduce other stressors that reduce the ability of the wetland ecosystem to respond.

c) Identify and support projects, that facilitate connectivity to marshes and wetlands prior to and as they are impacted by sea level rise, especially those that acquire land to allow for migration of wetland habitat upslope.

**Recommendation 4.9** – For agriculture:

a) Provide technical and financial incentives to transition management practices and crops that are affected by climate change.

b) Where possible, transition to organic and regenerative practices.

c) Where possible, trees, shrubs, and hedgerows into rangeland or farm landscapes to sequester carbon.

d) Where possible, implement soil management practices that sequester carbon as well as other climate beneficial practices promoted by SRCD and NRCS.

**Recommendation 4.10** – Identify and act upon opportunities to preserve habitat, wildlife corridors, and open and green spaces where feasible.

**Recommendation 4.11** – For watershed residents:

a) Install energy efficient fixtures and appliances as the opportunity arises.

b) Join neighborhood groups focused on improving green infrastructure and creating social cohesiveness.

c) Participate in local, regional, and state climate actions and strategies recommended for residences.

d) Walk, ride bikes, or use public transit when possible.

e) Participate in local, regional, and state governance by attending meetings as possible and being an informed voter in every election.

# CHAPTER 5. BUILT ENVIRONMENT

## DEVELOPMENT

As previously detailed, housing availability continues to be the primary urban land use issue in the Petaluma River Watershed. In 2021, due to multiple years of drought conditions, water supply is of increasing concern and the growing number of residents only adds strain to existing water resources.

Like in most areas, water and the many processes of the hydrologic cycle including drought, floods, stormwater, storage, groundwater, and freshwater, are limiting factors for both human needs and natural resources. Water requirements for both human and environmental needs should be considered at the forefront of future planning efforts.

Construction related impacts, such as topography changes (even subtle site grading) and increasing the amount of impervious cover associated with buildings and roads, alters and many times accelerates, natural processes or the rate of erosion and sedimentation in the waterway and refocuses the natural ecological change within a watershed. Additionally, existing urban and rural residential development contributes sedimentation, decreases groundwater infiltration, increases stormwater runoff and flooding, and increases pollutant loads to surrounding habitats and local waterways.

## TRANSPORTATION

Promoting connectivity in and out of Petaluma will impact the biotic and abiotic systems in the surrounding watershed. Currently, about 20,000 vehicles come into or leave Petaluma every workday. Increased vehicular traffic has the potential to generate air pollution and GHGs at higher rates as well as increasing litter and trash along roadways. Transitioning to more green fuels and modes of transportation may help alleviate these emissions. Supporting job creation and affordable housing locally would reduce the total vehicle miles traveled (VMT) and support more centered communities.

Increasing boat traffic for recreation, commerce, or industry can lead to pollutants including operating fuels, *E. coli* contamination, and garbage negatively impacting the surrounding ecology, the river waterway, and the San Pablo Bay.

## RECREATION

The Petaluma River has been identified as an underutilized recreational resource by multiple stakeholders in the community including the City of Petaluma and the November 2020 acquisition of the McNear Peninsula as the nascent Petaluma River Park begins to address this deficiency. Project 4, Petaluma River Park, has been prioritized for implementation in this plan's companion document, the Petaluma Watershed Action Plan.

## RECOMMENDED ACTIONS – CHAPTER 5. BUILT ENVIRONMENT

**Recommendation 5.1** – Center equity in all stakeholder outreach, planning, and implementation efforts.

**Recommendation 5.2** – Promote infill development away from river and creek corridors and outer urban-rural transition areas to minimize impacts to water ways, habitats, wildlife corridors, open space, and agricultural lands to restrict them to within existing developed areas.

**Recommendation 5.3 –** Identify and provide open and green spaces within and around infill development to support quality of residential life and facilitate wildlife movement.

**Recommendation 5.4** – Pursue acquisition, conservation easements, and/or protect private properties with environmental development potential, especially along river and sensitive creek/water channel corridors and urban-rural transition areas, for open space, habitat connectivity, wildlife movement and biodiversity, flood management, and groundwater recharge.

**Recommendation 5.5** – Use of the Sonoma Water's Water Smart Development Guidebook: increase water conservation and water reuse and reduce stormwater impacts

**Recommendation 5.6** – Adhere to requirements in the Phase II Small MS4 Permit (Order No. 2013-0001-DWQ) that include specific BMP and management measure requirements for commercial, industrial, municipal, and residential land uses.

**Recommendation 5.7**– Adopt and enforce next generation green building standards for all new development

**Recommendation 5.8** – Provide resources for landowners of all sizes to minimize residential impacts such as:

a. Slow it. Spread it. Sink it Guide to Beneficial Stormwater Management and Water Conservation Strategies; Spanish Version (abbreviated)

b. Management Tips to Enhance Land & Water Quality for Small Acreage Properties

c. Species list, habitat information, and guidance on habitat enhancement and restoration to support our area birds and wildlife.

**Recommendation 5.9** – Support community outreach and involvement efforts including wetland education and regional low water use programs such as Petaluma Wetlands Alliance Education Program, Daily Acts workshops, Friends of the Petaluma River Watershed Classroom and River cleanups, Paula Lane Action Network's and Madrone Audubon's bird and wildlife education and habitat gardening support.

**Recommendation 5.10 -** Include the new Petaluma City Schools Environmental Literacy Initiative to support climate change and water cycle lessons in all classrooms.

**Recommendation 5.11** – Implement Actions in the City of Petaluma Local Hazard Management Plan, including:

a. Floodplain property protection, acquisition, and relocation

b. Annual stream and creek channel maintenance

c. Higher regulatory standards for flood protection

d. Enhance structural flood mitigation projects to reduce near-annual floods on the north end of the city

**Recommendation 5.12** – Fully implement the 2008 Bicycle & Pedestrian Plan to reduce vehicle traffic and align transport projects with Safe Streets and Vision Zero goals.

**Recommendation 5.13** – Promote walking and bicycling to work, school, and local tasks such as shopping, receiving services, and visiting when feasible.

**Recommendation 5.14** – Promote use of electric vehicles by installing charging stations in appropriate locations.

**Recommendation 5.15** – Promote use of public transportation, especially the SMART train to reduce local and regional congestion.

**Recommendation 5.16** – Promote carpooling and ride sharing, especially encourage use of electric micro-mobility for local community and neighborhood ride sharing systems and programs.

**Recommendation 5.17** – As boat traffic increases, explore development of a program to install charging stations at docks and marinas as more electric boats enter the marketplace.

**Recommendation 5.18** - Build ADA access for small craft at Marina, Turning Basin, and River Park so all can access the river in human powered watercraft.

**Recommendation 5.19** – Through use of informational kiosks and signs, encourage appreciation for clean surroundings and unpolluted wildlife habitat and discourage littering and trash dumping.

**Recommendation 5.20** – Thoughtful development of recreational opportunities to ameliorate impacts associated with recreation and human use of natural areas. Examples include:

a) Promotion of public transportation, especially the SMART trains.

b) Provision of adequate restroom facilities.

c) Educational kiosks and signage to mitigate thoughtless visitor behavior such as overuse of water or vegetation trampling.

d) Adequate infrastructure to control visitor movement, such as railings and dedicated pathways.

**Recommendation 5.21** - Build Interpretive Environment and Education Center near river and bikeway for the mission of providing a local comprehensive environmental education platform highlighting the Petaluma River ecosystem that is appropriate for all age groups.

**Recommendation 5.22** - Encourage residents and visitors to make use of the watershed's stunning array of natural wealth by giving easy, multiple access to the river and creeks so people are more likely to become appreciative of, and hopefully protective of, these sensitive and valuable resources.

# CHAPTER 6. AGRICULTURAL AND RURAL SUSTAINABILITY

Agriculture continues to be a major land use in the watershed, shaping the culture of its communities. Increasing land prices and changing regulations present challenges to agricultural viability. Agriculture is an important contributor to quality of life in the watershed, producing goods and services that are vital to the health and well-being of its population.

Agricultural issues identified in the Sonoma County General Plan (2008) include fluctuating markets for the dairy and livestock industries and difficulties in maintaining agricultural viability. These challenges extend to other agricultural industries as well. Agricultural viability is especially challenging with ongoing drought conditions and increasing development pressure. Ranchers, hay growers, vineyards, and crop and livestock producers who are hard-pressed to make a living may sell at least part of their holdings for rural residential development, which decreases local food supply reliability and increases development impacts. Some on-farm practices can cause erosion, pollute land and waterways, and contribute GHGs and other pollutants to the atmosphere.

Supporting sustainable and regenerative agriculture in the watershed and improving the industry's viability is significant in preserving the local economy, community development and cultural history. Stewardship of the land is a significant hallmark of this plan and the sentiments of its contributors.

## AGRICULTURAL SUSTAINABILITY

Agriculture continues to be one of the main industries in Sonoma County and offers a significant base for the County's economy as well as a connection to social and historic resources (County of Sonoma Department Agriculture, Weights, and Measures 2019). The total value of crops produced in Sonoma County in 2019 totaled $958+ billion with an estimated "natural capital" (landscape and ecosystem) benefit totaling between $2.2 and $6.8 billion annually (Schmidt and Batker 2015). The Sonoma County General Plan 2020 (Sonoma County PRMD 2008b) contains an Agricultural Resources Element (Element) that provides "policies, programs and measures that promote and protect the current and future needs of the agricultural industry." These provide guidelines for land use and other decisions in agricultural areas to protect existing agricultural practices. The Element also provides policies to assist in the marketing and promotion of agricultural products and provide fair conditions for farm laborers. The current General Plan (adopted in 2008 and amended in 2016) is undergoing a multi-year update process, which has been delayed due to COVID-19 closures, so this Element has not yet been updated.

The concept of sustainability is based upon the principle that management activities should meet the needs of the present without compromising future generations' ability to meet their needs. Agricultural sustainability incorporates four main goals: preservation of environmental systems and processes, protection of cultural resources, economic profitability, and social and economic equity. Stewardship of natural, human, and cultural resources is important. Stewardship of natural resources includes the preservation and rehabilitation of ecological processes such as groundwater recharge, pollutant removal,

pollination services, and nutrient sequestration. Stewardship of human resources includes social concerns such as health and housing conditions for laborers, the needs of rural communities, and long-term consumer health and safety. Stewardship of cultural resources includes protecting culturally significant sites from disturbance or destruction, in addition to providing the means for future opportunities for people to benefit from the resource or sites value. Many agricultural enterprises throughout the county practice stewardship of natural and human resources; examples of such activities include unpaved roads maintenance and repair, riparian revegetation, livestock manure management, and provision of agricultural employee housing.

Conservation easements are a sustainability tool involving natural and human resources – they can preserve ecological processes while supporting the area's agricultural heritage. Private conservation easements are identified in the Sonoma County General Plan 2020 as a mechanism for natural resource and agricultural lands preservation and enhancement in several General Plan policies (Sonoma County PRMD 2008b). At least 1,100 acres of agricultural land under conservation easements exist within or near the City of Petaluma (City of Petaluma, 2021).

Sonoma Ag + Open Space and SLT collaborate with landowners to establish conservation easements on farms and ranches across Sonoma County. Conservation easements help to increase carbon storage capacity, promote groundwater recharge, maintain the County's rural character, create buffers between urban areas, and protect wildlife corridors. The Sonoma Ag + Open Space Vital Lands Initiative identifies high priority areas where conservation easements and other protected lands are needed most to safeguard ecosystem services and natural habitats. In the Petaluma River Watershed, protected farms and ranches stretching from Sonoma Mountain to western Petaluma play a role in maintaining a critical linkage for wildlife movement (Sonoma Ag + Open Space 2021). Many agricultural and rural landscapes around the City of Petaluma also create greenbelts that separate areas of development and reduce urban sprawl (City of Petaluma 2021).

Another tool for keeping land sustainably in agriculture is Williamson Act contracts, which involve the landowner agreeing to maintain land in agricultural or open space condition in exchange for reductions in tax obligations. About 300,000 acres of Sonoma County's agricultural land are under Williamson Act contracts (Sonoma County PRMD 2008a).

Efforts to increase economic sustainability include local farmers' markets and development of specialty and niche products, such as organic crops. In 2019, there were 329 organic producers in Sonoma County registered with the California Department of Food and Agriculture (CDFA); these operations cover nearly 57,000 acres of land (County of Sonoma Department Agriculture, Weights, and Measures 2019). This is an increase of more than 140 organic producers since 2009 (County of Sonoma Department Agriculture, Weights, and Measures 2009). Commodities produced through organic farming and ranching include fruits, vegetables, wine-grapes, meats, dairy, grain, and eggs. Sustainability practices such as organic agriculture can provide financial gain through higher pricing for organic goods as well as benefits to the agricultural lands and surrounding natural areas through resilience against drought and other climate change impacts. Droughts are expected to become increasingly frequent due to climate change, which underscores the importance of water conservation on agricultural lands (see *Ch. 9 Water Supply and Ch.4 Climate Change and Adaptation*).

Not only do sustainable agricultural practices reap long-term local benefit, but they also contribute toward implementation of state goals and programs. The Total Maximum Daily Load for Bacteria in the Petaluma River Watershed (Regional Water Board, 2020) identified confined animal facilities (predominantly cows and horses) as a significant source of fecal indicator bacteria in the watershed, and grazing lands as another source. Confined animal facilities and grazing operations can contribute to attainment of the TMDL by obtaining water quality permit coverage and implementing best management practices.

Agricultural landowners farming along the southern parts of the watershed near the Highway 37 corridors face additional challenges as tidal marsh restoration, difficulties maintaining levees, and sea level rise threaten to take more acreage out of production. Protecting ever-more-vulnerable farmland from the bay is expensive. Buying title or easement over farmland to return it to a natural state is complicated by the fact that public funds are prohibited from paying more than “fair market value”, which does not value wetlands or wildland functions.

Farmland plays a critical role in the success of land conservation and has been recognized statewide for its potential in climate mitigation (see Chapter 4). Specific management practices have been shown to increase the level of carbon uptake by working lands, reducing the amount of carbon in the atmosphere. Farmers should be supported and incentivized to maintain economically viable farms and adopt climate-beneficial management practices to maintain open space and assist with adapting to and mitigating climate change.

## CONSERVATION PLANNING

A conservation plan is a voluntary effort that includes setting goals, inventorying farm/ranch resources, assessing natural resource concerns and evaluating existing management practices. Once the plan is completed, implementing a monitoring program will help achieve goals and evaluate the effectiveness of the management practices.

The purpose of a conservation plan is to provide the landowner with comprehensive documentation of past and present management decisions, and to prioritize management actions for the future. It follows a step-by-step process to meet the producer’s goals and protect or enhance the natural resources within the property and broader watershed.

Conservation plans should be living documents that are revised as needed. Conservation plans and supporting data should be kept on-site at the ranch to be available for easy reference and updating.

The table below describes several resources for BMPs that have widespread acceptance and local applicability. Many of these management activities are supported through funding assistance from agencies such as the NRCS, CDFW, CDFA, SWRCB, DWR and the Sonoma County Energy Independence Program.

Table 6.1 Resources for Agricultural Management Measures.

| Resource | Description | Focus |
|---|---|---|
| *USDA Natural Resources Conservation Service electronic Field Office Technical Guide (eFOTG)* | This comprehensive system contains information specifically developed for Sonoma County. Section III contains information on Conservation Management Systems, which establish standards for sustained use. Detailed information about conservation practices is available in Section IV.<br><br>https://efotg.sc.egov.usda.gov/ | All aspects of agricultural operations – extensive list of irrigation water management measures. |
| *LandSmart* | This regional conservation initiative helps land managers and land owners meet their natural resource goals while supporting productive lands and thriving streams through LandSmart plans and on-the-ground beneficial management practice implementation.<br><br>www.LandSmart.org | All aspects of agricultural operations. |
| *Groundwork – A Handbook For Small Scale Erosion Control in Coastal California, 2nd Edition* | A comprehensive resource detailing erosion control methods for rural and agricultural lands.<br><br>http://www.marinrcd.org/wp/ | Erosion control |
| *Handbook for Forest and Ranch Roads: A Guide for planning, designing, constructing, reconstructing, maintaining and closing wildland roads.* | A comprehensive resource for planning, designing, constructing, reconstructing, maintaining and closing wildland roads.<br><br>http://www.pacificwatershed.com/roadshandbook | Roads |

| | | |
|---|---|---|
| *US EPA National Management Measures to Control Nonpoint Source Pollution from Agriculture* | This technical guidance document contains information on the best available, economically achievable means of reducing agricultural sources of pollution to surface and ground water.<br><br>https://www.epa.gov/nps/national-management-measures-control-nonpoint-source-pollution-agriculture | All aspects of agricultural operations – nutrient, pesticide, grazing, and irrigation water management, erosion and sediment control, and animal feeding operations. |
| *US Forest Service Pacific Southwest Region Water Quality Management for National Forest System Lands in California* | This technical guidance document provides BMPs for timber management, road and building construction, mining, recreation, vegetation, fuels management, watershed management, and range management. Written from an agency perspective.<br><br>https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5362512.pdf | BMPs that address all aspects of USFS activities in California. |
| *California State Water Board Nonpoint Source (NPS) Pollution Control Program* | Multi-tool website that contains a Management Measures Encyclopedia and NPS Guidance in Specific Interest Areas. The encyclopedia is a free online reference guide designed to facilitate understanding of NPS pollution control and provide quick access to resources available on the internet.<br><br>https://www.waterboards.ca.gov/water_issues/programs/nps/encyclopedia/ | All aspects of agricultural operations including erosion and sediment control, animal waste, nutrient management, pest and weed management, grazing management, irrigation water management, groundwater protection, and education/ outreach. Also contains management practices for Riparian Areas. |
| *Sonoma County University of California Cooperative Extension Farm & Ranch Stewardship Web Page* | This web page contains several UC Agriculture and Natural Resources publications to reduce Nonpoint source pollution from agricultural Operations.<br><br>http://cesonoma.ucanr.edu/Livestock_and_Range_Management/Watershed_Management923/General_Watershed_Management_Information/Farm_-_Ranch_Stewardship/ | Water quality management – NPS reduction, vegetative buffer strips, pesticide choice, greenhouse, and nursery management. |

| | | |
|---|---|---|
| *Best Management Practices and Technical Report Guidelines (Revised September 2021)* | BMPs presented in this document are specific to Sonoma County agricultural practices, soil types and weather conditions. Vineyard focused but many BMPs are applicable to other agricultural land uses.<br><br>https://sonomacounty.ca.gov/Agriculture-Weights-and-Measures/Agriculture-Division/Ordinances/Grading-Drainage-Vineyard/ | Control of water quality impacts from accelerated erosion from agricultural sources. |
| *Increasing Carbon Capture on Sonoma County's Working Lands* | This presentation provides a myriad of ways that farmers can increase the carbon storage of their lands.<br><br>https://rcpa.ca.gov/wp-content/uploads/2020/01/Carbon-Sequestration-CAAC-Presentation_Jan-2020.pdf | BMPs related to increasing carbon capture. |

**RURAL RESIDENTIAL**

Rural residential development can influence the watershed through erosion and sedimentation, hydromodification, habitat conversion, nutrient and pesticide runoff, spread of invasive species, and water use. Specific management practices relating to the "rural residential land use" category have not been developed for Sonoma County. However, many of the issues resulting from rural residential development are experienced in a more concentrated manner by urban areas – runoff, flood control, grounds keeping/chemical control, and onsite wastewater treatment systems. Therefore, much of the information about management measures to address conditions resulting from urbanization is applicable to rural residential land use, including water conservation measures.

Two aspects of rural residential development not commonly found in urban areas are the greater presence of unpaved access roads and the presence of the Wildland Urban Interface (WUI). Roads are widely recognized as a significant source of sedimentation (see *Chapter 12, Sediment Sources and Impacts*). Management practices to reduce erosion and sedimentation from unpaved roads vary by location, topography, and slope but several resources exist to support decision making. Table 6.2 below lists several sources for BMP manuals that have widespread acceptance and relevance to local rural residential issues.

The importance of managing wildfire hazards in the WUI has been recognized with large wildfires annually impacting Sonoma County or neighboring regions over the last several years. Catastrophic

wildfires create numerous watershed health impacts such as toxic runoff from burned home sites, erosion from vegetation loss and increased runoff, and loss of habitat. It is important to encourage and incentivize rural landowners to mitigate and plan for wildfire impacts by implementing home hardening, defensible space, and vegetation management BMPs across their rural lands, particularly those properties that fall within the designated WUI areas.

Table 6.2 Resources for Rural Residential Management Measures.

| Resource | Description | Focus |
|---|---|---|
| *USDA Natural Resources Conservation Service electronic Field Office Technical Guide (eFOTG)* | This comprehensive system contains information specifically developed for Sonoma County. The information is mostly intended for large landowners.<br><br>https://efotg.sc.egov.usda.gov/ | Natural resources conservation. Road and trail closure, habitat restoration. |
| *USEPA "National Management Measures to Control Nonpoint Source Pollution from Urban Areas"* | This document provides guidance regarding management measures to reduce nonpoint source pollution from urban activities.<br><br>https://www.epa.gov/sites/production/files/2015-09/documents/urban_guidance_0.pdf | This document provides implementation actions at the municipal scale. |
| *USEPA Protecting Water Quality from Urban Runoff* | This web page gives an overview of how individual dwellings impact a watershed and provides actions individuals can take to reduce NPS pollution.<br><br>http://www.epa.gov/owow/nps/urbanfacts.html#runoff | Reducing NPS pollution through individual, municipal, and planning implementation activities. |
| *California State Water Board Nonpoint Source (NPS) Pollution Control Program* | Multi-tool website that contains a Management Measures Encyclopedia, and NPS Guidance in Specific Interest Areas. The encyclopedia is a free online reference guide designed to facilitate understanding of NPS pollution control and provide quick access to resources available on the internet.<br><br>https://www.waterboards.ca.gov/water_issues/programs/nps/encyclopedia/ | Urban areas: Most information is agency level, however, individual homeowners will find useful information for landscaping and water management.<br><br>Forestry: Homeowners may find useful information |

| | | |
|---|---|---|
| | | regarding road construction, reconstruction, and management.<br>*Education and*<br><br>Outreach: Describes specific practices on the individual household scale. |
| *FishNet 4C Roads Manual* | This document provides guidelines for county road maintenance to protect aquatic habitat and fisheries.<br><br>https://www.marinwatersheds.org/resources/creek-stewardship/fishnet-4c | County road maintenance, some information applicable to homeowners. |
| *Handbook for Forest, Ranch & Rural Roads* | A guide for designing, constructing, maintaining, and upgrading wildland roads.<br><br>https://mcrcd.org/resources/publications | Achieving high quality rural roads with low environmental impact. |
| *Sonoma County Energy and Sustainability Division* | This website provides suggestions for residential and commercial improvements to conserve water and energy.<br><br>https://sonomacounty.ca.gov/General-Services/Energy-and-Sustainability/For-Residents/ | Financial incentives for individual homeowners to implement water and energy saving measures. |
| *Community Soil Foundation – Rebate Program Links* | Links to rebate programs available to landowners in Sonoma County or cities within it.<br><br>https://www.communitysoil.com/rebate-programs/ | Water conservation and energy efficiency rebates. |

| | | |
|---|---|---|
| *Marin County Stormwater Pollution Prevention Program* | This web page contains several publications that provide homeowner-level information about less-toxic pesticides, gardening, and water quality.<br><br>https://www.marincounty.org/depts/pw/divisions/creeks-bay-and-flood/mcstoppp | Reducing toxins in the environment, providing least-toxic pest management to homeowners and schools. |
| *City of Petaluma Water Conservation Programs* | Water conservation programs from the city to help residential and commercial customers conserve water; including rebates, water evaluations, and free water saving devices.<br><br>https://cityofpetaluma.org/water-conservation/ | Water conservation and waste reduction. |
| *Slow it. Spread it. Sink it. Store it! Guide to Beneficial Stormwater Management and Water Conservation Strategies* | Homeowner's and rural residential guide on practical ways to protect property and environment from effects of stormwater runoff.<br><br>https://sonomarcd.org/wp-content/uploads/2017/06/Slow-it-Spread-it-Sink-it-Store-it.pdf | Stormwater management. |
| *Less-Toxic Pest Management: Pesticides and Water Pollution.* | This is an informative brochure about homeowner contributions to water quality impairments.<br><br>http://ourwaterourworld.org/Portals/0/documents/pdf/PesticidesWQ.pdf | Provides tips for homeowner reduction of pesticide use. |
| *Fire Prevention and Post-fire Recovery- Sonoma Resource Conservation District* | This is a website with information about post-fire recovery from the Sonoma RCD as well as numerous links to fire prevention and fire recovery resources.<br><br>https://sonomarcd.org/resources/fire-recovery/ | Fire prevention, post-fire recovery, preparing for winter, erosion control, burned forests. |

| | | |
|---|---|---|
| *CAL FIRE Fuels Reduction Guide 2021* | A 15-page guide about to vegetation management for landowners.<br><br>https://www.fire.ca.gov/media/4jqerfjh/fuels-reduction-guide-final-2021-interactive.pdf | Fuels reduction projects and equipment, community engagement, funding opportunities. |
| *Ready, Set, Go! Wildfire Preparedness for Farmers and Ranchers* | A short brochure about defensible space for agricultural landowners.<br><br>https://sonomarcd.org/wp-content/uploads/2021/04/WildlandFirePreparedness_Farmers_Ranchers.pdf | Defensible space, orchards and groves, croplands, livestock and rangelands. |
| *Living with Fire in Sonoma County- Fire SAFE Sonoma* | A guide to defensible space and home hardening in Sonoma County.<br><br>https://www.firesafesonoma.org/wp-content/uploads/living_with_fire.pdf | Home ignition zone, vegetation management, landscape design, home retrofits. |
| *Wildfire Recovery Resources- County of Sonoma* | List of resources for homeowners and residents impacted by recent wildfires.<br><br>https://socoemergency.org/recover/ | Links to information on neighborhood groups, news and updates, and rebuilding. |

## RECOMMENDED ACTIONS – CHAPTER 6. AGRICULTURAL AND RURAL SUSTAINABILITY

**Recommendation 6.1** – Renew City of Petaluma's Urban Growth Boundary to protect surrounding agricultural lands from increased residential conversion pressure, currently set to expire in 2025.

**Recommendation 6.2** – Promote on-farm best management practices identified by USDA Natural Resources Conservation Service with implementation assistance provided by Sonoma Resource Conservation District.

**Recommendation 6.3** – Promote public support of local agriculture through farmers' markets and outreach campaigns to "buy local" when grocery shopping.

**Recommendation 6.4** – Promote public knowledge about and appreciation of local organizations that support farming, such as Sonoma Ag + Open Space and Marin Agricultural Land Trust.

**Recommendation 6.5** – Provide educational, technical, and financial services to help growers and ranchers understand and comply with applicable agricultural regulations.

**Recommendation 6.6** – Develop LandSmart ranch and farm conservation plans or carbon farm plans to document current and plan for future beneficial management practices.

**Recommendation 6.7** – Collaborate with landowners to design and implement projects to prevent and control soil erosion and enhance soil quality.

**Recommendation 6.8** – Support STRAW (Student and Teachers Restoring a Watershed) program and RCD efforts to restore ecosystems along water channels on working lands.

**Recommendation 6.9** – Improve water use efficiency of irrigation and frost protection systems. Seek out and develop alternative water sources for these uses whenever feasible.

**Recommendation 6.10** – Manage grazing to protect and enhance soil quality, plant communities and water quality.

**Recommendation 6.11 –** Conduct outreach about minimizing the impact of animal waste including confined livestock area runoff management, manure and fertilizer application, and silage storage.

**Recommendation 6.12** – Assist landowners with developing projects to ensure water reliability.

**Recommendation 6.13** – Provide educational, technical, and financial support to help growers and ranchers adopt climate beneficial farming practices that play a vital role in achieving regional climate goals.

**Recommendation 6.14** – Prioritize land conservation efforts that preserve agricultural and rural land identified as part of critical wildlife corridors/linkages or lands within zones predicted to be impacted by sea level rise.

**Recommendation 6.15** – Continue to educate landowners residing in the WUI zones about appropriate wildfire mitigation strategies to make their properties more resilient to wildfire impacts; identify and pursue funding to assist landowners with implementing appropriate BMPs.

# CHAPTER 7. RIPARIAN AND WETLAND ECOSYSTEMS

The Petaluma River Watershed encompasses many tributaries that drain the watershed through a series of marshlands to the San Pablo Bay. Historically, the riparian corridors along these tributaries consisted of willow, alder, oak, and California bay laurel forests with a robust mix of plant diversity forming varying canopy and understory layers. These layers provided shade that benefitted stream temperatures as well as providing critical habitat and food sources for a wide range of wildlife and insects. The riparian corridors further upstream maintained important biological and ecological characteristics of the watershed.

The Petaluma Marsh encompasses the lower 12 miles (19 km) of the Petaluma River and covers 5,000 acres (20 $km^2$) surrounded by approximately 7,000 acres (28 $km^2$) of reclaimed wetlands. It includes tidal marshes, mud flats, and seasonal and managed wetland habitat ecosystems and is one of the last remaining protected wetlands in the state of California and on the west coast.

The complex network of tributaries feeding the Petaluma River and the Petaluma Marsh plays a significant role in maintaining the ecological systems of the region. Terrestrial vegetation and riparian communities constitute an area of tremendous biodiversity, including agricultural areas, grasslands and oak savannas, wetlands, vernal pools, riparian corridors, and both salt and brackish water marshlands. Promoting conservation and enhancement of these important natural lands and environmental services offers direct benefits for improving overall ecological health and water quality in the Petaluma Watershed.

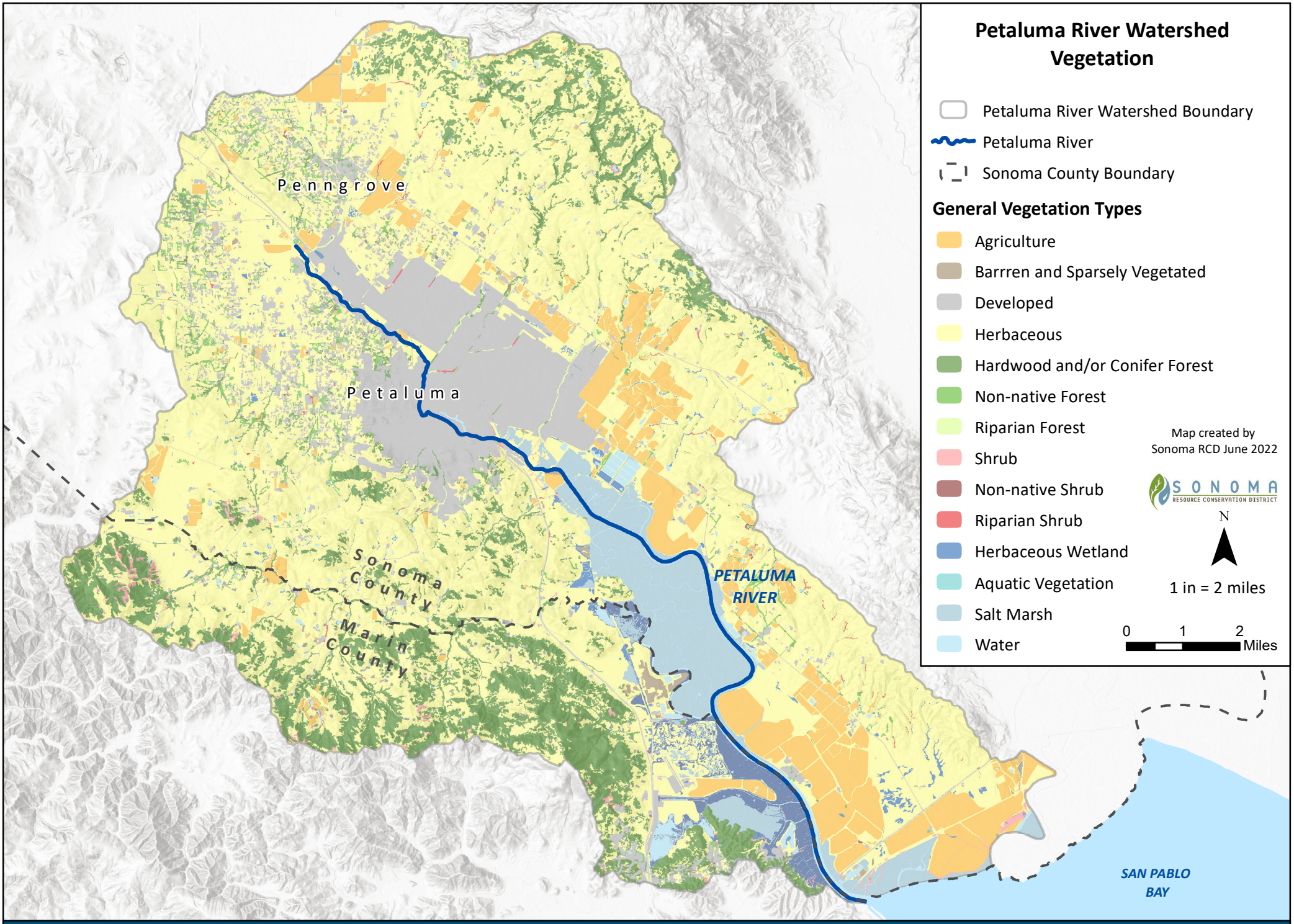


**Fig 7.1. Vegetation in the Petaluma River Watershed.**

Data: Sonoma County Vegetation Mapping and LiDAR Program, Golden Gate National Parks Conservancy (Marin County Fine Scale Vegetation Map)

## HISTORICAL CHANGES TO PLANT COMMUNITIES

In the early 1800s, significant alterations to the landscape began within the Petaluma Watershed as European agricultural practices took hold and California missions were established. Demand for lumber increased and by the 1870s it was estimated that about 50% of the hardwood acreage in Sonoma County had been logged. Historical riparian forest corridors, identified by soil and land grant maps dating back to the early 1900s, provide information on many of the waterways throughout the watershed and how they've changed over time.

Livestock compaction and grazing along these riparian corridors and small tributaries increased in the 1940s, causing little regeneration of natural vegetation. As a result, forest communities became sparse and most creeks in the middle and lower reaches of the watershed have been converted to vegetation offering less canopy cover or annual grasslands. Only pockets of remnant historical vegetation remain. The removal of woody plant cover and shrubs leaves streambanks unprotected and subject to increased erosional processes.

Historically, wetlands were much more prevalent in the Petaluma Watershed than they are today. Tidal wetlands occupied 16,150 acres along the lower Petaluma River and 11,400 acres of non-tidal wetlands were present throughout the valley floor of the watershed (Baumgarten et al. 2018). Tidal wetland conversion to agricultural and industrial/urban use, and water diversion and management (Marshall & Dedrick 1994) changed the landscape dramatically. Nearly all the lands within this area were once tidal salt marsh or tidal brackish marsh. During the mid-1800s the tidelands bordering San Pablo Bay were "reclaimed" for farmland. Conversion of tidelands to farmland occurred under the Swamp Land Act of 1849 (modified in 1850 and 1860). Private individuals were offered land at no cost, provided they would drain and develop these wetlands, which were defined as "wet and unfit for cultivation." Landowners installed a system of levees to keep tidewater out and ditches and pumps to remove stormwater making it possible to farm productively. This resulted in establishing a robust regional agricultural economy supporting hay, grain, pasture, and vineyards. Levees were constructed to keep out the bay waters and the lands were drained and allowed to dry out, rainwater flushed the salts from the land and crops were planted. This Federal wetland policy was reversed in 1988 when the "no net loss" of wetlands policy was adopted. However, by then the area of tidal wetlands had decreased by 58% and non-tidal wetlands by 84%.

A network of wet meadows historically existed in upper parts of the watershed where streams draining from hillsides flowed into the valley and tended to lose a defined channel (Baumgarten et al. 2018). These wet meadow habitats were lost due to agricultural and urban development and associated declines in groundwater levels. Many of the creek channels were lengthened in late 19$^{th}$ and early 20$^{th}$ centuries to improve drainage efficiency or control flooding, with total channel length increasing 50% from historical levels (Baumgarten et al. 2018). A large, contiguous non-tidal wet meadow complex existed on the east side of the Petaluma River in the alluvial plain. Other large wetland complexes included the Laguna de San Antonio (the head of San Antonio Creek) and in the Denman Flat area (the head of the Petaluma River) (Baumgarten et al. 2018). Beyond agriculture, transportation corridors,

residential developments, and industrial infrastructure were built across these areas, leading to greater loss of riparian and marshland habitat.

Even though the Petaluma Watershed sustained a great loss of wetlands, a portion of these areas still remains as open space or under agricultural production. The Petaluma Marsh is the largest contiguous area of historic tidal marsh in the entirety of San Pablo Bay, making it a targeted area regionally for restoration actions. For additional information related to the history and ecology of the Petaluma Watershed, please see the 2018 *Petaluma Historical Hydrology and Ecology Study (citation)*.

## CURRENT CONDITIONS

Riparian corridor vegetation currently consists of a variety of tree species that include Coast live oak, valley oak, and less common species such as Oregon ash, walnut, Fremont cottonwood, white alder, and cork oak. The understory in the riparian corridor is dominated by non-native species such as brome grasses, Italian ryegrass, English and Algerian ivy, periwinkle, Himalayan blackberry, Harding grass, bristly ox-tongue, and sweet fennel (Horizon Water and Environment 2020).

According to the NOAA Multispecies Recovery Plan for California Coastal Chinook Salmon, Northern California Steelhead and Central California Coast Steelhead (NMFS 2016), "only 50% (5 of 10) of major streams [within the Petaluma River Watershed] met optimal criteria (>70% canopy averaged for the stream). Specifically, Adobe, Washington, and Ellis Creek subbasins and their tributaries rated Fair (50-69% canopy), though the native structure of the riparian zone has been highly altered throughout the watershed. Only 7% of the riparian zone is made up of small trees in the class of Hardwood Forest and Hardwood Woodland species; large trees for bank stabilization and the future recruitment of large wood are essentially lacking in this watershed. The surrounding forest, which was historically present, was cleared for livestock and dairy operations."

Current and future impacts to the conditions of riparian zones can be remedied by incentivizing agricultural landowners to re-establish hardwood riparian zones and increase canopy cover through grant funding and technical assistance for implementing restoration. It is also important to educate rural and agricultural landowners about the important ecosystem services provided by these natural areas and the value of protecting and restoring them. Future expansion of agricultural production should encompass sustainable land management practices that preserve critical riparian areas through setbacks such as those defined within the Sonoma County Riparian Corridor Ordinance (https://sonomacounty.ca.gov/PRMD/Regulations/Riparian-Corridors/).

Sonoma Water performs vegetation management in several tributaries of the Petaluma River including Lichau, Corona, Capri, Washington, Adobe, and Thompson Creeks. Sonoma Water management of these tributaries balances the value of riparian corridors for streambank stability, canopy, and potential food sources for fish, wildlife, and insects with human needs for flood protection, flood conveyance capacity, and public safety concerns such as fire risk, improved visibility, and a reduction of homeless encampments. Control methods include pruning, mowing, grazing, and herbicide application to manage problematic vegetation. Management activities usually occur from June 15 to October 31 (Horizon Water and Environment 2020).

The Vital Lands Initiative report identifies most of the Petaluma River tributaries, particularly in the northwest and eastern portions of the watershed, as “High Priority Riparian Habitat” and calls for increased protection of these high-value areas as well as headwater streams (Sonoma Ag + Open Space 2021). The majority of the Bayland marshlands in the southern portion of the watershed as well as smaller networks of wetlands in the northern, upper portion of the watershed are also highlighted as “High Priority Wetlands”. The report emphasizes the importance of protecting these high-priority wetland zones “including estuaries and marshes, vernal pools, and other freshwater wetlands (Sonoma Ag + Open Space 2021).”

Compared to the rest of the San Francisco Estuary, the Petaluma River Watershed is largely undeveloped. The region currently supports 6,810 acres of tidal wetland, 90 acres of wet meadow, and 20 acres of vernal pools (Baumgarten et al. 2018). The ancient Petaluma Marsh is the largest intact tidal marsh in the estuary (Goals Project 2015). Recently, restoration efforts have begun to bring tidal flows back into some of the former salt and brackish marsh areas that have been cut off from flows for the last 100 years or more.

Land in the Baylands region of Petaluma River is in both private and public ownership and supports local agricultural operations and infrastructure (i.e. roads) in addition to important habitat found only in this portion of the watershed. Well-developed levee infrastructure prevents these lands from flooding and requires ongoing maintenance. Privately owned, operated, and maintained levees offer protection of major transportation routes and prevent greater flooding in upland areas. Agricultural baylands, especially portions that have seasonal ponds, provide habitat for several species of wildlife. Farmers who continue to produce crops in the baylands may be able to improve wildlife habitat by using management practices recommended by NRCS, CDFW, and other organizations.

In 1974 the US government designated over 19,000 acres bordering the San Pablo Bay as the San Pablo Bay National Wildlife Refuge, overseen by the USFWS. This refuge lies along the north shore of San Pablo Bay in Sonoma, Solano, and Napa Counties protecting migratory birds, wetland habitat, and endangered species. The refuge includes open bay/tidal marsh, mud flats, and seasonal and managed wetland habitat supporting one of the largest wintering populations of Canvasbacks on the west coast, protects the endangered salt marsh harvest mouse, and the Ridgeway's Rail (formerly California Clapper Rail). Approximately 2,200 acres of the refuge lies at the southernmost end of the Petaluma River Watershed near the intersection of Highway 37 and Lakeville Highway.

The CDFW Petaluma Marsh Wildlife Area consists of a variety of discontinuous parcels of tidal marshlands of different ages and physiography along the western side of the Petaluma River. The largest parcel is the Petaluma Marsh, the largest and least disturbed example of ancient tidal marshland in California. It includes the only examples of undisturbed high-order tidal marsh drainage systems that were historically typical of tidal marshland in much of the region. These drainage systems are complexly dendritic, and include pronounced natural levees along the largest channels, extensive slump blocks on the large- and medium-sized channels, and large, natural, tidal marsh ponds on drainage divides. Petaluma Marsh is bordered on the west by San Antonio Creek, which drains a privately-owned rural watershed used for cattle grazing, and Neils Island, which is a hilltop surrounded by existing and diked tidal marshlands.

Petaluma Marsh provides an excellent opportunity to restore large patches of tidal marsh, some as isolated marsh islands and others with natural transitions to the adjacent uplands. Marsh and tidal restoration, and preservation of important agricultural lands has been achieved by local, state, and federal agencies including SLT, Sonoma Ag + Open Space, Point Blue, California Coastal Conservancy, CDFW, and USFWS. There are large areas that are likely suited for management as diked wetlands for shorebirds and waterfowl. The wetlands, waterways, and grasslands surrounding the river corridor are habitat for a wide variety of native fauna and flora, including several state and federally protected species. Protected species include: the Delta smelt, green sturgeon, Sacramento splittail, steelhead trout, and Chinook salmon, California black rail, Ridgeway's Rail, and salt marsh harvest mouse.

Restoring tidal marsh in this watershed would greatly expand the area of shallow channel habitat for many fish species. Increased tidal prism would also enlarge existing deep channels to the benefit of fish and diving ducks. Increasing the area of tidal marsh would expand suitable tidal marsh habitat for endangered tidal marsh species such as the Ridgeway's Rail and the salt marsh harvest mouse. Restoring marsh at the periphery of the Baylands, where natural transitions to adjacent uplands exist, would benefit several rare plants, as well as birds, mammals, and amphibians that depend on the marsh/upland transition zone. Large areas of managed diked wetlands provide important roosting and foraging habitat for shorebirds and waterfowl.

Throughout the watershed, large scale restoration and planning efforts have occurred to identify climate change mitigation opportunities for riparian and tidally influenced areas. Sea level rise puts wetlands at a high risk for habitat loss and jeopardizes land use with more frequent inundation of tidal waters and levee breaches. Predicted changes to sea levels and climatic conditions should be taken into consideration for planning and implementing future restoration and land preservation efforts within this watershed, particularly in the Baylands.

**FUTURE CONDITIONS**

In the next 50 to 100 years about 3-4 feet rise is expected and in 200 years seas could rise more than 10 feet. We need to start now and work hard over the next 10-20 years to save the SF Bay shorelines and Petaluma Marsh. These are the methods currently recommended for the entire SF Bay region to prepare our wetlands for rising sea levels:

- Restore estuary-watershed connections.
- Design complexity and connectivity into the Baylands landscape.
- Restore and conserve complete tidal wetlands systems.
- Restore Baylands to full tidal action prior to 2030.
- Plan for the Baylands to migrate.
- Actively recover, conserve, and monitor wildlife populations.
- Develop and implement a comprehensive regional sediment management plan.
- Invest in planning, policy, research, and monitoring.

- Develop a regional transition zone assessment program.
- Improve carbon management to prevent further subsidence, increase organic matter accumulation, reduce GHG emissions, and sequester more carbon.

Most of these concepts of meeting the challenge of rising sea level is to use sediments from dredging waterways with additional sediment from the bay and placing them where needed. There are several other methods that can be used around the bay including modifying beaches and storm walls, but sediment layering seems to be the most cost efficient and effective. The volume of sediment needed is quite large and will take long range planning and funding.

Innovative approaches to making managed ponds and marshes more resilient could be pursued for retrofitting existing diked baylands or constructing new ones. These might include designs for more flexible water-control structures or water management configurations that can accommodate changes in sea level. Also, there may be ways to allow the bathymetry of managed ponds and marshes to rise with sea levels by capturing sediment, which could ameliorate the need for reinforcing levees and pumping water.

Habitat types will naturally shift over time due to sea-level rise, salinity changes, and restoration. To ensure that the habitat needs of waterbirds are being met, a large-scale, long-term planning and monitoring effort across the bay, delta, and Central Valley (and ideally the rest of coastal California) is needed. The reliance of Pacific Flyway waterbirds on bayland habitats is partly due to the extensive loss of wetlands in the Central Valley (particularly the delta) and other parts of coastal California.

Nature Based Solutions (NBS) are the most cost-effective means of long-term strategies.

## INVASIVE SPECIES

Invasive, non-native and/or exotic species are any organism including animals, plants, and microorganisms that are not native to a specific area. Exotic and invasive species can have many negative impacts on the natural environment, human health, and the economy. Introduced species often create competition for native or vulnerable species, cause habitat destruction, inflict disease or illness, and prey on native species, occasionally leading to extinction. Invasive species weaken natural habitat functions and are considered one of the leading causes of biodiversity loss in aquatic and terrestrial ecosystems. If left unchecked, invasive species can outcompete native species and establish a dominant presence in the environment. Examples of some common invasive plant species are Himalayan blackberry (*Rubus armeniacus*), giant reed (*Arundo donax)*, water primrose (*Ludwigia peploides*), pepperweed (*Lepidium latifolium*), and non-native *Spartina spp.* Examples of some common invasive non-native animal species are common carp (*Cyprinus carpio*), black bullhead (*Ameiurus melas*), American bullfrog (*Lithobates catesbeianus*), red-eared slider (*Trachyemys scripta elegans*), red swamp crayfish (Procambarus clarki), and pet varieties of snakes, lizards, and fish released into the environment.

## RECOVERY PLANS

### U.S. Fish and Wildlife Service Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California

The 2013 USFWS *Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* outlines the highest priority areas for protection and/or restoration of tidal marsh and associated habitats. Following is a list of ecosystem-level recovery actions identified by USFWS in the 5 identified recovery units, including the San Pablo Bay Recovery Unit.

1. Acquire existing, historic, and restorable tidal marsh habitat to promote the recovery of listed species and the long-term conservation of species of concern and other tidal marsh species.

2. Manage, restore, and monitor tidal marsh habitat to promote the recovery of listed species and the long-term conservation of species of concern and other tidal marsh species.

3. Conduct range-wide species status surveys/monitoring and status reviews for listed species and species of concern.

4. Conduct research necessary for the recovery of listed species and the long-term conservation of species of concern.

5. Improve coordination, participation, and outreach activities to achieve recovery of listed species and long-term conservation of species of concern.

Specifically, the Petaluma Watershed is identified as a priority restoration area for "prompt implementation of tidal restoration projects" in this Recovery Plan for areas of "Petaluma Baylands, on both sides of the river and toward the mouth, with opportunities for expanding habitat around rare species populations and restoring gradual gradients from high marsh well into uplands (U.S. Fish and Wildlife Service 2013)."

### The Baylands and Climate change, What We Can Do (Baylands Ecosystem Habitat Goals Science Update 2015)

The 2015 revision of the Goals Update documents the progress of the 1999 Baylands Ecosystem Habitat Goals and identifies the changing opportunities, new science, lessons learned, and current conditions for continued Baylands restoration. The Petaluma River section is identified as Baylands Segment F, comprising the northwestern edge of San Pablo Bay and lands in the lower Petaluma River drainage. The Goals Update details unique opportunities, segment features, drivers of change, and considerations for restoration in addition to recommended actions. The list of Recommended Actions below is specific to the Petaluma River segment of the 2015 Goals Update.

For Habitats and the Landscape in General:

- Protect and restore tidal marsh on both sides of the Petaluma River, particularly on the eastern side, between Highway 37 and False Bay (Dustman Road), which is already vulnerable to flooding.

- Protect, restore, and manage agricultural lands and other open space to reestablish a transition zone and buffers adjacent to tidal marsh and to provide space for landward migration. Create transition zone habitats on gentle slopes in front of flood-risk-management levees.

- Enhance the stream–marsh transition zone between San Antonio Creek and tidal habitats, one of the few places where such restoration can take place.

- Consider ways to increase the sediment supply to tidal baylands. Reconnect stream channels into marshes and augment the trapping efficiency of tidal baylands to foster accretion, as appropriate.

- Protect and enhance moist grassland habitats on the eastern portion of this segment.

- Elevate Highway 37 to a causeway, and remove, realign, or elevate other barriers (such as the SMART rail) to achieve unimpeded tidal and other hydrological connectivity.

For Particular Wildlife Populations:

- Identify, conserve, and manage selected refugia for native bayland plants. Focus on unique or core populations of uncommon plants, especially in low marshes.

- Reduce the runoff of agricultural contaminants and nutrients from agricultural activities to improve water quality in the adjacent wetlands.

- Control perennial pepperweed invasions in otherwise intact tidal brackish marsh to prevent a loss of high-marsh plant diversity.

- Continue to control invasive Spartina in the Petaluma River and other tidal areas in this segment.

### Petaluma River Baylands Strategy

The 2022 *Petaluma River Baylands Strategy* focuses on the tidal areas of the Petaluma River, identifying opportunities and constraints for restoration and adaptation of a changing tidal landscape due to sea level rise and climate change. Sonoma Land Trust (SLT), San Francisco Estuary Institute (SFEI), Point Blue Conservation Science, Ducks Unlimited, and SRCD (the project team) began developed specific goals and objectives for the adaptation and resilience of the Petaluma River Baylands based on the goals identified in the 1999 *Baylands Habitat Ecosystem Goals Report* and the 2015 update

*The Baylands and Climate Change: What We Can D*o. The project team utilized existing sources of information to summarize existing conditions in the region, including the major groups of species and habitats to be targeted for conservation and restoration as well as the essential ecological processes that promote and sustain them.

Using modeling tools, the project team assessed projected changes in the water levels, sediment supply, and geomorphology of the Petaluma River over the next century to illustrate vulnerabilities of habitats (e.g. tidal to subtidal), agricultural lands, and other infrastructure with and without actions to increase resilience and promote strategies for adaptation. These highlighted vulnerabilities identified future actions to build resilience and promote adaptation including acquisition, restoration, and changes in management. Components of this assessment included extensive community and stakeholder outreach and geomorphic and landscape analysis.

Stakeholder input, future vulnerabilities, and model results were considered to provide a detailed opportunities and constraints analysis. Opportunities include, the acquisition of easements and new parcels (both tidal marsh, adjacent upland, and freshwater wetlands areas), restoration of private and public land, beneficial reuse of dredge materials, and changes in management for the benefit of wildlife habitat.

### The Convention on Wetlands (Ramsar Convention)

Negotiated in the 1960s, this intergovernmental treaty provides a framework for national action and international cooperation for the conservation of wetlands. The Convention on Wetlands is the oldest among the modern global intergovernmental environmental agreements (City of Petaluma undated). Forty sites within the United States have received the Ramsar designation, deeming them as wetland sites of international importance.

In 2018, the U.S. Fish and Wildlife Service included several locations with the Petaluma wetlands under a larger San Francisco Bay Ramsar designation. These sites are selected and designated based on the international significance of their ecology, botany, zoology, limnology, or hydrology (City of Petaluma undated). Those represented in Petaluma are:

- Alman Marsh tidal wetlands
- Shollenberger Park wetlands
- Gray's Marsh tidal wetlands
- Ellis Creek Water Recycling Facility wetlands
- Hill Property tidal wetlands

## RECOMMENDED ACTIONS – CH. 7 RIPARIAN AND WESTLAND ECOSYSTEMS

**Recommendation 7.1 –** Partner with the Federated Indians of Graton Rancheria to incorporate Traditional Ecological Knowledge and stewardship practices in the planning, decision making, and management surrounding restoration and stewardship of natural and cultural resources, especially surrounding the planning and implementation of activities that may disturb sacred sites. Practitioners engaging with tribes should communicate early on and clearly with Tribe on how shared knowledge and resources will be maintained and safeguarded to ensure confidentiality in documentation, reporting, and conversations.

**Recommendation 7.2** – Revegetate riverbank from upper marsh to northern reach with cooperation of city to increase habitat and prepare for future flooding and sea level rise.

**Recommendation 7.3** – For Petaluma Marsh:

a) Restore large patches of tidal marsh along the entire shoreline of San Pablo Bay, especially near mouths of sloughs and major streams using nature-based solutions.

b) Allow natural processes such as flooding and laying down new layers of sediment.

c) Reuse dredge material where sediment is needed; this practice is included in the companion document to this plan, the Petaluma Watershed Action Plan.

d) Bury large logs to create mini dikes that break wave action and provide backside habitat protection.

e) Move dikes back in "retreat."

**Recommendation 7.4** – Complete large wetland restoration projects to buffer tidal flooding and sea level rise.

**Recommendation 7.5 –** Manage, restore, and monitor tidal marsh habitat to promote the recovery of listed species and long-term conservation of species of concern and other tidal marsh species.

**Recommendation 7.6** – Purchase privately owned parts of the Petaluma Marsh and start restoration.

**Recommendation 7.7** – For marsh landowners:

a) Establish managed marsh or enhanced seasonal pond habitat (especially for shorebirds) on agricultural baylands that are not restored to tidal marsh.

b) Establish managed marsh or enhanced seasonal pond habitat (especially for shorebirds) on agricultural baylands that are not restored to tidal marsh.

c) Create small diked ponded areas adjacent to levees where possible.

d) Work with private landowners currently doing an agricultural service in the lower Petaluma River to shift how they manage their dikes.

e) Instead of building bigger, higher front dikes, experts are recommending moving the dike back and grading the land in front with a gradual slope that breaks wave action and provides space for marsh habitat that slows water energy from reaching the main dike.

**Recommendation 7.8** – In agricultural upland areas:

a) Allow ponding in field depressions for shorebirds and waterfowl.

b) Create small diked ponded areas adjacent to levees where possible.

c) Encourage growth of vegetation along fence rows or field edges to provide habitat for small birds and mammals.

d) Delay spring harvest of oat-hay as late as possible to avoid nesting waterfowl.

e) Fence cattle from wetland areas during wet periods.

f) Increase the practice of rotational grazing to encourage a more diverse grassland habitat.

**Recommendation 7.9 –** In planting and restoration projects, incorporate and utilize native vegetation and plants that are of cultural significance to Federated Indians of Graton Rancheria.

**Recommendation 7.10 –** Test various planting palettes and methods for restoring marsh edges and dikes, for example, the Shollenberger Levee Planting Project by STRAW.

**Recommendation 7.11** – Prepare and distribute information to the public about the habitat needs of native species and how watershed residents can help with recovery efforts.

**Recommendation 7.12** – Revegetate high and medium priority riparian sites with cooperative landowners. Project 9, Washington Creek Enhancement, prioritized in the companion document to this plan, the Petaluma Watershed Action Plan, will partially fulfill this recommendation.

**Recommendation 7.13 –** Help landowners apply for cost share programs to implement stream enhancement plans and riparian revegetation projects.

**Recommendation 7.14 –** Manage livestock access to the creeks, especially during the wet season and assist landowners to develop grazing plans and exclusion zones.

**Recommendation 7.15 –** Conduct community outreach and provide technical assistance to landowners to help manage and protect riparian areas.

**Recommendation 7.16** – Develop LandSmart ranch and farm water quality plans, in collaboration with landowners, to document current and plan for future beneficial management practices.

**Recommendation 7.17 –** With willing landowners, establish managed marsh or enhanced seasonal pond habitat (especially for shorebirds) on agricultural baylands that are not restored to tidal marsh. Project 5, King Creek Wetland Enhancement, which is prioritized for implementation in the companion document Petaluma Watershed Enhancement Plan, partially implements this recommendation.

**Recommendation 7.18 –** Enhance riparian habitat and, where possible, enhance marsh/upland transitions and provide buffers for anticipated climatic drift of habitats.

**Recommendation 7.19** – Prepare and distribute information to the public about the habitat needs of special status species and how watershed residents can help with recovery efforts.

**Recommendation 7.20** – In agricultural areas create small diked ponded areas adjacent to levees where possible.

**Recommendation 7.21** – In agricultural areas, encourage native vegetation along fence rows or field edges to provide habitat for small birds, mammals, and pollinators.

**Recommendation 7.22** – In agricultural areas, exclude cattle from wetland areas during wet periods.

**Recommendation 7.23 –** In agricultural areas, increase the practice of rotational grazing to encourage a more diverse grassland habitat.

# CHAPTER 8. FISH AND WILDLIFE RESOURCES

The Petaluma Watershed is unique in the San Francisco Bay Area in that there are relatively low levels of urbanization and no dams in the watershed. Although these points are very positive, there have been extensive land modifications that have altered the watershed and data suggests that current salmonid populations do not represent once abundant historical populations.

Major land modifications from urbanization, agriculture, and road development have led to alterations to the estuary, flood plain, and river channel. High road densities within the riparian zone have altered sediment transport, limiting spawning gravel recruitment and quality. Additionally, the riparian canopy has been reduced to less than 70% in Adobe, Washington, and Ellis creeks (CDFW 2007). These land changes have affected habitat conditions in many ways and have resulted in stressors that adversely affect salmonid habitat.

Despite land modifications and alterations, the Petaluma Watershed supports many fish and wildlife species. The estuary and salt and freshwater wetlands provide a dynamic patchwork of diverse aquatic habitats that play a key role in the life cycle of migratory and resident birds and fishes. Restoration of a naturally functioning ecosystem with its component elements as described in *Chapter 7. Riparian and Wetland Ecosystems* is consistent with the Plan's goals of maintaining and improving water quality, riparian function, and habitat value.

**FISH**

The estuary serves as a migratory route and nursery area for steelhead trout (*Oncorhynchus mykiss*), Chinook salmon (*Oncorhynchus tshawytscha*), striped bass (*Morone saxatilis*), green sturgeon (*Acipenser medirostris*), and American shad (*Alosa sapidissima*). These anadromous fish spend most of their adult lives either in the lower bays of the estuary or in the ocean. Resident fish in the estuary include delta smelt (*Hypomesus transpacificus*), longfin smelt (*Spirinchus thaleichthys*), Sacramento splittail (*Pogonichthys macrolepidotus*), catfish (*Siluriformes*), largemouth bass (*Micropterus salmoides*), black bass (*Micropterus salmoides)*, crappie (*Pomoxis nigromaculatus*), and bluegill (*Lepomis macrochirus*).

Of particular interest in the watershed is the status of salmonids such as steelhead trout, which are part of the Central California Coast (CCC) Distinct Population Segment (DPS). CCC steelhead were federally listed as threatened under the Endangered Species Act on August 18, 1997 and critical habitat was designated for the Petaluma River and its tributaries on September 2, 2005.

According to the California Department of Fish and Wildlife (CDFW) and the National Marine Fisheries Service (NMFS), the Petaluma River is a low gradient stream that would not have historically supported coho or Chinook salmon. Chinook salmon are generally found in much bigger river systems such as the Sacramento River. Although it is unknown if the Petaluma Watershed historically supported Chinook, Chinook have been documented and are currently returning to the watershed. Genetic testing has not been conducted on the returning Chinook, but the current theory is that these fish are strays entering San

Pablo Bay that get “lost” on their way to the Sacramento River. Chinook that are returning to the Napa River system are produced by the Feather River Hatchery in the Central Valley and it is possible that this could also be the case for Chinook in the Petaluma system. To date, it is unknown if Chinook salmon are successfully spawning or whether there is a self-sustaining population in the watershed. More comprehensive monitoring is necessary to determine the status of Chinook and the necessity for habitat enhancement (Amanda Morrison, Personal Communication, May 29, 2013).

There is limited information available about the historic and current numbers of steelhead in the Petaluma River Watershed. However, the low elevations, valley confinement, and marsh habitat connected to the San Francisco Bay suggest that in the past steelhead were plentiful. A CDFW (formerly CDFG) survey conducted in 1968 found juvenile steelhead in Adobe Creek at an estimated 150 individuals per 30 meters (Leidy et al. 2005). Bill Cox, a biologist (retired) with CDFW, believes that steelhead were historically found in Lichau, Adobe, and San Antonio creeks, and possibly in Lynch, Willow Brook, and Thompson creeks. Between 1987-2012, in surveys conducted by United Anglers of Casa Grande High School (UACGHS) in Adobe Creek, the highest number of adult spawners observed was 60 individuals (UACC 2012). CDFW conducted habitat assessments across major tributaries in 2007 and found juvenile steelhead present in most anadromous reaches. NOAA’s 2016 Final Coastal Multispecies Recovery Plan for California Coastal Chinook Salmon, Northern California Steelhead and Central California Coast Steelhead (Recovery Plan) sets a recovery target of 2,100 spawning adults for the Petaluma River Watershed during winter runs (NMFS 2016).

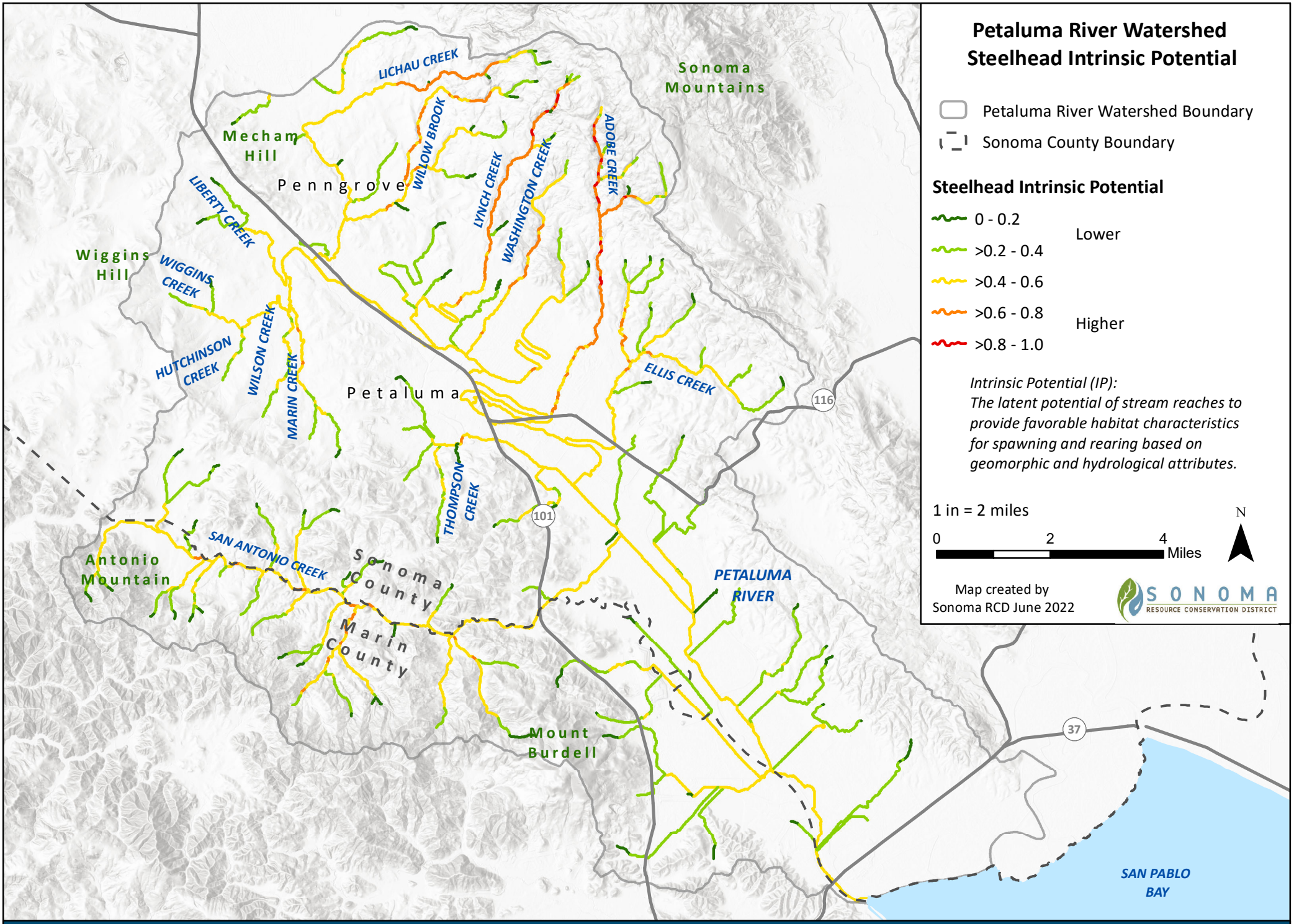


**Fig 8.1. Intrinsic Potential for Central California Coast Steelhead in the Petaluma River Watershed (data updated 2018).**

Data: NOAA Fisheries Southwest Fisheries Science Center, Santa Cruz, CA. NOAA Fisheries West Coast Region, Santa Rosa, CA. CDFW BIOS Database.

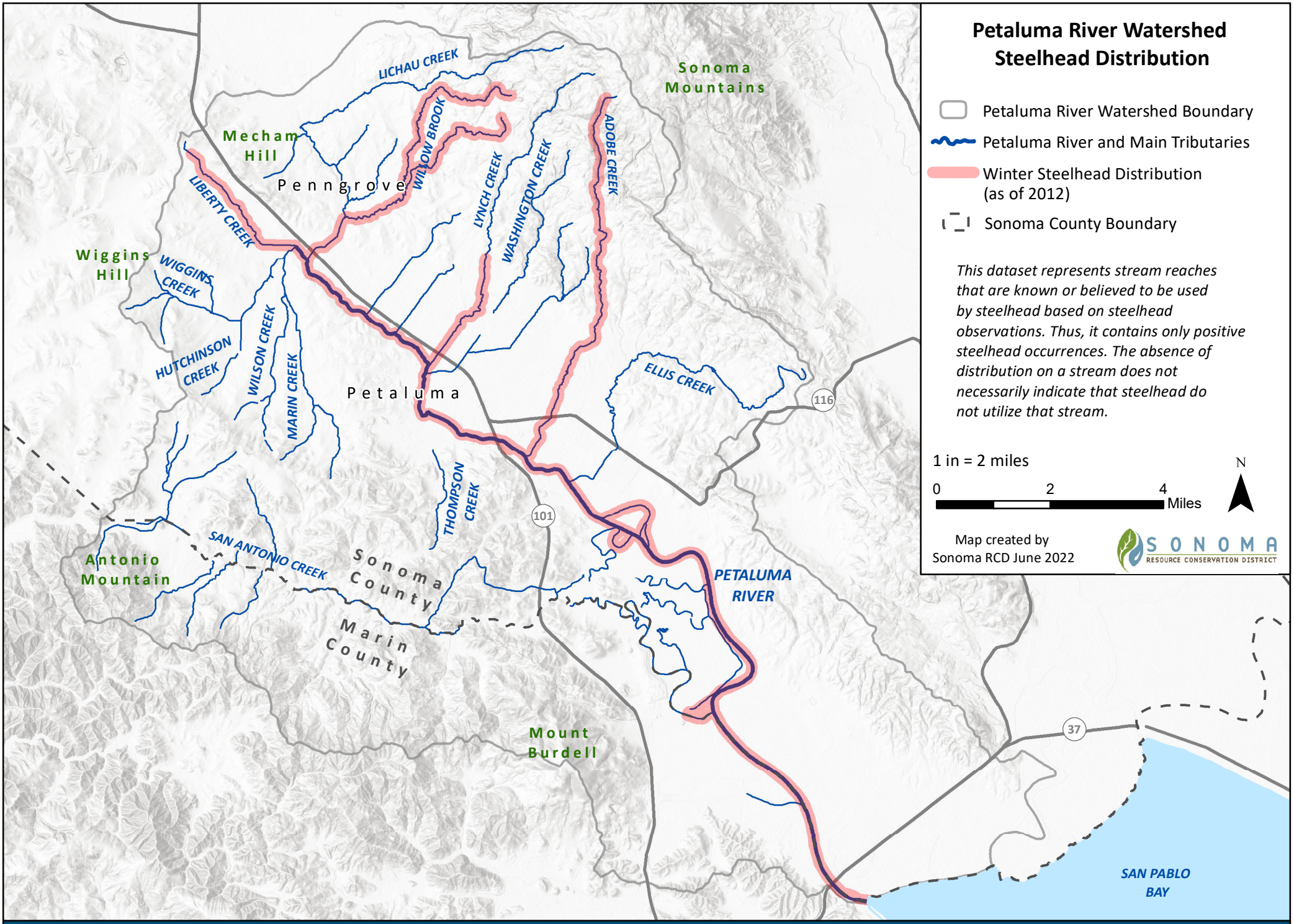


**Fig 8.2. Winter distribution of Central California Coast Steelhead in the Petaluma River Watershed (data updated 2012).**

Data: CDFW BIOS Database. Aquatic Species Observation Database (ASOD)

## Conservation Efforts

The Recovery Plan provides general recovery strategies for steelhead in the Petaluma River Watershed. The priority recovery actions include: “improving riparian habitat and canopy cover, reducing the input of sand and silt, improving stream flows in tributaries, removing passage barriers, addressing water pollution problems, and increasing population numbers through supplementation efforts following significant habitat restoration to address the above issues. San Antonio, Ellis, Adobe, Lynch, Lichau, and Willow Brook creeks are all high priority creeks to begin implementing recovery actions.”

The United Anglers of Casa Grande High School (UACGHS) was developed as an educational monitoring program in 1983. Additional program efforts to improve survival of steelhead and Chinook salmon were established in 1993. Through the expanded program, students and program leads conduct salmonid-focused surveys in Lynch and Adobe creeks.

Students have observed adult steelhead in Adobe, Lynch, and Lichau creeks. Steelhead redds (a salmonid nest for eggs) have been observed only in Adobe and Lynch creeks. However, the presence of steelhead young-of-the-year in Lichau Creek indicates that successful spawning has occurred despite no redd sightings. Adobe Creek historically has the highest number of total steelhead observations.

During spawner surveys conducted by UACGHS from 1987 to 2007 in Adobe Creek, the highest number of adult steelhead spawners observed was 60 individuals (UACGHS 2003). Over the last three years, spawner surveys have continued, but only Adobe Creek has had salmonid presence. Surveys did not record spawners, but young-of-the year have been observed in small numbers during later surveys, indicating that some spawners had been present. This causes concerns that Adobe Creek is the creek rearing the majority of the steelhead in the Petaluma Watershed. In 2007 CDFW conducted watershed wide habitat assessments to document habitat conditions. During these assessments, juvenile steelhead were observed in many of the streams surveyed (NMFS 2016). Since then, drought, low flow conditions and limited land access has created challenges for steelhead monitoring and therefore it is difficult to determine where they are successfully spawning.

The first Chinook salmon was observed in 1987 in Adobe Creek and they have been observed returning every year since. Chinook salmon are primarily observed in the confluence of Adobe, Lynch, Lichau, Ellis, and Washington creeks and the Petaluma River. At times, they have been observed as high in the watershed as the Penngrove area of Lichau Creek.

The UACGHS Hatchery reared Chinook salmon in the watershed from 1994-2010. The hatchery was instructed to cease those rearing operations by CDFW due to feedback from regulatory agencies speculating that there is a lack of habitat for spawning Chinook in the Petaluma Watershed, and with no data on the genetic origins of the fish, concerns arose that these fish may not be native Petaluma Watershed populations but rather strays from Central Valley fish runs. No juvenile Chinook salmon have ever been released in the Petaluma River Watershed, rather they were released directly into the San Francisco Bay. More recently, the hatchery has reared steelhead for the Warm Springs Hatchery in the Russian River Watershed (Hubacker, Personal Communication, June 5, 2013). In 2022, UACGHS was issued a Section 10 permit by NMFS and they are beginning to implement a Rescue Rearing Management Plan for CCC steelhead in the Petaluma Watershed.

Conditions of this permit and plan were predetermined by NMFS based on common fish sampling practices and previously conducted studies. Adobe, Lynch, Lichau, Willow Brook, and San Antonio creeks will be monitored and sampled at the beginning of the dry season, before pools begin drying and conditions become lethal for juvenile fish survival. Fifty percent of the young-of-the-year observed during sampling efforts will be collected from the creek and transported to the hatchery facility to be reared for one year. The remaining fish will be left within the sampling location.

The fish collected will be reared for one year at the hatchery. At this time, the fish will be considered a smolt (age class that is physiologically ready for ocean conditions) and ready for outmigration to the ocean. These smolts will be returned to the creeks they were collected from, allowing for acclimation and imprinting of native water, and naturally out-migrate to the bay and ocean.

The rescue portion of this plan includes relocating juvenile young-of-the-year to suitable summer habitat (in locations known to sustain viable conditions throughout the dry months) once the imminent threat of dewatering, lethal temperatures, and lethal dissolved oxygen levels near. Adobe, Lynch, Lichau, and Willow Brook creeks will be sampled for rescue efforts. San Antonio Creek will not be sampled but may be used as a control for evaluating the effectiveness of these efforts. Fifty percent of the fish sampled will be relocated to suitable summer habitat. The remaining fish will have DNA samples collected and returned to the location they were collected from.

These programs will be evaluated for effectiveness after multiple seasons through close monitoring of habitat conditions, fish abundance, and fish survival. As DNA samples will be collected from all fish, the unique opportunity will be present to compare survival, genetic relatedness, return rates, and location-specific trends based on watershed of origin. These data will increase the understanding of the Petaluma Watershed population of CCC steelhead for future conservation support and action.

## Limiting Factors and Stressors

NMFS (2016) rates several habitat indicators as Poor through the Conservation Action Planning (CAP) process for steelhead.

- Habitat Complexity (all indicators): This includes lack of pools and riffles and shelter complexity. Threats to these conditions include agriculture practices, channel modification, and residential and commercial development.

- Floodplain Connectivity: Historic sloughs which provided complex winter rearing habitat are diked, or flanked by levees, with significant agricultural development. Urban development and agricultural lands encroach upon the historic floodplain and road building, culverts, and grazing have led to severe channel incision. Threats that contribute to these conditions include agriculture, channel modification, residential and commercial development, and roads and railroads.

- Impaired Water Flow (Redd scour and baseflows) and Quality (Turbidity and toxicity): This includes channel incision that contributes to the retention of spawning gravels and shelter as they are mobilized during high flow events, and consequently providing a high potential for redd scour. The threats contributing to these conditions include agriculture practices, channel modification, and roads and railroads.

- Riparian Vegetation: The major tributaries lack vegetation and canopy as well as hardwood forest trees that could provide future LWD to the creek to increase habitat complexity. Threats contributing to these conditions include agriculture practices, channel modification, livestock farming and ranching, residential and commercial development, roads and railroads, and severe weather patterns and climate change.

- Gravel Quality: This includes gravel embeddedness which can impact the survivability of incubating eggs through decreased oxygenation, prevention of release of metabolic wastes from the redd, and inhibiting emergence of alevins. Contributing land uses include livestock farming, ranching, roads, and railroads.

- Road Density: Altered sediment transport due to hydrologic changes associated with high road density limits spawning and gravel recruitment and impacts spawning gravel quality. Road densities may increase as residential development expands. Factors contributing to increased road density include residential and commercial development.

- Urbanization**:** Urban development affects watershed processes, which impact wildlife habitat.

- Viability (Abundance and density): The numerous habitat impacts and dysfunctional watershed processes described above contribute to reduced steelhead population viability.

Some of the highest ranked stressors listed for steelhead in the Petaluma Watershed include increased sediment transport and stream incision, alterations to the estuary from straightening and dredging, changes to flood plain connectivity and degradation to the wetlands, impaired water flow through increased residential and agricultural water use pressures, lack of riparian cover due to land use changes affecting water temperatures, degraded water quality and lack of instream complexity (such as spawning gravel, shelter and deep pools), increased fish passage barriers, and increased water pollution from both urban and rural sources.

## WILDLIFE

### Wildlife Habitat

The Petaluma River Watershed includes a diversity of fresh water, brackish water, and saltwater habitats and several distinct upland habitats including coastal oak woodland and coastal scrub. A significant number of the state's Pacific flyway migratory water birds rely on the watershed's wetlands being used heavily during the fall and winter months but can be witnessed year-round as well.

Ecological balance, the dynamic equilibrium between living things and their environments, is critical to a healthy watershed. The many diverse species present in the Petaluma River Watershed depend on habitats that provide necessary forage, shelter, and reproductive opportunities in addition to maintaining predator-prey and symbiotic relationships. A reduction in the quantity and quality of the watershed's habitat limits its ability to support aquatic and terrestrial wildlife species alike.

For example, the American badger (*Taxidea taxus*) – a species of concern (see below) – once inhabited all northern California but has been gradually forced westward from their historic grassland range as development has occurred. Badgers predominantly prey on small rodents and are preyed upon by Golden Eagles (*Aquila chrysaetos*), coyotes (*Canis latrans*), and bobcats (*Lynx rufus*). As a part of the ecological balance with any species, a disruption in one species or a significant loss of habitat can lead to many other consequences in local ecology and wildlife trophic systems including the loss of ecosystem services (Dobson et al., 2006).

The Petaluma River Watershed contains six identified wildlife corridors with several crossings over Highway 101 (Paula Lane Action Network, 2021). These corridors will benefit from preservation to provide habitat connectivity and facilitate wildlife movement north, south, east and west. The Petaluma River Watershed connects to Marin County habitat via three wildlife corridors and to the Blue Ridge-Marin Coast segment of regional wildlife movement macro-mapping known as Critical Linkages, Bay Area and Beyond (2013).

## FEDERALLY AND STATE LISTED SPECIES

The Petaluma River Watershed provides vital habitat for a variety of species including those listed as threatened or endangered by state and federal regulations. The Federal Endangered Species Act of 1973 (ESA) authorizes the listing of species as threatened or endangered and provides protection for listed

species through laws that limit taking of these species and allow acquisition of land and disbursement of funds for conservation of listed species' habitats. Species eligible for listing under the ESA exhibit the following criteria: 1) habitat is under thret of modification or destruction; 2) species is over-utilized for commercial, recreational, scientific, or educational purposes; 3) species is subject to extreme disease or predation; 4) existing regulatory mechanisms are inadequate to protect the species; or 5) the species' continued existence is threatened by other natural or manmade factors.

The California Endangered Species Act (CESA) also allows listing of species and protection through limits of takes on those species. Species can be listed under either or both the ESA and CESA, and can have a different status on each list. Additionally, CDFW has the authority to list Species of Special Concern (SSC). These species are not listed under the ESA or the CESA but are either declining at a rate that could result in listing, or have historically occurred in low numbers and are known to have current threats to their existence. SSC listing criteria are similar to ESA criteria, and include small, isolated populations, marked population declines, habitat decline, and conversion of land adjacent to limited and specialized habitat. Other criteria include prevalence on historic land, and limited records of recent presence in the state. Through land and resource conservation there is an opportunity to allow for the survival of such listed species.

The Petaluma River is a diverse habitat supporting 25 species of marine, estuarine, and freshwater fish. Twelve of the twenty-five species are native to California. The river hosts several fish species currently listed as "threatened" under the ESA. These species use the Petaluma River and its tributaries as habitat for spawning, rearing, and migration.

Several terrestrial species found in the Petaluma Watershed are also federally listed under the ESA. The wetland habitats identified in *Chapter 5* are vital for the survival of such species. For example, the Ridgeway's Rail, California Black Rail, and the salt marsh harvest mouse are completely dependent upon marshlands. Uniquely, the Ridgeway's Rail and the salt marsh harvest mouse survive only in tidal marshlands, whereas the California Black Rail lives in freshwater and saltwater marshland habitats. Among the other many diverse species inhabiting the watershed is the Great Blue Heron, Great Egret, Willow Flycatcher, California red-legged frog (*Rana draytonii*), Bank Swallow (*Riparia riparia*), steelhead, spring/winter-run Chinook salmon, and American badger.

The CNPS maintains lists of plants to categorize degrees of concern for the survival of native plant species. These lists include but are not limited to plants that are listed under the ESA and CESA.

For a complete list of listed wildlife and plant species in the Petaluma River Watershed, please see Appendix C.

## SPECIAL STATUS SPECIES

The tidal marshlands of the Petaluma River Wildlife Area support two species (Ridgeway's Rail and salt marsh harvest mouse) that are listed as endangered through ESA and CESA. The marsh also supports a variety of other species of special status or concern, including the Black Rail, Golden Eagle, Prairie

Falcon, Northern Harrier, Black-shouldered Kite, Short-eared Owl, Salt Marsh Song Sparrow, and soft bird's-beak (*Cordylanthus mollis* A. Gray ssp. M*ollis)*.

### Ridgeway's Rail

The Ridgeway's Rail (formerly California Clapper Rail) lives in coastal salt and brackish marshes and tidal sloughs. The Petaluma Marsh is part of the northern limits of Ridgeway's Rail habitat. Its distribution within the Petaluma Marsh extends upstream with increasing aqueous salinity during drought years. A year-round resident, the Ridgeway's Rail lives mostly in the zones of coastal salt marshes dominated by pickleweed and cordgrass *(Spartina foliosa*); some birds also live in coastal brackish marshes. The Ridgeway's Rail forages in shallow water along the mudflat interface and along tidal creeks. They require adjacent higher vegetation for cover during high water. The clapper rail mostly preys on crabs, mussels, clams, snails, insects, spiders, and worms. Nesting activity occurs from mid-March through July. The birds most often nest near tidal sloughs where cordgrass is abundant. They build a nesting platform concealed by a canopy of woven cordgrass stems or pickleweed and gumweed (Grindelia sp.).

Historically, Ridgeway's Rail were found in tidal salt marshes and brackish marshes from Humboldt Bay in Humboldt County to Morro Bay in San Luis Obispo County. The bird is now found only in San Francisco Bay and Suisun Bay. In the Petaluma River Watershed, Ridgeway's Rail are resident and breed along the river as far north as Schultz Creek.

In the early 1980s, more than a decade after the Ridgeway's Rail was first listed as endangered, an estimated 1,500 birds remained, with at least 80% of the surviving population confined to the southern part of San Francisco Bay. In the mid-1980s, the population was estimated to have declined steeply. In 1992, nineteen pairs of Ridgeway's Rail were estimated to inhabit the Petaluma Marsh; these were primarily found at the mouth of the Petaluma River and in nearby large portions of tidal salt marsh.

Destruction of marsh habitat for industrial, municipal, agricultural, and salt pond use, as well as over-hunting depleted the Ridgeway's Rail population. Habitat loss also resulted from the dying out of marsh vegetation. Ridgeway's Rail eggs have been found to harbor elevated levels of mercury, selenium, and other contaminants, probably because sewage effluent, industrial discharges, and urban run-off have contaminated their food supply. Predators of both Ridgeway's Rail and their eggs include raptors (northern harrier, red-tailed hawk, and peregrine falcon) and mammals (red foxes, rats, and cats). Predators are a serious threat to Ridgeway's Rail populations, and predator management is not regularly practiced in the North Bay. The introduced horse mussel may also kill clapper rails by trapping the bills or feet of birds that have stepped on or probed into the shell. The Ridgeway's Rail was listed as endangered by the state of California and under the federal ESA in 1970.

### California Black Rail

The California Black Rail is a scarce, rarely seen, year-round resident of saline, brackish, and freshwater emergent wetlands. California Black Rail are mostly found in tidal emergent wetlands dominated

by pickleweed or in brackish marshes that support bulrushes *(Scirpus robustus*) and pickleweed. In freshwater, they are usually found in bulrush, cattail (*Typha spp.*), and salt grass *(Distichlis spicata)* areas.

They prefer high marsh regions that have shallow, stable water levels and that seldom flood. This type of marshland features dense stands of low growing, semi-aquatic plants interspersed with areas of open water and drier upland habitat; it provides materials for nest building and cover for nests. Nests are built at ground level or elevated several inches and are concealed in dense vegetation near the upper limits of tidal flooding. California Black Rail eat insects, crustaceans, and other arthropods, as well as aquatic plant seeds.

Information on the historic range of the California Black Rail is scarce. Limited numbers are known to have bred along the coast from Tomales Bay to northern Baja California in Mexico. The bird also bred inland at freshwater marshes including the Sacramento-San Joaquin River Delta. Population numbers have declined since the 1970s; today California Black Rail inhabit San Francisco Bay, Bodega Bay in Sonoma County, omales Bay and Bolinas Lagoon in Marin County, and Morro Bay in San Luis Obispo County. The California Black Rail no longer breeds in coastal southern California. More than 80% of the remaining population is estimated to be concentrated in the marshes of northern San Francisco Bay.

The major cause of decline and principal barrier to recovery of the California Black Rail is the loss and degradation of wetland habitat in northern and southern California. This includes coastal and estuarine salt marshes, inland freshwater marshes, and Colorado River marshlands. Of crucial concern for the California Black Rail is loss of high marsh habitat that provides refuge areas from high tides. Lack of refuge has left California Black Rail exposed as easy prey for domestic and feral cats, herons, egrets, and other birds, as well as red foxes and rats. The California Black Rail is designated as a threatened subspecies in California. Under the federal Endangered Species Act (ESA), it is designated as a Candidate Species (C-1).

### Salt Marsh Harvest Mouse

Two subspecies of salt marsh harvest mouse (*Reithrodontomys raviventris)* are endemic to the San Francisco Bay area. The mice inhabit the middle to upper levels of dense pickleweed stands in tidal and diked coastal salt marshes. They rely on escape cover formed by dense vegetation in the higher zones of the marsh to shelter them during high tides. Grasslands adjacent to pickleweed saline emergent wetlands are used when new grass growth provides suitable cover in spring and summer months. Their diet is comprised of seeds and green vegetation, and they can drink water with a relatively high salt content. Reproduction generally occurs from April through September. Salt marsh harvest mice build nests of grass and sedge on the ground; they do not burrow. Predators include hawks, owls, gulls, weasels, and other mammals.

Historically, the salt marsh harvest mouse was found throughout the extensive marshes that once bordered San Francisco, San Pablo, and Suisun Bays. It is now restricted to scattered, discontinuous, coastal salt marshes within its original range. The northern subspecies *(R. r. haliocoetes)* is found in the

salt marshes of San Pablo and Suisun Bays in Contra Costa, Solano, Napa, and Sonoma counties. Most populations of the southern subspecies *(R. r. raviventris)* inhabit the southern half of San Francisco Bay in Alameda, Santa Clara, and San Mateo counties, and few occur along the eastern portion of the Marin Peninsula in Marin County and at Point Richmond in Contra Costa County.

Decline in salt marsh harvest mouse populations is linked to habitat loss, especially of escape cover, fragmentation of the remaining marshes, widespread loss of the high marsh zone because of backfilling, land subsidence from excessive groundwater pumping, and vegetational changes from freshwater sewage discharge, especially in the South Bay. Most of the remaining marshes are too small and too widely separated to support viable populations.

Excessive pumping of groundwater in some regions has triggered subsidence of land along the bays' edges. This and backfilling have eliminated important escape cover in the marshland's higher zones, making these marshes unsuited to the mice's needs. Fragmentation of remaining marshes, as well as filling and diking of marshes for commercial salt production and urbanization, have also eliminated habitat throughout the species' range.

Both the state and federal governments listed the salt marsh harvest mouse as an endangered species in 1970. Since populations of the mice cannot be supported long term on the small, widely separated marshes that remain, the USFWS recovery plan for the species focuses on restoring and preserving existing habitat and acquiring additional habitat. Specific objectives include acquiring privately owned marshes and restoring former b108aylands that have been diked. The plan also calls for creating vegetative cover in the upper portions of marshes. Further objectives include studying the effects of such factors as sewage effluent, pollution, flood control, and marsh erosion on existing populations and habitat.

### American Badger

The American Badger has been a California Species of Concern since 1987, and some biologists postulate that the badger merits a status of Threatened. There is an identified 100-year sustaining American Badger population in the Paula Lane area of West Petaluma, CA (Paula Lane Action Network, undated).

The American Badger digs out gopher, voles, and mice from the soil with long claws. Badgers also eats some reptiles, insects, earthworms, eggs, and birds. They rely mainly on their olfactory and hearing senses when hunting. Badgers dig burrows for cover and may reuse old burrows or create new ones each night, particularly during the summer. They are found in shrub, forest, and herbaceous habitats with friable soils. Badgers mate in summer and early fall and give birth in March and April (CDFW undated).

The biodiversity and connectivity of American Badger habitat has been diminished as human development has increased and thus badger populations are declining. Badgers rely on grasslands and hilly upland areas; protection of badger habitat and conservation of connectivity between habitat patches for dispersal and mating is important for ensuring the survival of the species.

## California (CA) Red-Legged Frog

CA red-legged frogs (CRF) are listed as Threatened under Section 10 of the Endangered Species Act and are regulated by the USFWS. They are moderate to large frogs ranging between two to five inches in length. Back coloration can vary from brown, grey, olive, or reddish color with black flecks and dark, irregular, light-centered blotches with dark bandings on the legs. A defining characteristic feature of the red-legged frog is its dorsolateral fold, which is a raised skin fold visible on both sides of the frog extending roughly from the eye to the 'hip'. CRF remain immobile to avoid detection, but when a threat gets too close, they quickly leap into the brush or water. Outside of breeding season, they generally do not vocalize (Cantor undated).

The CA red-legged frog prefers moist forested areas close to a water source such as quiet pools of streams, marshes, and ponds. Breeding and rearing success requires permanent or nearly permanent pools for larval development, which takes 11 to 20 weeks. Intermittent streams need to retain surface water in pools year-round for frog survival (CDFW 2008). Breeding sites are usually bodies of water that have the following characteristics: deeper than 5" (preferably deeper than 1'), wet through June, slow or no water flow, shallow areas for egg mass attachment to aquatic vegetation, lack of dramatic fluctuations in water levels, and an upland site within 300 yards of the breeding site.

Management to enhance CA red-legged frog habitat consist of planting native, aquatic vegetation for egg mass attachment, control of non-native plants that may choke the wetland, elimination or minimization of chemical contaminants such as herbicides and pesticides within 300 yards of breeding sites, and removal of non-native predators such as the American bullfrog (*Rana catesbeiana*).

## RECOMMENDED ACTIONS – CH. 8 FISH AND WILDLIFE RESOURCES

**Recommendation 8.1** – Implement NOAA's 2016 Final Coastal Multispecies Recovery Plan for Central California Coast Steelhead (Recovery Plan) including the addressing the following areas as identified in the Recovery Plan.

a) Improve riparian composition and structure: native riparian planting, development and enforcement of riparian buffers, livestock exclusion fencing, and aligning stream maintenance objectives with riparian conservation objectives.

b) Existing problem roads and active erosion sites should be evaluated, prioritized, and addressed as part of a comprehensive sediment reduction and transportation plan for the entire Petaluma River basin.

c) Instream habitat complexity and shelter ratings should be improved within poor quality reaches of all tributaries.

d) Existing riparian corridors should be protected, and where opportunity exists, riparian buffers should be widened and/or floodplain areas lowered to benefit wintertime rearing. Significant consideration should be focused on addressing the ongoing maintenance costs, property damage, and habitat impacts related to flood control structures in the watershed.

e) Improving distribution of livestock to reduce prolonged concentrated utilization of grassland and riparian areas to provide periods of rest for improved grasslands.

f) Consider and evaluate the role of a conservation hatchery or hatchery stocking within the Petaluma River basin.

g) Protect and enhance summer baseflows to increase the extent of summer rearing habitat in Petaluma River tributaries.

h) Assessing and removing barriers will greatly improve the current access to quality habitat for steelhead in the Petaluma River Watershed.

i) A limiting factors assessment should be conducted in the estuary to determine the current and future potential habitat conditions for rearing juvenile and smolt salmonids.

**Recommendation 8.2 –** Focus riparian restoration and erosion control efforts on tributaries that do, or potentially can, support steelhead trout and Chinook salmon. These tributaries are Lichau, Adobe, San Antonio, and possibly Lynch and Willow Brook creeks.

**Recommendation 8.3 –** Increase riparian canopy cover to 70% and install livestock exclusion fencing within key reaches of major tributaries.

**Recommendation 8.4 –** Work with CDFW, UACGHS, and NMFS to conduct surveys for threatened species and species of concern, including but not limited to, pond-breeding and stream-breeding amphibians throughout the watershed in addition to supporting ongoing monitoring and survey efforts of salmonids and wildlife populations.

**Recommendation 8.5 –** Conduct genetic testing on Chinook salmon to understand origins and patterns.

**Recommendation 8.6 –** Conduct assessments of potential fish passage barriers and remove on priority streams.

**Recommendation 8.7 –** Rehabilitate and reclaim historic tidal wetland/slough estuarine habitat for rearing juvenile steelhead.

**Recommendation 8.8 –** Create more pool connectivity and increased summertime flow for steelhead and Chinook survival.

**Recommendation 8.9 –** In aligning with the state's 30x30 initiative, acquire vital habitat for conservation. The Petaluma Watershed Action Plan's Project 6, Acquisition for Conservation partially implements this recommendation.

**Recommendation 8.10 –** Evaluating Highway 101 for median modifications to facilitate wildlife crossing areas to support east-west connectivity and biodiversity.

**Recommendation 8.11 –** Conserve and enhance wetlands that provide habitat for listed ESA and CESA endangered species such as Ridgeway's Rail and salt marsh harvest mouse.

**Recommendation 8.12 –** Conduct studies to determine the steelhead and Chinook salmon carrying capacity of watershed streams.

**Recommendation 8.13 –** Building on the work of the UACGHS, conduct population viability analyses for steelhead and, if appropriate, Chinook salmon in the watershed.

# CHAPTER 9. WATER SUPPLY

## OVERVIEW

Water resources are vital to ecosystem function, agricultural prosperity, community health, and economic livelihood. In Northern Coastal California's Mediterranean climate, water quantity can be a key limiting factor. As a limited natural resource, water is subject to impact from both abiotic and biotic processes. Limiting water use while managing stormwater runoff and flooding events will aid in protecting water supply. Due to ongoing statewide and local concerns with the current and future supply of water, there is increased public awareness and bureaucracy surrounding the sustainable use of both surface water and groundwater in Sonoma County and Petaluma Valley. The purpose of water resources management outreach is to properly inform and guide landowners and residents to engage in water smart conservation initiatives.

Drought is a continued stressor on water supply conservation in the Petaluma River Watershed. Watershed planning promotes balanced solutions that satisfy environmental, domestic, and agricultural interests while maintaining the economic viability of the watershed and preparing to meet future water demands, including expected increased and prolonged drought conditions caused by climate change.

## WATER SOURCES IN THE PETALUMA RIVER WATERSHED

The City of Petaluma imports the majority of its drinking water from Sonoma Water. In addition to imported surface water, the City of Petaluma has several municipal groundwater wells that serve as emergency backup water supply and a robust recycled water program. The City continuously seeks to expand its local water supply. The major source of potable water supply outside of the City's water service area is groundwater pumped from private wells.

### Groundwater

Groundwater is the main source of water for rural residents to attain water needed for domestic uses (Wood Environment & Infrastructure Solutions, Inc. 2020). A combination of groundwater, recycled water, surface water, and hauled potable water supply rural landowners the water needed for agricultural and vineyard irrigation. Private wells convey water to rural residences, provide drinking water for livestock, and irrigation for farms and gardens. The City of Petaluma has several municipal groundwater wells that serve as emergency backup water supply.

The natural geology of the Petaluma River Watershed influences well water depth. The areas where water percolates into the ground and recharges the aquifers are called recharge areas and they are generally located in the mountains around Petaluma Valley. From these upland recharge areas, the water flows down towards the city and then south towards the San Pablo Bay (Wood Environment & Infrastructure Solutions, Inc. 2020). Drought and human use of groundwater also impact groundwater supply and distribution in the Petaluma Valley Groundwater Basin, which has shown a reduction in

groundwater levels caused by the 2012-2015 drought. The northwest part of the basin is showing signs of long-term declines in its groundwater supply while water levels in wells throughout the rest of the basin have remained fairly stable (Wood Environment & Infrastructure Solutions, Inc. 2020).

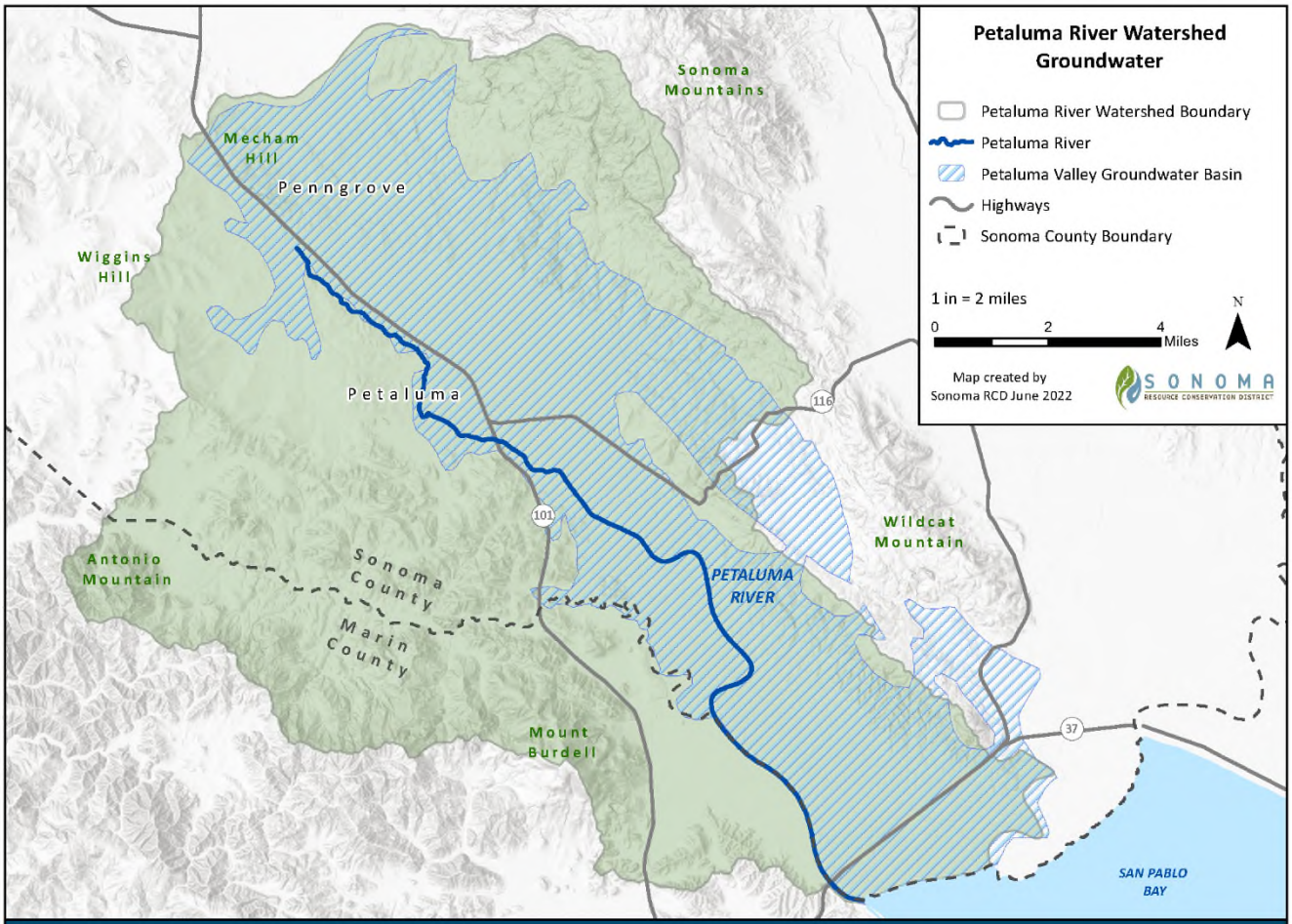


Fig 9.1. Petaluma Valley Groundwater Basin and the Petaluma River Watershed. Data: California Department of Water Resources

## Surface Water

Surface water in the Petaluma River watershed originates along the southwest slopes of Sonoma Mountain, the southern slopes of Meacham Hill, the eastern slopes of Wiggins Hill, and Mount Burdell. Flow in the upper reaches of the Petaluma River and its tributaries is seasonal, with main-stream channels at times going dry during summers, especially in drier than normal conditions. The river flows from the confluence of Willow Brook, Lichau Creek, and Wiggins Creek southeast through Denman Flat and the City of Petaluma and then through the Petaluma marsh and into the San Pablo Bay. The lower reach is tidally influenced and is prone to flooding during periods of high flow. The river is hydrologically connected to groundwater, with seepage occuring from the Petaluma River and its tributaries (Traum et al. 2022).

Surface water diversion for agriculture and rural residential use is not well quantified. Data obtained from the enhanced Water Right Information Management System (eWRIMS), which is managed by the State Water Board, indicate that the total amount diverted from streams ranged from 1,300 acre-ft in WY 2013 to 2,900 acre-feet in WY 2010 (Traum et al. 2022). The number of diversions supplying rural residential properties is unknown; however, about 80% of indoor rural water use is estimated to return to the groundwater system as septic seepage (Traum et al. 2022).

At least 95 percent of the City of Petaluma's municipal water is supplied through a contract with Sonoma Water in which surface water from the Russian River Watershed is purchased by the city and imported into Petaluma. The city sells most of its water supply to single-family homes; in 2015 it provided water to more than 61,798 households and businesses. As a water supplier with over 3,000 connections, the City is required to prepare an Urban Water Management Plan (UWMP) every five years. This plan supports the City's long-term water supply planning to ensure that adequate water supplies are available to meet existing and future water needs. The City's UWMP assesses the reliability of water sources over a 20-year planning time frame, describes City actions under a water shortage emergency, and discusses the City's projected use of recycled water.

### Recycled and Reclaimed Water

Water conservation and potable offset through the use of recycled water are both important water supply resiliency methods used in the Petaluma River watershed. The Ellis Creek Water Recycling Facility (Ellis Creek) in Petaluma opened in July 2009 replacing Petaluma's original Hopper Street wastewater treatment plant which was built in 1937. The Ellis Creek facility combines natural wetland treatment processes and state-of-the art technology to provide tertiary-treated recycled water to customers for landscape irrigation. Petaluma's recycled water is distributed outside the water service area for agricultural and vineyard irrigation. Within the City's water service area recycled water serves to offset the use of potable water use for irrigation of parks, schools, and other landscaped areas. The city is continually looking for opportunities to expand the recycled water program, with plans to expand several sections of recycled water pipeline between 2022-2025 to connect additional agricultural, vineyard, and urban recycled water customers. Graywater use, a method of reclaiming household water for landscape irrigation, is an option for small-scale onsite water recycling. It is described in greater detail in the Urban and Suburban Landscapes Section below.

## WATER CONSERVATION ISSUES

### Past and Recent Drought

Drought has long been a component of California's climate. Paleoclimate records dating back more than 1,000 years indicate that multi-year droughts were not uncommon. Droughts had a major influence on California's early history, with the Great Drought of 1863-1864 contributing to the downfall of the cattle rancho system and the 1929-1934 drought causing immense hardship for farmers, workers, and newcomers in California during the Dust Bowl. More recently, between 1950 and 2020, there have been at least six multi-year droughts, and three of those have happened since 2000 (Wood Environment & Infrastructure Solutions, Inc. 2020). The droughts of 1976-1977, 1987-1992, and 2007-2009 each stand out as events that placed significant stress on the state's water supplies (DWR 2021).

During the 2012-2016 drought, a state of emergency was declared in California in 2014, and water supplier throughout the state were mandated to reduce water use and promote water conservation. This was only the second time that a statewide declaration of emergency was instituted for drought. At the local level, Sonoma County declared a Proclamation of Local Emergency Due to Drought Conditions in 2015 and the City of Petaluma announced Stage 2 mandatory water restrictions the same year in response to the state mandated water conservation. The drought state of emergency for most of California was officially lifted in 2017.

However, two consecutive years of critically low rainfall in 2019 and 2020 prompted the Sonoma County Board of Supervisors and California Governor Gavin Newsom to declare a local drought emergency in April 2021. At the time of the declaration, Lake Sonoma, one of Sonoma Water's water supply reservoirs, was at 62% capacity which was the lowest it had ever been. The Petaluma City Council in September 2021 issued a proclamation of local drought emergency and entered into Stage 4 of its Water Shortage Contingency Plan (Shortage Plan). The City's Shortage Plan achieves a target demand reduction by implementing mandatory water use restrictions of all water customers.

As of the writing of this Plan, 2022 is the driest year on record for California; January 2022 through April 2022 (California's wet season) was recorded as the driest start to a year, and lowest precipitation on record in California since 1895 (NOAA 2022) with 96% of the state classified under severe drought conditions.

### Drought in the Future

California is projected to have more frequent and prolonged droughts throughout the 21st century due to climate change (see *Chapter 6. Climate Change Issues and Adaptation).* Warmer temperatures, more intense heat waves, and changes in rainfall and snowfall trends are expected based on the most recent scientific studies. Coupled with population growth and aging water infrastructure, climate change presents a significant challenge to ensuring adequate water supply for Californians (Bedsworth et al. 2018).

In Sonoma County, land is expected to become drier overall as higher temperatures increase the rate of water transfer from plants and soil into the air. Climate water deficit, which is defined as the extent to

which plants' need for water exceeds moisture available in soil, is expected to increase during the 21st century and create soil conditions that are 10-20% drier in the summer months (Fig. XX). This increase is predicted to be most pronounced in the southern areas of Sonoma County including the Petaluma River Watershed (Sonoma County RCPA 2016). While precipitation is expected to be variable, the City of Petaluma could experience a decline in average annual rainfall from 31 inches to 26.3 inches within the next 30 years (City of Petaluma 2021).

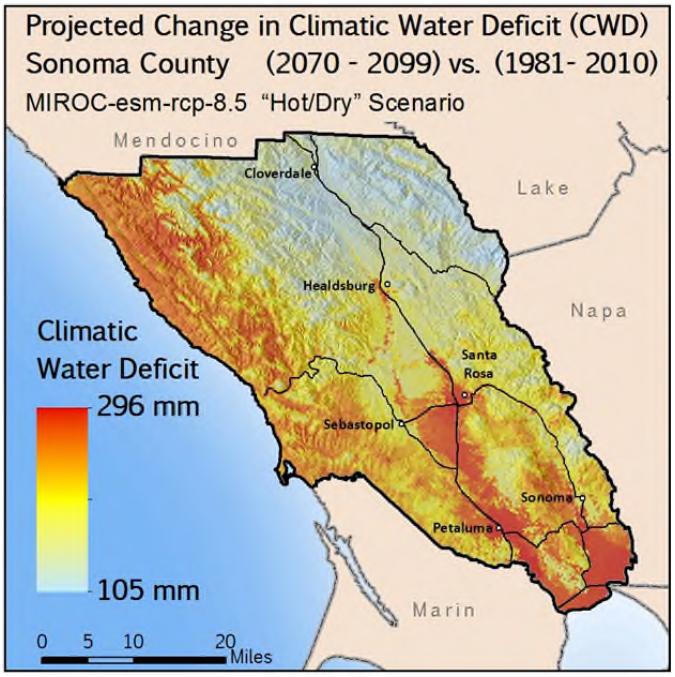


**Fig. 9.2**. Projected change in Climate Water Deficit (CWD) in Sonoma County between the averages of the thirty-year time periods 1981-2010 and 2070-2099 under a "hot/dry" scenario. Source: North Bay Climate Adaptation Initiative.

Drier conditions are likely to have significant impacts on the people, property, economy, and natural environment in the Petaluma River Watershed. Reduced groundwater recharge and runoff into creeks and streams is likely to result in less water available for urban, rural, and agricultural needs. Farmers and the agriculture workforce could experience economic losses. Low-income populations are expected to be particularly impacted due to increases in food and water and food prices. Fish, wildlife, and natural habitats such as the Petaluma River and its wetlands will also be affected, and wildfire risk is expected to increase due to tree mortality, increased heat and the dryness of vegetation (Wood Environment & Infrastructure Solutions, Inc. 2020).

### Reduced Groundwater Recharge

The continued availability of groundwater resources depends on infiltration from natural and working landscapes such as farmland, rangeland, grassland, woodlands, and wetlands. Loss of these recharge areas due to land use changes such as urban development, road building, stream channelization, draining of wetlands, and tile draining on farms can reduce infiltration during winter storms and limit recharge potential. Promoting groundwater recharge in the Petaluma River and its tributaries through

"slow it, spread it, sink it" projects and the conservation of natural and working landscapes is essential. The Southern Sonoma County Storm Water Resource Plan identifies and prioritizes projects in the Petaluma Valley Basin to improve groundwater rechange while providing multiple benefits to the watershed (Sonoma Water 2019).

### Saline Water Intrusion

Saline water intrusion is a concern in coastal aquifers. When groundwater supplies are over-pumped, saltwater may begin to intrude into an aquifer and create brackish water that is unsuitable for agricultural or rural uses. In the lower Petaluma River Watershed, projected rises in seal level due to climate change could lead to more frequent inundation of low-lying areas and a higher risk of saline water intrusion. The impacts would be mostly likely during winter storm surges (Wood Environment & Infrastructure Solutions, Inc. 2020). While no instances of saline water intrusion have been documented in the City of Petaluma's wells, this process has occurred in shallow private wells located along stretches of the Petaluma River with tidal influence (West Yost 2021).

## WATER CONSERVATION POLICIES AND INITIATIVES

### Water Conservation Act

The Water Conservation Act of 2009 (Senate Bill X7-7) required all urban and agricultural water suppliers in California to increase water use efficiency. Under the bill, agricultural water suppliers are required to prepare and adopt agricultural water management plans and update them every five years. Other mandates are to measure the volume of water delivered to customers, develop water use standards, create a pricing structure based on quantity of water delivered, and implement supplementary water conservation practices. Senate Bill X7-7 also set requirements for urban water suppliers, with the overall goal of reducing urban per capita water use across the state by 10% before the end of 2015 and 20% before the end of 2020. Urban and agricultural water suppliers who did not meet the requirements set by Senate Bill X7-7 would become ineligible for state water grants or loans. Through various water conservation efforts, the City of Petaluma met its 2015 and 2020 targets for water use as required by the bill (West Yost 2021).

### Sustainable Groundwater Management Act

The Sustainable Groundwater Management Act (SGMA) was adopted by the state of California in 2014. The main goals of the SGMA are to ensure that medium and high priority groundwater basins are sustainably managed and to provide local agencies with the authority, resources, and assistance needed to sustainably manage groundwater. The SGMA requires that Groundwater Sustainability Agencies be established in medium and high-priority groundwater basins by June 30, 2017 and that these agencies adopt Groundwater Sustainability Plans by January 31, 2022. The Petaluma Basin is designated as a medium priority basin and is managed by the Petaluma Valley Groundwater Sustainability Agency (GSA). As of October 31, 2022, the Petaluma Valley GSA completed the final draft of its sustainability plan and had closed the public comment period. The plan establishes a standard for the careful management and use of the Petaluma Valley Groundwater Basin for the next 20 years.

### Urban Water Management Planning Act

The Urban Water Management Planning Act became a part of the California Water Code in 1983. The Act requires that urban water supplies that serve at least 3,000 customers or provide more than 3,000 acre-feet of water per year create an Urban Water Management Plan (UWMP) and update it every five years. The City of Petaluma and Sonoma Water both updated their UWMP's in 2020, which includes information on projected water supplies and water conservation activities for the next 25 years. The City of Petaluma has a Water Shortage Contingency Plan that it will rely on when water demand exceeds available supply due to drought, climate change, regulatory constraints, natural or human-caused disasters, or other events. The Water Shortage Contingency Plan includes six water shortage stages and corresponding measures to reduce water demand.

### Water Conservation in Landscaping Act

The Water Conservation in Landscaping Act (AB 1881) required the California Department of Water Resources to update the State Model Water Efficient Landscape Ordinance (MWELO). MWELO establishes new development and retrofitted landscape water efficiency standards within the state. All land use agencies need to either adopt and implement MWELO or create an ordinance of their own that is more stringent. The City of Petaluma and Sonoma County have individual landscape ordinances which require certain projects to meet standards for efficient landscape design, installation, and maintenance.

## REGIONAL WATER CONSERVATION PROGRAMS

### North Bay Water Reuse Program

The North Bay Water Reuse Program is a regional initiative involving 11 municipal, water, and wastewater agencies to improve recycled water supply in Sonoma, Marin, and Napa Counties. The program uses a multi-benefit approach to meet the needs of urban, agricultural, and environmental water demands. It does so through the planning and implementation of treatment, storage, distribution, and water management projects that support local agencies while helping to protect water supply for water users across the North Bay. The program has two phases that include over $180 million in projects, and it has the capacity to provide more than 30,000 acre-feet per year of recycled water for the region. Examples of projects include adding a reservoir at the Sonoma Valley County Sanitation District and building a pipeline that transfers treated recycled water to the Napa-Sonoma Marshes Wildlife Area.

### Sonoma-Marin Saving Water Partnership

The Sonoma-Marin Saving Water Partnership was established to comply with the Water Conservation Act of 2009 with the purpose of recommending water conservation projects that maximize cost effectiveness in Sonoma and Marin Counties. The partnership includes 13 utilities: Sonoma Water, Marin Water, North Marin Water District, Valley of the Moon Water District, California American Water-Larkfield District, the town of Windsor, and the cities of Santa Rosa, Rohnert Park, Petaluma, Sonoma, Cotati, Cloverdale, and Healdsburg. Each partner has water conservation programs that help their

community increase water efficiency and conserve water supply. Examples include rebate programs for high-efficiency appliances, training for water efficient landscapers, and public information and education programs on water conservation.

### LandSmart Program

The LandSmart Program helps landowners and land managers achieve their natural resource management goals while supporting productive lands and thriving streams. The program was created by the Sonoma, Mendocino County, Napa County, and Gold Ridge Resource Conservation Districts in collaboration with the USDA Natural Resources Conservation Services. A key component of the LandSmart Program is the LandSmart Plan, in which current management practices are assessed and recommendations are made to benefit natural resources such as water supply and water quality. The Sonoma RCD and its partners have helped landowners in the Petaluma River Watershed develop LandSmart Plans that promote rainwater capture, groundwater recharge, irrigation system improvements, and water conservation on their properties.

## WATER CONSERVATION IN AGRICULTURAL AND URBAN LANDSCAPES

The Petaluma River Watershed supports a variety of land uses that each demand water supplies at a broad range of intensities. Understanding these differences and evaluating methods to conserve water will aid in the overall protection of this limited resource. Installing water efficient household appliances, using water minimally, implementing appropriate irrigation systems, cover cropping, no-tillage practice on farms and ranches, planting native species or xeriscaping gardens, monitoring the water intake of crops and livestock, and rainwater catchment are all viable methods to conserve water. The following sections describe the main land use categories and suggest water conservation efforts for each, but it is important to note that suggested conservation measures are applicable to multiple land uses.

### Agricultural Landscapes

Agricultural production in the Petaluma River Watershed includes but is not limited to dairy, cattle, row crops, vineyards, and orchards. Each of these uses demands healthy soil and water supply to maintain a productive landscape. The Sonoma County General Plan 2020 includes a policy to encourage and support agricultural activities that increase water use efficiency on farms and rangelands. There are methods applicable to landowners that would aid in storing water, managing irrigation, planting for soil moisture conservation, implementing no-tillage practices, preserving crop residue, and monitoring groundwater levels.

Croplands which are tilled regularly are subject to soil erosion and soil moisture loss. Incorporating reduced tillage practices can help to limit water use, retain topsoil, and improve crop production. In addition, leaving crop residues to be incorporated into the soil can increase nutrient levels and reduce soil evaporation rates (Mitchell et al. 2012). Planting cover crops can help increase infiltration into aquifers and manage runoff that would otherwise occur if the soil was left barren.

Landowners can also focus on maintaining or updating their irrigation systems to save water. Important aspects of sprinklers to consider include reducing the discharge rate of a sprinkler head and increasing

application uniformly for efficient irrigation (Schwankl et al. 2007). Furthermore, landowners can benefit from implementing rainwater catchment projects that collect storm runoff from roof surfaces. Water captured during winter storms can be used for non-potable uses during the summer months when water is scarce. Rainwater catchment can improve summer instream habitat by reducing water use from direct diversions or wells near a stream.

### Urban and Suburban Landscapes

The City of Petaluma offers many water conservation programs to help residential and commercial water customers conserve water; including rebates, water use evaluations, and free water saving devices. The city's water conservation program partners with the local non-profit organization Daily Acts to offer workshops and trainings on water efficient landscaping practices. For more information on the city's water conservation program, visit the program's website at https://cityofpetaluma.org/water-conservation.

In the outdoor area around the home, adjustments can be made to reduce water use related to landscaping. The city has a Mulch Madness Program that offers free sheet mulching supplies to qualifying customers to convert thirst lawns to a drought-tolerant mulched landscape. Drought tolerant landscaping practices in the Petaluma River watershed encourage the practice of planting with native, drought-tolerant species that are adapted to the local climate and need little or no watering. Native plant species require less water to survive than many non-native plants while also creating a beautiful aesthetic and providing habitat for native insects, birds, and other wildlife. If a landowner has a lawn or garden, short watering cycles are recommended to limit water waste and provide sufficient time for plants and the soil to absorb the water.

In addition to sheet mulching, residents can support groundwater recharge by creating rain gardens. Rain gardens are depressed areas of land often planted with grasses or perennials that capture runoff from surfaces such as roofs and driveways and allow it to percolate into the groundwater basin. Installing pervious concrete is another option for increasing infiltration on driveways, walkways, and streets.

The use of graywater for landscape irrigation is gaining popularity among homeowners seeking to conserve water. Graywater systems divert used water from sinks, showers, or washing machines to water outdoor plants. Daily Acts has provided in-person workshops and online tutorials for residents who want to install permitted graywater systems.

## RECOMMENDED ACTIONS – CH. 9 WATER SUPPLY

**Recommendation 9.1** – Continue using Urban Water Management Plans, General Plans, and well permitting requirements to assure that water is available for any new developments in the watershed.

**Recommendation 9.2** – Support the City of Petaluma, Sonoma Water, and the Petaluma Valley GSA in building a locally resilient water supply by conserving water and implementing drought-resilient landscape practices.

**Recommendation 9.3** – Increase water conservation of all water supply sources including recycled water, groundwater, and surface water.

**Recommendation 9.4** – Seek funding for watershed-wide multiple-benefit projects that involve elements of water quality improvement, surface and groundwater storage, rainwater harvesting, use of recycled water, wetland restoration, and seasonal flood easements.

**Recommendation 9.5** – Develop a rainwater catchment demonstration program for both residential and agricultural landowners. Project 8, Sonoma Mountain Institute Rainwater Catchment, identified as a priority project in this plan's companion document the Petaluma Watershed Action Plan, will partially fulfill this recommendation.

**Recommendation 9.6** – Provide resources to landowners on the benefits of groundwater recharge and methods for increasing recharge in upland areas through small landowner meetings.

**Recommendation 9.7** – Outreach to agriculture and vineyard properties to determine if there are opportunities to increase water use efficiency and/or implement alternative water sources.

**Recommendation 9.8** – Implement urban and rural water conservation measures such as low water use landscaping, installation of water saving fixtures and appliances, and installation of rainwater catchment and graywater systems.

# CHAPTER 10. WATER QUALITY

Water quality in the Petaluma River Basin is under the jurisdiction of the State Water Board and its San Francisco Bay Regional Water Quality Control Board. A Water Quality Control Plan for the San Francisco Bay Basin was developed by the Regional Board and adopted by the State Board in 1975. Several amendments have been adopted since with the most current Basin Plan amendment approved in June 2020 allowing the establishment of the Petaluma River Watershed Bacterial TMDL (total maximum daily load).

## WATER QUALITY MONITORING

The tributaries of the Petaluma River begin in the surrounding hills and meander through areas of varying land uses, each of which contributes some level of pollution and impacts to both natural and man-made waterways. The Petaluma River is influenced by tidal action from the bay and receives little freshwater inflow from May to November when there is little or no rainfall. With insufficient fresh water to flush the river during the summer months, temperature and salinity increase and reduce the ability of the water to hold oxygen. Inadequate dissolved oxygen not only contributes to an unfavorable environment for fish and other aquatic life but can also result in objectionable odors from anaerobic decomposition.

Monitoring for water quality protection purposes is conducted through a variety of federal, state, and local programs. The state evaluates current water quality conditions and prioritizes funding efforts for protection, cleanup, and monitoring programs through individual water quality assessments that are compiled into the SWRCB Section 305(b) reporting process, which is mandated under the federal Clean Water Act (California State Water Board 1996a). The Section 305(b) report includes the Section 303(d) lists, which identify water bodies that do not meet applicable water quality standards or designated beneficial uses that are subject to technology-based controls for waste discharges.

Monitoring water quality of the Petaluma River has been performed by the Regional Water Quality Control Board since mid-1970. More recently California Assembly Bill 982 (Water Code Section 13192; Statutes of 1999) required the State Water Board to assess and report on State water monitoring programs and prepare a proposal for a comprehensive surface water quality monitoring program. The Surface Water Ambient Monitoring Program (SWAMP) completed five years of watershed monitoring with the Petaluma River Watershed among the four watersheds monitored in year 3 (2003-2004).

In addition to SWAMP, the San Francisco Estuary Institute's (SFEI) Regional Monitoring Program (RMP) monitors contamination throughout the Bay and provides water quality regulators with information they need to effectively manage it. The RMP is a long-term, collaborative effort between SFEI, the Regional Water Quality Control Board, and the regulated discharger community, producing a comprehensive dataset on estuarine contaminants. Monitoring

from other sources to provide a comprehensive assessment of chemical contamination in the Bay.

## Beneficial Uses

State policy for water quality control in California is directed toward achieving the highest water quality consistent with maximum benefit to the people of the state. Aquatic ecosystems and underground aquifers provide many benefits to the people of the state. These beneficial uses define the resources, services, and qualities of aquatic systems and serve as a basis for establishing water quality objectives and discharge prohibitions that support the ultimate goals of protecting and achieving high water quality (Basin Plan 2019).

Numerous beneficial uses have been designated in the Petaluma River Watershed. Table 10.1, below, shows designated beneficial uses in several important Petaluma River tributaries as defined in the 2019 Basin Plan.

Table 10.1. Petaluma tributary beneficial uses.

| | Black John Slough | San Antonio Creek | Adobe Creek | Lynch Creek | Willow Creek | Lichau Creek |
|---|---|---|---|---|---|---|
| **COLD** | | E | E | E | E | E |
| **EST** | E | | | | | |
| **MIGR** | E | P | E | E | E | E |
| **RARE** | | | E | E | E | |
| **SPWN** | | P | E | E | E | E |
| **WARM** | | E | E | E | E | E |
| **WILD** | E | E | E | E | E | E |
| **REC-1** | E | E | E | E | E | E |
| **REC-2** | E | E | E | E | E | E |

E = beneficial use exists in water body

P = water body could potentially support the beneficial use

**Cold Water Habitat (COLD)**

Uses of water that support cold water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. Cold freshwater habitats in the watershed support rainbow trout and diadromous steelhead fisheries, as well as California red-legged frog, Foothill yellow legged frog, and Western pond turtle. Cold water habitats are commonly well oxygenated and life within these waters is relatively intolerant to environmental stresses.

**Estuarine Habitat (EST)**

Uses of water that support estuarine ecosystems, including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds), and the propagation, sustenance, and migration of estuarine organisms. Estuarine habitat provides an essential and unique habitat that serves to acclimate diadromous steelhead migrating into fresh or marine water conditions. The protection of estuarine habitat is contingent upon (1) the maintenance of adequate Delta outflow to provide mixing and salinity control; and (2) provisions to protect wildlife habitat associated with marshlands and the Bay periphery (i.e., prevention of fill activities). Estuarine habitat is generally associated with moderate seasonal fluctuations in dissolved oxygen, pH, and temperature and with a wide range in turbidity.

**Fish Migration (MIGR)**

Uses of water that support habitats necessary for migration, acclimatization between fresh water and saltwater, and protection of aquatic organisms that are temporary inhabitants of waters within the region. This beneficial use brings specific attention to maintaining zones of passage. Any barrier to migration or free movement of migratory fish is harmful. Natural tidal movement in estuaries and unimpeded river flows are necessary to sustain migratory fish and their offspring. A water quality barrier, whether thermal, physical, or chemical, can destroy the integrity of the migration route and lead to the rapid decline of dependent fisheries. Water quality may vary through a zone of passage as a result of natural or human- induced activities. Fresh water entering estuaries may float on the surface of the denser salt water or hug one shore as a result of density differences related to water temperature, salinity, or suspended matter.

**Preservation of Rare and Endangered Species (RARE)**

Uses of waters that support habitats necessary for the survival and successful maintenance of plant or animal species established under state and/or federal law as rare, threatened, or endangered. The water quality criteria to be achieved that would encourage development and protection of rare and endangered species should be the same as those for protection of fish and wildlife habitats generally. However, where rare or endangered species exist, special control requirements may be necessary to assure attainment and maintenance of particular quality criteria, which may vary slightly with the environmental needs of each particular species.

Below is an excerpt from the NMFS (2016) that describes water quality control issues as they relate to threatened CCC steelhead in the Petaluma River Watershed:

> "The lack of riparian habitat and the high occurrence of bank erosion contribute to high siltation and low oxygen levels in the water, which affect incubating eggs. Turbidity is also considered to be a problem for winter rearing juveniles because it inhibits their ability to forage for food and avoid predators. High water temperatures exist throughout the watershed due to the lack of riparian corridor, or thin riparian corridor (and the resulting shade produced from an intact riparian corridor) in many tributaries. In 1982, the State Water Resources Control Board (SWRCB) reported that dissolved oxygen and nutrient problems persist in the watershed (SSCRCD 2013). Threats contributing significantly to this condition include livestock farming and ranching, roads and railroads."

**Fish Spawning (SPWN)**

Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish are vital. Dissolved oxygen levels in spawning areas should ideally approach saturation levels. Free movement of water is essential to maintain well oxygenated conditions around eggs deposited in sediments. Water temperature, size distribution and organic content of sediments, water depth, and current velocity are also important determinants of spawning area adequacy.

**Warm Freshwater Habitat (WARM)**

Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. The warm freshwater habitats supporting various warm water fish species are generally lakes and reservoirs, although some minor streams will serve this purpose where stream flow is sufficient to sustain the fishery. The habitat is also important to a variety of nonfish species, such as frogs, crayfish, and insects, which provide food for fish and small mammals. This habitat is less sensitive to environmental changes, but more diverse than the cold freshwater habitat, and natural fluctuations in temperature, dissolved oxygen, pH, and turbidity are usually greater.

**Wildlife Habitat (WILD)**

Uses of waters that support wildlife habitats, including, but not limited to, the preservation and enhancement of vegetation and prey species used by wildlife, such as waterfowl. The two most important types of wildlife habitat are riparian and wetland habitats. These habitats can be threatened by development, erosion, and sedimentation, as well as by poor water quality.

The water quality requirements of wildlife pertain to the water directly ingested, the aquatic habitat itself, and the effect of water quality on the production of food materials. Waterfowl habitat is particularly sensitive to changes in water quality. Dissolved oxygen, pH, alkalinity, salinity, turbidity, settleable matter, oil, toxicants, and specific disease organisms are water

quality characteristics particularly important to waterfowl habitat. Dissolved oxygen is needed in waterfowl habitats to suppress development of botulism organisms, which has killed millions of waterfowl. It is particularly important to maintain adequate circulation and aerobic conditions in shallow fringe areas of ponds or reservoirs where botulism has caused problems.

**Water Contact Recreation (REC-1)**

Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs. Water contact implies a risk of waterborne disease transmission with respect to human health. For example, excessive algal growth has reduced the value of shoreline recreation areas in some cases, particularly for swimming. Where algal growths exist in nuisance proportions, particularly bluegreen algae, all recreational water uses, including fishing, tend to suffer.

**Non-Contact Water Recreation (REC-2)**

Uses of water for recreational activities, involving proximity to water but not normally involving contact with water where water ingestion, is reasonably possible. These uses include, but are not limited to picnicking sunbathing, hiking, beachcombing, camping, boating, tide pool and marine

life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Water quality considerations relevant to noncontact water recreation, such as hiking, camping, or boating, and those activities related to tide pool or other nature studies require protection of habitats and aesthetic features. In some cases, preservation of a natural wilderness condition is justified, particularly when nature study is a major dedicated use. With conservation and access advocates such as the Friends of the Petaluma River, the Petaluma Small Craft Center Coalition, and Petaluma River Access Partners, these types of activities will only increase in popularity.

## Numeric and Narrative Criteria

There are two types of criteria for defining water quality objectives: narrative and numerical. Narrative criteria present general descriptions of water quality that must be attained through pollutant control measures and watershed management. They also serve as the basis for the development of detailed numerical criteria (Basin Plan, 2007).

Historically, numerical objectives were developed primarily to limit the adverse effect of pollutants in the water column. Two decades of regulatory experience and extensive research in environmental science have demonstrated that beneficial uses are not fully protected unless pollutant levels in all parts of the aquatic system are also monitored and controlled. The Regional Board is actively working towards an integrated set of objectives, including numerical sediment objectives that will ensure the protection of all current and potential beneficial uses.

Numerical objectives typically describe pollutant concentrations, physical/chemical conditions of the water itself, and the toxicity of the water to aquatic organisms. These objectives are designed to represent the maximum amounts of pollutants that can remain in the water column without causing any adverse effect on organisms using the aquatic system as habitat, on people consuming those organisms or water, and on other current or potential beneficial uses (Basin Plan, 2007).

### Antidegradation Policies

NPDES regulations at 40 CFR 131.12 require that state water quality standards include an antidegradation policy consistent with the federal policy. The State Water Board established California's antidegradation policy through State Water Board Resolution No. 68-16, which incorporates the federal antidegradation policy where the federal policy applies and requires that existing quality of waters be maintained unless degradation is justified based on specific findings. The Basin Plan implements, and incorporates by reference, both the State and federal antidegradation policies.

## IMPAIRED USES AND/OR WATER QUALITY THREATS

Water quality in the Petaluma Watershed is impaired for six pollutants: Sediment, Pesticides, Pathogens, Nutrients, Nickel, Trash.

## WATER QUALITY DATA

### Pathogens

Data was collected from 2015-2018 throughout the watershed. See Total Maximum Daily Load section below for specific details.

### Nutrients

From 2014-2016, SWAMP collected seasonal data at 16 sites along the mainstem and tributaries, for a total of 109 samples. Each sample included tests for ammonia, nitrite, nitrate, total nitrogen, orthophosphate, and phosphorous. The Water Board doesn't have numerical water quality objectives to assess nutrient impairment, with the exception of chronic ammonia and nitrite and nitrate for municipal water usage. Nutrient levels were evaluated by comparing values to reference sites across our region.

There were no exceedances of chronic ammonia threshold or municipal water quality objectives. Generally, tributaries such as Ellis, upper Lichau, and upper Lynch had lower nutrient levels compared to the Petaluma River and San Antonio Creek. Likewise, nutrient levels tended to be higher at most sites during the winter. Nutrient levels for all analytes and sites were significantly higher than reference sites; however further studies are needed to determine the spatial and temporal extent of the impairment.

### Sediment

In 2017 SWAMP collected water and sediment samples for various metals and pesticides at 5 sites including upper Petaluma River, lower San Antonio Creek, Lynch Creek, and Lichau Creek. These data have not been compared to water quality objectives. Data are available on CEDEN.

### Dissolved Oxygen

In response to a fish kill in 2016 along the upper Petaluma River, SWAMP collected continuous monitoring data to assess dissolved oxygen (DO) levels across multiple years. In July-October 2016, 2017, and 2021 DO levels on the Petaluma River at the outlet mall were consistently below the minimum concentration for cold (7mg/L) and warm (5 mg/L) water habitats (SFBRWQCB Water Quality Objectives), with 60% of the samples below 2mg/l and daily drops to 0 mg/L. In 2017, DO conditions 0.5mi downstream of the outlet mall were slightly better, but there were high daily DO swings and over 50% of the samples were <5mg/l and 20% were below 2mg/l. In 2021, DO levels in downtown Petaluma and the marina were not anoxic but were below the 5 mg/L threshold for more than 40% of the time. Following 2021 October rain events, the DO concentrations in the outlet mall stabilized to match those of the downtown and the marina, but all three sites still exhibited DO levels consistently below 5 mg/L.

The data suggest that during the dry season, the Petaluma River from the outlet mall to directly upstream of downtown Petaluma, is consistently impaired for DO. The conditions are often anoxic, creating uninhabitable conditions for aquatic life. Conditions are slightly improved in the lower section of the Petaluma River, although DO conditions may negatively impact sensitive species.

### Bioassessment

In 2016 bioassessment data was collected at 10 sites on tributaries to the Petaluma River, including Adobe Creek, Ellis, Lichau, Lynch, San Antonio Creek. All sites were in poor condition, with the exception of a site on Adobe Creek (based on the California Stream Condition Index, a standardized biological index used to score the condition of benthic macroinvertebrates in perennial wadable streams). The lower reaches of Lichau, Ellis and Lynch Creeks had the lowest CSCI scores of the sites sampled. Of the seven sites previously sampled in 2003, five had higher CSCI scores in 2017, although further studies are needed to determine a positive trend in BMI condition.

## TOTAL MAXIMUM DAILY LOAD (TMDL)

The San Francisco Bay Regional Water Quality Control Board (Water Board) administers the Federal Clean Water Act and State Porter-Cologne Water Quality Control Act in the San Francisco Bay region to achieve an effective water quality control program for waters within its jurisdiction, and is responsible for the regulation of activities and factors that may affect the quality of the waters of the State.

The Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) is the Water Board's master water quality control planning document. It designates beneficial uses and water quality objectives for Basin waters, including surface waters and groundwater. It also includes programs of implementation to achieve water quality objectives (SFB RWQCB 2019).

The 2018 Federal Clean Water Act 303(d) list of impaired water bodies designated the Petaluma River main stem and tidal portion at the mouth impaired by diazinon (a pesticide), nutrients, and pathogens. The main stem was additionally listed as impaired by sediment and trash. The tidal portion was also listed as impaired by nickel.

Specifically, the entire Petaluma River main stem, including the tidal portion at the mouth, was listed on the 2014-2016 Federal Clean Water Act 303(d) list of impaired water bodies due to elevated fecal indicator bacteria levels. San Antonio Creek and other tributaries to the Petaluma River are also impaired due to bacteria. High fecal indicator bacteria levels (e.g., *E. coli*) indicate presence of pathogenic organisms that are found in warm-blooded animal (e.g., human, cows, horses, dogs, etc.) waste and pose potential health risks to people who recreate in contaminated waters. The listing of the Petaluma River and San Antonio Creek as impaired was based on exceedances of bacterial water quality objectives for the water contact recreation beneficial use (e.g., swimming, wading, and kayaking).

Under the Federal Clean Water Act, the Water Board is required and authorized to establish the total maximum daily load (TMDL) for those pollutants identified as causing impairment of waters on the 303(d) list. Additionally, under California Water Code Section 13242, the Water Board is authorized to develop an implementation program to achieve water quality objectives.

As a result, on November 13, 2019, the Water Board adopted a Basin Plan amendment that establishes a TMDL to address the bacteria impairment in the entire Petaluma River Watershed. The TMDL establishes a concentration-based load for bacteria and includes bacteria load allocations for all identified bacteria sources.

The identified controllable sources of bacteria in the watershed are listed in Table 10.2.

The Basin Plan amendment establishes an Implementation Plan that requires implementing parties to act to reduce discharges of bacteria to Petaluma River and its tributaries. The Implementation Plan builds on existing local efforts and relies on some regulatory programs that are already in place and actions that are already required, such as eliminating sanitary sewer overflows and reducing bacteria discharges from dairy confined animal facilities, managing municipal stormwater systems, and controlling bacteria discharges from the wastewater treatment plant.

The TMDL also includes additional requirements with regard to sanitary sewer system inspections and repairs, onsite wastewater treatment systems (e.g., septic systems) inspection and repairs by homeowners when a septic system is within 200 feet of a major stream; vessel waste management in marinas, homeless encampments, and grazing lands waste management; enhanced municipal stormwater best management practices; and monitoring by implementing parties to determine where to focus implementation actions and better identify bacteria sources.

| Table 10.2. Identified Controllable Sources of Fecal Indicator Bacteria in the Petaluma River Watershed TMDL. | | |
|---|---|---|
| **Source Category** | **Potential Sources** | **Examples** |
| Human Waste | Wastewater Treatment Plant | Ellis Creek Wastewater Treatment Plant and Water Recycling Facility |
| | Sanitary Sewer Collection Systems | Petaluma City collection system;<br>Sonoma County Water Agency collection system-Penngrove |
| | Private Sewer Laterals | Sewer laterals serving individual private properties |
| | Onsite Wastewater Treatment Systems | Septic systems |
| | Vessel Marinas | Marina facilities, recreational boats, live-aboard boats, house boats |
| | Homeless Encampments | Various encampments on municipal properties and Caltrans right-of-way within the watershed |
| Animal Waste | Livestock- Confined Animal Facilities | Cow dairies, commercial horse facilities |
| | Livestock-Grazing Lands/Operations | Cattle ranches, sheep farms |
| | Domestic Pets | Pet dogs, pet cats, etc. |
| Stormwater Runoff | Municipal Stormwater Runoff | Discharges into the municipal storm drain system from human and animal waste sources listed above; pet waste; dumpsters and trash cans; landfills; illicit sanitary sewer connections to storm drains; biofilms and bacteria regrowth in storm drains; |
| | Caltrans Stormwater Runoff | Discharges into the storm drain system located within Caltrans' right-of-way such as discharges from homeless encampments |

The TMDL directs the Water Board to create a non-point source program to address bacteria sources from grazing cattle and sheep in the Petaluma River Watershed, to enroll commercial horse confined animal facilities into the existing regional confined animal facility program, and to monitor and assess improvement in water quality resulting from these activities. The Water Board's holistic monitoring of the Watershed will begin five years after the TMDL effective date of May 10, 2021.

Table 10.3 summarizes bacteria source categories, key implementation actions, and the parties responsible for implementing them.

Table 10.3. Petaluma River Bacteria TMDL Implementation Plan Summary.

| Bacteria Source | Implementation Actions | Implementing Parties |
|---|---|---|
| Ellis Creek Wastewater Treatment plant | • Comply with existing permit<br>• No additional actions | City of Petaluma |
| Sanitary sewer collection systems | • Assess & repair problem areas within a 2000 feet buffer of river and major tributaries | City of Petaluma;<br>Penngrove Sanitation Zone |
| Septic systems | • Assess & repair faulty systems within a 200 feet buffer of river and major tributaries | Septic system owners;<br>local oversight agencies (Sonoma and Marin Counties) |
| Vessel marinas | • Provide adequate waste management capacity<br>• Education & outreach | Marina owners or operators (City of Petaluma; Gilardis Lakeville Marina) |
| Homeless camps | • Prevention and clean up measures<br>• Provide restroom facilities | City of Petaluma; Caltrans |
| Confined animal facilities (CAFs) | • Comply with existing CAF permit measures | Owners or operators of CAFs |
| Grazing lands/operations | • Comply with upcoming Grazing permit measures | Owners or operators of grazing lands/operations |
| Municipal Stormwater runoff (includes pet waste) | • Various stormwater pollution prevention BMPs<br>• Targeted education & outreach<br>• Install pet waste stations and signage<br>• Conduct water quality monitoring to characterize bacteria contributions from sources, evaluate corrective actions effectiveness, and assess | Municipal stormwater permittees (Cities of Petaluma and Novato; Counties of Sonoma and Marin) |

| | | |
|---|---|---|
| | progress towards load allocation attainment | |

More information on the bacteria TMDL for the Petaluma River Watershed can be found on the project website at:

https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/petalumabacterianutrienttmdl.html.

**POINT SOURCE POLLUTION**

Point source pollution is a stationary location or fixed facility from which pollutants are discharged or emitted or any single, identifiable discharge point of pollution, such as a pipe, ditch, or smokestack.

Local government plays an important role in the management of hazardous materials and coordinating with State and federal regulators is part of the management process to keep people and natural resources safe from exposure.

From the California Water Resources Control Board GeoTracker database, there are currently 20 active hazardous pollution sites in the City of Petaluma. Six of these sites are part of the State Water Control Board's Cleanup Program Sites and the other 14 are Leaking Underground Storage Tanks (LUST) Cleanup Sites.

There is rising concern for homeless encampments along the river, a source of urban trash. People living in informal shelters inside the watershed may also pose a risk to water quality. In July 2017, an informal survey by Petaluma River enthusiasts estimated there were 17 established encampments along waterways within Petaluma city limits. If encampment residents are not disposing of their waste properly, this situation could be a considerable addition of point source pollutants to the watershed.

Abandoned boats, fishing shacks, and unclaimed materials pose as additional sources of pollutants along the river. Following large storms or kind tides, river recreators observe materials such as parts of roofs, windows, pipes, and lumber floating away.

**POLLUTANT DISCHARGE**

The National Pollutant Discharge Elimination System (NPDES) was originally created as an amendment to the Clean Water Act (CWA) in 1972 and established a permit program to control water pollution by regulating the discharge of pollutants into waters of the United States. Initially, NPDES permits focused on regulating point source pollution which originates from a

definite source, such as industrial facilities, and discharges at a specific point. In the early 1970s, only one-third of the nation's waters were considered safe for fishing and swimming. Through the advancement of CWA and NPDES, two-thirds of the nation's waters were considered safe by the mid-1990s.

## Industrial General Permit (IGP)

The Industrial Stormwater General Permit Order No. 97–03–DWQ is an NPDES permit that regulates discharges associated with 10 broad categories of industrial activities. The General Industrial Permit requires the implementation of management measures that will achieve the performance standard of best available technology economically achievable and best conventional pollutant control technology. The General Industrial Permit also requires the development of a Stormwater Pollution Prevention Plan (SWPPP) and a monitoring plan. Through the SWPPP, sources of pollutants are identified and the means to manage the sources to reduce stormwater pollution are described. The General Industrial Permit requires that an annual report be submitted each July 1.

The ten categories covered under the Industrial Stormwater General Permit include:

1. Facilities subject to stormwater effluent limitations guidelines, new source performance standards or toxic pollutant effluent standards
2. Manufacturing facilities
3. Oil and gas/mining facilities
4. Hazardous waste treatment, storage or disposal facilities
5. Landfills, land application sites and open dumps
6. Recycling facilities
7. Steam electric power generating facilities
8. Transportation facilities
9. Sewage or wastewater treatment works
10. Manufacturing facilities where industrial materials, equipment or activities are exposed to stormwater

## Construction General Permit (CGP)

Applicants of construction projects disturbing 1 or more acres of soil are required to file for coverage under the State Water Board National Pollutant Discharge Elimination System (NPDES) General Permit for Discharges of Stormwater Runoff Associated with Construction Activity (Construction General Permit, or CGP). Construction activities include clearing, grading, excavation, stockpiling, and reconstruction of existing facilities involving removal and replacement.

Project owners are required to submit a complete Notice of Intent (NOI) package to the SWRCB. A complete NOI package consists of an NOI form, site map and fee. The General Permit also requires the development and implementation of a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP should contain a site map which shows the construction site perimeter, existing and proposed buildings, lots, roadways, stormwater collection and discharge points, general topography both before and after construction, and drainage patterns across the project. The SWPPP must list BMPs the discharger will use to protect stormwater runoff and the placement of the BMPs. Agricultural construction related to reservoirs, access avenues and structures are still subject to the CGP requirement.

The SWRCB website has more information regarding the CGP and associated requirements. Even if a construction project is exempt from the CGP, it is not exempt from discharging polluted runoff under Sonoma County Code Chapter 11.

### Municipal Stormwater Program – MS4 Permits

Municipalities are required to obtain Municipal Separate Storm Sewer Systems (MS4s) Permits which regulate stormwater discharges. MS4 permits are issued by the State Water Quality Control Board and implemented by the Regional Water Quality Control Boards (RWCQB) are usually issued to a group of co-permittees encompassing an entire metropolitan area.

The MS4 program has a Phase I and Phase II program based on the size of a municipality. The Phase I MS4 Permit is for municipalities serving more than 100,000 people and in Northern Sonoma County is administered by the North Coast RWQCB. The County of Sonoma is a co-permittee with the City of Santa Rosa and the Sonoma Water for the Phase I boundary which includes the City of Santa Rosa and unincorporated areas near the cities of Healdsburg, Windsor, Santa Rosa, Rohnert Park, Cotati, and Sebastopol.

The Phase IIMS4 Permit for municipalities serving between 10,000 and 100,000 people and in Southern Sonoma County is administered by the San Francisco Bay RWQCB. The County of Sonoma is a co-permittee with Sonoma Water and the City of Petaluma for the Phase II boundary which includes the unincorporated areas near the cities of Petaluma and Sonoma.

### Ellis Creek Water Recycling Facility

The City of Petaluma's Ellis Creek Water Recycling Facility is covered by its own NPDES permit for seasonal discharges of treated wastewater made to the Petaluma River from a permitted discharge location. The San Francisco Bay RWQCB is responsible for implementation and enforcement of this permit.

## UNDERGROUND STORAGE TANKS

In EPA Region 9, the Underground Storage Tanks (UST) Program Office works to prevent leaks from USTs, clean up contaminated sites, and redevelop formerly contaminated sites into beneficial use. They oversee state UST programs and partner closely with tribes and Pacific Island

territories. Several tribes and territories in Region 9 have their own UST programs and staff which work cooperatively with EPA to oversee and regulate UST facilities on their lands.

The Sonoma County Local Oversight Program (LOP) oversees the investigation and cleanup of fuel releases from underground storage tanks in all areas of the county with the exception of the cities of Santa Rosa and Healdsburg. Sites are entered into the LOP when a release from an underground tank is reported. This typically happens when an underground tank is removed and signs of a release are either obvious or else reported in laboratory sample results. Releases are also reported when contamination is found while repairing fuel delivery systems or when environmental site assessments are done at the time of property sales. Once entered into the LOP, the site must be investigated and cleaned up in accordance with the California Underground Storage Tank Regulations, Sonoma County Program Guidelines for Site Investigations, and Regional Water Quality Control Board water quality objectives.

The LOP is authorized to regulate underground storage tank releases by the State Water Board (SWRCB). Appeals for action or inaction by Sonoma County LOP may be made through the Sonoma County Local Review Process or directly to the SWRCB.

The State Petroleum Underground Storage Tank Cleanup Fund, which is administered by the SWRCB, is available to eligible tank owners and operators, and may pay up to $1.5 million for the investigation and cleanup of sites. Deductibles may apply, and only reasonable and necessary expenses are reimbursed.

Information regarding sites in the Sonoma County program is available online from the State web-based information system GeoTracker. http://www.swrcb.ca.gov/rwqcb1/

**RCRA & BROWNFIELD SITES**

A potential Resource Conservation and Recovery Act (RCRA) Brownfield is a RCRA facility that is not in full use, where there is redevelopment potential, and where reuse or redevelopment of that site is slowed due to real or perceived concerns about actual or potential contamination, liability, and RCRA requirements. The RCRA Brownfields Prevention Initiative was established by EPA to encourage the reuse of potential RCRA Brownfields so that the land better serves the needs of the community either through more productive commercial or residential development or as greenspace.

Brownfields are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties protects the environment, reduces blight, and takes development pressures off greenspaces and working lands.

## CERCLA SITES AND OVERVIEW

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress on December 11, 1980. This law created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. Over five years, $1.6 billion was collected and the tax went to a trust fund for cleaning up abandoned or uncontrolled hazardous waste sites.

Specific information on CERCLA sites in the Petaluma Watershed can be found on EPA's national priorities list at: http://www.epa.gov/superfund/sites/query/basic.htm.

## NON-POINT SOURCE POLLUTION

An easily identifiable water quality problem, which directly affects stream capacity, is sedimentation, particularly in the Petaluma River and adjacent tidal areas. Although the precise causes of sedimentation are less readily identifiable than the effects, they can be separated into those attributable to the natural sediment load of the streams and those attributable to the additional loads created by current and historic human activities.

Sediment movement is a natural part of watershed processes. However, when management activities and changes in watershed condition disrupt the sediment balance, excessive erosion and sedimentation can lead to loss of valuable soils, endangerment of structures, adverse impacts to stream channel function, and impaired water quality. This section discusses erosion processes, impacts to land and water quality, and recommended actions for controlling excess sediment in the watershed. Portions of this section have been updated based on the study completed by Prunuske Chatham, Inc. in 1999 that was an appendix in the first version of the Enhancement Plan.

### Erosional Processes and Concerns

Soils vary widely in physical structure, fertility, mineral content, and the way they react to wind and water. Some soils drain slowly, making them poor choices for unsurfaced roads or septic systems. Others are highly erodible, and the smallest disturbance can lead to headcuts, gullies or streambank washouts.

Soil erosion is a natural process. When detached soil (sediment) enters a water system, it settles out—at a culvert inlet, in a stream channel, in a pond, or in an estuary. While some sediment is needed to bring nutrients and substrate materials to aquatic ecosystems, too much causes problems. It can reduce the capacity of watercourses to hold storm flows, thereby increasing flooding. Fine soil particles fill in wetlands and cement stream bottoms into uniform surfaces that no longer provide nooks and crannies to shelter young fish and the aquatic animals they eat. Erosion and sedimentation are a major cause of the decline of many animal species including salmon and steelhead trout. Increased sedimentation impacts downstream flooding, siltation, and water quality. Erosion problems mean loss of valuable agricultural land.

Erosion can be chronic and/or episodic. Chronic erosion is constant and occurs during significant rainfall. Common types of chronic erosion are sloughing, sheet erosion, rilling, and headcutting. Episodic erosion occurs occasionally, and sediment often moves in a big pulse, such as during a storm event or series of storm events. Landslides are an example of episodic erosion. Erosion problems can also be both chronic and episodic, such as a landslide that continues to erode over time.

Sources of sediment can include natural background erosion in areas that are not intensively used, erosion from intensively used areas with sparse cover, and erosion from streambanks. Common areas of concern are sheet erosion from hillsides, gullies, landslides, active streambank erosion that threatens property, and poorly designed or maintained roads. Each is briefly described below.

### Background Erosion

Background erosion occurs naturally by the action of wind and water on the landscape even in watersheds that have little or no human impact. In watersheds that have been intensively used, it can be difficult to assess how much erosion is caused by human activity and how much is natural.

### Sheet and Rill Erosion

Sheet erosion is the loss of thin layers of soil from a slope. Rills are miniature gullies, less than one foot deep, that often occur in clusters along with sheet erosion. Slopes that have lost their vegetative cover through severe grazing, fire, or other disturbances are subject to sheet and rill erosion. A common place to see this type of erosion is on new fill slopes at a construction site after a heavy rain.

### Gullies

Gullies are often the most visible sign of erosion. Gullies occur in natural drainages, ditches, and outflow areas from culverts. They move upslope with a headcut—a sharp break in slope gradient— at the top of the gully. Gully activity and size are dependent on soil type, cause, water flow into it, and rate of run-off from the surrounding watershed.

### Landslides

Mass earth movements such as landslides usually occur naturally, although they can be exacerbated by human activities, such as road construction and vegetation removal.

### Streambank Erosion

Streams are highly dynamic. Left to themselves, they continually adjust their length, width, and gradient to changes in weather patterns and in the landscape. We see these changes as erosion. For example, when sediment loads increase in some creeks, gravel bars grow larger and push the flow farther into the opposite bank, which cuts away soil and leads to more sediment in the

creek. As this process repeats itself downstream, it can lead to a highly sinuous channel with great, sweeping curves and severe bank erosion.

Bank erosion can also be caused by downcutting, which lowers the channel bottom. As the bottom drops, the banks are destabilized. Downcutting can occur throughout entire systems and can cause dramatic changes in the watershed as each tributary incises to bring its water down to the level of the main channel. Eventually, groundwater levels will also drop, which leads to drier soil conditions and changes in vegetation type. Causes of downcutting include geological uplifting, upstream dams that trap sediment, gravel removal, and changes in the watershed's hydrology such as the rate at which rainfall enters the stream channels.

Local bank erosion can also occur from an obstruction, such as a fallen tree that pushes water into a streambank, or from excessive subsurface flow, such as an overly watered lawn or a poorly placed rain gutter.

### Roads

Poorly designed roads are a chronic source of sediment. Typical road-related erosion problems include improper road sloping, inadequate armored culvert outlets, plugged or broken culverts,

lack of cross drainage on the road surface, headcutting and downcutting along road drainage ditches, sheet and rill erosion on road surfaces, and rilling on cut slopes above roads.

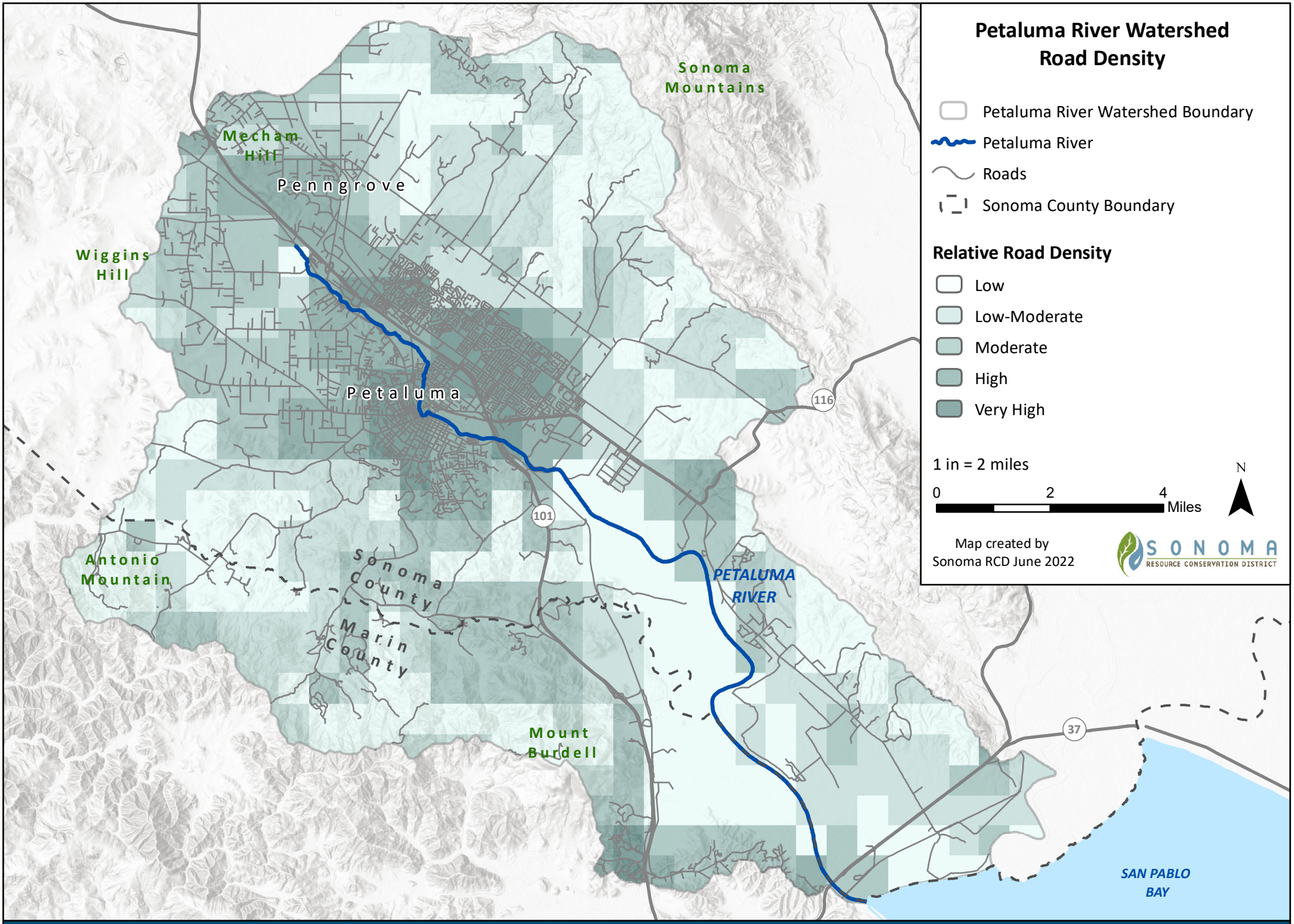


**Fig 10.1. Road Density in the Petaluma River Watershed.**
Cell values (meters of road per one square kilometer) were categorized into relative road densities (low-very high).

Data: U.S. Census TIGER files,
NOAA National Geophysical Data Center

## Soil Erosion and Watershed Processes

In stable watersheds, rates of erosion are slow, and natural healing processes can keep up. But in many watersheds, human use of the land has accelerated the rate of change beyond nature's short-term healing capabilities. Today's problems are often a result of land use and management practices that occurred 100s of years ago.

Many erosion problems are complex and occur on a wide scale. A gully, for example, may be caused by channel downcutting within the entire subwatershed. Checkdams in such a gully would probably be undercut and rendered useless unless downstream incision is also addressed. A cut bank could be caused by road erosion in the upper watershed that dumped sediment downstream and led to increased meandering. Flooding is integrally tied to upstream activities, such as erosion and covering of permeable surfaces with pavement and structures. Understanding existing conditions using a watershed-wide perspective is integral to selecting an effective repair. While stabilizing active erosion sites is important, long-term watershed health will ultimately depend upon holistic land stewardship.

As part of a report prepared in 1998 by Prunuske Chatham, Inc. (PCI) with SRCD, subwatersheds were ranked as high, moderate, or low priority for repair based on the erosion potential and erosion activity (see below table). The rating system is highly subjective and intended to give a general picture of where erosion control could make the greatest difference in conserving the natural resources of the watershed.

Table 10.4. Prioritization of Subwatersheds for Erosion Control (PCI 1998).

| **Subwatershed** | **Square Miles** | **Erosion Activity** | **Erosion Potential** | **Priority** |
|---|---|---|---|---|
| Lichau Creek | 9.7 | Low | Moderate | Moderate |
| Willow Brook Creek | 5.3 | High | High | High |
| Corona & Capri Creeks | 5.1 | Low | Low | Low |
| Lynch Creek | 4.0 | High | High | High |
| Washington Creek | 8.3 | Moderate | Moderate | Low |
| Adobe Creek | 4.9 | Moderate | High | High |
| Ellis Creek | 9.4 | High | High | High |
| Lakeville Tributaries | 19.8 | High | High | Moderate |
| Rush Creek | 9.2 | Low | Low | Low |
| San Antonio Creek | 36.5 | High | High | High |

| | | | | |
|---|---|---|---|---|
| Westside Tributaries | 13.9 | Low | Moderate | Low |
| Liberty Creek | 15.3 | Moderate | Moderate | Moderate |

Sediment Transport from road density conditions has a rating of Poor. Altered sediment transport limits spawning gravel recruitment and impacts spawning gravel quality. Juvenile rearing habitat suffers from channel incision and lack of floodplain refugia in all tributaries to the Petaluma River. With continued pressure to convert working lands to residential development, road densities are likely to increase throughout the watershed; thus, altered sediment transport will continue to impair juvenile and adult salmonid habitat conditions. Threats contributing significantly to this condition include Residential and Commercial Development, and Roads and Railroads.

## Sediment Source Budget

A discernible problem in the Petaluma Watershed is sedimentation which affects stream capacity, flooding and overall water quality. Although the precise causes of sedimentation are less readily identifiable than the effects, they can be separated into those attributable to the natural sediment load of the streams and those attributable to the additional loads created by current, ongoing human activities.

The effects of sedimentation appear to be aggravated and magnified by past construction of levees and landfills in the tidal areas. Confinement of the natural waterway by levees has accelerated sediment buildup in the remaining areas without levees. As a result, the flood-carrying capacity of the remaining waterway area is gradually diminished by sedimentation and soon the levees begin to lose their effectiveness.

Sediment from erosion in the upper tributaries of the watershed decreases the capacity of downstream and tidal waterways. The USACE in 1933 removed over half-a-million cubic yards of sediment from the Petaluma River to improve its navigability. Since 1937, USACE has dredged millions of cubic yards of deposited material from the river to maintain the navigable channel. The channel was most recently dredged in 2020 (see below, *City of Petaluma Flood Management Efforts Section*).

Some tributaries to the Petaluma River northwest of Petaluma are over 50 percent filled with sediment, believed to be primarily from natural sources. Although adoption of erosion control ordinances, such as the City of Petaluma's Ordinance 1576, helps to limit sedimentation produced from human activities, public funds have been and will continue to be used to remove this material from critical reaches of the waterway (Sonoma Water 1986).

Back in 1998, Prunuske Chatham Inc., performed a qualitative characterization of the Petaluma River Watershed. Qualitative assessments provide practical, cost-effective information on a more general scale but can identify priority areas for erosion control, subwatersheds with complex, chronic problems that may warrant more in-depth analysis, and where limited funding can most

effectively be spent. Most of the information was from outdated maps from the 1970s, aerial ortho-photos of the watershed in 1990 and interviews with professionals who were familiar and had worked in the watershed. This is a summary of their findings (Petaluma River Watershed, PCI 1998).

Findings indicated that most of the landslide activity occurs on the steep slopes of San Antonio Creek subwatershed, Ellis Creek subwatershed, and along the Lakeville area subwatershed tributaries. The most pressing issue on San Antonio Creek is severe creek bank erosion, which cuts into pastures and riparian vegetation. Some of the banks are 20 feet high and have exposed bedrock.

Moderate amounts of landslide activity occur on the upper slopes of the Adobe Creek, Washington Creek, and Lynch Creek subwatersheds and less significant activity occurs on the steeper slopes of Willow Brook Creek, Lichau Creek, and Wiggins Creek. The most stable subwatersheds are Liberty, Capri and Corona Creeks. Prunuske Chatham, Inc. recommended a more detailed analysis of erosion, channel stability, and geomorphology but felt the priority subwatersheds to concentrate on include Willow Brook, Lynch, Adobe, Ellis, and San Antonio Creeks.

A study on San Antonio Creek, by Laurel Collins et. al. (Application of the San Francisco Estuary Institute Watershed Science Approach to San Antonio Creek, December 2000), recommended that bank and bed conditions should be quantified and tributary channels and hillsides for the entire watershed be assessed to develop a sediment budget and to determine changes in drainage density. A water budget should be constructed for the watershed to evaluate the potential for restoration that may include re-establishment of the laguna, disconnection of small tributaries from the mainstem channel, realignment of lower San Antonio Creek into its original tidal slough, and reduction in total amount of water withdrawal.

## RECOMMENDED ACTIONS – CH. 10 WATER QUALITY

**Recommendation 10.1 –** Encourage landowners and managers in the watershed to implement practices to reduce pollutants from entering the water way.

**Recommendation 10.2 –** Implement management actions to reduce erosion and sediment from entering streams.

**Recommendation 10.3 –** Assist residents in working with the Counties on well and septic installation and management to maintain or improve ground and surface water quality.

**Recommendation 10.4 –** Due to current habitat conditions, investigate the possibility of using Adobe Creek as an urban reference site.

**Recommendation 10.5 –** Increase flow monitoring to better interpret water quality data.

**Recommendation 10.6 –** Develop LandSmart ranch and farm water quality plans in priority watersheds and implement beneficial management practices to decrease sediment, pathogen, and nutrient loads.

**Recommendation 10.7 –** Maintain septic systems based on State Water Board and Sonoma County PRMD requirements and guidelines found in the "Homeowner's Guide to Septic System Operation."

**Recommendation 10.8 –** Comply with all conditions of municipal NPDES permits for stormwater and sewer systems.

**Recommendation 10.9 –** Concentrate erosion control activities in the high priority sub-watersheds of Willow Brook, Lynch, Adobe, Ellis, and San Antonio Creeks.

**Recommendation 10.10 –** Seek funding and cost share programs for landowners in the upper watershed for installation and maintenance of erosion control measures.

**Recommendation 10.11 –** Manage livestock access to creeks and gullies, especially in the wet season.

**Recommendation 10.12 –** Provide educational and technical assistance for "do-it-yourself" erosion control, small farm and pasture management, and reducing rill and sheet erosion for pastures and corrals.

**Recommendation 10.13 –** Maintain drainage ditches, spillways, culverts, etc. to avoid overtopping and delivery of sediment to the streams.

**Recommendation 10.14 –** Improve upstream waterways for flood and sediment control by planting native species and building water and sediment catchment basins.

**Recommendation 10.15 –** Assist landowners and pursue funding to repair eroding banks, install riparian fencing and revegetation and implement LandSmart ranch and farm water quality plans.

# CHAPTER 11. STORMWATER AND FLOOD CONTROL MANAGEMENT

Typical weather patterns for Northern California, where most rainfall occurs between October and May, make stormwater management and flood protection necessary components of watershed and community management. Population growth experienced over the last two decades has led to more development within historical floodplains, creating greater risk and impacts during major storm events. During the rainy season, the Petaluma River regularly leaves its banks and spreads into the floodplain. Damaging flood events that occurred between 1982 – 1998 and again in 2004 – 2005 resulted in a coordinated approach by multiple agencies and the community at large. The City of Petaluma, USACE, San Francisco Bay Regional Water Quality Control Board, EPA and many other entities are working collaboratively to address the rural and urban issues in managing surface water.

## STORMWATER MANAGEMENT

In 1958, Flood Protection Zones were created to encompass the major watersheds of Sonoma County. This enabled Sonoma Water to promote the financing, construction, and maintenance needs of each of the zones. For the past 50 years, the common approach has been to direct stormwater runoff away from a property as quickly as possible using pipes and pavement. While largely effective, it is now recognized that this approach shifts problems further downstream. Impervious surfaces such as roofs and pavement can alter natural hydrology, increasing the volume and velocity of stormwater runoff. Concentrating flow, whether in a ditch or pipe, can create similar increases in stormwater runoff. This leads to a variety of impacts including stream bank erosion, flooding, damage to public and private property, degradation of wildlife habitat, and in severe cases, land and mud slides. Increased runoff also decreases the amount of groundwater recharge that can occur during large storm events. Climate change is expected to further exacerbate the intensity and flashiness of storms, increasing the need for robust stormwater and flood management strategies.

Sonoma County is taking comprehensive approach to understand and manage stormwater to minimize flooding, increase groundwater recharge, and minimize the pollutants and sediment being added to waterways. Sonoma Water leads many of these efforts including preparing the *Petaluma River Watershed Master Drainage Plan* and leading the management of Flood Control Zone 2A. Zone 2A encompasses the upper watershed (including drainages within the City of Petaluma) and the Zone 2A Flood Control Advisory Committee provides recommendations on needs and efforts to manage drainage and works of flood protection. Stormwater management objectives are outlined in the second edition of the Sonoma RCD's S4 guidebook "Slow it. Spread it. Sink it. Store it!;" the guidebook provides practical actions for rural and urban landowners to protect and replenish groundwater resources, reduce erosion and pollution, and provide many

associated environmental benefits. The principles of S4 are also being applied to riparian habitat enhancement and stormwater management projects throughout the Petaluma Watershed. Local municipalities are also exploring ways to use concepts in S4 to increase groundwater recharge, alleviate flooding, and support streamflow.

## STORMWATER QUALITY IMPACTS

Stormwater and its associated water quality impacts have led to the listing of the Petaluma River on the Clean Water Act 303(d) list for the past several decades (see water quality section). As per the mandated requirements of the federal Clean Water Act, the City of Petaluma developed a Stormwater Management Plan. These stormwater systems are regulated under the National Pollutant Discharge Elimination System (NPDES) through Municipal Separate Storm Sewer System (MS4) permits. Petaluma's MS4 permit is anticipated to be issued by the end of 2022. This permit includes the following Minimum Control Measures:

1. Public Education: Petaluma must educate the public in its permitted jurisdiction about the importance of the stormwater program and the public's role in the program.

2. Public Participation: Petaluma must comply with all State and local notice requirements when implementing a public involvement and participation program.

3. Illicit Discharge Detection and Elimination: Petaluma has adopted and enforces ordinances that prohibit illicit discharges. Petaluma will continue its implementation of detecting illicit discharges.

4. Construction Site Stormwater Runoff Control: Petaluma has developed a program to control the discharge of pollutants from construction sites greater than or equal to one acre in size within its permitted jurisdiction. These programs must include inspections of construction sites and enforcement actions against violators.

5. Post Construction Stormwater Management: Petaluma must require that long-term post-construction beneficial management practices which protect water quality and control runoff flow be incorporated into development and significant redevelopment projects. Post-construction programs are most efficient when they emphasize low impact design, source controls, and treatment controls.

6. Pollution Prevention and Good Housekeeping for Municipal Operations: Petaluma must continue to develop and implement a program to reduce the amount of polluted runoff resulting from municipal operations. Municipal operations include street sweeping, storm drain system cleaning, and responding to hazardous spills.

## FLOODING

Flooding is a serious concern in portions of the watershed and being exacerbated by climate change. This section discusses historic and current flooding conditions, opportunities, constraints, and recommended actions related to flooding.

## HISTORIC AND CURRENT FLOOD CONDITIONS

In the mid-1800's stormwater runoff from the Petaluma Watershed, which drained to the Petaluma River and its tributaries, often overtopped the existing channels and spread across the valley until it could return to the waterways and complete its flow to San Pablo Bay. With colonization of Petaluma and the surrounding areas, and the urbanization of the region since the 1950's, such overflow became damaging to built infrastructure. Measures were implemented to improve drainage and control the flooding -- flood control projects were constructed, standards were adopted for private development, and floodplain zoning was instituted. All of these helped to solve many of the problems but, as was most dramatically evident during the storms of January 1982, February 1986 and most recently December 2017, considerable flooding still exists.

The most serious of these is the flooding that occurs along the Petaluma River itself. This waterway, which once meandered across the valley, now flows through the most heavily urbanized area of the City of Petaluma and causes significant damage and disruption when storm runoff from its tributaries exceeds the channel's capacity. Historically, two main areas of significant flooding have occurred along the Petaluma River.

The first lies between Denman Flat and the confluence of the Petaluma River and Lynch Creek and "consists mainly of commercial, industrial, retail, and undeveloped properties (City of Petaluma 2015)." The second is an area between Lynch Creek/Petaluma River confluence and the Lakeville Street bridge that consist mainly of residential properties developed in the 1960's (i.e., Payran Reach Floodplain). This area has seen fewer flooding impacts since the Petaluma River Flood Control Project was implemented. The most recent phase of the four-phase project was the creation of a flood detention basin to store excess stormwater from Denman Reach. This project was completed in 2020 using a 5.47-acre parcel of land on Industrial Drive near the auto mall building stormwater detention ponds, creating seasonal wetlands, riparian restoration, and sediment removal under the Corona Road Bridge. This DWR and Zone 2A funded flood protection project also includes 1,000 feet of new walking paths around a seasonal wetland that attracts birds and other wildlife. Previous phases of the project widened the river bank, deepened the channel to increase stormwater capacity and constructed flood walls along Payran reach. A public path to improve access to the river and provide linkage between neighborhoods was included in the earlier phases.

Sonoma Water's Master Drainage Plan describes in detail the climatic, hydrologic, and topographic factors, which contribute to the delineation of floodplains or flood prone areas. Specifically, the flood plain delineation closely approximates the base (100-year) flood elevation

lines developed by the U. S. United States Army Corps of Engineers (USACE) for the National Insurance Administration, Federal Emergency Management Agency's Flood Insurance Rate Maps for the City of Petaluma and Sonoma County. The term 100-year flood is a measure of water level rather than rate of occurrence and therefore can happen any time. The term "100-year flood" is often used inconsistently which leads to misunderstanding and may foster a belief that if a 100-year flood occurs in any one year, then it cannot occur for another 100 years. This is false because it implies that floods occur deterministically rather than randomly; because periods of heavy rainfall and floods occur randomly, there is a finite probability that a 100-year flood could occur in any year but can occur in back-to-back years. It uses statistical probability to determine the likelihood of a single event in any year. Characteristic floods in the Petaluma River Basin are normally of short duration, lasting a few hours to one or two days. Floods on the Petaluma River may develop within hours after the beginning of a flood-producing storm and begin to recede within hours of the end of the storm. Although floods have been recorded as early as November and as late as April, most occur between December and February after prolonged rainy periods, which fully saturate the soil, increasing runoff volume. Flooding can occur along the entire length of the river and sections of many tributaries.

"The natural storage area of Denman Flat in the northwestern part of the City, where Willow Brook, Liberty, Marin and Wiggins Creeks come together to form the Petaluma River, acts as a detention basin and helps to reduce downstream peak discharges. Significant flooding occurs in this natural storage area and to the area east of Denman flat between Highway 101 and the Northwestern Pacific railroad line when excess flows in the Willow Brook channel escape as sheet flow to the southwest. Flooding from the Petaluma River can occur in the reach between Denman Flat and the confluence with Lynch Creek and is generally shallow. Flooding is reduced in depth downstream of Lakeville Street and is fairly well contained in the Petaluma River channel below the "D" Street Bridge (City of Petaluma 2015)." However, in 2022 flooding occured downstream in the Lakeville area where pumps are needed to move floodwater. The City of Petaluma has acquired property within Denman Flat to create a flood terracing project to accommodate more flood alleviation and retention in this area of the watershed. Flood Management Through Time

To adequately address downstream flooding, Sonoma Water, City of Petaluma, and others have studied and developed specific plans and actions that will both reduce flooding and increase beneficial recharge of groundwater. In 1959, the Petaluma Benefit Assessment Zone 2A was created as a joint flood control endeavor between the City of Petaluma and Sonoma Water. This zone encompasses 87 square miles bounded by San Antonio Creek on the south; Browns Lane and Stage Gulch Road on the southeast; Railroad Avenue, Roberts Road, and Lichau Road on the North; and Laguna Road, Lake Street and Two Rock Road on the west. In general, the Zone includes all tributary drainage reaching the Petaluma River north of the mouth of San Antonio Creek. Property owners within this Zone pay an extra tax to fund flood management studies and structural projects that will reduce flooding risks. There is a seven-member Zone 2A Advisory Committee, appointed by the Board of Supervisors, comprised of citizens who reside within the Zone and a representative from the City of Petaluma. This committee is responsible for advising on flood protection needs and

making recommendations on annual budget priorities. In November 1986 and again in 1996, and extended in 2007, the electorate of Zone 2A authorized the levying of benefit assessments within this zone for 10 years to augment funds received from general property taxes. Since 1986 these revenues have supplemented the property taxes received by Zone 2A.

The officially formed Flood Protection Zone has financed the construction of flood protection and drainage facilities, the maintenance of natural waterways, the preparation of master drainage plans for areas subject to flooding, and erosion and sediment control activities. The zone has also financed the flood protection operation and stream maintenance activities of Sonoma Water.

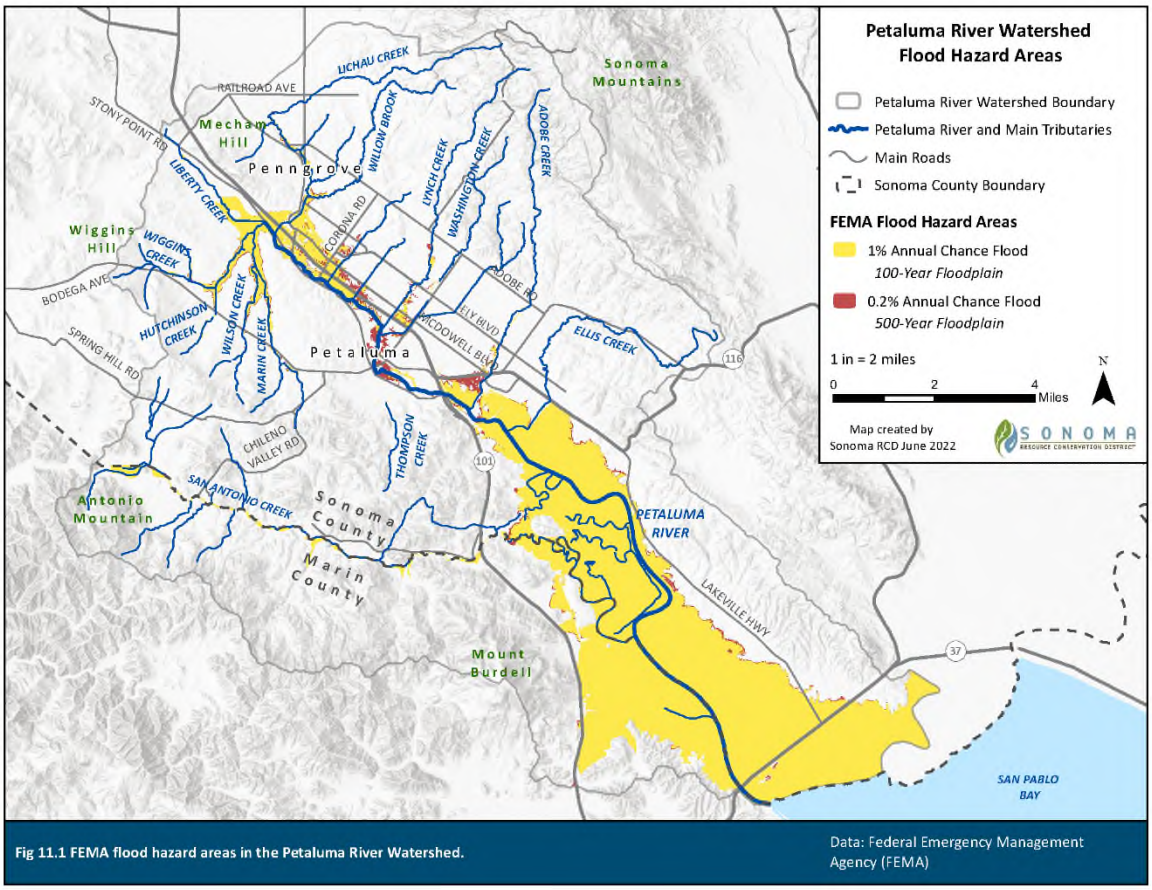

Fig 11.1 FEMA flood hazard areas in the Petaluma River Watershed.

Data: Federal Emergency Management Agency (FEMA)

## Sonoma Water Stream Maintenance Program

Stream maintenance activities support a proactive regional approach to flood protection and stream and wildlife habitat restoration. Sonoma Water works in and around streams throughout the Petaluma Watershed, removing sediment and garbage and planting trees. The agency routinely repairs and stabilizes banks along its engineered channels. Eroding banks that are not repaired will continue to destabilize and deposit sediment into the waterways. Maintenance activities include minimizing hardscape by back-filling with soil, installing erosion control fabric, seeding with grasses, and planting native trees and plants to provide shade, cover, habitat and additional stability. The Stream Maintenance Program also undertakes vegetation management

practices to restore local streams into waterways that provide not only flood protection but also to improve water quality and enhance habitat for fish and wildlife.

### City of Petaluma Flood Management Efforts

Petaluma worked with the United States Army Corps of Engineers making over $40 million in improvements to bridges, channel widening, floodwalls and pumping stations to address systemic flooding within the City in the 2010s?. The Petaluma Flood Control Project has taken steps to reduce flooding to a level that would allow FEMA torevise flooding maps wto reduce the level of flood insurance required of landowners. The City of Petaluma updated their Floodplain Management Action Plan (FMP) in 2015; it sets forth recommendations and actions to reduce flood losses and address current flooding problems (City of Petaluma 2015). The FMP contains recommendations such as protection of existing marshland, establishment of development constraints in riparian zones, erosion and stormwater pollution management, further recharge acquisition within the Denman Reach floodway, and continued implementation of the Petaluma River Flood Control Project.

In addition to floodplain management, the Petaluma River mainstem was again dredged by USACE in Fall of 2020. Dredging occurred from the Turning Basin, near downtown, to the San Francisco Bay and addressed spots of shoaling along the channel (City of Petaluma). The Marina is also slated to be dredged in 2021/22 and the City of Petaluma is continuing work on obtaining 10-year maintenance dredging permits to support future dredging events.

### Channelization

One prominent historical change within the Petaluma Watershed has been the “channelization and lengthening of many streams, particularly in downstream reaches on the valley floor and within the former Baylands (Baumgarten et al. 2018).” Total channel length increased by approximately 50% from these changes; many streams that historically terminated in upstream areas were lengthened to increase drainage efficiency or control flooding. Today, these channelized streams convey flow and sediment loads further downstream through artificial channels (particularly through the developed areas) that require ongoing stream maintenance and exacerbate sediment loads and downstream flooding.

### Integrated Approaches to Flood and Stormwater Management

The California Department of Water Resources promotes Flood-Managed Aquifer Recharge (Flood-MAR), an integrated and voluntary resource management strategy that uses flood water for managed aquifer recharge (MAR) on agricultural lands and working landscapes, including but not limited to refuges, floodplains, and flood bypasses. Flood-MAR can be implemented at multiple scales from individual landowners to government infrastructure projects. Flood-MAR projects are promoted because they can provide broad benefits in addition to flood protection, including water supply reliability enhancement, drought preparedness, ecosystem enhancement, water quality improvement, and climate change adaptation.

Local entities working in the Petaluma Watershed are employing integrated approaches to flood and storm management to maximize effectiveness and benefits. Projects are now designed to meet multiple watershed goals such as flood reduction that also reduces erosion by slowing stormwater and also improves groundwater recharge through dispersing spreading stormwater into the floodplain. New construction requirements minimize storm runoff and recharge groundwater. The Southern Sonoma Stormwater Resources Plan contains 62 stormwater-related projects that have been prioritized based on their provision of multiple watershed goals. Projects were ranked using quantitative methods that analyzed expected attainment of water quality, water supply, flood management, environmental, and community related goals. To access the plan, please visit: www.sonomawater.org/swrp

The Petaluma Floodplain Management Plan calls for the use of flood terraces adjacent to riparian corridors. These terraces provide the opportunity for sediment and pollutants, including trash, to settle out of the flowing water and facilitate easy pick-up and disposal following the storm events. The floodplain management plan also calls for bank repairs, channel re-contours, and installation of a sediment capture feature to increase the stability of project reach channels and reduce sedimentation to the river and tributaries. These flood terraces reconnect the flow channel to the historic floodplain, reducing depth of out-of-bank flows; and, where possible, allow the day-lighting of culverted storm flows to a natural channel. Augmentation of the river corridor floodplain to capture and transport additional surface flows provides multiple benefits. Slowing the storm flows to allow ponding and recharge through pervious soils within the flood terraces provides recharge benefits for shallow aquifers. Ponding increases groundwater infiltration and terracing reduces the volume and velocity of downstream runoff.

Sonoma Water is in the process of conducting a two-phase flood reduction feasibility study for the Upper Petaluma River. In the first phase of the project Sonoma Water developed a combined hydrologic and hydraulic model of the upper Petaluma River watershed to identify the most suitable watersheds and project types to reduce flooding. Two screening concept types, detention basins and floodplain modifications, were tested in the five tributary watersheds of Marin, Liberty, Lichau, Willow Brook and Lynch creeks to capture how the diversity of watershed size, shapes, and attributes may influence downstream flooding. With respect to project type, detention projects were found to provide greater flood reduction benefits compared to floodplain modification. Offline detention was less likely to result in adverse downstream flood impacts when compared to floodplain modification and expansion. The analysis demonstrated that peak flow attenuation was greatest from projects along Willow Brook and Lichau Creek due to their larger size, peaked hydrographs, and location in the Petaluma River watershed. Projects along Marin and Liberty Creeks may still provide localized flood reduction benefits but already benefit from significant attenuation in the Denman Flat region of the Petaluma River (Woodard & Curran 2019). The second phase of the project is ongoing and extends the watershed and project type rankings to Wiggins, Wilson, Corona, and Capri creek and the Upper Petaluma River for a more comprehensive understanding of potential project benefits. The second phase uses the extended ranking analysis and combines the Sonoma Water hydrologic and hydraulic models

with the City's flood model to simulate detention basins at 20 locations and their expected benefits.

The combined hydrologic and hydraulic model is being leveraged to support other Sonoma Water projects in the area and a comprehensive model update by the City of Petaluma. The Sonoma Water projects include a focused detention basin study between Copeland and Robert's Creeks that is transitioning into preliminary design and a targeted flood mitigation feasibility study along Lichau Creek near Penngrove that was completed in 2020. The City of Petaluma is currently transitioning their flood model and incorporating the additional detail of Sonoma Water's upper Petaluma River watershed hydrologic and hydraulic model which will provide a single comprehensive model of the Petaluma River Watershed for flood planning activities. This collaboratively developed model will help inform various watershed and City planning needs as well as provide the foundation for project development to address flooding, stormwater management, climate change and restoration opportunities in both the rural and urban areas.

Implementation of Flood Detention Basins is the third prioritized project identified in the Petaluma Watershed Action Plan, this plan's companion document. Low Impact development provides another suite of potential solutions to flooding and stormwater management. Low Impact Development is an approach that integrates specialized landscape features into the urban environment that use "Slow It, Spread It, Sink It" concepts for capturing runoff.

**Regional Flood Management Assessment**

Sonoma Water is currently embarking on an assessment of countywide flood risk management under the Board of Supervisors awarded Climate Resiliency Funds. Flood risk management responsibilities and services in Sonoma County are fragmented amongst various organizations and jurisdictions and there is little comprehensive planning for countywide risk management among these organizations. Sonoma Water plan to implement a roject that will conduct a countywide assessment of flood risk management responsibilities and authorities and develop recommendations for integrated flood risk actions from the collective flood management agencies within Sonoma County. This Assessment will integrate various elements including: historic, current, and future flood risk, assessment of where and how local and federal agencies currently provide flood risk management services.

Many of the recommended actions below will be implemented through the prioritized project: Stormwater Friendly Landscape Transformation, described in detail in this Plan's companion document: Petaluma Watershed Action Plan.

## RECOMMENDED ACTIONS – CH. 11 STORMWATER AND FLOOD CONROL MANAGEMENT

**Recommendation 11.1** – Implement the Southern Sonoma County Storm Water Resources Plan.

**Recommendation 11.2** – Assist individual rural and urban landowners to install "Slow It, Spread It, Sink It!" practices such as rain gardens, downspout outlet protection and pervious hardscapes.

**Recommendation 11.3** – Support the goals and practices of the City of Petaluma Storm Water Management Plan.

**Recommendation 11.4** – Support planning measures that control development to appropriate locations, preserve open space and agricultural lands.

**Recommendation 11.5** – Use flood managed aquifer recharge land management practices and develop LandSmart ranch and farm water quality plans.

**Recommendation 11.6** – Encourage the City of Petaluma and Sonoma County to incorporate more "Slow It, Spread It, Sink It!" concepts and promoting and incentivizing Low Impact Development practices as part of new development and redevelopment projects seeking permits and approvals.

**Recommendation 11.7** – Develop trash catching systems along waterways where feasible.

**Recommendation 11.8** – Investigate ways to incorporate Flood-MAR principles into existing planned projects.

**Recommendation 11.9** – Support erosion and sediment control efforts such as the development of LandSmart ranch and farm management plans and implement Beneficial management practices to decrease sediment loads. Project 10, Tolay Lake Regional Park Gully Restoration, which is prioritized in the companion document to this plan, the Petaluma Watershed Action Plan, partially implements this recommendation.

**Recommendation 11.10** – Implement the City of Petaluma's Floodplain Management Plan and support the completion of the Petaluma Flood Control Project, particularly along the north river and headwater tributaries.

**Recommendation 11.11** – Participate in local Stream Maintenance & Storm Drain Improvements projects including re-contouring creeks, terracing, creation of basin ponds. Follow findings and recommendations developed by the Zone 2A Advisory Council and the Groundwater Basin Assessment and Management Program.

**Recommendation 11.12** – Implement projects that provide flood protection, habitat enhancement, groundwater recharge, and where feasible passive recreation.

**Recommendation 11.13** – Acquire lands through willing sales and/or easements on each side of the north river area and develop into flood control management projects.

# CHAPTER 12. EDUCATION AND COMMUNITY OUTREACH

Diverse communities are healthy communities. The foundation of a healthy community is a healthy watershed. Incorporating Diversity, Equity, and Inclusion (DEI) into the framework of watershed management and strong and authentic partnership development is vital to the success of this plan and its goals. Engaging all stakeholders of the watershed to inspire voluntary management of our natural and cultural resources is vital for the present and future health of our communities.

We recognize that the Coast Miwok have stewarded the watershed's natural resources as cultural resources since time immemorial. We value and hope to elevate this traditional knowledge of ecological relationships within the Petaluma River Watershed. Collectively we have much work to do in building cooperative and trusting relationships with our local Indigenous communities and we have begun by including members of the Dry Creek Rancheria Band of Pomo Indians and Federated Indians of Graton Rancheria in this planning effort

## PETALUMA WATERSHED COLLABORATIVE

Beginning in 2015, a core group of watershed-based natural resource practitioners began convening to share updates, current progress, and actions needed in the Petaluma River Watershed. This initial group was made up of representatives from Redwood Empire Trout Unlimited, National Marine Fisheries Service, Sonoma Resource Conservation District, Sonoma Water, and Friends of the Petaluma River. The attendance at these gatherings grew as watershed stakeholders became aware of each other's efforts, until various local entities volunteered to coordinate and schedule periodic meetings to discuss watershed-wide projects and concerns. Over time, this group grew into a frequently-meeting assembly of over 20 distinct entities.

Sonoma RCD applied to lead and facilitate the planning and coordination efforts of the Collaborative by applying to the Bureau of Reclamation's WaterSMART grant program, a "program of the Department of the Interior that focuses on improving water conservation and helping water-resource managers make sound decisions about water use (BOR 2021)."Funded in 2019 by the WaterSMART program, the Sonoma Resource Conservation District (SRCD) led efforts to increase the institutional capacity among local stakeholder groups to carry out sustainable watershed management and restoration in the Petaluma Watershed by supporting and further facilitating the Petaluma River Watershed Collaborative. While funded under the grant (July 2019 through June 2022), SRCD organized and held stakeholder meetings to develop a revised version of the *Draft Petaluma Watershed Enhancement Plan* and an *Action Plan* to identify and advance watershed restoration projects and priorities. The goal is to identify and implement solutions and improvements within the watershed to mitigate negative effects associated with climate change, sea level rise, and water quality and quantity impairments, while

protecting and preserving the economic, recreational, and cultural ecosystem services within our watershed.

Local land managers, residents, business owners, Tribes, natural resource professionals, representatives from local entities, and or individuals and community members with interest were invited to attend and participate in regularly held stakeholder meetings, as well as any additional watershed stakeholders that may have not been included within previous invitations.

Mission of the Collaborative: To restore and manage the Petaluma River Watershed through cooperative actions.

Vision of the Collaborative: Perpetuate a community of active, informed, and engaged stakeholders that cooperatively improve landscape functions and resource values to improve the health of the Petaluma River Watershed and surrounding community.

**Objectives of the Collaborative**

The listed objectives of the Collaborative were determined amongst a subset of Collaborative stakeholders. The Federated Indians of Graton Rancheria were invited to participate but were unable. The Collaborative wants to acknowledge the shortcoming of not having Tribal review of these objectives early on in this process; however, we have worked to ensure the Tribe's feedback has been included before the Watershed Plan finalization and recognize the Tribe's involvement is critical in its stewardship management.

1. Establish successful relationships with the Federated Indians of Graton Rancheria and other Watershed Collaborative organizations and agency participants, local landowners, and community members within the Petaluma River Watershed to build trust and work as project partners to develop solutions to employ conservation stewardship across diverse land uses, emphasize cultural resource knowledge and protection, and address water management needs.

2. Identify priority areas and advocate for the implementation of projects to advance natural resource objectives in the Petaluma River Watershed.

3. Develop projects that meet the goals and objectives of available funding opportunities.

4. Position the Petaluma River Watershed to be prepared for future funding opportunities by developing a framework for outreach and synergistic project efforts.

5. Develop a platform for communications and materials to remain transparent and available to all.

6. While developing projects and deliverables, identify opportunities to address climate change resiliency.

Table 12.1 illustrates the local, state, and federal agencies, non-profits, and private entities that have actively participated in the Collaborative.

Table 12.1. Petaluma Watershed Collaborative stakeholders.

| **Organization/Agency** | **Representative(s)** |
|---|---|
| Bureau of Reclamation | Laurie Sharp<br>Gene Lee<br>Bradley Hubbard<br>William Degrush, Natural Resource Specialist<br>Alisha James, Grants Management Specialist<br>Jamie Griffin, NEPA and Compliance Branch Chief |
| CA Department of Fish and Wildlife | Ryan Watanabe, Fisheries Biologist |
| CA State Parks | Christina Freeman, Senior Environmental Scientist<br>Rosa Schneider, Senior Environmental Scientist |
| CA State Senate, Third District<br>City of Petaluma | Logan Pitts, Senior Field Representative<br>Chelsea Thompson, Environmental Services Analyst<br>Christina Paul, Principal Policy Planner<br>Emmanual Ursu, Principal Planner<br>Gina Benedetti-Petnic, Assistant Director<br>Jason Beaty, Director of Public Works and Utilities<br>Johnathan Sanglerat, Associate Civil Engineer<br>Ken Eichstaedt, Senior Traffic Engineer |
| County of Sonoma, Second District | Supervisor David Rabbitt<br>Tina Thomas, Board of Supervisors Aide<br>Andrea Krout, District Director |
| Daily Acts | Briana Schaefer, Program Director |
| Dry Creek Rancheria Band of Pomo Indians | Chris Ott, Environmental Director<br>David Delira, Tribal Engineer |
| Environmental Science Associates<br>Environmental Protection Agency | Liane Ware, Restoration Design Engineer<br>Jennifer Siu, Life Scientist |
| Federated Indians of Graton Rancheria | Amanda Vasquez, Environmental Programs Manager |
| Friends of the Petaluma River | Stephanie Bastianon, Executive Director<br>Andy Rogers, Board Member |
| Marin Agricultural Land Trust | Eric Rubenstahl, Stewardship Program Manager |
| National Marine Fisheries Service | Jodi Charrier, Fisheries Biologist<br>Sara Azat, Fisheries Biologist |
| National Resource Conservation Service | Chris Howington, Soil Conservationist<br>Drew Loganbill, District Conservationist |
| Petaluma River Council | David Keller, City Council Member |
| Petaluma Wetlands Alliance | John Shribbs, President |
| Point Blue Conservation Science | John Parodi, STRAW Restoration Director<br>Gina Graziano, Education Coordinator |
| San Fransisco Estuary Institute | Scott Dusterhoff, Lead Geomorphologist |
| Sonoma County Farm Bureau | Tawny Tesconi, Executive Director |

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| Sonoma County Regional Parks | Hattie Brown, Natural Resource Manager |
| Sonoma Resource Conservation District | Katie Robbins, Project Manager |
| Sonoma Land Trust | Kendall Webster, Acquisition Program Manager<br>Julian Meisler, Baylands Program Manager |
| Sonoma Water | Susan Haydon, Project Specialist |
| Redwood Empire Trout Unlimited | Charlie Schneider, North Coast Coordinator |
| United Anglers of Casa Grande | Dan Hubacker, Director |

## COMMUNITY ENGAGEMENT

**Petaluma River Watershed Enhancement Plan**

Last updated as a draft in 2015, the Petaluma River Watershed Enhancement Plan is due for an update and to be finalized. Stakeholders within the Petaluma Watershed Collaborative began updates to the plan in 2021 by incorporating recent information and identifying data gaps. Community input was sought beyond the Collaborative during the 2015 update and again in 2021. This input provided important considerations and recommendations that have been included in the most recent update.

The SRCD collaborated with the City of Petaluma, which is updating the City of Petaluma General Plan 2025. In 2021, the City published 19 Existing Conditions Reports that address key areas of the General Plan and inform parts of the Petaluma Watershed Enhancement Plan. The County of Sonoma is also updating its general plan, which will guide development, land use, and natural resource conservation for the next 20 years. Strong partnership between the City, the County, and the SRCD will ensure that planning across the Petaluma River Watershed is consistent, collaborative, and successful.

**Petaluma River Watershed Action Plan: Top 10 Projects**

Intended as the “next step” for identifying and progressing project ideas in the Petaluma Watershed, the Action Plan will include a list of the Top 10 Implementation Projects recommended for local stakeholders to pursue as a next phase of Collaborative work.

In late 2021, the Collaborative solicited watershed improvement projects from the stakeholder community for consideration for inclusion in the Action Plan. Projects were evaluated using a set of criteria created by the Collaborative and the ten highest ranking projects were included in the Petaluma Watershed Action Plan. Examples of project types include (but are not limited to) "on-the-ground" or implementation projects (such as habitat restoration, fish passage barriers, addressing erosion/sediment concerns, vegetation management or revegetation, flood control), educational programs, community service and engagement projects, planning efforts that address a watershed-related concern, scientific studies, habitat mapping, community access, etc. The Action Plan is being developed concurrently with this 2022 update of the Petaluma Watershed Enhancement Plan.

### Petaluma River Baylands Strategy

As noted in Chapter 7, the *Petaluma River Baylands Strategy* (Strategy) developed specific goals and objectives for the Baylands region of the Petaluma River Watershed. This document will be released in early 2023 highlighting vulnerabilities, opportunities, and constraints for climate change resilience and adaption in this region. Extensive outreach with landowners, a Regional Science Advisory Team, local stakeholders and interested parties, and regulatory agencies took place with the development of this Strategy. Continued outreach and engagement is planned as next steps for continuing upon this effort to move towards willing implementation of strategies and identified projects within the document. Acquisition for Conservation is the sixth prioritized project identified in the Petaluma Watershed Action Plan, this plan's companion document, which is one strategy identified in the *Petaluma River Baylands Strategy.*

## YOUTH ENVIRONMENTAL EDUCATION

The benefits of a healthy watershed, such as clean water, clean air, and access to open space should be available to all. Environmental education is a gateway through which a student from any background can have a memorable experience in their local watershed and create positive impact in their community. Below is a summary of environmental education programs that are introducing youths to the Petaluma River Watershed and inspiring a new generation of watershed stewards.

### Friends of the Petaluma River: Watershed Classroom

Watershed Classroom was launched in 2014 as a project of the Friends of the Petaluma River. The mission of the Watershed Classroom is to "support the implementation of exceptionally engaging curriculum about the Petaluma River and Watershed with the goals of inspiring youth, improving local education, and celebrating our local environment (Watershed Classroom 2014)." The program supports teachers that develop and implement projects focused on the Petaluma River and/or Watershed. A multi-year program supports local teachers financially to plan lessons and engage students with actionable projects that directly impact the watershed. The program offers free field trips to the Steamer Landing and the David Yearsley River Heritage Center with direct access to the river where water testing training and kits are offered for class use.

### Point Blue Conservation Science: STRAW Program

STRAW (Students and Teachers Restoring a Watershed) is a collaborative program of students, educators, scientists, ranchers, and public agencies working to restore ecosystem health and watershed function. The program teaches K-12 students about stream and wetland restoration through classroom and field-based activities that meet science standards. In 2018, STRAW was awarded a $2.7 million grant from San Fransico Bay Restoration Authority Measure AA funds to engage students in hands-on restoration projects in Petaluma, San Rafael, and the San Pablo Bay National Wildlife Refuge.

### Tolay Lake Regional Park School Program

Sonoma County Regional Parks and the Federated Indians of Graton Rancheria host school groups at Tolay Lake Regional Park with a focus on Tribal history. This award-winning field trip engages students with the rich heritage and culture of the Coast Miwok in Sonoma County (Sonoma County Regional Parks 2021). Early California tribes had an incredibly detailed knowledge of natural resources and passed this knowledge down through generations. Students take an extended hike exploring the use of native plants and participate in storytelling and crafts specific to the living culture of the Tribe.

### Sonoma Land Trust: Bay Camp

Bay Camp is a bilingual summer day camp on San Pablo Bay for children ages 7 to 12, connecting them to the tidal marsh ecosystem through exploration of the environment and learning about and experiencing the ecology of this vital habitat (Sonoma Land Trust 2021). Bay Camp offers children the opportunity to immerse themselves in nature through exploration, hands-on activities and recreation along the tidal marsh. Camp headquarters is at the Ralph Benson Center at the Baylands on the San Pablo Bay National Wildlife Refuge.

### Sonoma Resource Conservation District: LandSmart Education

The FARMS (Farming, Agriculture, Resource Management and Sustainability) Leadership Program and TEAM (Teaching Environmental and Agricultural Memories) Program offer on-farm conservation education to students ranging in age from elementary to high school. The programs provide innovative hands-on experiences coupled with classroom sessions to foster an appreciation for our diverse communities and ecosystems, while supporting social emotional learning and leadership skills. The content of both programs incorporates the significant role that Sonoma County's characteristic agricultural landscape plays in environmental stewardship.

### Petaluma Wetlands Alliance: Education Program

The PWA Education Program helps students in the Petaluma River watershed understand the role of wetlands and appreciation of all living organisms. The program began in 2003, serving 300 students. We now serve from 28-30 classes and 750-800 students each year. Designed to align with California third grade science standards, our program is delivered by trained and supervised volunteer docents. For each classroom, several docents conduct a morning session of slide presentation and hands-on activities in the classroom followed immediately by a second morning of field activities at Shollenberger Park. PWA previously designed an Interpretive and Education Center to be built at ECWRF, but did not get funded.

### United Anglers of Casa Grande, Inc.

The United Anglers of Casa Grande, Inc. is an established non-profit educational organization whose purpose is to promote environmental awareness and activism through hands-on habitat restoration that supports the survival and recovery of federally threatened salmon fishes. Students conduct stream surveys for both spawning and juvenile salmonids. Much of the data

collected in the watershed to date has been from the United Anglers work in the watershed starting in 1983. United Anglers students additionally operate and maintain a state-of-the-art conservation fish hatchery on the Casa Grande High School campus in Petaluma, next door to Adobe Creek.

### Petaluma High School Wildlife Museum

The Petaluma Wildlife Museum is a student-run natural history museum where student docents give conservation-themed tours of the facility and small animal zoo to children from visiting local elementary schools. In addition, student docents bring Animal Ambassadors to community events and travel to local schools and organizations to provide conservation themed workshops/presentations in addition to running an Open House at the facility for the public in an effort to spread the Museum's message of the importance of biodiversity and wildlife conservation.

## CONTINUED EFFORTS

The Petaluma Watershed Plan is a living document and will be updated again as our community and landscape evolve. The Recommended Actions itemized below summarize the future vision for continued action in the Petaluma Watershed as it relates to Education and Community Outreach.

## RECOMMENDED ACTIONS – CH. 12 EDUCATION AND COMMUNITY OUTREACH

**Recommendation 12.1** – Promote greater awareness and understanding of the relationships between cultural and natural resources to support conservation of native biodiversity and watershed health.

**Recommendation 12.2** – Establish relationships with land managers, residents, and community members within the Petaluma River Watershed to build trust and reach a common goal of developing solutions to employ conservation stewardship and address water management needs.

**Recommendation 12.3** – Build the institutional capacity of Petaluma River Watershed stakeholders to carry out sustainable watershed management and restoration in the watershed through the Petaluma River Watershed Collaborative.

**Recommendation 12.4** – Develop institutional and grassroots capability to improve the functioning condition of rivers and streams through water conservation, improved water quality, ecological and climate resiliency, and the reduction of water conflicts.

**Recommendation 12.5 –** Evaluate the potential interest and fundability of creating an online database (or tapping into existing online databases) that stakeholders in the Petaluma Watershed Collaborative can use to track progress of plan and project implementation that cohesively integrates natural resource actions throughout the watershed.

**Recommendation 12.6 –** Periodically update the Petaluma Watershed Enhancement Plan with new scientific studies, technical information, and recommended actions for the watershed to ensure that the plan reflects the latest knowledge and conditions.

**Recommendation 12.7 -** Support youth education efforts. Build new Interpretive and Education Center with cooperation of above nonprofits and Petaluma City Schools to teach both youth and adults the ecological and social value of water, wetlands, and the watershed.

# Section Three: Implementation

This section includes Chapter 14 which catalogs all the recommendations made in previous chapters supporting plan implementation.

Photo credit Sonoma Resource Conservation District

# CHAPTER 13. PLAN IMPLEMENTATION

Any land management action, including low-impact management practices such as grazing or native plant revegetation, has the potential to disturb cultural resources. All activities in both the planning and implementation phases should seek to avoid disturbance to cultural resources and sacred sites in addition to actively working with the Federated Indians of Graton Rancheria by establishing a point of contact with the Tribe, conducting site visits, communicating project details, and working with appropriate restoration-based organizations for suitable practice implementation.

During planning phases of projects, permitting and regulatory requirements should be evaluated through regulatory organizations and contacting appropriate staff contacts for project evaluation and compliance assistance. Before and during implementation of projects, all permitting requirements should be adhered to.

Funding for projects may be sought after from a range of sources including but not limited to private funds and donations, fundraising efforts, and local, state, and federal grant sources.

A complementary document to the 2022 update of the *Petaluma River Watershed Conservation and Enhancement Plan* was developed as an implementation guide for the Petaluma River Watershed. The *Petaluma Watershed Action Plan* (Action Plan) was developed to include a list of priority management and restoration projects to be implemented with leadership from the Petaluma Watershed Collaborative (Collaborative).

Please see the Action Plan for highlighted projects referenced throughout this Plan and for a list of project actions to be pursued and implemented by watershed stakeholders and practitioners.

## DATA GAPS WITHIN THE PETALUMA RIVER WATERSHED

Despite the continuing efforts occurring in the watershed, data gaps remain that pose challenges to natural resource practitioners seeking funding and knowledge to prioritize project type(s) and location(s) within the watershed. During the update of this Plan, Stakeholders have identified data gaps that remain for the Petaluma River Watershed and the actions needed to improve upon the collective knowledge for successful watershed restoration.

Having the below resources, knowledge, and information would assist in the planning of projects, illustrating the rational of projects to funders, and garnering support for projects from community members, partnering agencies, and regulators alike.

This plan's companion document, the Petaluma Watershed Action Plan, prioritizes Project 7, Studies for Increased Knowledge and Identification of Next Steps to begin filling some of the data gaps identified below.

**Riparian and Wetland Ecosystem Data Gaps**

1. Knowledge of sediment sources, management, and best use for restoration activities in the watershed.

2. Knowledge and identification of the best use and placement of dredged materials from Petaluma River dredging activities.

3. Current surveys to identify location and abundance of listed plan species within the watershed.

4. Knowledge of the best management and requirements of listed plant species for the long-term conservation and recovery of such species.

5. Updated information of habitat restoration potential and priorities provided at the sub-watershed level to aide practitioners in project prioritization.

**Fish and Wildlife Data Gaps**

1. Research and knowledge to better understand habitat potential and carrying capacity for steelhead survival in the watershed.

2. Current watershed-wide species surveys and monitoring for endangered, threatened, and special status species.

3. Current watershed-wide species surveys and monitoring for tidal marsh, riparian, upland, aquatic, and migratory species within the watershed.

4. Information, research, and/or surveys to better understand the viability of naturally occurring salmonid populations throughout the watershed.

5. Assessments of potential fish passage barriers throughout the entirety of the watershed in salmonid bearing streams.

**Water Quality and Quantity Data Gaps**

1. Current spatial distribution of nitrate contamination in addition to other water quality pollutants and concerns.

2. Outreach and surveys to determine the extent that rural residential and agricultural stream diversions may be impacting streamflow conditions and aquatic habitat and wildlife.

3. Streamflow monitoring and gauging network throughout the watershed to build knowledge of instream flow conditions and patterns.

4. Wet-dry mapping throughout historical salmonid-bearing streams to better understand drying and re-wetting patterns of streams.

**Stormwater and Flood Control Management Data Gaps**

1. Increased knowledge of the effects of dredging the Petaluma River for future best management recommendations and practices.

## SUMMARY OF RECOMMENDATIONS

**Table 13.1.** Summary of Recommendations from chapters four through twelve.

| Action # | Description |
|---|---|
| **Chapter 4. Climate Change Impacts and Adaptation** | |
| 4.1 | Follow recommendations in California's Climate Change Adaptation Strategy 2018 Climate Justice Chapter:<br><br>a) Actively engage, educate, and partner with communities to enable early, continuous, and meaningful participation in adaptation initiatives.<br><br>b) Identify the most vulnerable communities to climate change to prioritize initiatives and build grassroots capacity.<br><br>c) Support and coordinate adaptation efforts across jurisdictions and policy areas to maximize community resilience.<br><br>d) Promote holistic approaches to climate adaptation that maximize co-benefits and economic development.<br><br>e) Make equity an integral consideration for climate research. |
| 4.2 | In riparian areas:<br><br>a) Encourage a patchwork of habitats, such as a small grassy area near a dense shrubby area near a group of tall trees.<br><br>b) Encourage multi-story native vegetation: groundcover, shrubs, and trees.<br><br>c) Leave old and dead trees in place if they do not threaten infrastructure. |
| 4.3 | Where feasible, allow natural hydrologic processes, such as flooding and laying down new layers of sediment. |
| 4.4 | In forestlands monitor for pest insects and pathogens, invasive species, and dying trees. If you have questions, contact University of California Cooperative Extension Master Gardeners or a private arborist. |
| 4.5 | Support improvement of the Urban Forest to increase biodiversity, reduce urban heat, sequester carbon, improve quality of life, and provide multiple other benefits. |

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| 4.6 | Improve and beautify the downtown ecosystem with planting native trees, restoring riverbanks with native vegetation, and creating larger park settings in community areas such as the River Park, Outlet Mall flood area, and Fairgrounds which improve living standards for the local underserved communities. |
| 4.7 | Assist landowners to eradicate non-native pest insects, pathogens, and invasive weeds. |
| 4.8 | For wetlands:<br>a) Complete large wetland restoration projects to serve as buffers to tidal flooding as well as sea level rise.<br>b) Reduce development in low-lying areas, behind levees, or adjacent to the bay/coast and prevent and reduce other stressors that reduce the ability of the wetland ecosystem to respond.<br>c) Identify and support projects, that facilitate connectivity to marshes and wetlands prior to and as they are impacted by sea level rise, especially those that acquire land to allow for migration of wetland habitat upslope. |
| 4.9 | For agriculture:<br>a) Provide technical and financial incentives to transition management practices and crops that are affected by climate change.<br>b) Where possible, transition to organic and regenerative practices.<br>c) Where possible, trees, shrubs, and hedgerows into rangeland or farm landscapes to sequester carbon.<br>d) Where possible, implement soil management practices that sequester carbon as well as other climate beneficial practices promoted by SRCD and NRCS. |
| 4.10 | Identify and act upon opportunities to preserve habitat, wildlife corridors, and open and green spaces where feasible. |
| 4.11 | For watershed residents:<br>a) Install energy efficient fixtures and appliances as the opportunity arises.<br>b) Join neighborhood groups focused on improving green infrastructure and creating social cohesiveness.<br>c) Participate in local, regional, and state climate actions and strategies recommended for residences. |

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| | d) Walk, ride bikes, or use public transit when possible.<br><br>e) Participate in local, regional, and state governance by attending meetings as possible and being an informed voter in every election. |
| **Chapter 5. Urban Land Use** | |
| 5.1 | Center equity in all stakeholder outreach, planning, and implementation efforts. |
| 5.2 | Promote infill development away from river and creek corridors and outer urban-rural transition areas to minimize impacts to water ways, habitats, wildlife corridors, open space, and agricultural lands to restrict them to within existing developed areas. |
| 5.3 | Identify and provide open and green spaces within and around infill development to support quality of residential life and facilitate wildlife movement. |
| 5.4 | Pursue acquisition, conservation easements, and/or protect private properties with environmental development potential, especially along river and sensitive creek/water channel corridors and urban-rural transition areas, for open space, habitat connectivity, wildlife movement and biodiversity, flood management, and groundwater recharge. |
| 5.5 | Use of the Sonoma Water's Water Smart Development Guidebook: increase water conservation and water reuse and reduce stormwater impacts |
| 5.6 | Adhere to requirements in the Phase II Small MS4 Permit (Order No. 2013-0001-DWQ) that include specific BMP and management measure requirements for commercial, industrial, municipal, and residential land uses. |
| 5.7 | Adopt and enforce next generation green building standards for all new development |
| 5.8 | Provide resources for landowners of all sizes to minimize residential impacts such as:<br>d. Slow it. Spread it. Sink it Guide to Beneficial Stormwater Management and Water Conservation Strategies; Spanish Version (abbreviated)<br><br>e. Management Tips to Enhance Land & Water Quality for Small Acreage Properties<br><br>f. Species list, habitat information, and guidance on habitat enhancement and restoration to support our area birds and wildlife. |
| 5.9 | Support community outreach and involvement efforts including wetland education and regional low water use programs such as Petaluma Wetlands Alliance Education Program, Daily Acts workshops, Friends of the Petaluma River Watershed Classroom and River cleanups, Paula Lane Action Network's and Madrone Audubon's bird and wildlife education and habitat gardening support. |

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| 5.10 | Include the new Petaluma City Schools Environmental Literacy Initiative to support climate change and water cycle lessons in all classrooms. |
| 5.11 | Implement Actions in the City of Petaluma Local Hazard Management Plan, including:<br>e. Floodplain property protection, acquisition, and relocation<br>f. Annual stream and creek channel maintenance<br>g. Higher regulatory standards for flood protection<br>h. Enhance structural flood mitigation projects to reduce near-annual floods on the north end of the city |
| 5.12 | Fully implement the 2008 Bicycle & Pedestrian Plan to reduce vehicle traffic and align transport projects with Safe Streets and Vision Zero goals. |
| 5.13 | Promote walking and bicycling to work, school, and local tasks such as shopping, receiving services, and visiting when feasible. |
| 5.14 | Promote use of electric vehicles by installing charging stations in appropriate locations. |
| 5.15 | Promote use of public transportation, especially the SMART train to reduce local and regional congestion. |
| 5.16 | Promote carpooling and ride sharing, especially encourage use of electric micro-mobility for local community and neighborhood ride sharing systems and programs. |
| 5.17 | As boat traffic increases, explore development of a program to install charging stations at docks and marinas as more electric boats enter the marketplace. |
| 5.18 | Build ADA access for small craft at Marina, Turning Basin, and River Park so all can access the river in human powered watercraft. |
| 5.19 | Through use of informational kiosks and signs, encourage appreciation for clean surroundings and unpolluted wildlife habitat and discourage littering and trash dumping. |
| 5.20 | Thoughtful development of recreational opportunities to ameliorate impacts associated with recreation and human use of natural areas. Examples include:<br>e) Promotion of public transportation, especially the SMART trains.<br>f) Provision of adequate restroom facilities. |

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| | g) Educational kiosks and signage to mitigate thoughtless visitor behavior such as overuse of water or vegetation trampling.<br><br>h) Adequate infrastructure to control visitor movement, such as railings and dedicated pathways. |
| 5.21 | Build Interpretive Environment and Education Center near river and bikeway for the mission of providing a local comprehensive environmental education platform highlighting the Petaluma River ecosystem that is appropriate for all age groups. |
| 5.22 | Encourage residents and visitors to make use of the watershed's stunning array of natural wealth by giving easy, multiple access to the river and creeks so people are more likely to become appreciative of, and hopefully protective of, these sensitive and valuable resources. |
| **Chapter 6. Agricultural and Rural Sustainability** | |
| 6.1 | Renew City of Petaluma's Urban Growth Boundary to protect surrounding agricultural lands from increased residential conversion pressure, currently set to expire in 2025. |
| 6.2 | Promote on-farm best management practices identified by USDA Natural Resources Conservation Service with implementation assistance provided by Sonoma Resource Conservation District. |
| 6.3 | Promote public support of local agriculture through farmers' markets and outreach campaigns to "buy local" when grocery shopping. |
| 6.4 | Promote public knowledge about and appreciation of local organizations that support farming, such as Sonoma Ag + Open Space and Marin Agricultural Land Trust. |
| 6.5 | Provide educational, technical, and financial services to help growers and ranchers understand and comply with applicable agricultural regulations. |
| 6.6 | Develop LandSmart ranch and farm conservation plans or carbon farm plans to document current and plan for future beneficial management practices. |
| 6.7 | Collaborate with landowners to design and implement projects to prevent and control soil erosion and enhance soil quality. |
| 6.8 | Support STRAW (Student and Teachers Restoring a Watershed) program and RCD efforts to restore ecosystems along water channels on working lands. |
| 6.9 | Improve water use efficiency of irrigation and frost protection systems. Seek out and develop alternative water sources for these uses whenever feasible. |
| 6.10 | Manage grazing to protect and enhance soil quality, plant communities and water quality. |
| 6.11 | Conduct outreach about minimizing the impact of animal waste including confined livestock area runoff management, manure and fertilizer application, and silage storage. |

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| 6.12 | Assist landowners with developing projects to ensure water reliability. |
| 6.13 | Provide educational, technical, and financial support to help growers and ranchers adopt climate beneficial farming practices that play a vital role in achieving regional climate goals. |
| 6.14 | Prioritize land conservation efforts that preserve agricultural and rural land identified as part of critical wildlife corridors/linkages or lands within zones predicted to be impacted by sea level rise. |
| 6.15 | Continue to educate landowners residing in the WUI zones about appropriate wildfire mitigation strategies to make their properties more resilient to wildfire impacts; identify and pursue funding to assist landowners with implementing appropriate BMPs. |
| **Chapter 7. Riparian Lands and Ecosystem Services** | |
| 7.1 | Partner with the Federated Indians of Graton Rancheria to incorporate Traditional Ecological Knowledge and stewardship practices in the planning, decision making, and management surrounding restoration and stewardship of natural and cultural resources, especially surrounding the planning and implementation of activities that may disturb sacred sites. Practitioners engaging with tribes should communicate clearly with Tribe on how shared knowledge and resources will be maintained and safeguarded to ensure confidentiality in documentation, reporting, and conversations. |
| 7.2 | Revegetate riverbank from upper marsh to northern reach with cooperation of city to increase habitat and prepare for future flooding and sea level rise. |
| 7.3 | For Petaluma Marsh:<br><br>f) Restore large patches of tidal marsh along the entire shoreline of San Pablo Bay, especially near mouths of sloughs and major streams using nature-based solutions.<br><br>g) Allow natural processes such as flooding and laying down new layers of sediment.<br><br>h) Reuse dredge material where sediment is needed; this practice is included in the companion document to this plan, the Petaluma Watershed Action Plan.<br><br>i) Bury large logs to create mini dikes that break wave action and provide backside habitat protection.<br><br>j) Move dikes back in "retreat."<br><br>k) Build "horizontal levees" where sediments are loaded onto the land to create a gradual slope. |

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| 7.4 | Complete large wetland restoration projects to buffer tidal flooding and sea level rise. |
| 7.5 | Manage, restore, and monitor tidal marsh habitat to promote the recovery of listed species and long-term conservation of species of concern and other tidal marsh species. |
| 7.6 | Purchase privately owned parts of the Petaluma Marsh and start restoration. |
| 7.7 | For marsh landowners:<br><br>f) Establish managed marsh or enhanced seasonal pond habitat (especially for shorebirds) on agricultural baylands that are not restored to tidal marsh.<br><br>g) Establish managed marsh or enhanced seasonal pond habitat (especially for shorebirds) on agricultural baylands that are not restored to tidal marsh.<br><br>h) Create small diked ponded areas adjacent to levees where possible.<br><br>i) Work with private landowners currently doing an agricultural service in the lower Petaluma River to shift how they manage their dikes.<br><br>j) Instead of building bigger, higher front dikes, experts are recommending moving the dike back and grading the land in front with a gradual slope that breaks wave action and provides space for marsh habitat that slows water energy from reaching the main dike. |
| 7.8 | In agricultural upland areas:<br><br>a) Allow ponding in field depressions for shorebirds and waterfowl.<br><br>b) Create small diked ponded areas adjacent to levees where possible.<br><br>c) Encourage growth of vegetation along fence rows or field edges to provide habitat for small birds and mammals.<br><br>d) Delay spring harvest of oat-hay as late as possible to avoid nesting waterfowl.<br><br>e) Fence cattle from wetland areas during wet periods. |

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| | f) Increase the practice of rotational grazing to encourage a more diverse grassland habitat. |
| 7.9 | In planting and restoration projects, incorporate and utilize native vegetation and plants that are of cultural significance to Federated Indians of Graton Rancheria. |
| 7.10 | Test various planting palettes and methods for restoring marsh edges and dikes, for example, the Shollenberger Levee Planting Project by STRAW. |
| 7.11 | Prepare and distribute information to the public about the habitat needs of native species and how watershed residents can help with recovery efforts. |
| 7.12 | Revegetate high and medium priority riparian sites with cooperative landowners. Project 9, Washington Creek Enhancement, prioritized in the companion document to this plan, the Petaluma Watershed Action Plan, will partially fulfill this recommendation. |
| 7.13 | Help landowners apply for cost share programs to implement stream enhancement plans and riparian revegetation projects. |
| 7.14 | Manage livestock access to the creeks, especially during the wet season and assist landowners to develop grazing plans and exclusion zones. |
| 7.15 | Conduct community outreach and provide technical assistance to landowners to help manage and protect riparian areas. |
| 7.16 | Develop LandSmart ranch and farm water quality plans, in collaboration with landowners, to document current and plan for future beneficial management practices. |
| 7.17 | With willing landowners, establish managed marsh or enhanced seasonal pond habitat (especially for shorebirds) on agricultural baylands that are not restored to tidal marsh. Project 5, King Creek Wetland Enhancement, which is prioritized for implementation in the companion document Petaluma Watershed Enhancement Plan, partially implements this recommendation. |
| 7.18 | Enhance riparian habitat and, where possible, enhance marsh/upland transitions and provide buffers for anticipated climatic drift of habitats. |
| 7.19 | Prepare and distribute information to the public about the habitat needs of special status species and how watershed residents can help with recovery efforts. |
| 7.20 | In agricultural areas create small diked ponded areas adjacent to levees where possible. |
| 7.21 | In agricultural areas, encourage native vegetation along fence rows or field edges to provide habitat for small birds, mammals, and pollinators. |
| 7.22 | In agricultural areas, exclude cattle from wetland areas during wet periods. |
| 7.23 | In agricultural areas, increase the practice of rotational grazing to encourage a more diverse grassland habitat. |
| **Chapter 8. Fish and Wildlife Resources** | |

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| 8.1 | Implement NOAA's 2016 Final Coastal Multispecies Recovery Plan for Central California Coast Steelhead (Recovery Plan) including the addressing the following areas as identified in the Recovery Plan.<br>j) Improve riparian composition and structure: native riparian planting, development and enforcement of riparian buffers, livestock exclusion fencing, and aligning stream maintenance objectives with riparian conservation objectives.<br>k) Existing problem roads and active erosion sites should be evaluated, prioritized, and addressed as part of a comprehensive sediment reduction and transportation plan for the entire Petaluma River basin.<br>l) Instream habitat complexity and shelter ratings should be improved within poor quality reaches of all tributaries.<br>m) Existing riparian corridors should be protected, and where opportunity exists, riparian buffers should be widened and/or floodplain areas lowered to benefit wintertime rearing. Significant consideration should be focused on addressing the ongoing maintenance costs, property damage, and habitat impacts related to flood control structures in the watershed.<br>n) Improving distribution of livestock to reduce prolonged concentrated utilization of grassland and riparian areas to provide periods of rest for improved grasslands.<br>o) Consider and evaluate the role of a conservation hatchery or hatchery stocking within the Petaluma River basin.<br>p) Protect and enhance summer baseflows to increase the extent of summer rearing habitat in Petaluma River tributaries.<br>q) Assessing and removing barriers will greatly improve the current access to quality habitat for steelhead in the Petaluma River Watershed.<br>r) A limiting factors assessment should be conducted in the estuary to determine the current and future potential habitat conditions for rearing juvenile and smolt salmonids. |
| 8.2 | Focus riparian restoration and erosion control efforts on tributaries that do, or potentially can, support steelhead trout and Chinook salmon. These tributaries are Lichau, Adobe, San Antonio, and possibly Lynch and Willow Brook creeks. |
| 8.3 | Increase riparian canopy cover to 70% and install livestock exclusion fencing within key reaches of major tributaries. |

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| 8.4 | Work with CDFW, UACGHS, and NMFS to conduct surveys for threatened species and species of concern, including but not limited to, pond-breeding and stream-breeding amphibians throughout the watershed in addition to supporting ongoing monitoring and survey efforts of salmonids and wildlife populations. |
| 8.5 | Conduct genetic testing on Chinook salmon to understand origins and patterns. |
| 8.6 | Conduct assessments of potential fish passage barriers and remove on priority streams. |
| 8.7 | Rehabilitate and reclaim historic tidal wetland/slough estuarine habitat for rearing juvenile steelhead. |
| 8.8 | Rehabilitate and reclaim historic tidal wetland/slough estuarine habitat for rearing juvenile steelhead. |
| 8.9 | In aligning with the state's 30x30 initiative, acquire vital habitat for conservation. The Petaluma Watershed Action Plan's Project 6, Acquisition for Conservation partially implements this recommendation. |
| 8.10 | Evaluating Highway 101 for median modifications to facilitate wildlife crossing areas to support east-west connectivity and biodiversity. |
| 8.11 | Conserve and enhance wetlands that provide habitat for listed ESA and CESA endangered species such as Ridgeway's Rail and salt marsh harvest mouse. |
| 8.12 | Conduct studies to determine the steelhead and Chinook salmon carrying capacity of watershed streams. |
| 8.13 | Building on the work of the UACGHS, conduct population viability analyses for steelhead and, if appropriate, Chinook salmon in the watershed. |
| **Chapter 9. Water Supply** | |
| 9.1 | Continue using Urban Water Management Plans, General Plans, and well permitting requirements to assure that water is available for any new developments in the watershed. |
| 9.2 | Support the City of Petaluma, Sonoma Water, and the Petaluma Valley GSA in building a locally resilient water supply by conserving water and implementing drought-resilient landscape practices. |
| 9.3 | Increase water conservation of all water supply sources including recycled water, groundwater, and surface water. |
| 9.4 | Seek funding for watershed-wide multiple-benefit projects that involve elements of water quality improvement, surface and groundwater storage, rainwater harvesting, use of recycled water, wetland restoration, and seasonal flood easements. |
| 9.5 | Develop a rainwater catchment demonstration program for both residential and agricultural landowners. Project 8, Sonoma Mountain Institute Rainwater Catchment, identified as a priority project in this plan's companion document the Petaluma Watershed Action Plan, will partially fulfill this recommendation. |
| 9.6 | Provide resources to landowners on the benefits of groundwater recharge and methods for increasing recharge in upland areas through small landowner meetings. |
| 9.7 | Outreach to agriculture and vineyard properties to determine if there are opportunities to increase water use efficiency and/or implement alternative water sources. |

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| 9.8 | Implement urban and rural water conservation measures such as low water use landscaping, installation of water saving fixtures and appliances, and installation of rainwater catchment and graywater systems. |
| **Chapter 10. Water Quality** | |
| 10.1 | Encourage landowners and managers in the watershed to implement practices to reduce pollutants from entering the water way. |
| 10.2 | Implement management actions to reduce erosion and sediment from entering streams. |
| 10.3 | Assist residents in working with the Counties on well and septic installation and management to maintain or improve ground and surface water quality |
| 10.4 | Due to current habitat conditions, investigate the possibility of using Adobe Creek as an urban reference site. |
| 10.5 | Increase flow monitoring to better interpret water quality data. |
| 10.6 | Develop LandSmart ranch and farm water quality plans in priority watersheds and implement beneficial management practices to decrease sediment, pathogen, and nutrient loads. |
| 10.7 | Maintain septic systems based on State Water Board and Sonoma County PRMD requirements and guidelines found in the "Homeowner's Guide to Septic System Operation." |
| 10.8 | Comply with all conditions of municipal NPDES permits for stormwater and sewer systems. |
| 10.9 | Concentrate erosion control activities in the high priority sub-watersheds of Willow Brook, Lynch, Adobe, Ellis, and San Antonio Creeks. |
| 10.10 | Seek funding and cost share programs for landowners in the upper watershed for installation and maintenance of erosion control measures. |
| 10.11 | Manage livestock access to creeks and gullies, especially in the wet season. |
| 10.12 | Provide educational and technical assistance for "do-it-yourself" erosion control, small farm and pasture management, and reducing rill and sheet erosion for pastures and corrals. |
| 10.13 | Maintain drainage ditches, spillways, culverts, etc. to avoid overtopping and delivery of sediment to the streams. |
| 10.14 | Improve upstream waterways for flood and sediment control by planting native species and building water and sediment catchment basins. |
| 10.15 | Assist landowners and pursue funding to repair eroding banks, install riparian fencing and revegetation and implement LandSmart ranch and farm water quality plans. |
| **Chapter 11. Stormwater and Flood Control Management** | |
| 11.1 | Implement the Southern Sonoma County Storm Water Resources Plan. |
| 11.2 | Assist individual rural and urban landowners to install "Slow It, Spread It, Sink It!" practices such as rain gardens, downspout outlet protection and pervious hardscapes. |

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| 11.3 | Support the goals and practices of the City of Petaluma Storm Water Management Plan. |
| 11.4 | Support planning measures that control development to appropriate locations, preserve open space and agricultural lands. |
| 11.5 | Use flood managed aquifer recharge land management practices and develop LandSmart ranch and farm water quality plans. |
| 11.6 | Encourage the City of Petaluma and Sonoma County to incorporate more “Slow It, Spread It, Sink It!” concepts and promoting and incentivizing Low Impact Development practices as part of new development and redevelopment projects seeking permits and approvals. |
| 11.7 | Develop trash catching systems along waterways where feasible. |
| 11.8 | Investigate ways to incorporate Flood-MAR principles into existing planned projects. |
| 11.9 | Support erosion and sediment control efforts such as the development of LandSmart ranch and farm management plans and implement Beneficial management practices to decrease sediment loads. Project 10, Tolay Lake Regional Park Gully Restoration, which is prioritized in the companion document to this plan, the Petaluma Watershed Action Plan, partially implements this recommendation. |
| 11.10 | Implement the City of Petaluma’s Floodplain Management Plan and support the completion of the Petaluma Flood Control Project, particularly along the north river and headwater tributaries. |
| 11.11 | Participate in local Stream Maintenance & Storm Drain Improvements projects including re-contouring creeks, terracing, creation of basin ponds. Follow findings and recommendations developed by the Zone 2A Advisory Council and the Groundwater Basin Assessment and Management Program. |
| 11.12 | Implement projects that provide flood protection, habitat enhancement, groundwater recharge, and where feasible passive recreation. |
| 11.13 | Acquire lands through willing sales and/or easements on each side of the north river area and develop into flood control management projects. |
| **Chapter 12. Education and Community Outreach** | |
| 12.1 | Promote greater awareness and understanding of the relationships between cultural and natural resources to support conservation of native biodiversity and watershed health. |
| 12.2 | Establish relationships with land managers, residents, and community members within the Petaluma River Watershed to build trust and reach a common goal of developing solutions to employ conservation stewardship and address water management needs. |
| 12.3 | Build the institutional capacity of Petaluma River Watershed stakeholders to carry out sustainable watershed management and restoration in the watershed through the Petaluma River Watershed Collaborative. |
| 12.4 | Develop institutional and grassroots capability to improve the functioning condition of rivers and streams through water conservation, improved water quality, ecological and climate resiliency, and the reduction of water conflicts. |

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| 12.5 | Evaluate the potential interest and fundability of creating an online database (or tapping into existing online databases) that stakeholders in the Petaluma Watershed Collaborative can use to track progress of plan and project implementation that cohesively integrates natural resource actions throughout the watershed. |
| 12.6 | Periodically update the Petaluma Watershed Enhancement Plan with new scientific studies, technical information, and recommended actions for the watershed to ensure that the plan reflects the latest knowledge and conditions. |
| 12.7 | Support youth education efforts. Build new Interpretive and Education Center with cooperation of above nonprofits and Petaluma City Schools to teach both youth and adults the ecological and social value of water, wetlands, and the watershed. |

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# GLOSSARY

**Anadromous fish** - Fish that live some or their entire adult lives in saltwater but migrate to freshwater to spawn.

**Aquifer -** A geologic layer of permeable rock, sand, or gravel that is water bearing and is often a source for well water.

**Baseline data** - A selected set of data that forms a known starting point that will enable determining of system status and help determine trends as the system changes.

**Bedrock** - The solid rock underlying the soils of the earth's surface.

**Beneficial Management Practices (BMPs)** - Accepted conservation practices used by land

stewards that are designed to be the most effective and practicable way in addressing local watershed concerns.

**Biodiversity** - Biological diversity; variety of life forms in an area.

**Cover crop** - A close-growing crop used primarily for the purpose of protecting or improving

soil between periods of regular crop production or between trees and vines in orchards or vineyards.

**Effluent** – To flow out; an outflow of waste, as from a sewer

**Endangered species** - Wild species with so few individual survivors that the species could soon become extinct in all or most of its natural range.

**Endemic -** prevalent in or restricted to a particular locality.

**Exotic species** - A species of plant or animal that belongs by nature or origin to another part of the world.

**Geographic Information System (GIS)** - Technology that links traditional map information with computer database information about locations by allowing users to enter, manage, analyze, and output information.

**Groundwater recharge** - The process involved in the absorption and addition of water to the zone of saturation.

**Habitat** - An area in which an organism or population of organisms survive.

**Land stewardship** - A land ethic of cultural value set that promotes existing land use practices that protect the resources for succeeding generations.

**Native species** - Species that normally live and thrive in a particular ecosystem

**Natural resources** - The soil, water, air, plants, animals, and geologic processes created by the earth's natural processes.

**Nonpoint source pollution** - Pollution that enters water from dispersed and uncontrolled sources, such as surface runoff, rather than through pipes. Nonpoint source (e.g., forest practices, agricultural practices, on-site sewage disposal, automobiles, and recreational boats) may contribute pathogens, suspended solids, and toxins. While individual sources may seem insignificant, the cumulative effects of nonpoint source pollution can be significant.

**Point source pollution** - A single identifiable source that discharges pollutants into the environment. Examples are the smokestack of a power plant or an industrial plant.

**Rill erosion** - An erosion process in which numerous small channels of only several centimeters in depth are formed; occurs mainly on recently cultivated soils.

**Riparian** - Pertaining to a river or stream.

**Runoff** - Rainwater and melting ice that flows on the earth's surface into nearby streams, lakes, wetlands, and reservoirs.

**Salmonid** - Any species of the genus Oncorhynchus, Pacific Ocean fishes in the salmon or trout family that can breed in rivers and stream tributaries to the North Pacific.

**Sheet erosion** - The removal of a uniform layer of soil from the land surface by surface runoff.

**Spawn** - To produce as spawn, deposit eggs or roe.

**Stakeholder** - an entity (individual/agency/group) who has an interest or responsibility or livelihood in the activities within the watershed and its health.

**Water Rights** - Specific policies governing rights to water.

**Watershed** – An entire drainage area that delivers water, sediment, and dissolved substances via streams and rivers.

**Wetland** - Land that: 1) has a predominance of hydric soils, 2) is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, 3) supports a prevalence of such vegetation under normal circumstances.

# Appendices

Photo credit Sonoma Resource Conservation District

# APPENDIX A. PETALUMA RIVER WATERSHED LAND USE MAP, USE TYPES DEFINED

Data used in Map 3.1 in Chapter 3 was gathered from the Farmland Mapping and Monitoring Program, Division of Land Resource Protection, California Department of Conservation's California Important Farmland: Most Recent data layer. The below description are from the data source's metadata and describe how the data was generated and use codes defined.

Abstract: This dataset may be a mix of two years and is updated as the data is released for each county. For example, one county may have data from 2014 while a neighboring county may have had a more recent release of 2016 data. For specific years, please check the service that specifies the year, i.e. California Important Farmland: 2016.Established in 1982, Government Code Section 65570 mandates FMMP to biennially report on the conversion of farmland and grazing land, and to provide maps and data to local government and the public. The Farmland Mapping and Monitoring Program (FMMP) provides data to decision makers for use in planning for the present and future use of California's agricultural land resources. The data is a current inventory of agricultural resources. This data is for general planning purposes and has a minimum mapping unit of ten acres.

Purpose: The Farmland Mapping and Monitoring Program (FMMP) provides data to decision makers for use in planning for the present and future use of California's agricultural land resources. The data is a current inventory of agricultural resources. This data is for general planning purposes and has a minimum mapping unit of ten acres.

Supplemental Information: The Important Farmland survey area is based on Natural Resources Conservation Service (NRCS) modern soil surveys covering most non-governmental lands in California; 49 counties are fully or partially surveyed at this time. Soil surveys specific to National Forests or other government land units are not surveyed. Beginning in 2002, SSURGO digital soil information was incorporated into the Important Farmland data. Data subsequent to 2002 may have acreage and soil line differences due to incorporation of newer NRCS-SSURGO editions. Prior to the availability of SSURGO, soil information was hand-transferred from the paper soil surveys. Older versions of the data have not been modified. The land use minimum mapping unit of ten acres has not changed, but digital soil units of down to one acre occur in the SSURGO-enhanced Important Farmland data. Due to the interaction of land use and soil components of the data, incorporation of SSURGO may also result in units of less than ten acres for categories such as Other Land (or Nonagricultural and Natural Vegetation). For more information on SSURGO, contact the USDA-Natural Resources Conservation Service: http://www.nrcs.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/geo/

Use Constraints: This data does not reflect general plan or zoning designations, city limit lines, changing economic or market conditions, or other factors which may be taken into consideration when land use policies are determined. This data is not designed to be used for parcel specific planning purposes due

to its scale and the size of the minimum mapping unit (10 acres). The Department of Conservation makes no warranties as to the suitability of this data for any particular purpose.

Use Codes (General Land Use Types) Defined:

Grazing: Land on which the existing vegetation is suited to the grazing of livestock. This category is used only in California and was developed in cooperation with the California Cattlemen's Association, University of California Cooperative Extension, and other groups interested in the extent of grazing activities.

Farmland of Local Importance: Land of importance to the local agricultural economy as determined by each county's board of supervisors and a local advisory committee.

Prime Farmland: Irrigated land with the best combination of physical and chemical features able to sustain long term production of agricultural crops. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Land must have been used for production of irrigated crops at some time during the four years prior to the mapping date.

Farmland of Statewide Importance: Irrigated land similar to Prime Farmland that has a good combination of physical and chemical characteristics for the production of agricultural crops. This land has minor shortcomings, such as greater slopes or less ability to store soil moisture than Prime Farmland. Land must have been used for production of irrigated crops at some time during the four years prior to the mapping date.

Unique Farmland: Lesser quality soils used for the production of the state's leading agricultural crops. This land is usually irrigated, but may include non-irrigated orchards or vineyards as found in some climatic zones in California. Land must have been cropped at some time during the four years prior to the mapping date.

Urban and Built-up Land: Urban and Built-Up land is occupied by structures with a building density of at least 1 unit to 1.5 acres, or approximately 6 structures to a 10-acre parcel. Common examples include residential, industrial, commercial, institutional facilities, cemeteries, airports, golf courses, sanitary landfills, sewage treatment, and water control structures.

Water: Water areas with an extent of at least 40 acres.

Other Land: Land which does not meet the criteria of any other category. Typical uses include low density rural development, heavily forested land, mined land, or government land with restrictions on use.

# APPENDIX B. SPECIFIC RECOMMENDED ACTIONS BY SUBWATERSHED

## LICHAU CREEK

Lichau Creek is located in the northern portion of the Petaluma River Watershed east of Sonoma Mountain. The main channel flows southeast for about 7.5 miles through the town of Penngrove until it joins Willow Brook Creek. The subwatershed contains several small creeks that flow east and west into the main channel. They include Highland, Martenoni, Meacham, Penngrove, and Davis Lane Creeks. Together they comprise approximately 4.5 miles of riparian corridor. The entire subwatershed drains an area of approximately 9.7 square miles, which is 7% of the Petaluma River Watershed.

Soils in the lower reach of Lichau Creek are Cotati fine sandy loam with a moderate erosion hazard rating according to the *Soil Survey of Sonoma County, California* (1972). Moving upstream, the soils turn to Diablo clay and then to Goulding cobbly clay loams. These soils are associated with rapid run-off and high erosion hazard.Riparian vegetation along the middle and lower reaches of Lichau Creek shows a high degree of impact from development and agriculture since historical times when a contiguous forest of dense trees and shrubs (VRI 4-6D) characterized the corridor. Today the lower reach of creek east of Petaluma Hill Road and south along the Northwestern Pacific Railroad to its confluence with Willow Brook Creek, drains through areas that have been converted for municipal and residential use.

Enhancing the two miles of converted annual grassland along the riparian corridor of Lichau Creek east of Petaluma Hill Road was given high priority. Enhancement would include installation of livestock control fencing and planting willow and oak. The corridor east of the annual grassland (AGS 1D) site and west of the dense forest (VRI 4, 5 & 6D) would also benefit from fencing and scattered planting of oak and California bay in the sparse (VRI 4S) areas; this was given medium priority. The reach between Highland Creek and Penngrove Creek (VRI 45M) is accessed by cattle and has erosion problems. Fencing and planting are recommended and given high priority. High priority was also given to fencing and planting oak and California bay in all the open (VRI 4P) sites.

Enhancing the riparian corridor along Highland, Martenoni, Meacham, and Penngrove Creeks is worth pursuing. Because the area has numerous landowners, it may be difficult to coordinate their involvement. For this reason, this area was given a medium priority rating for riparian enhancement. Public outreach in the form of community meetings and education and/or a publicized and distributed creek care guide could bring important information to people with interests in the area. Enhancement would include control of exotic plant species in the area, installation of fencing, and planting willow and oak in areas where woody vegetation is minimal (VRI 4P). Fencing and planting the annual grassland sites (AGS 1D) along Davis Lane Creek was given high priority.

Enhancement along the lower reaches of Cold Springs Creek was given high priority. Enhancing areas that have been converted to annual grassland (AGS 1D & VRI 4P)) by installing livestock control fencing and planting would help to substantially extend the existing corridor. Managing livestock access to the upper reaches will help to preserve the health and aesthetics of the existing corridor; this was given

medium enhancement priority. The upper reaches of Cold Springs Creek are relatively healthy and intact.

## WILLOW BROOK CREEK

Willow Brook Creek subwatershed is in the northeast portion of the Petaluma River Watershed and drains an area of about 5.3 square miles, which is 4% of the watershed. It includes Willow Brook, Davis, Waugh, and Lower Lichau Creeks.

Soils along the main channel are mostly Clear Lake clay in the lower reaches and Gullied land in the upper reaches. The clay soils are the poorly drained soils of floodplains. Slow run-off characteristic of these soils keeps erosion potential low. Gullied land, occurring within the upper reaches of the Willow Brook Creek corridor, is unique to certain areas east of Petaluma. Here, where livestock impacts have diminished protective plant cover, excess run-off cuts into the natural watercourses resulting in very high erosion hazard.

Most of the length of Willow Brook Creek has a seasonal rather than perennial water regime with water flow occurring only during the wet season. South of Ely Road and into the urban boundary, the riparian vegetation is composed of moderately dense trees (VRI 4M) dominated by willow and oak. Riparian vegetation has been reduced to an occasional tree in the portion of creek north of Ely Road and south of Adobe Road. Years of agricultural use and municipal expansion have converted the vegetation to annual grassland (AGS 1D) dominated by introduced grasses such as annual rye and wild oat.

Historically, the overall streamside vegetation was likely a continuous, dense forest similar to the present upper reach, with medium to large riparian trees (VRI 4-6D). About 21 acres of annual grassland habitat (AGS 1D) located in the lower reach of Willow Brook Creek, just north of Adobe Road and running south to Ely Road, was identified as having high enhancement opportunity. This would include installing livestock control fencing and planting willows. Landslips are common along this stretch of creek, and revegetation would help to decrease erosion hazards and increase water quality.

Along the middle reach of the creek, an area of approximately 43.5 acres north of Adobe Road (including the eastern tributary) is comprised of a mixture of moderately dense to open tree canopy (VRI 4M, 4S & 4P) and annual grassland (AGS 1D). This area was rated as having medium enhancement priority. The riparian corridor here could be considerably enhanced by limiting cattle access with fencing. Areas where woody vegetation is scarce or absent (VRI 4S & 4P and AGS 1D) could be planted with live oak and California bay.

The uppermost reach, an area of about 68 acres (about 2 linear miles), has been protected by its unique gullied topography and management practices. This area, which resembles historic riparian conditions (VRI 4-6D), was given a low priority rating for enhancement.

Enhancement along Waugh Creek and Davis Creek would increase wildlife values in areas nearer the urban boundary and help to minimize erosion problems along the streambanks. These areas were given high enhancement priority due to their degraded condition. Enhancement would include fencing and

planting willow and oak along the annual grassland (AGS 1D) sites and areas with sparse to open woody vegetation (VRI 4S & 4P) Lower Lichau Creek is located within small, rural residential properties. Enhancement by fencing and planting open areas with willow and oak (VRI 4P) was given medium priority.

## CORONA AND CAPRI CREEKS

Corona and Capri Creeks are small creeks located southeast of Willow Brook Creek and northwest of Lynch Creek. Their headwaters are located on Sonoma Mountain and flow south across Adobe Road into the urban boundary, entering the Petaluma River just west of the Highway 101 corridor. They drain an area of approximately 5.1 square miles, which is 3% of the Petaluma River Watershed.

Riparian habitat along these creeks has been almost entirely converted into annual grassland (AGS 1D). Corona Creek has a small patch (less than 0.25 mile) of moderately dense (VRI 4M) riparian vegetation remaining, and Capri Creek is characterized entirely by annual grassland (AGS 1D).

Enhancement along both creeks would increase wildlife value in areas nearer the urban boundary and help to minimize erosion problems along the streambanks. These areas were given high enhancement priority due to their degraded condition. Enhancement would include fencing and planting willow and oak among the annual grassland (AGS 1D) sites and areas with sparse woody vegetation (VRI ).

Many vehicles abandoned along creek need removal prior to restoration work. Banks are highly eroded.

## LYNCH CREEK

Lynch Creek is situated in the northeast portion of the Petaluma River Watershed, draining approximately 4.0 square miles and comprising 3% of the watershed. The headwaters are located in steep hillsides along Sonoma Mountain Ridge near Sonoma Mountain Road. The main channel drains south 6.8 miles (4 miles are outside the urban boundary) with 3.5 miles of tributary and enters the Petaluma River west of Highway 101 at the confluence of what is locally-known as Petaluma Creek.

Soils of the lower half of Lynch Creek are primarily Gullied land and Diablo clay with Clear Lake loam appearing in the floodplain where the channel nears the Petaluma River. Both Gullied land and Diablo clay soils have high erosion potential and land slippage associated with excess run-off. Moving upstream into the upper reaches, the soils become Goulding cobbly clay loam. These shallow soils are also associated with rapid run-off and high erosion hazard.

Inside the urban boundary south of Adobe Road, about 13 acres (approximately 0.75 linear miles) of densely vegetated stream still exist. Outside the boundary, the riparian corridor is generally open in the middle reach. Cattle access to the creek and other agricultural practices have reduced the historically dense corridor to scattered individual trees and small groupings.

Enhancement opportunity exists for the riparian corridor south of the dense riparian forest in the upper watershed. The presence of mature, relatively intact forest in the upper watershed gives value to remnant areas downstream. Connecting the corridor south into the City boundary will increase water quality, wildlife usage, and aesthetics throughout the subwatershed.

Enhancement would include installing livestock control fencing along the moderately dense (VRI 4M) portion of the corridor (medium priority), as well as fencing and planting willow, oak, and California bay (high priority) along the open portions of the riparian corridor.

**WASHINGTON CREEK**

Washington and East Washington Creeks are located in the northern portion of the Petaluma River Watershed between Lynch Creek to the northwest and Adobe Creek to the southeast. Together they drain an area of approximately 8.3 square miles, which is 6% of the entire watershed.

The main channel of Washington Creek flows south adjacent to Ielmorini Lane, crossing Adobe Road and following East Washington Blvd. and finally draining into the Petaluma River north of Petaluma Blvd. The riparian corridor is approximately 7 miles long with about 2 miles of tributary, nearly 3 miles of which are located outside the urban boundary. The upper reaches of the riparian corridor are utilized by a wide variety of wildlife.

Soils along the main channel are Diablo clay. Storm run-off is moderate to rapid, resulting in medium to high erosion hazard. Landslips are characteristic of these soils. Portions of Washington Creek north of Adobe Road have a perennial water regime with water running all year round. Cattle graze the rural hillsides and have access to the creek, although steeply incised banks have helped to protect the integrity of the riparian vegetation. The Valley Foothill Riparian vegetation characteristic of the channel north of Adobe Road is a dense, two-story riparian forest dominated on the upper banks by a canopy of live oak, black oak, and California bay with buckeye in the understory.

The majority of the Washington Creek riparian plant community north of Adobe Road constitutes a contiguous corridor of moderate to densely populated large trees and shrubs. This portion of creek was given low enhancement priority due to its relatively good condition. This should not underrate the value of landowners seeking ways to preserve the integrity of this habitat. Installing livestock control fencing to limit access to the creek will help to insure creek protection and limit existing or potential erosion hazards.

An exotic plant problem is developing in a portion of the creek directly adjacent to Lelmorini Lane. A thick layer of introduced German ivy is displacing the natural creekside groundcovers and shrubs. Poison hemlock is well established and expanding its territory. Indigenous wildlife is adapted to the native flora for food and cover. Displacement of these natives can have serious impact on wildlife inhabiting the area. Certain exotic plant species, such as German ivy, are suspected to contain chemical substances that can be poisonous to native fishes. Removal of these exotic species was given a medium priority rating.

South of Adobe Road and north of the urban boundary is an area of approximately 14 acres that has high enhancement potential. The existence of a contiguous riparian corridor to the north increases the potential wildlife values of this portion of creek. Enhancement would include fencing and planting willow and other native riparian trees.

Enhancement opportunity along the upper reaches of East Washington Creek north of Adobe Road was given a medium priority. Fencing the entire channel would promote natural revegetation with occasional planting in areas where woody vegetation is absent. Fencing and planting in the sparse and open sites along the western tributary would speed the natural recovery of the creek. Revegetation will reduce erosion hazards that may be a problem due to the patchy habit of the streamside vegetation.

## ADOBE CREEK

Adobe Creek is located in the northeastern portion of the Petaluma River Watershed. The seasonal creek meanders south from the steep slopes of Sonoma Mountain, draining an area of approximately 4.9 square miles, which is 3% of the watershed. The main channel flows southward approximately 7.5 miles, crossing Manor Lane, Adobe Road, and Casa Grande Avenue and entering the low-lying areas within the urban boundary. Adobe Creek enters the Petaluma River south of Highway 116 and east of Highway 101. Tributaries account for another 2 miles of riparian corridor.

Soils in the lower reach of Adobe Creek are Clear Lake clay and have a slight erosion hazard due to slow run-off according to the *Soil Survey of Sonoma County, California* (1972). Moving upstream, soils turn to Diablo clay with increasing erosion potential and land slippage. The upper reaches are characterized by Goulding cobbly clay loam and Sobrante loam soils. Goulding soils are shallow soils with cobblestones; run-off is rapid, and erosion hazard is high.

The riparian vegetation in most of the low-lying areas south of Adobe Road and adjacent to Adobe Creek Golf Course has been almost eliminated. A sparsely populated remnant patch of riparian forest remains in a 1,000-foot stretch of creek in the northeast corner of the golf course. Above Adobe Road the riparian habitat remains sparse until it approaches the intersection with Manor Lane. Here an approximately 1 mile stretch of creek is characterized by moderately dense small trees dominated by willow with oak and alder. In recent years enhancement work has been carried out improving some reaches of riparian habitat however, the channel is very incised which restricts the riparian corridor width in some locations.

Overall, the riparian vegetation along the middle and lower reaches of Adobe Creek has been significantly degraded through various form of development and some agricultural; however, there have been recent efforts to improve these reaches. South of Adobe Road where the creek meanders in an out of the Golf Course, Casa Grande High School has implemented some planting projects to establish mostly willows and oaks where it has been needed. Since 2015, State Parks has been managing dense infestations of invasive Himalayan blackberry on the creek banks within Petaluma Adobe State Historic Park (to date, in the portion north of Adobe Road).

North of Adobe Road, approximately 33 acres including tributaries (nearly 2 linear miles) were identified as having high enhancement opportunities. South of Adobe Road and east of the Adobe Creek Golf Course, a stretch of creek approximately 0.5 miles long (approximately 9 acres) that has no riparian vegetation was also given a high enhancement rating. These areas could be enhanced by fencing and planting. Streambank stability is low to moderately low in several places along the main channel. Re-establishing the riparian vegetation in these areas would have a significant effect on

reducing existing and potential erosion problems. Control of exotic plant species that are displacing native species is important for overall wildlife values and is a medium priority enhancement opportunity.

Enhancement along the upper part of the creek, has a lower priority but should still be considered for its restoration potential especially as it relates to oversummer habitat for juvenile salmonids. The naturally steep topography has limited access, and, in most locations, there is dense cover that lowers erosion potential and maintains high water quality and wildlife values.

Addressing the fish passage barrier where Adobe Creek crosses Adobe Road is a priority for multiple resource agencies, as juvenile fish become stranded below the road during low flows.

**ELLIS CREEK**

Ellis Creek and its tributaries are located in the western Petaluma River Watershed, draining an area of approximately 9.4 square miles, which is 6% of the watershed. The main channel meanders east and south approximately 5.7 miles, traveling through flat agricultural and marshland and entering the Petaluma River at a great bend just south of Petaluma's wastewater ponds. Hutchinson, Cherry, and Gregory Creeks are northern tributaries of Ellis Creek, flowing south into Ellis Creek before it changes course and journeys southward. Together they comprise approximately 12 miles (including their tributaries) of stream. Higgins Creek is a more southerly tributary, located north of South Ely Road between Frates Road and Browns Lane; it flows westward about 1 mile into Ellis Creek.

Soils along Ellis Creek and its tributaries are primarily Gullied land with very high erosion hazard. In the lower reach of Ellis Creek south of the confluence of Higgins Creek, the main channel has been severely depleted of natural vegetation with only occasional willow and oak remaining (VRI 4P). The corridor south of Lakeville Highway and west of the Petaluma wastewater ponds (approximately 0.75 miles) has been channelized for flood control. A sparse canopy of woody vegetation remains in this portion and is characterized by a habitat stage of VRI 4S.

North of Higgins Creek, the main channel develops into a dense canopy of willow and oak (VRI 4D). Although the corridor is much narrower here (approximately 75 feet) than what likely occurred historically (greater than 300 feet), the vegetation is contiguous. The eastern and upper reaches of Ellis Creek become open once again just east of its confluence with Gregory Creek. This portion of the corridor is characterized by an open canopy of willow and live oak (VRI 4P).

All the tributaries that flow into Ellis Creek have been significantly altered by land use during the past two hundred years. Historical corridor conditions, which likely included riparian forest widths over 200 feet, have been reduced to narrow bands of trees dominated by oak and open grassland.

Apart from the channelized area of Ellis Creek west of the Petaluma wastewater ponds, most of the main channel and its tributaries were rated with a high enhancement priority. Above Lakeville Highway, the riparian corridor would benefit from livestock control fencing and planting. Large landslips are common along Ellis Creek and all four tributaries. Limiting streamside access would help to promote natural revegetation while reducing erosion hazards.

Planting along the sparse and open areas (VRI 4S & 4P; see Riparian Vegetation Area Map R3) would hasten recovery time and increase water quality, wildlife, and aesthetic values.

The dense forest (VRI 4D) north of Higgins Creek and south of Adobe Road to the confluence with Cherry Creek received a medium enhancement priority, which would include installing livestock control fencing.

**LIBERTY CREEK**

The Liberty Creek subwatershed drains the upper northwest portion of the Petaluma River Watershed. The area is approximately 15.3 square miles, which is 10% of the entire watershed. The main channel of Liberty Creek outside the urban boundary is approximately 3 miles long. Liberty Creek drains into the Petaluma River just inside the urban border where Stony Point Road meets Petaluma Blvd. North. The surrounding land use has been agricultural since the 1800s (mostly range and pasture) and is characterized by European annual grasses.

Soils along the main channel are mostly Pajaro fine sandy loams with a low erosion hazard rating due to moderate streambank sloping. Soils along the lower reach of the creek turn to sandy Alluvial soils, sandy, in which streambank cutting and erosion have occurred.

Liberty Creek has a seasonal water regime. The land use surrounding it is primarily dairy. Cattle access to the creek has maintained a predominantly grassland habitat (with occasional remnant willows) along the majority of the creek that can be characterized as Annual Grassland (AGS 1D) dominated by species such as annual rye, soft chess broom, Mediterranean barley, and wild oat. The riparian vegetation, which occurs only occasionally along the main channel west of Jewett Road and north of Pepper Road (approximately 0.5 miles long), is characterized by mostly moderate cover of small trees (VRI 4M) dominated by willow and live oak with patches of non- native eucalyptus.

Nearly the entire riparian corridor along Liberty Creek has high potential for enhancement except the vegetated portions near Jewett and Pepper Roads. Enhancement could include installation of fencing and planting willows and coast live oak along 2 miles of creek, thus connecting and integrating the now fragmented riparian habitat. Increasing the riparian vegetation along the creek will help reduce any existing or potential erosion and sedimentation problems along the streambank while providing new and extended habitat for wildlife.

Enhancement along Wiggins, Wilson and Marin Creeks was given low priority. These creeks have had a history of being cleared and dewatered due to intense agricultural use. Enhancement would be a formidable task because of development pressures, diverse landownership, and the disturbed nature of the area from a wildlife habitat perspective. There is probably little habitat value to be gained without a major restoration of the entire stream corridor. Restoration would involve fencing, regrading, and planting of wetland plants, as well as riparian woody species.

## KELLY, THOMPSON, KASTANIA, SUTTON, AND SCHULTZ CREEK

Kelly, Thompson, Kastania, Sutton, and Schultz Creeks are small creeks draining a low-lying area of 6.8 square miles (not including areas within the urban boundary), which is 4.6% of the Petaluma River Watershed. This area is west of the Petaluma River and Highway 101 north of the San Antonio Creek subwatershed.

Kelly and Thompson Creeks have their headwaters in the hilly agricultural land south of the City and run through the town before their confluence with the Petaluma River. Soils in the upper reaches are Los Osos clay loams with moderate to high erosion hazard rating. The lower reaches are Pleasanton loams with slight to moderate erosion hazard rating. These creeks were probably moderate to dense forests historically (VRI 4M & 4D) with willows and oaks. The riparian corridor has largely been converted to annual grasses (AGS 1D) with a few areas of open remnant woody cover (VRI 4P).

Kastania and Sutton Creeks enter the Petaluma River in the marshlands to the south. They still have good, continuous riparian cover (VRI 4M) on Los Osos clay loams with Zamora silty clay loams downstream. Both soils have a slight to moderate erosion hazard rating. Historically these creeks may have had a wider riparian cover zone.

Schultz Creek enters the marshlands further to the south and overall has less riparian cover, ranging from none (AGS 1D) to sparse (VRI 4S) to dense (VRI 4D). The area is active rangeland with houses and a barn adjacent to the creek. Soils are Zamora silty clay loams and Los Osos clay loam with moderate to high erosion hazard.

The upper reaches of Kelly and Thompson Creeks could be enhanced with fencing and planting. Within the urban boundary on Thompson Creek, there has been a streamside planting program with good community involvement that could be carried farther upstream. The isolated nature of the habitat from a wildlife perspective lowers the value of enhancement projects. However, the higher erosion hazard, low woody cover, and social values argue for rating this as a medium priority enhancement site.

Fencing and planting the 5,000 feet of open area within the Schultz Creek stream zone could connect upper and lower habitat areas in this drainage and potentially reduce erosion. This area is rated high priority for enhancement.

## SAN ANTONIO CREEK

San Antonio Creek drains most of the southwest portion of the Petaluma River Watershed encompassing approximately 36.5 square miles, which is 24% of the entire watershed. The main channel and riparian corridor are approximately 11 miles long with 13 miles of significant tributary on the north side and another 26 miles of significant tributary on the south (“Significant tributary” in this case is a “blueline” stream as found on the USGS 7.5 minute topo map). Almost the entire creek follows the Marin and Sonoma County boundary.

The confluence of San Antonio Creek and the Petaluma River is in marshland west of Highway 101 at the Marin-Sonoma County line. The surrounding land use has been agricultural since the early 1800s. The majority of the watershed is now characterized by European annual grasses with scattered oak woodlands and narrow bands of riparian forest. The riparian corridor is utilized by a wide variety of wildlife including resident and migratory bird species, coyote, deer, mountain lion, raccoon, and skunk. A more complete species list is included in the Restoration Design and Management Guidelines for the Petaluma River Watershed by Questa Engineering Corporation, et al., July, 1996.

Most of the length of San Antonio Creek has a seasonal rather than perennial water regime. Soils along the riparian corridors are Zamora silty loams, Clear Lake clay, and Los Osos clay loam with a slight to moderate erosion hazard rating. On the Marin County side, soils are Ballard gravely loam, Blucher silt loam, Cole clay loam, and Clear Lake clays (Soil Survey of Marin County, California, 1985). The erosion potential increases in the tributaries with increased slope steepness.

The riparian vegetation in lower reaches follows the main channel in a roughly 150-foot wide corridor. The habitat stage is mostly dense, small trees (VRI 4D) dominated by willow, live oak, buckeye, and California bay. There are patches of non-native eucalyptus as well. This vegetation type graduates into a dense, two-story (VRI 6D) riparian forest of valley oak and buckeye with willows downstream of D Street.

In the lower reach of San Antonio Creek east of Highway 101, an area of about 11 acres was identified as a potential enhancement opportunity. Enhancement would consist of installing livestock control fencing and planting willows, coast live oak, buckeye, and California bay. This area was given a medium priority rating.

Between Highway 101 and D Street, there are stretches that could be fenced (or fences repaired) to limit livestock from the riparian corridor. In so doing, natural regeneration of oaks, which is currently low to moderate, would be enhanced along with streambank stability and reduced water pollution. One of the northern tributaries in this reach has a lower canopy cover on approximately 2.5 acres with a moderate to high erosion hazard rating. Again, fencing and planting are recommended.

Most of the medium to high priority sites for riparian enhancement, which would include both fencing and tree planting, are located west of D Street along San Antonio Creek and inside tributaries. In some cases, livestock crossings and alternate water sources, such as stock tanks, may need to be developed. Some areas would also be enhanced by the control of exotic species such as star thistle and broom.

Both Marin RCD and Sonoma RCD, share most of the San Antonio Creek and there is a long history of partnership and opportunity for leveraging funding for stream enhancement within key reaches. Recent work with multi-organizational partnerships and ongoing studies and outreach suggests that there is great potential in this watershed for marsh restoration and habitat restoration in general.

**LAKEVILLE**

Several small creeks are located in the lower southeastern portion of the watershed east of the Petaluma River. Positioned south of Ellis Creek, these small tributaries drain into the extensive marshlands that surround the southern portion of the river. This entire subwatershed, which includes the marshland east of the river, comprises an area of 19.8 square miles, 14% of the Petaluma River Watershed. Soils characteristic of these creeks are primarily Gullied land with high erosion potential due to rapid run-off according to the Soil Survey of Sonoma County, California (1972).

The riparian vegetation in this area has been dramatically altered by agriculture and livestock grazing. Approximately 1.7 miles (20 acres) of moderately dense forest and less than 0.25 miles (8 acres) of dense forest remain in the subwatershed. Primarily woody vegetation has been converted to annual grassland (AGS 1D) with occasional tall willows remaining in small clusters along some of the creeks with rushes and sedges in seasonally saturated areas. Groves of planted eucalyptus occur in several areas within the subwatershed.

Enhancement along all of the tributaries in this southern subwatershed has been given high priority. Several gullies and landslips are present in the area where riparian vegetation has been removed by years of overgrazing and farming. Enhancement would include installing livestock control fencing and planting along approximately 7.5 miles (82 acres) of Wheat Creek, the tributary adjacent to Stage Gulch Road, and the several unnamed creeks located south to Highway 37. Generally, willow is the dominant riparian tree species in this area. Vineyards occupy portions of the hills surrounding some of these creeks, and willow is an undesirable species to be planted near grapes. To prevent any problems, willow should be planted discriminately in areas distant from local vineyards. Alder or ash with live oak could substitute for willows in areas of concern.

# APPENDIX C. LISTED WILDLIFE AND PLANT SPECIES

**Table C.1.** Listed wildlife species[1] in the Petaluma River Watershed.

| **Common Name, *Scientific Name*** | **Legal Status[2]** |
|---|---|
| **Mammals** | |
| American badger, *Taxidea taxus* | SSC |
| Pacific Western (Townsend's) big-eared bat, *Corynorhinus townsendii* | SSC |
| Pallid bat, *Antrozous pallidus* | SSC |
| Point Reyes mountain beaver, *Aplodontia rufa phaea* | SSC |
| Salt-marsh harvest mouse, *Reithrodontomys raviventris* | FE, SE |
| Suisun ornate shrew, *Sorex ornatus sinuosus* | SSC |
| **Birds** | |
| Bank Swallow, *Riparia riparia* | ST |
| Black Swift, *Cypseloides niger* | SSC |
| Ridgeway's Rail, *Rallus obsoletus obsoletus* | FE, SE |
| California Black Rail, *Laterallus jamaicensis coturniculus* | ST |
| Common Salt Marsh Yellowthroat, *Geothlypis trichas sinuosa* | SSC |
| Grasshopper Sparrow, A*mmodramus savannarum* | SSC |
| San Pablo Song Sparrow, *Melospiza melodia samuelis* | SSC |
| Swainson's Hawk, *Buteo swainsoni* | ST |
| Tricolored Blackbird, *Agelaius tricolor* | ST, SSC |
| Western Burrowing Owl, *Athene cunicularia hypugea* | SSC |
| Western Snowy Plover, *Charadrius 204aylands204ca204 nivosus* | FT |
| Western Yellow-billed Cuckoo, *Coccyzus americanus occidentalis* | FT, SE |
| Yellow Rail, *Coturnicops noveboracensis* | SSC |
| **Reptiles** | |
| Western pond turtle, *Emys marmorata* | SSC |
| **Amphibians** | |
| California giant salamander, *Dicamptodon ensatus* | SSC |
| California red-legged frog, *Rana draytonii* | FT, SSC |
| California tiger salamander, *Ambystoma californiense* | FE, ST |
| Foothill yellow-legged frog, *Rana boylii* | SE |
| Red-bellied newt, *Taricha rivularis* | SSC |

| | |
|---|---|
| **Fish** | |
| California roach, *Lavinia symmetricus* | SSC |
| Central California Coast steelhead, *Oncorhynchus mykiss irideus* | FT |
| Coho salmon, *Oncorhynchus kisutch* | FE, SE |
| Longfin smelt, *Spirinchus thaleichthys* | Federal Candidate, ST |
| Sacramento splittail, *Pogonichthys macrolepidotus* | SSC |
| Tidewater goby, *Eucyclogobius newberryi* | FE |
| **Invertebrates** | |
| California freshwater shrimp, *Syncaris pacifica* | FE, SE |
| Monarch butterfly, *Danaus plexippus* | Federal Candidate |

[1] Species List: Animal species listed in this table were developed from a California Natural Diversity Database (CNDDB) search on October 21, 2021 of the Cotati, Glen Ellen, Novato, Petaluma Point, Petaluma River, San Geronimo, Sears Point and Sonoma USGS 7.5m quadrangles.

[2] Legal Status:

FE: Listed as endangered under the Federal Endangered Species Act (FESA)

FT: Listed as threatened under the FESA.

SE: Listed as endangered under the California Endangered Species Act (CESA)

ST: Listed as threatened under the CESA

SSC: A CDFW species of special concern

**Table C.2.** Listed plant species[1] in the Petaluma River Watershed

| Common Name (Scientific Name) | Legal Status[2] | CNPS Rare Plant Rank[3] |
|---|---|---|
| **Plants** | | |
| Alkali milk-vetch, *Astragalus tener* var. *Tener* | - | 1B.2 |
| Baker's navarretia, *Navarretia leucocephala* ssp. *bakeri* | - | 1B.1 |
| Bent-flowered fiddleneck, *Amsinckia lunaris* | - | 1B.2 |
| Big-scale balsamroot, *Balsamorhiza macrolepis* | - | 1B.2 |
| Burke's goldfields, *Lasthenia burkei* | FE, SE | 1B.1 |
| Cobb Mountain lupine, *Lupinus sericatus* | - | 1B.2 |
| Congested-headed hayfield tarplant, *Hemizonia congesta* ssp. *congesta* | - | 1B.2 |
| Contra Costa goldfields, *Lasthenia conjugens* | FE | 1B.1 |
| Dwarf downingia, *Downingia pusila* | - | 2B.2 |
| Fragrant fritillary, *Fritillaria liliacea* (SSC) | - | 1B.2 |
| Franciscan onion, *Allium peninsulare* var. *franciscanum* | - | 1B.2 |
| Jepson's Leptosiphon, *Leptosiphon jepsonii* | - | 1B.2 |
| Koch's cord, *Entosthodon* | - | 1B.3 |
| Legenere, *Legenere limosa* | - | 1B.1 |
| Marsh microseris, *Microseris paludosa* | - | 1B.2 |
| Marin checkerbloom, *Sidalcea hickmanii* ssp. *viridis* | - | 1B.1 |
| Marin checker lily, *Fritillaria lanceolata* var. *tristulis* | - | 1B.1 |
| Marin County navarretia, *Navarretia rosulata* | - | 1B.2 |
| Marin Knotweed, *Polygonum marinense* | - | 3.1 |
| Marin manzanita, *Arctostaphylos virgata* | - | 1B.2 |
| Marin western flax, *Hesperolinon congestum* | FT, ST | 1B.1 |
| Mount Burdell jewelflower, *Streptanthus anomalus* | - | 1B.1 |
| Mt. Tamalpais bristly jewelflower, *Streptanthus glandulosus* ssp. *pulchellus* | - | 1B.2 |
| Mt. Tamalpais Manzanita, *Arctostaphylos montana* ssp. *Montana* | - | 1B.3 |
| Mt. Tamalpais thistle, *Cirsium hydrophilum* var. *vaseyi* | - | 1B.2 |
| Napa False Indigo, *Amorpha 206aylands206ca* var. *Napensis* | - | 1B.2 |
| Narrow-anthered brodiaea, *Brodiaea leptandra* | - | 1B.2 |
| Nicasio ceanothus, *Ceanothus decornutus* | - | 1B.2 |

| | | |
|---|---|---|
| North Coast semaphore grass, *Pleuropogon hooverianus* | ST | 1B.1 |
| Oval-leaved viburnum, *Viburnum ellipticum* | - | 2B.3 |
| Pacific Grove clover, *Trifolium polyodon* | CA Rare | 1B.1 |
| Pappose Tarplant, *Centromadia parryi* ssp. *parryi* | - | 1B.2 |
| Petaluma Popcornflower, *Plagiobothrys mollis* var. *vestitus* | - | 1A |
| Pitkin Marsh lily, *Lilium pardalinum* ssp. *pitkinense* | FE, SE | 1B.1 |
| Point Reyes salty bird's beak, *Chloropyron maritimum* ssp. *palustre* | - | 1B.2 |
| Point Reyes checkerbloom, *Sidalcea calycosa* ssp. *rhizomata* | - | 1B.2 |
| Rincon Ridge ceanothus, *Ceanothus confusus* | - | 1B.1 |
| Saline clover, *Trifolium hydrophilum* | - | 1B.2 |
| Seaside bittercress, *Cardamine angulata* | - | 2B.1 |
| Sebastopol meadowfoam, *Limnanthes vinculans* | FE, SE | 1B.1 |
| Soft salty bird's-beak, *Chloropyron 207ayl* ssp. *molle* | FE, CA Rare | 1B.2 |
| Sonoma ceanothus, *Ceanothus sonomensis* | - | 1B.1 |
| Sonoma spineflower, *Chorizanthe valida* | FE, SE | 1B.1 |
| Sonoma sunshine, *Blennosperma bakeri* | FE, SE | 1B.1 |
| Tamalpais jewelflower, *Streptanthus batrachopus* | - | 1B.3 |
| Tamalpais lessingia, *Lessingia micradenia* var. *micradenia* | - | 1B.2 |
| Tamalpais oak, *Quercus 207ayland* var. *Tamalpaisensis* | - | 1B.3 |
| Thin-lobed horkelia, *Horkelia tenuiloba* | - | 1B.2 |
| Tiburon buckwheat, *Eriogonum luteolum* var. *caninum* | - | 1B.2. |
| Tiburon paintbrush, *Castilleja affnis* var. *neglecta* | FE, ST | 1B.2 |
| Two-fork clover, *Trifolium amoenum* | FE | 1B.1 |
| Western leatherwood, *Dirca occidentalis* | - | 1B.2 |
| Wooly-headed gilia, *Gilia capitata* ssp. *tomentosa* | - | 1B.2 |

[1] Species List: Animal species listed in this table were developed from a California Native Diversity Database (CNDDB) search on October 21, 2021 of the Cotati, Glen Ellen, Novato, Petaluma Point, Petaluma River, San Geronimo, Sears Point and Sonoma USGS 7.5m quadrangles.

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[3] California Native Plant Society Rare Plant Ranking System:

| **CA Rare Plant Rank** | **Description** |
|---|---|
| 1A | Plants presumed extinct in California and rare/extinct elsewhere |
| 1B.1 | Plants rare, threatened, or endangered in California and elsewhere; seriously threatened in California |
| 1B.2 | Plants rare, threatened, or endangered in California and elsewhere; fairly threatened in California |
| 1B.3 | Plants rare, threatened, or endangered in California and elsewhere; not very threatened in California |
| 2A | Plants presumed extirpated in California, but more common elsewhere |
| 2B.1 | Plants rare, threatened, or endangered in California, but more common elsewhere; seriously threatened in California |
| 2B.2 | Plants rare, threatened, or endangered in California, but more common elsewhere; fairly threatened in California |
| 2B.3 | Plants rare, threatened, or endangered in California, but more common elsewhere; not very threatened in California |
| 3.1 | Plants about which we need more information; seriously threatened in California |
| 3.2 | Plants about which we need more information; fairly threatened in California |
| 3.3 | Plants about which we need more information; not very threatened in California |
| 4.1 | Plants of limited distribution; seriously threatened in California |
| 4.2 | Plants of limited distribution; fairly threatened in California |
| 4.3 | Plants of limited distribution; not very threatened in California |

SONOMA
RESOURCE CONSERVATION DISTRICT