Draft Petaluma Watershed Enhancement Plan

An owner's manual for the residents & landowners of the Petaluma Watershed.

Prepared by:

SONOMA RESOURCE CONSERVATION DISTRICT

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ACKNOWLEDGEMENTS

The Draft Petaluma Watershed Enhancement Plan is a collaborative effort of many individuals and organizations. The first version of the Enhancement Plan, completed in 1998, included valuable input from a Landowner Advisory Committee and concerned residents of the Petaluma 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 updated Draft Petaluma Watershed Enhancement Plan has been completed by the Sonoma RCD and includes updating of technical information, and reformatting of the original plan in to the Environmental Protection Agency's (EPA) format for the 9 Elements of a Watershed Plan. Stakeholder outreach and agency review of the technical elements of the updated plan are currently underway.

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ACRONYMS

ACOE	United States Army ACOE of Engineers (ACOE)
ACP	Agricultural Conservation Program
AWC	Sonoma Marin Animal Waste Committee
BCDC	San Francisco Bay Conservation and Development Commission
CDF	California Department of Forestry
CDFW	California Department of Fish and Wildlife
CIWMB	California Integrated Waste Management Board
DOC	California Department of Conservation
DWR	California Department of Water Resources
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FSA	Farm Service Agency (USDA)
FOPR	Friends of the Petaluma River
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmosphere Administration
NRCS	Natural Resources Conservation Service
PCI	Prunuske Chatham, Inc.
RCD	Resource Conservation District
RWQCB	Regional Water Quality Control Board
SCWA	Sonoma County Water Agency
RCD	Sonoma Resource Conservation District
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
UCCE	University of California Co-operative Extension
USDA	United States Department of Agriculture

Draft Petaluma Watershed Enhancement Plan

SECTION 1. INTRODUCTION AND BACKGROUND

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 in order to determine how to more effectively manage the watershed. This draft 2013 Plan updates and replaces the 1998 Plan, with current information on the watershed and new recommendations for watershed management strategies. This new plan also focuses on including new technical information from the urban and rural areas of the watershed, and both social and resource related recommendations for improved water quality, habitat, and agricultural and rural sustainability throughout the watershed. The objective of this 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, the Plan reviews existing information, identifies data gaps and recommends additional data collection activities.

Purpose of the Petaluma Watershed Enhancement Plan

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

Draft Goals

A. Maintain long-term, local control of watershed planning and enhancement. Establish integrated watershed management.

B. Conserve and improve the natural resources of the watershed. Protect the quality and quantity of water.

C. Maintain streams to maximize beneficial uses.

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

E. Educate the community about the natural features of the watershed, its people, ecology, and economy.

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

STAKEHOLDER GROUPS

Community outreach is an important part of the development and implementation of any watershed management plan. The RCD is an advocate of coordinated watershed management by agencies, watershed groups and landowners to meet common watershed goals and will continue outreach to stakeholder groups toward the development of this living planning document. Below are many of the stakeholder groups working on conservation concerns in the Petaluma River Watershed.

Sonoma Resource Conservation District (RCD)

The 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 oversees multiple watersheds covering 85 percent of Sonoma County. A Board of Directors comprised of local landowners advises the functions and management of the district. The RCD works with landowners on soil erosion and flooding, project identification, improving water quality, sediment reduction projects, habitat enhancement, optimizing water usage and conservation, in addition to updating the Petaluma Watershed Plan. The RCD is an important entity between landowners and agencies to carry out: conservation initiatives; developing, funding, and implementing on-the-ground projects; monitoring; and creating opportunities for environmental and agricultural education.

Sonoma County Water Agency (SCWA)

The SCWA oversees and manages water resources throughout the county and play a significant role in caring for the people and the environment through resource and environmental stewardship and technical innovation. In 1958, Flood Protection Zones were created to encompass the major watersheds of Sonoma County. This would enable SCWA to promote financing, construction and maintenance focused on the needs of each of the nine zones. The services provided by the agency are vast: providing water to nine cities and special districts through a water transmission system distributing water to more than 600,000 individuals, responsible for managing the county sanitation zones and districts, provide flood protection services and steam maintenance, partner with local water suppliers to support water conservation efforts, offer environmental services related to environmental laws and regulations, and support community outreach and Water Smart education.

US Army Corps of Engineers (ACOE)

The ACOE is a federal entity that acts as the nation's environmental engineer, managing one of the largest federal environmental missions to restore degraded ecosystems. Through this mission they also manage natural resources and regulate waterways to support both anthropogenic uses as well as abiotic needs. Working alongside federal, state and non-governmental organizations the ACOE supports the clean-up and protection of the environment; working diligently to restore impacted ecosystems to encourage native species populations.

California Department of Fish and Wildlife (CDFW)

Historically the CDFW had conducted stream surveys in parts of the watershed in 1957. The CDFW is actively engaged in the restorative measures of native salmonid species within the watersheds of Sonoma County. They developed the Coastal Watershed Planning and Assessment Program (CWPAP) that focuses on fishery-based watershed assessments throughout the California Coast. Other plans related to salmonids are the Coho Recovery Plan and the Steelhead Recovery Plan that both aid in the selection of basins for further study. In addition CDFW supports many local entities and stakeholders with funding to carryout vital salmonid habitat recovery and habitat enhancement projects, including environmental education programming in the Sonoma Creek watershed.

City of Petaluma

The City of Petaluma actively engages in conservation measures within the watershed. The Water Resources and Conservation department provides a comprehensive and integrated approach to the City's water supplies and conservation measures. A Groundwater Management Plan for the area will further address conservation efforts and sustainable practices. They work with a variety of partners to better the environment and the waterways of Petaluma.

Federated Indians of the Graton Rancheria

The Tribe consists of both Coast Miwok and Southern Pomo peoples whose territorial lands span areas of Marin and Southern Sonoma County; where their ancestors once resided and where many still live with their families. They are an important entity within the region and provide support for the protection and sustainable management of lands throughout the watershed boundary.

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 access and conservation initiatives the group is committed to long-term sustainable stewardship to protect a valuable resource. They act on behalf of the river resources as well as the public interest.

National Oceanic and Atmospheric Administration's National Marine Fisheries Service's (NMFS)

The NMFS is responsible for planning the recovery of threatened and endangered salmon in the U.S. The Petaluma watershed is considered an ecological refuge for native aquatic species such as steelhead trout, Chinook salmon, and California freshwater shrimp. The NMFS has listed steelhead trout and chinook salmon as threatened while the U.S. Fish and Wildlife Service listed freshwater shrimp as endangered. Leading recovery planning efforts throughout California, the NMFS works diligently with several partner agencies and organizations to recover salmonid populations to sustainable levels, they have implemented projects throughout Sonoma County.

Natural Resources Conservation Service (NRCS)

The Natural Resources Conservation Service is the federal agency that helps landowners implement conservation projects on agricultural lands with 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.

North Bay Agricultural Alliance

The North Bay Agricultural Alliance is an organization driven by local individuals who represent landowner concerns throughout the Petaluma River Watershed and a considerable number of stakeholders in the low-lying land on the shore of the San Pablo Bay. Providing alternative perspectives to issues relate agricultural production, the organization has an established voice concerning areas surrounding Highway 37, California Water Plans, planning for sea-level rise in the San Pablo Bay and similar restoration, conservation and development projects.

North Bay Watershed Association (NBWA)

The NBWA consists of 16 regional and local public agencies encompassing Marin, Sonoma and Napa Counties. They were established to help regulate agencies work cooperatively and collaboratively on water related issues. In addition, the NBWA also facilitates partnerships between groups and aids in the stewardship and conservation of resources across watershed boundaries.

Petaluma River Flood Control Zone 2A Advisory Committee

The Zone 2A advisory committee represents agricultural, residential, municipal and commercial interests providing leadership concerning flood control in the region. The committee is comprised of seven members, six appointed by the Second District Director; meetings are indefinitely scheduled to discuss needs within the Zone 2A boundary.

Petaluma Small Craft Center (PSCC)

The PSCC organizes to improve river access for the community and visitors for human-powered watercraft. Their goal is to establish a waterfront community boathouse which would act as a center to learn about boating basics, water safety, the environment and the importance of appreciating the river for all purposes and fitness.

Petaluma Wetlands Alliance (PWA)

The PWA is committed to the creation, restoration and continued stewardship of wetlands supporting wildlife habitat. As a committee of Madrone Audubon the group works closely with local governments and organizations to educate on the ecology, diversity and significance of

wetland systems. They have supported efforts in Shollenberger Park, Alman Marsh and the wastewater treatment facility in the Petaluma River Watershed.

Point Reyes Bird Observatory (Point Blue) Conservation Science (PRBO)

PRBO works closely with partners to carry out their mission and dedication to the environment. Conserving birds and other wildlife and ecosystems through innovative scientific research, restoration, outreach and partnerships has remained their ultimate goal and purpose. Providing assistance, monitoring, ecosystem research, planning and management, as well as education opportunities, PRBO continues to engage in local and global conservation issues.

San Francisco Bay Joint Venture (SFBJV)

The SFBJV stands to protect, restore, increase and enhance wetlands, riparian habitats and associated lands throughout the San Francisco Bay region in order to benefit all wildlife. They are one of eighteen Joint Ventures established under The Migratory Bird Treaty Act collaborating with both public and private agencies, conservation organizations, developers and a number of other entities focused on wetland restoration and habitat in the San Francisco Bay region.

San Francisco Bay Regional Water Quality Control Board

The San Francisco Bay Regional Water Quality Control Board is a branch of the State Water Board administering water rights, water pollution control, groundwater monitoring, and water quality initiatives as part of the California Environmental Protection Agency (Cal/EPA). In conjunction with the Regional Water Boards the State Water Board shares its authority to carry out the federal Clean Water Act.

Sonoma County Agricultural Preservation and Open Space District (SCAPOSD)

The SCAPOSD permanently protects the diverse agricultural, natural resources, and open space properties for Sonoma County. They are one of the first districts in the country to also strive to preserve valued agricultural lands. Since their establishment the district has preserved over more than 83,000 acres of open space and agricultural lands throughout the county and continues to educate the public and manage lands for future generations.

Sonoma County Farm Bureau

The Farm Bureau is created of farm and ranch families who have come together to evaluate issues in order to formulate effective resolutions to achieve educational improvement, economic opportunity and to promote overall wellbeing. They are an independent, non-governmental not for profit organization dedicated to: protecting water resources, actively participating in legislation, electing government officials with agricultural interests, protecting the land, environmental conservation, promoting healthy and safe farms, supporting safe labor programs, food safety initiatives, as well as preserving the farmers voice throughout communities and government.

Sonoma County Wine Grape Commission

The Sonoma County Wine Grape Commission was established in 2006 and represents the 1,800 winegrape growers throughout Sonoma and Marin Counties. They are a non-profit marketing and educational organization with the goal of increasing awareness and recognition of the diversity and quality of the grapes grown in Sonoma County. Through efforts of dynamic marketing and educational programs for winegrape growers and the public they strive to reach wine consumers globally.

Sonoma Land Trust (SLT)

The Sonoma Land Trust is a local, non-governmental, non-profit organization that works closely with land owners, SCAPOSD, and an array of public agencies and government. They conserve scenic, natural, agricultural and open land through developing long term land protection strategies, active stewardship, conservation easements, and provide educational opportunities. The SLT has protected more than 25,000 acres of land since their establishment in 1976 for Sonoma County.

United Anglers of Casa Grande High School

The United Anglers of Casa Grande High School is a non-profit organization established in 1983, whose mission has been to promote environmental awareness through education and hands-on experience to revive species from extinction and create healthy stream systems. The program allows for students to actively engage with their environment, while brining waterways back to life for threatened salmonids.

University of California Cooperative Extension (UCCE)

The UCCE holds 64 cooperative offices throughout California to be local problem-solving centers to connect issues with the latest UC research, collaborating with federal, state and local entities. They are advocates for healthy landscapes and communities, helping farmers become more efficient, educate on stewardship, promote water-wise solutions and irrigation methods, support 4-H Youth Development, and help to preserve natural areas.

Western United Dairymen (WUD)

The Western United Dairymen informs the public on agricultural issues from a local to international level, provide technical support, committed to sustainable ecosystems and biological health, and are instrumental in water quality projects and groundwater protection efforts. Their partnerships with landowners and agencies take on an important role to sustain dairy families and their businesses as well as the communities they support.

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, the Department provides varied 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 CAL

FIRE Resource Management Program. CAL FIRE oversees enforcement of California's forest practice regulations, which guide timber harvesting on private lands.

The Sonoma County Forest Conservation Working Group

The Sonoma County Forest Conservation Working Group was created seven years ago to help provide information and resources to private forest and woodland owners of small parcels—tools to address the threats with the goal of protecting the health and long-term tenure of forests and oak woodlands. This group is made of an interagency association of Sonoma County Agricultural Preservation and Open Space District, Sonoma Land Trust, CAL FIRE, University of California Cooperative Extension, local land trusts, Southern Sonoma County (Sonoma), Sotoyome (Sonoma) and Gold Ridge RCDs, and Landowners.

ORGANIZATION OF THE PLAN

The organization of this plan is based upon the US Environmental Protection Agency's nine elements of an effective watershed management plan, as described in the "Handbook for Developing Watershed Plans to Restore and Protect Our Waters" (2005). This Plan addresses the following descriptions of the USEPAs nine elements.

a) An identification of causes of impairment and pollutant sources.
b) An estimate of load reductions expected from management measures.
c) A description of the nonpoint source management measures that will be implemented to achieve load reductions.
d) An estimate of the amounts of technical and financial assistance needed to implement those management measures.
e) An information and education component used to enhance public understanding of the project and to encourage their early and continued participation in selecting, designing, and implementing nonpoint source management measures.
f) A schedule for implementing nonpoint source management measures identified in the plan.
g) A description of interim measurable milestones for project implementation efforts.
h) A set of criteria that can be used to determine whether load reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.
i) A monitoring component to evaluate the effectiveness of implementation efforts over time.

CHAPTER 2: WATERSHED DESCRIPTION AND HISTORY

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

OVERVIEW

Historically the Petaluma Watershed has been a vital system for tribal communities, agriculture, city commerce, and capital. Providing transportation of goods and services to growing communities, the Petaluma River including its headwaters and smaller tributaries, gave life to the North Bay area. The watershed maintains a biologically diverse ecosystem with unique features supporting a rich habitat for species of special concern and endemic plant populations. Through time the area has grown to encompass an array of land uses including: vineyards, croplands, ranches, state and regional parks, and urban development. Nonetheless, riparian corridors have continuously become fragmented and channeled, often mixing with silt from erosion of streambanks and pollutants from urban and rural regions. Activities within the watershed have a direct impact on the San Pablo Bay where the lower reaches of the slough undergo a constant tidal exchange. This waterbody has been known as the Petaluma Creek, Petaluma Slough and Petaluma River. The lower reaches of the "slough" experience regular tidal exchange from San Pablo Bay.

History and Cultural Resources

The history and cultural resources of the Petaluma Watershed illustrate an evolution of land use, economic development, and resource exploitation. Cultural resources are defined as: historic buildings, archaeological sites, prehistoric or ethno-historic Native American sites, as well as areas of the natural world which hold cultural value. These resources are important in understanding the present landscape.

The cultural setting of the region has undergone numerous changes throughout the years, beginning with a significant Native American heritage. Radiocarbon tests indicate settlement in the Petaluma region by Native Americans as far back as 9,000 years.8 The Coast Miwok people occupied an area that includes modern day Marin and southern Sonoma County. These peoples are believed to have moved into the Petaluma area approximately 3,000 to 3,500 years ago. They utilized wetland areas in particular, collecting shellfish and plants from the tidal estuaries and tributaries.

The area around Petaluma River is marked by the presence of midden soil deposits, including marine shells and animal bones, as well as shell, stone and bone jewelry and implements. Two villages were found in the Petaluma area, E'tem, located in the old town of Petaluma and Tutcaiy'lin, located 1 mile northwest of old town Petaluma.

In the late 1700's to early 1800's, various expeditions were led through the Petaluma area. In 1823, a mission was founded in Sonoma. Mariano Guadalupe Vallejo was sent by the Mexican

government to Sonoma to oversee settlement in the area. In 1834, he applied for ten square leagues, the Petaluma Rancho, as his personal property. The Petaluma land grant stretched from San Pablo Bay on the South, Petaluma Creek on the West, and Sonoma Creek on the East.

In 1850, the first European settlers set up a hunting camp on the banks of the Petaluma River. They eventually built a trading post, which is speculated to have existed on the site which became Cedar Grove Park. By 1853, a street pattern was developed, lots designated and a wharf built at the end of present day Western Avenue. A drawbridge was constructed in 1857 across the river at Washington Street; the following year the town became incorporated.

In 1870, a railroad was built which headed to Santa Rosa. These tracks passed approximately $^{1}/_{2}$-mile to the southwest of the project area. The late 1800's saw Petaluma developed with poultry hatcheries and farms. The river was dredged and straightened, which allowed better ship passage. During the early 1900's, the river industry thrived and warehouses were constructed along the river.

Because of its proximity to San Francisco, Petaluma Creek has had a colorful history and has gone through many changes both physically and legislatively. Because the creek was narrow and shallow, much work was done to dredge it, widen it and straighten it. By the 1860's Chinese laborers began the work of straightening the more difficult segments of the creek. Work on the creek has continued ever since with more projects yet to be built. In the 1850's the Petaluma Creek was declared a navigable stream and a century later (1959) it was declared a "river" by an Act of Congress.

One version of the origin of the word Petaluma, from *pe'ta*, flat, and *luma*, back, was derived from the Miwok people who lived in Sonoma County for more than 2500 years. Petaluma was the name of a village on a low hill east of Petaluma creek and north east of the present day town of Petaluma. The Miwok were "hunters and gatherers" and thought to be especially adept at exploitation of the wetland resources (Archeological Resource Service, 1997).

The first recorded exploration of the Petaluma River was by a Spaniard in 1776. While other members of his expedition prepared adobe and timber for new missions in the area, Fernando Quiros was accompanied by a number of sailors when entering the Petaluma Slough. They believed they might be able to sail from San Pablo Bay to Bodega Bay, but were unsuccessful.

Gold was discovered in California at the beginning of 1848. San Francisco Bay and its surrounding rivers and tributaries became the major source of transportation of goods. Petaluma Creek, even though it was narrow, shallow and difficult to navigate, became a vital way of transporting goods from the towns of the North Bay to San Francisco. Commercial use of the Petaluma Creek began in 1851 when a warehouse was built near the present Washington Street Bridge.

The town of Petaluma became one of the wealthiest towns in California. By 1852, schooners were a common sight on the creek as people began to find that it was cheaper to transport goods along the calm creek rather than go overland or sail from a coastal town. By 1855, farming and other businesses along the creek's banks had contributed so much debris and mud that it became impossible for larger boats to go all the way to Petaluma. In 1859 laborers spent two months dredging the creek to remove the debris and mud. In spite of constant problems, the creek continued to be a steady source of revenue for the residents of Petaluma. In 1879 Lyman Byce invented the Petaluma Incubator, greatly increasing the number of chickens and eggs hatched and bringing a new level of industry to Petaluma.

The ACOE widened the creek in 1880 to fifty feet wide and deepened it to three feet at high tide. By 1915 the area was shipping out an estimated ten million eggs a year, most of them via the Petaluma Creek.

In 1918 Petaluma was declared the *Egg Basket of the World* and the world's richest city of its size. Spanning the next few decades the Petaluma poultry industry achieved world acclaim. The Petaluma Creek was used extensively for transporting chickens and eggs as well as many other products. Advancing technology made it more and more difficult for family farms to compete with the new industry of poultrymen. From 1890 to 1960 chickens and eggs remained the primary source of income for the Petaluma vicinity.

In 1931 the ACOE, again, widened the River to 100 feet wide and deepened it to eight feet at low tide. In 1959 the tidewater estuary of the Petaluma River was declared a river by an Act of Congress. Within a year, much of the poultry industry moved to southern California. By 1961 the major cargo moved via the Petaluma River was fuel.

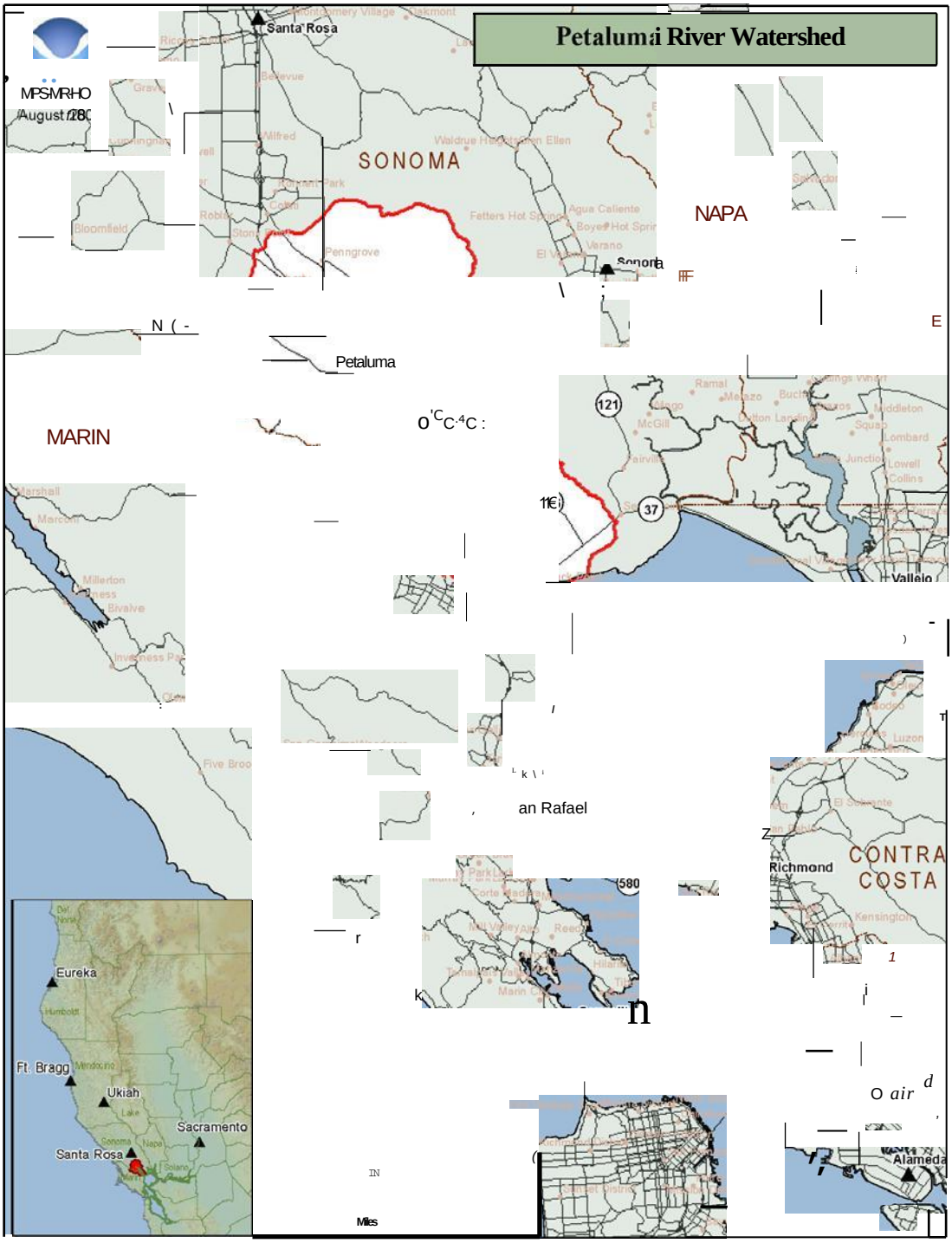
After the chicken industry declined, dairies began to flourish with 46,000 cows and the largest cooperative creamery in the U.S. In 1972 the City Council of Petaluma passed a controversial ordinance limiting growth to 500 housing units per year. By 1997 there were only 15 dairies in the Petaluma watershed. These dairies are mostly in the San Antonio Creek and Adobe Creek regions. Although vineyards were established in the Lakeville area before the prohibition era of the 1920's, the area was historically considered too cool for wine grapes. Recently, however, vineyard development has increased in the watershed, particularly in the Lakeville area. Urban development is concentrated within the city limits of Petaluma. Limited commercial and rural residential development is located in the community of Penngrove.

Watershed Boundaries

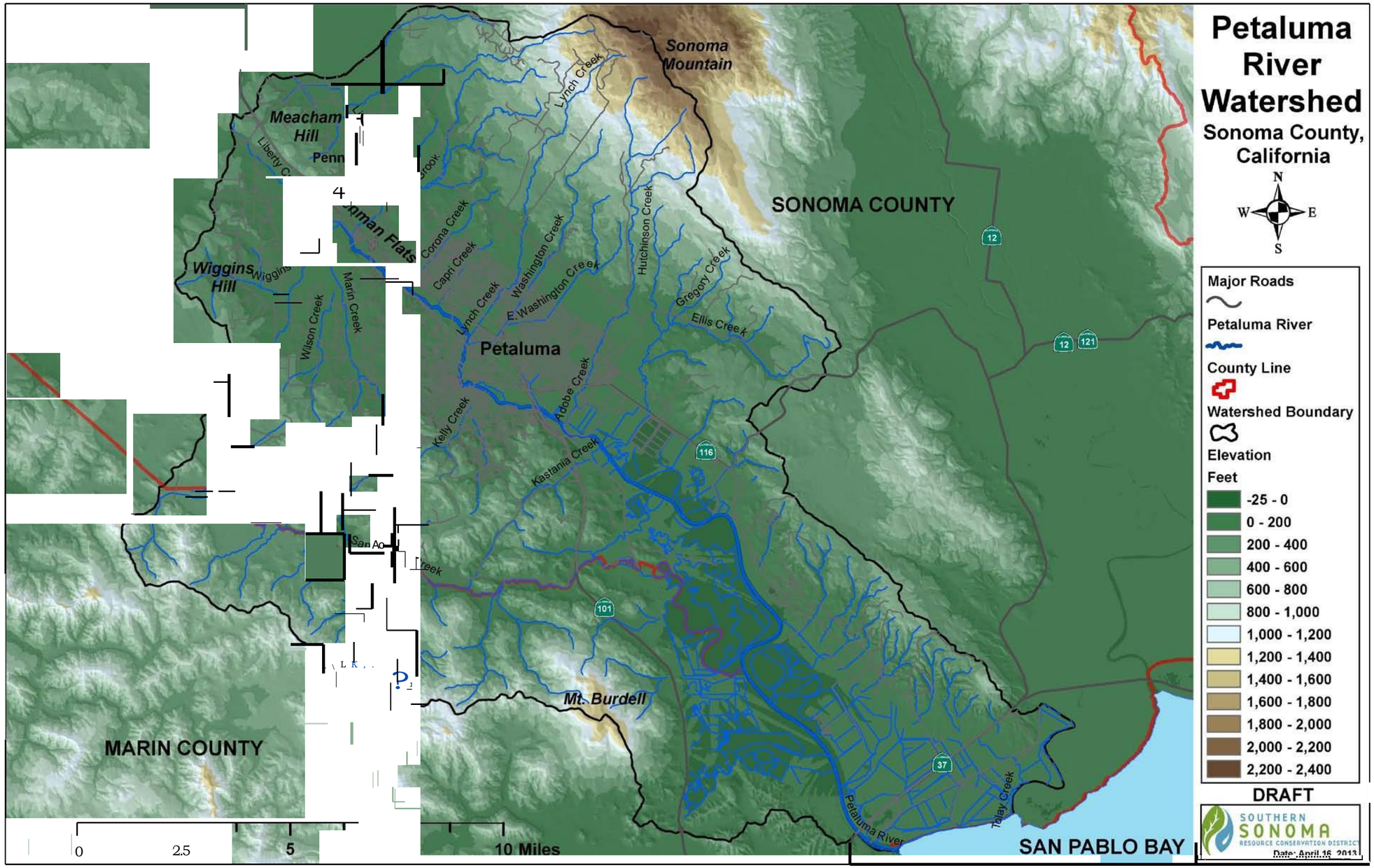
Located in southern Sonoma County, California, and a portion of northeastern Marin County, California, the Petaluma River Watershed encompasses a 146 square mile, pear shaped basin. The watershed is approximately 19 miles long and 13 miles wide with the City of Petaluma near its center. U.S. Highway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

Map 2.1 Petal a River Watershed—Bay Area (NOAA, 2008).



Map 2.2 Petaluma River Watershed— Sonoma County, California.



Hydrology

The headwaters and ephemeral tributaries of 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 1.2, depicting the Petaluma 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. 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 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.

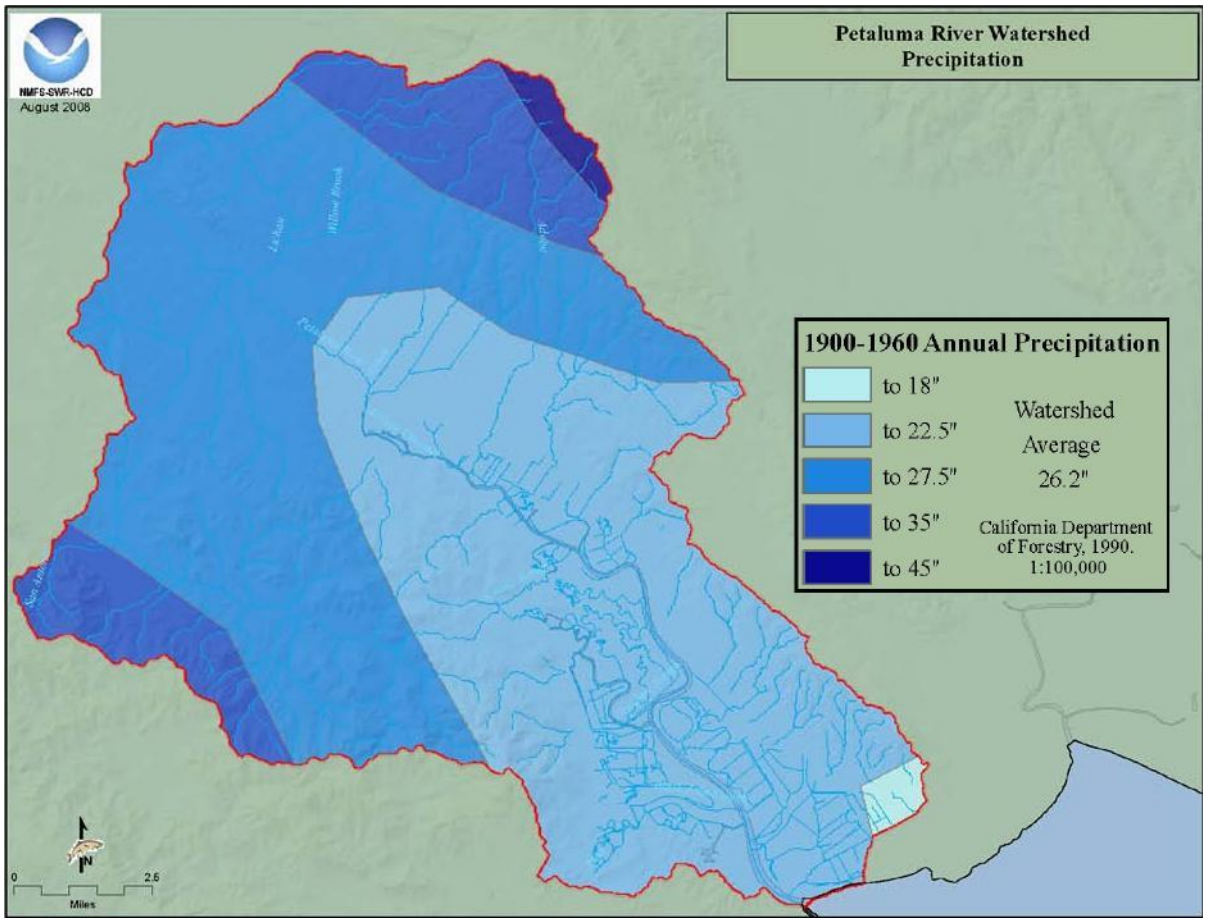
Three major creeks are located on the western side of the watershed. Wiggins Creek and Marin Creek flow into Liberty Creek, which also feeds into Denman Flat. The largest sub-watershed is San Antonio Creek located in the western portion of the watershed south of Petaluma. San Antonio Creek flows from 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.

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 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. Rainfall and its resultant runoff, is the most significant factor in the planning and design of flood control drainage facilities and in considering erosion and sedimentation control devices.

Map 1.3 Petaluma River Watershed Precipitation (NOAA, 2008).



Water Resources

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

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 storm water 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 slops 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, leaving the lower 12 miles of the river to flow directly into the Petaluma Marsh. To date the Petaluma Marsh is the largest remaining marsh in the San Pablo Bay encompassing 5,000 acres; surrounded by approximately 7,000 additional acres of reclaimed marshland.

Major portions of the Petaluma River watershed lie outside of the urban boundary and marshes are used for livestock grazing, urban residences and largely viticulture. The Petaluma River system maintains 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 both fisheries and riparian plant communities.

Groundwater resources are important in serving the water supply needs of the Petaluma area citizens, commerce, industry, and agriculture. The state of the aquifers and the groundwater quality are vital to the health of the watershed. Groundwater is a limited and valuable resource, although 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 such a resource including: local agriculture, dairies, government, local water purveyors, business, and environmental interests.

Ground water levels near the city of Petaluma dropped from the mid-1950 until the early 1960's, 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 the Agency's Petaluma Aqueduct (SCWA). 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 in the volume of ground water affected by sea water intrusion. As long as ground water pumping near the tidal portion of the Petaluma River does not substantially increase, the volume of affected ground water should not increase.

A computer analysis completed by the California Department of Water Resources (DWR) indicates that the total groundwater storage capacity of the Petaluma Valley is 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. This figure includes water of all quality types, including brackish water caused by seawater intrusion. The report summarizing the computer analysis states that natural topographic constraints prevent the Petaluma Valley ground water basin from filling to more than the 84%. If the basins are more than the 84% full, the additional groundwater begins to leak out along roadcuts and into streams as "rejected recharge." The report concludes that "The Petaluma Valley basin is therefore, in effect, completely filled at the present time." (DWR, June 1982).

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. The Department of Water Resources (DWR) developed the California Statewide Groundwater Elevation Monitoring (CASGEM) program with the purpose of establishing long-term, locally-managed monitoring of groundwater basins. Local entities must work in collaboration with DWR to collect and maintain groundwater elevation data.

To comply with the CASGEM Program procedures and guidelines, the City of Petaluma Department of Water Resources and Conservation in January 2011 began drafting a Groundwater Level Monitoring Plan (GLMP). The monitoring plan will focus on the Petaluma Valley groundwater basin (DWR basin 2-1, North Central Region). Plans will be developed in coordination with Sonoma County Water Agency (SCWA), Department of Water Resources (DWR), and the City of Petaluma by a range of stakeholders who live within the basin, as well as a panel of technical experts.

The collaboration and cooperation of these individuals and agencies will drive the implementation of the Petaluma Valley GLMP. Wells selected in the basin will provide a reasonable representation of the geography and well depth intervals identified in each area. RCDs throughout the County are actively working in partnership with the SCWA on outreaching to private landowners for voluntary well monitoring.

Results from the groundwater monitoring program in the Petaluma Valley monitoring network and groundwater level data will be submitted to DWR semiannually as required by CASGEM. Under the authority of the Groundwater Management Act, a subsequent Groundwater Management Plan (GMP) is also being considered for the Petaluma Valley groundwater basin.

As groundwater is a limited resource, landowners in the San Antonio Creek subwatershed continue to express concerns about its future availability. It is believed by some that intensive water extraction for some types of agricultural activities and development has impacted historical groundwater levels in the area. Alterations of the land in the upper watershed has changed the hydrology of San Antonio Creek, but impacts to individual wells is unclear and likely varies due to local geology. Stakeholder concerns include an array of impacts to the watershed and their effects to the vitality of groundwater resources, and changes in agricultural operations in relation to economic pressures.

The following discussion provides an overview of the groundwater resources in the Petaluma Watershed and is summarized from the SCWA's Master Drainage Plan.

Several physical factors control natural recharge of groundwater in an area, including:

- Slope of the land surface
- Permeability of the soils
  - Subsurface
  - Amount of available storage space in the

The largest concentration of soils suitable for recharge is northwest of the city of Petaluma. These soils have formed on the sandy Merced Formation and cover 28% of the land surface in this area. Many soils in

this area, not classified as recharge areas, were excluded because land slope exceeded 15%. The Merced Formation in this area is essentially one continuous aquifer averaging 450 feet in thickness. Because few creeks cross the recharge areas, the major source of natural recharge to the Merced Formation appears to be from rainfall on suitable soils.

Other recharge areas dot the western uplands and are scattered on the western flank of the Sonoma Mountains. In these areas, most recharge is from rainfall because few streams flow across the recharge areas.

Soils suitable for recharge underlie portions of the city of Petaluma, having formed on top of a thin deposit of alluvium and, to a lesser extent, alluvial fan deposits and the Tolay Volcanics. The Petaluma River flows across some of these recharge areas; however, because there is little storage available in aquifers beneath these recharge areas, the loss of surface water to the ground water body is probably small. Because the Petaluma River is tidal and brackish at the City limits, an increase in river recharge in this area would not be desirable.

Floodplains

The SCWA'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 floodplain delineation closely approximates the base (100-year) flood elevation lines developed by the U. S. Army ACOE of Engineers (ACOE) 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 therefore can happen any time. The term "100-year flood" is often used inconsistently and misunderstood by many people. 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 finite probability that the 100-year flood could occur in any year.

Land use, specifically developed lands, is an important topographic factor influencing surface runoff of storm waters. The watershed's decrease in water quality, susceptibility to erosion and flooding is directly linked to the increased urbanization and accompanying pavement (SCWA, 1986).

Geology and Soils

The Petaluma River Basin lies within the southern portion of the northern Coast Ranges of California. 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 fairly thin in the upper Petaluma Valley but thicken to over 300 feet near the 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,

extending inland as far as the City of Petaluma, with younger alluvium and soft marine silts and clays which are known as Bay Mud.

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 time. Information on the geological units in the Petaluma Valley and their characteristics is contained in the State Department of Water Resources' Evaluation of Ground Water Resources in Petaluma Valley (Volume 3, Bulletin 118-4) published in June 1982.

Five fault 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 easterly 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.

Marshland

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. Only 27% of the historic tidal marshes in San Pablo Bay remain. 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.

The Petaluma Marsh is the largest remaining salt marsh in San Pablo Bay, totaling an estimated 5,000 acres. The marsh has three zones: low marsh of cordgrass or tules, which receives maximum submergence; a middle marsh of pickleweed, 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.

Wildlife and Protected Species

The Petaluma River watershed is a subwatershed of the San Francisco Bay Delta watershed which includes the largest estuary on the coast of both the western continents. The Petaluma River watershed includes a diversity of fresh water, brackish water, and salt water habitats. A significant amount of the state's Pacific flyway migratory water birds rely on the watershed's wetlands. Among the many diverse species found in the watershed is the great blue heron (Ardea herodias), great egret (Ardea alba), willow flycatcher, (Empidonax traillii), California red-legged frog (Rana aurora draytonii), bank swallow (Riparia riparia), steelhead (Oncorhynchus mykiss) and spring/winter-run Chinook salmon (Oncorhynchus tshawytscha), and the American badger (Taxidea taxus).

Ecological balance, the equilibrium between, and harmonious coexistence of, organisms and their environment is critical to maintain a healthy watershed. A stable balance in the numbers of each species in an ecosystem depends on how much it is affected by human population and development. The balance may be disturbed by several factors such as the introduction of new species, the sudden death of some

species, natural hazards or man-made causes. The many diverse species present in the Petaluma River watershed depend on symbiotic relationships to survive. As land is preserved and resources are managed effectively, fish and wildlife will have a chance to thrive in this watershed.

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 threat 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 of the ESA and CESA, and can have different status on each list. Additionally, the California Department of Fish and Wildlife (CDFW) have 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. Maintaining ecosystem functionality for the Petaluma Watershed and surrounding areas can be done through such protective measures.

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 Petaluma River hosts a number of fish species, which are currently listed as "threatened" by the National Marine and Fisheries Service. These species use the Petaluma River and its tributaries as habitat for spawning, rearing, and migration.

A number of species found in the Petaluma Watershed are federally listed under the ESA. The habitat varieties identified in this region are vital for the survival of such species. For example, the California clapper rail, California black rail, and the salt marsh harvest mouse are completely dependent upon marshlands. Uniquely the California clapper rail and the salt marsh harvest mouse survive only in tidal marshlands; whereas the California black rail lives in freshwater and saltwater marshland habitats.

The California Native Plant Society (CNPS) maintains lists of plants to categorize degrees of concern for the survival of these species. These lists include but are not limited to plants that are listed under the ESA and CESA.

A California Native Diversity Database (CNDDB) search of the Cotati, Glen Ellen, Novato, Petaluma Point, Petaluma River, San Geronimo, Sears Point and Sonoma, USGS 7.5m quadrangles produced the following lists of animal and plant species.

Federally and State Listed Species, Species under a CDFW Status, in the Watershed
Federally Threatened (FT), Federally Endangered (FE),
State Threatened (ST), State Endangered (SE), and
Species of Special Concern (SSC)

Mammals
Salt marsh harvest mouse, Reithrodontomys raviventris (FE), (SE)
Pacific Western (Townsend's) big-eared bat, Corynorhinus townsendii (SSC)
Pallid bat, Antrozous pallidus (SSC)
American badger, Taxidea taxus (SSC)
Suisun ornate shrew, Sorex ornatus sinuisus (SSC)

Birds
California clapper rail, Rallus longirostris obsoletus (FE), (SE)
California black rail, Laterallus jamaicensis coturniculus (ST)
Western yellow-billed cuckoo, Coccyzus americanus (Federal candidate) (ST)
Bank swallow, Riparia riparia (ST)
Bald eagle, Haliaeetus leucoccophalus (SE)
Western snowy plover, Charadrius alexandrinus nivosus (FT)
Willow flycatcher, Empidonax traillii (SE)
Western burrowing owl, Athene cunicularia hypugea (SSC)
Common salt marsh yellowthroat, Geothlypis trichas sinuosa (SSC)
Black swift, Cypseloides niger (SSC)
San Pablo song sparrow, Melospiza melodia samuelis (SSC)
Tricolored blackbird, Agelaius tricolor (SSC)

Reptiles
Northwestern pond turtle, Clemmys marmorata marmorata (SSC)

Amphibians
California red-legged frog, Rana aurora draytonii (FT) (SSC)
Foothill yellow-legged frog, Rana boylii (SSC)
California tiger salamander, Ambystoma californiense (FT), (ST)

Fish
Central California Coast steelhead, Oncorhynchus mykiss (FT)
Delta smelt, Hypomesus transpacificus (SE), (FT)
Chinook salmon (Oncorhynchus tshawytscha) (ST), (FT)
Tidewater goby, Eucyclogobius newberryi (FE), (SSC)
Sacramento splittail, Pogonichthys macrolepidotus (SSC)

Invertebrates
Myrtle's silverspot butterfly, Speyeria zerene myrtleae (FE)
Callippe silverspot butterfly, Speyeria callippe callippe (FE)
California freshwater shrimp, Syncaris pacifica (FE), (SE)

Plants Species

Soft Bird's-Beak, Cordylanthus mollis ssp. mollis (E)
Sonoma Spineflower, Chorizanthe valida (E) Baker's
Stickyseed, Blennosperma bakeri (E) Burke's
Goldfields, Lasthenia burkei (E) Showy Indian
Clover, Trifolium amoenum (E) Sebastopol
Meadowfoam, Limnanthes vinculans (E) Yellow
Larkspur, Delphinium luteum (E)
Fragrant Fritillary, Frillaria lilacae (SSC)
Franciscan Onion, Allium peninsulare var. franciscanum (SSC)
Jepson's Leptosiphon, Leptosiphon jepsonii (SSC)
Marsh Microseris, Microseris paludosa (SSC)
Petaluma Popcorn Flower, Plagiobothrys mollis var. vestitus (SSC)
Point Reyes Bird's Beak, Chloropyron maritimum ssp. Palustre (SSC)
Point Reyes Checkerbloom, Sidalcea calycosa ssp. Rhizomata (SSC)
Marin Knotweed, Polygonum marinense (SSC)
Nappa False Indigo, Amorpha californica car. Napensis (SSC)
Mt. Tamalpais Manzanita, Arctostaphylos hookeri ssp. Montana (SSC)
Pappose Tarplant, Centromadia parryi ssp. Parryi (SSC)
Round-leaved Filaree, California macrophylla (SSC)
White Seaside Tarplant, Hemizonia congesta ssp. Leucocephala (SSC)
Alkali Milk-Vetch, Astragalus tener var. tener (SSC)

Navigational Channels, Ports and Harbors

The Petaluma River, formally known as Petaluma Creek, is a tidal slough that has been reshaped and renamed many times to suit human purposes. It has played an integral role in the human history within the Petaluma Watershed. Before automobiles and the railroad, rivers were the main system of travel and transportation of goods. In 1852 the first wharf was constructed in town to accommodate the increasing river use. Petaluma Creek was being used so intensely that in 1880 ACOE spent $8,000 to widen the Petaluma Creek to 50ft wide and 3ft deep at low tide. By 1905 Petaluma Creek had the third highest commercial traffic of any river in California. Again in 1906 the ACOE began a project to create a river 50ft wide by 6ft deep from its mouth to the city border. Due to a growing population and increased usage for transportation of goods and materials in 1927 the river was widened to 100 feet and was made 8 feet deep. These new dimensions were from the mouth of the river all the way up to Washington Street in the city center.

In 1959 the United States Congress officially declared that Petaluma Creek was a River. In the process of making navigation channel improvements, many old river meanders were filled with dredged material. These old meanders are primarily located on the eastern banks of the Petaluma River.

The navigability of the Petaluma River and its importance in the exploration, settlement and development of the watershed are mentioned in several sections of this Plan. Flooding along the banks of the river, and siltation of the streambed, affecting both navigation and water-carrying capacity, have been increasingly serious problems for more than a century. This is evident when one compares a depiction of the waterway from the late 1800's to the present. Some of the early recommendations for straightening the alignment of the Petaluma River throughout the City were subsequently implemented. The Petaluma River today is no longer the "tortuous watercourse" described by Thompson in 1877 as "...winding through the green marsh, sometimes doubling back upon its course, (and) making in a distance of eight miles a direct progress of but two."

The problems of siltation and flooding recognized over a century ago still exist today. Since the 1880's the ACOE has improved and maintained the Petaluma River for navigation. The ACOE's first dredging project, authorized in 1930 and completed in 1933, provided for a 200-foot wide, 8-foot deep channel for 33,000 feet across the mudflats in San Pablo Bay to the mouth of the Petaluma River. For the next 69,000 feet upstream to Western Avenue in the City of Petaluma, the channel was widened 100 feet and deepened 8 feet. Included in this part of the project was a 300' x 400' turning basin, 8 feet deep. From Western Avenue upstream to the Washington Street Bridge, the channel is now 50 feet wide and 4 feet deep (SCWA, 1986).

Dredging is a continuing project and under present scheduling, the San Francisco District of the ACOE maintains the San Pablo Bay Channel on a 144-month cycle and the Upper River channel on a 48-month cycle. The ACOE's dredging experience was also used as the basis for evaluating any impacts a proposed project might have on silt deposition in the Petaluma River. Based on the ACOE's experience over the past fifty years, it appears that an average of 60,000 cubic yards of material is deposited in the River each year (SCWA, 1986).

CHAPTER 3: LAND USE

The Petaluma River Watershed supports an array of land use activities, due to its hydrology, soils and geographic location. Land uses in the watershed include intensive urban development, rural residential, agriculture, and open space. The following information describes the predominant land uses and impacts identified within the Petaluma Watershed boundary.

OVERVIEW WATERSHED LAND USE

Urban Areas

Petaluma has an urban core with over 45,000 residents. 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. In summer months, it is quite common to view trash and unwanted household items filling the waterways and storm drains throughout the downtown river's segment.

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. Urban development impacts ultimately affect all the stakeholders in a watershed and commit our non-renewable resources, such as water, forever.

Urban development is concentrated within the city limits of Petaluma. Limited commercial and rural residential developments are located in the community of Penngrove. The City and Sonoma County both have general plans and formal planning-related relationships. For example, annexation proposals are reviewed by the County both through Local Agency Formation Committee (LAFCO) and at a financial level. In addition, the City and County have a joint referral and review system. The 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 has expressed a desire to review proposed projects in areas of interest that are beyond the City's formal sphere of influence. The City and County planning staff and public representatives also have working relationships and less formal means of cooperation, such as meetings on various topics related to planning. The City has also adopted policies in the General Plan that support agricultural businesses located within Petaluma. Concentrating development in urban areas and reducing conversion of rural lands is valuable to both local communities and the environment.

Urban growth boundaries (UGBs) are considered to be 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, 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 (Greenbelt Alliance, 2013). The City 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.

Map 3.1 Petaluma River Watershed Development (NOAA, 2008).

Open Space

Parks and open spaces are integral to Petaluma's character, comprising a substantial portion of land — nearly 1,300 acres, or 18 percent of acreage—within the Urban Growth Boundary (UGB). The City owns and maintains a full range of open space and recreational resources, including regional, community, neighborhood, and pocket parks. Petaluma possesses a multifaceted park and recreation system in addition to surrounding rural lands, which allows for the preservation its unique identity. Policies continue to focus on the city's greatest natural resource, the Petaluma River, to expand land conservation and preservation.

The California Department of Fish and Wildlife (CDFW) manage 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 Open Space District is located south of Basalt Creek and north of Novato. 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.

The Sonoma Land Trust owns and manages West of Lakeville and Reclamation road, over 1000 acres, about half in oat hay, half grazed (in combination with seasonal wetlands) and 528 acres in agricultural easement. East of Lakeville and Reclamation road, the Land Trust manages 1800 acres, of which around 1000 are grazed and a few 100 are farmed. 1000 of the Land Trust's total acreage in the watershed will eventually be restored to tidal marsh. The Sonoma County Agricultural Preservation and Open Space District has numerous conservation easements on agricultural properties in the watershed that include hay, sheep, dairy, and grazing use.

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, Schollenberger Park , a dredge disposal and international bird hotspot, Rocky Memorial Dog Park (on an old landfill), the Alman Marsh near the marina, a portion of the McNear Peninsula near downtown, and 160 acres of marsh and oxidation ponds near Schollenberger Park. On the eastern side of its boundaries, the City owns a municipal airport on East Washington Street, Prince Park, Wiseman Park, a golf course, and urban separator lands.

Other open space land in the watershed includes: Helen Putnam Park (Sonoma County Department of Parks and Recreation), the Burdell Ranch (CDFW), Petaluma Adobe State Historic Park and Olompali State Historic Park (both owned by California Department of Parks and Recreation), offer an array of activities for individuals such as hiking, mountain biking, and horse-back-riding.

The Tolay Lake Regional Park illustrates a long presence of Native American cultural history throughout the landscape includes 1,769 acres of ecologically and historically rich lands. The preservation of such areas has been vital to the community, cultural histories, and natural resources that support a number of threatened species. The land has been identified as a historic spiritual center for Native Americans across California and is considered by the Federated Indians of Graton Rancheria as an area of spiritual significance. Historically the site, including the lake, was a place where tribes convened to perform sacred ceremonies.

Urban separators create boundaries between adjacent Urban Growth Boundaries (UGBs) designed to buffer agricultural lands from urban development and offer areas for public recreation. Similarly, community separators are intended to prevent swaths of urbanization, while retaining separate and easily identifiable cities. There are currently about 157 acres acting as urban separators in Petaluma. Community separators from Petaluma and Novato amount to approximately 2,755 acres acting as the gateway

between Sonoma and Marin Counties. In addition, community separators to the north east buffering Petaluma and Rohnert Park account for roughly 3,360 acres of farmland and foothills.

The largest community parks in Petaluma are Lucchesi (30 acres), Wiseman (21 acres), and Prince (22 acres) parks. Shollenberger Park, is a community park designed around a dredge disposal site for the Petaluma River which also provides trails throughout the wetlands area. Helen Putnam Park encompassing 256 acres in the south western portion of Petaluma is a County Regional Park.

Agricultural Lands

For over a century, agriculture has been the dominant land use throughout the Petaluma Watershed. Historically, the area has been a production center for poultry and dairy products. Although the poultry industry has declined, milk continues to be one of the watershed's leading agricultural commodities. Dairy operations are found throughout the watershed, particularly in the San Antonio Creek watershed and Adobe Creek Watershed. Vineyard development has increased in the watershed, 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. 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.

Levees

During the late 1800s the tidelands bordering San Pablo Bay were "reclaimed" for farm land. 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, rain water flushed out the salts from the land and crops were planted. Currently, these lands are either private or publically owned and support local agricultural operations, infrastructure (i.e. roads) and important habitat and the levees require ongoing maintenance to prevent these lands from flooding. The ACOE is not responsible for the many levees throughout the Petaluma watershed and private landowners have to maintain them at their own expense.

In order to maintain the levees, landowners are required to obtain permits from some, or all, of the following regulatory agencies: the U.S. Army ACOE of Engineers (with consultation from the National Marine Fisheries Service and U.S. Fish and Wildlife), County, Department of Fish and Wildlife, 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 RCD administers several permits issued by each regulatory agency for levee maintenance activities being completed by numerous landowners in the Petaluma River Watershed.

Recreation

The Petaluma River and complex park and open space network provides for an array of recreation opportunities. Development focused on capitalizing the uses of the natural resources allows public education and involvement in the natural world. Protecting areas for community enjoyment would ideally

promote a public commitment to conserve and care for such environments. However, with increased use also comes the potential for increased pollution, impacts on flora and fauna, and resource degradation.

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. Through an assortment of trainings and events it has been their mission to better connect the community with the city's river heritage. Plans to develop a Small Craft Center boathouse by the coalition 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.

Vessels solely powered and operated by human fitness create little impact on river ecology and function when compared to motor powered crafts requiring additives. Pollutants including operating fuels and garbage negatively impact the surrounding ecology, the river waterway, and the San Pablo Bay where the slough empties. As developing and enhancing previously established recreational areas is a significant element of fostering public relationships with the natural world, concerns also arise where increasing use will alternatively impact biotic and abiotic systems.

Transportation

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.

According to the Petaluma General Plan 2025, based on the 2000 census, the majority of employed residents in Petaluma commute to work beyond city boundaries. To accommodate future motor vehicle congestion and population increases in Sonoma County, a series of plans are in the process of development and implantation. A Central Petaluma Specific Plan adopted in 2003, focused on directing growth into Petaluma's historic core. 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 in order to develop and implement the passenger rail system slated to run on the Northwestern Pacific Railroad corridor between the Marin and Sonoma counties. The district oversees the engineering, planning, evaluations and necessary assessments to properly enable the passenger train service. Two stations in Petaluma are currently in development.

Pedestrian improvement priorities are to remove barriers limiting foot traffic and mobility throughout the City of Petaluma. Establishing a strong pedestrian network would consist of 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. Implementing plans to promote the use of public pedestrian corridors would reduce vehicle use made on local roadways.

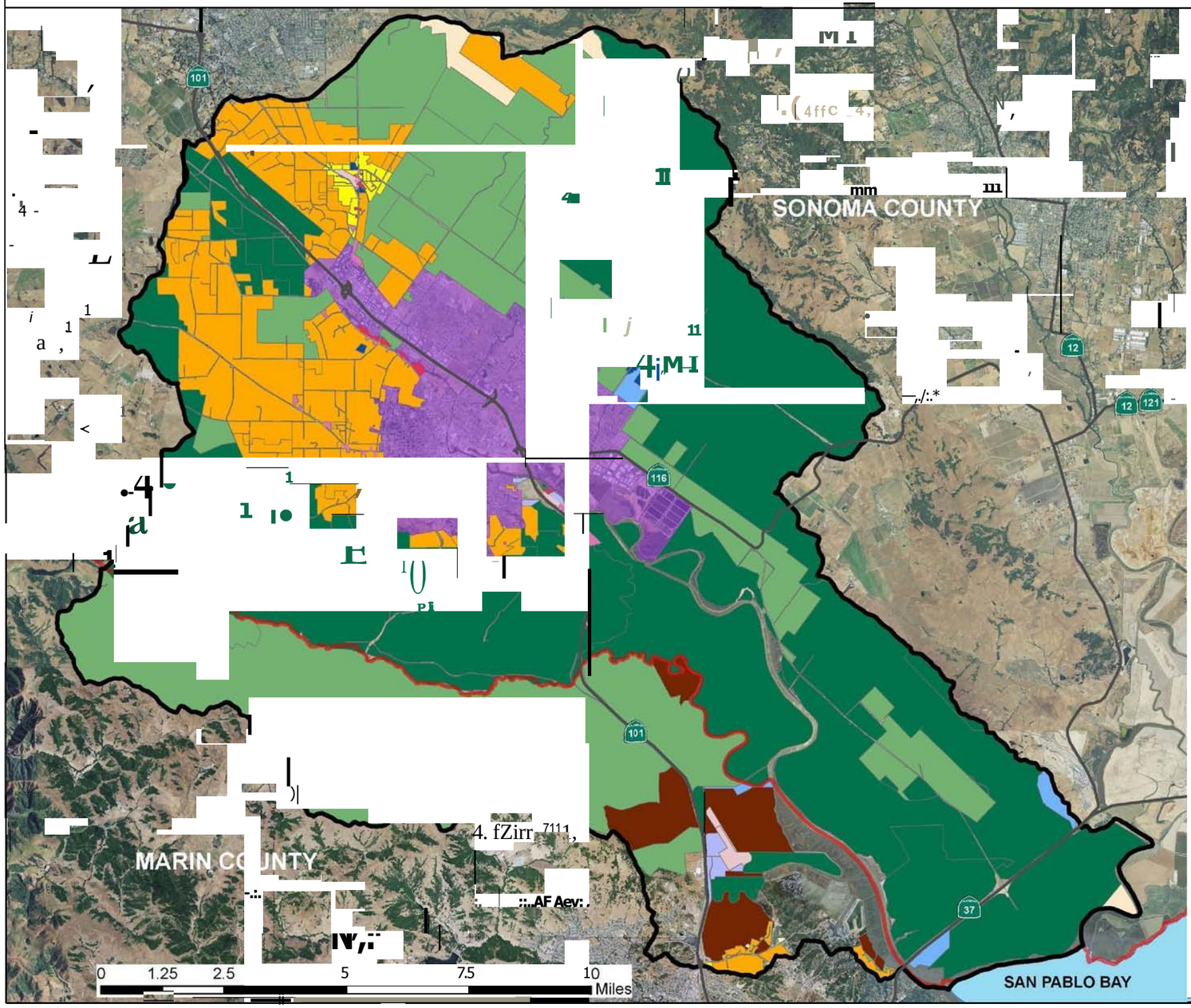
Developing methods to promote connectivity into the City of Petaluma will impact the surrounding watershed biotic and abiotic systems. Increased transportation methods have the potential to generate pollutants at higher rates as the population of the city and surrounding areas grow.

DEMOGRAPHIC CHARACTERISTICS

According to the 2010 Census data, the total population of City of Petaluma is 57,941 and the town of Penngrove is 2,522. These numbers do not account for County residents living within the watershed. The Petaluma County Census Division (CCD), which is a subdivision of the County of Sonoma and covers the City of Petaluma, the town of Penngrove, the City of Cotati, a portion of the City of Rohnert Park, and "remainder" areas that are not officially part of any city or town, reports a total population of 125,304.

From these numbers we can estimate the total population impacting the Petaluma watershed as of 2010 at approximately 70,000 to 74,000. The Sonoma County General Plan 2020 projects total population for the Petaluma planning area by the year 2020 at 76,300.

Map 3.2 Petaluma River Watershed Land Use Classifications in unincorporated Sonoma & Marin Counties.



Petaluma River Watershed Land Use Classifications in unincorporated Sonoma & Marin counties

Sonoma Co. Land Use Classifications

- Diverse Agriculture
- General Commercial
- General Industrial
- Light Commercial
- Land Extensive Agriculture
- Light Industrial
- Public/Quasi Public
- Rural Residential
- Resources Rural Development
- Recreation Visitor Serving Commercial
- Urban Residential

Marin Co. Land Use Classifications

- Agriculture
- Agriculture Public Facility
- Agriculture and Conservation
- Industrial
- Industrial Public Facility
- Medium to High Density Residential
- Open Space
- Planned Residential
- Recreational Commercial
- Recreational Commercial Public Facility
- Rural/Residential

de Petaluma City Limits

Major Roads

Watershed Boundary

4? Sonoma County

N W E

DRAFT

SOUTHERN SONOMA RESOURCE CONSERVATION DISTRIC1

Date: **April 16, 2013**

Draft Petaluma Watershed Enhancement Plan

SECTION 2. MANAGEMENT AND RECOMMENDATIONS

CHAPTER 4: AGRICULTURAL AND RURAL SUSTAINABILITY

Past and present, the Petaluma community is founded on agriculture. Currently, the increasing land prices and stricter environmental regulations threaten the viability of the agricultural community. One of the most important factors contributing to the quality of life in the community is its history of and continued linkage, to agriculture. Supporting sustainable agriculture in the watershed and improving its viability and industry 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

Sonoma County ranks 6th in the state and 34th in the nation in agricultural productivity; the county recognizes that agriculture is an important economic, social, and historic resource and has taken measures to protect it (Sonoma County PRMD 2008a). 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. It also provides policies to assist in marketing and promotion of agricultural products and provide fair conditions for farm laborers.

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 three main goals: preservation of environmental systems and processes economic profitability, and social and economic equity. Stewardship of both natural and human resources is important. Stewardship of natural resources includes preservation and rehabilitation of ecological processes such as groundwater recharge, pollutant sequestration, 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. Many agricultural enterprises throughout the county practice stewardship of natural and human resources; such activities include unpaved roads maintenance and repair, riparian revegetation, and provision of agricultural employee housing.

Conservation easements are a form of sustainability involving natural and human resources – they 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). Conservation easements can be acquired through Williamson Act contracts or through purchase. Williamson Act contracts 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 agricultural land are under Williamson Act contracts with almost 300,000 acres in fee title easements 32 (Sonoma County PRMD 2008a).

Efforts to increase economic sustainability include local farmers' markets and development of specialty and niche products, such as organic crops and processed products. Organic farming increased in Sonoma County from 2007 to 2008; commodities produced included fruits, vegetables, wine-grapes, meats, grain, and eggs (Sonoma County Office of the Agricultural Commissioner 2008). Sustainability practices such as organic growing can provide financial gain.

Not only do sustainable agricultural practices reap long-term local benefit, they also contribute toward implementation of statewide goals and programs. Implementation of sediment-control, water conservation, and other BMPs contributes toward attainment of Total Maximum Daily Load (TMDLs) allocations for sedimentation, temperature, and nutrients. Sustainable agricultural practices also contribute toward achievement of goals in the North Coast Regional Water Quality Control Board Watershed Management Initiative Chapter, the California Water Plan, the California Department of Fish and Game Coho Recovery Plan, the North Coast Integrated Regional Water Management Plan, and the Sonoma County Climate Action Plan.

Agricultural landowners farming along the southern parts of the watershed near the Highway 37 corridors face challenges as tidal marsh restoration, difficulties maintaining levees, and sea level rise threaten to take ever 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.

Farmers in the area, with their equipment, their cattle, and experience are critical to the success of land conservation. Therefore, ranching and grazing should be supported to the degree that people can make a living ranching and grazing. Agricultural operations require a certain economy of scale to be profitable. Oat hay supports local dairies and horses, and it's more local, less carbon-intensive, and fresher than central valley hay.

CONSERVATION PLANNING

A conservation plan is a voluntary effort involving the processes of setting goals, inventorying ranch resources, assessing water quality concerns and evaluating existing management practices. Once the plan is completed, implementing a monitoring program will help achieve set goals and evaluate the effectiveness of the management practices.

The purpose of a conservation plan is to develop a plan that will provide the landowner with a comprehensive integrated understanding of the past, present, and future management decisions and developments of their property. It follows a step by step process to meet the producer's goals and to assess the impact those goals may have on the natural resources in that watershed.

Conservation plans should be working documents that are revised as needed. Ranch plans and supporting data should be kept on-site at the ranch where it is available for easy reference and updating.

The table below describes several sources 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, SWRCB, DWR and the Sonoma County Energy Independence Program.

Table 4.1 Resources for Agricultural Management Measures.

Resource	Description	Focus	URL/Contact
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.	All aspects of agricultural operations – extensive list of irrigation water management measures.	http://efotg.nrcs.usda.gov/treemenuFS.aspx
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.	All aspects of agricultural operations.	www.LandSmart.org
The Vineyard Manual	The "Vineyard Manual" outlines the basic standards and guidelines for good vineyard management as well as technical information regarding development and environmentally sound practices beneficial to all grape growers.	Agriculture--Vineyards	To request a copy please fill out an order form here: http://www.sscrcd.org/pdf/Vineyard%20Manual%20Order%20Form.pdf
Groundwork – A Handbook For Small Scale Erosion	A comprehensive resource detailing erosion control methods for rural and agricultural lands.	Erosion control	http://www.conservation.ca.gov/dlrp/RCD/Documents/ErosionControl/Groundwork4-18.pdf

Control in Coastal California, 2nd Edition			
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.	Roads	http://www.krisweb.com/biblio/gen_mcrcd_weaveretal1994handbook.pdf
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.	All aspects of agricultural operations – nutrient, pesticide, grazing, and irrigation water management, erosion and sediment control, and animal feeding operations.	http://www.epa.gov/owow/nps/agmm/index.html
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.	BMPs that address all aspects of USFS activities in California.	http://www.fs.fed.us/r5/publications/waterresources/waterquality/
California State Water Resources Control Board Nonpoint Source (NPS) Pollution Control Program	Multi-tool website that contains a Management Practices Miner Tool, a Management Measures Encyclopedia, and NPS Guidance in Specific Interest Areas. The Miner Tool is a compendium of documented NPS pollution management	All aspects of agricultural operations including erosion and sediment control, animal waste, nutrient management, pest and weed management, grazing management,	http://www.swrcb.ca.gov/water_issues/programs/nps/tools.shtml http://www.swrcb.ca.gov/water_issues/programs/nps/encyclopedia/6_wtldvts.shtml

	practices collected from scientific texts, journals, web sites, grant projects, and presentations. 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.	irrigation water management, groundwater protection, and education and 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.	Water quality management – NPS reduction, vegetative buffer strips, pesticide choice, greenhouse and Nursery management.	http://cesonoma.ucdavis.edu/WatershedManagement923/Farm&RanchStewardship.htm
Sonoma County Agricultural Division New Best Management Practices for Agricultural Erosion and Sediment Control Handbook Est. January 2010	BMPs presented in this document are specific to Sonoma County agricultural practices, soil types and weather conditions.	Control of water quality impacts from accelerated erosion from agricultural sources.	http://www.sonomacounty.org/agcomm/vesco.htm

RURAL RESIDENTIAL

Rural residential development is associated with watershed impacts including sedimentation, nutrient and pesticide runoff, spread of invasive species, and water supply issues, but management practices specific to the category "rural residential land use" have not been developed for Sonoma County. 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 ameliorate conditions resulting from urbanization is applicable to rural residential land use, including water conservation measures.

An aspect of rural residential development not commonly found in urban areas is the construction, use, and maintenance of unpaved access roads. Roads are widely recognized as a

significant source of sedimentation (see *Chapter 12, Sediment Sources and Impacts*). Management practices to reduce sedimentation from roads are available from many sources. The table below lists several sources for BMPs that have widespread acceptance and relevance to local rural residential issues.

Table 4.2 Resources for Rural Residential Management Measures.

Resource	Description	Focus	URL
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.	Natural resources conservation. Road and trail closure, habitat restoration.	http://efotg.nrcs.usda.gov/treemenuFS.aspx
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.	This document provides implementation actions at the municipal scale.	http://www.epa.gov/owow/nps/urbanmm/index.html#06
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.	Reducing NPS pollution through individual, municipal, and planning implementation activities.	http://www.epa.gov/owow/nps/urbanfacts.html#runoff
California State Water Resources Control Board Nonpoint Source (NPS) Pollution Control Program	Multi-tool website that contains a Management Practices Miner Tool, a Management Measures Encyclopedia, and NPS Guidance in Specific Interest Areas. The Miner Tool is a compendium of documented NPS pollution management practices collected from scientific texts, journals, web sites, grant projects, and presentations. 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.	*Urban areas* – most information is agency level, however individual homeowners will find useful information for landscaping and water management. *Forestry* –homeowners may find useful information regarding road construction, reconstruction, and management. *Education and Outreach* – describes specific practices on the individual household scale.	http://www.swrcb.ca.gov/water_issues/programs/nps/tools.shtml http://www.swrcb.ca.gov/water_issues/programs/nps/encyclopedia/2forest.shtml http://www.swrcb.ca.gov/water_issues/programs/nps/encyclopedia/33edu.shtml
FishNet 4C Roads Manual	This document provides guidelines for county road maintenance to protect aquatic habitat and fisheries.	County road maintenance, some information applicable to homeowners.	http://www.fishnet4c.org/projects_roadsmanual.html
Energy Independence A Sonoma County Program	This website provides suggestions for residential and commercial improvements to conserve water and energy.	Financial incentives for individual homeowners to implement water and energy saving measures.	http://www.sonomacountyenergy.org/

Marin County Stormwater Pollution Prevention Program Resources About Pesticides and Alternatives Web Page	This web page contains several publications that provide homeowner – level information about less-toxic pesticides, gardening, and water quality.	Reducing toxins in the environment, providing least-toxic pest management to homeowners and schools.	http://www.mcstoppp.org/pesticides.htm
House and Garden Audit: Protecting Your Family's Health and Improving the Environment, A Guidebook to Reducing Your Impacts on the Environment	"The House and Garden Audit is for all people interested in learning how to protect their health while improving the environment."	Reducing toxins in the environment through individual homeowner effort.	
Less-Toxic Pest Management: Pesticides and Water Pollution.	This is an informative brochure about homeowner contributions to water quality impairments.	Provides tips for homeowner reduction of pesticide use.	http://ourwaterourworld.org/Portals/0/documents/pdf/PesticidesWQ.pdf

RECOMMENDED ACTIONS

Recommendation ARS1 – Provide educational, technical, and financial services to help growers and ranchers understand and comply with applicable agricultural regulations.

Recommendation ARS2 – Develop LandSmart ranch and farm water quality plans to document current and plan for future beneficial management practices.

Recommendation ARS3 – Prevent and control soil erosion, and enhance soil quality.

Recommendation ARS4 – Improve water use efficiency of irrigation and frost protection systems. Explore alternative water sources for these uses.

Recommendation ARS5 – Manage grazing to protect and enhance soil quality, plant communities and water quality.

Recommendation ARS6-Conduct outreach about minimizing the impact of animal waste include managing run-off from confined livestock areas near waterways, manure and fertilizer application, and silage storage.

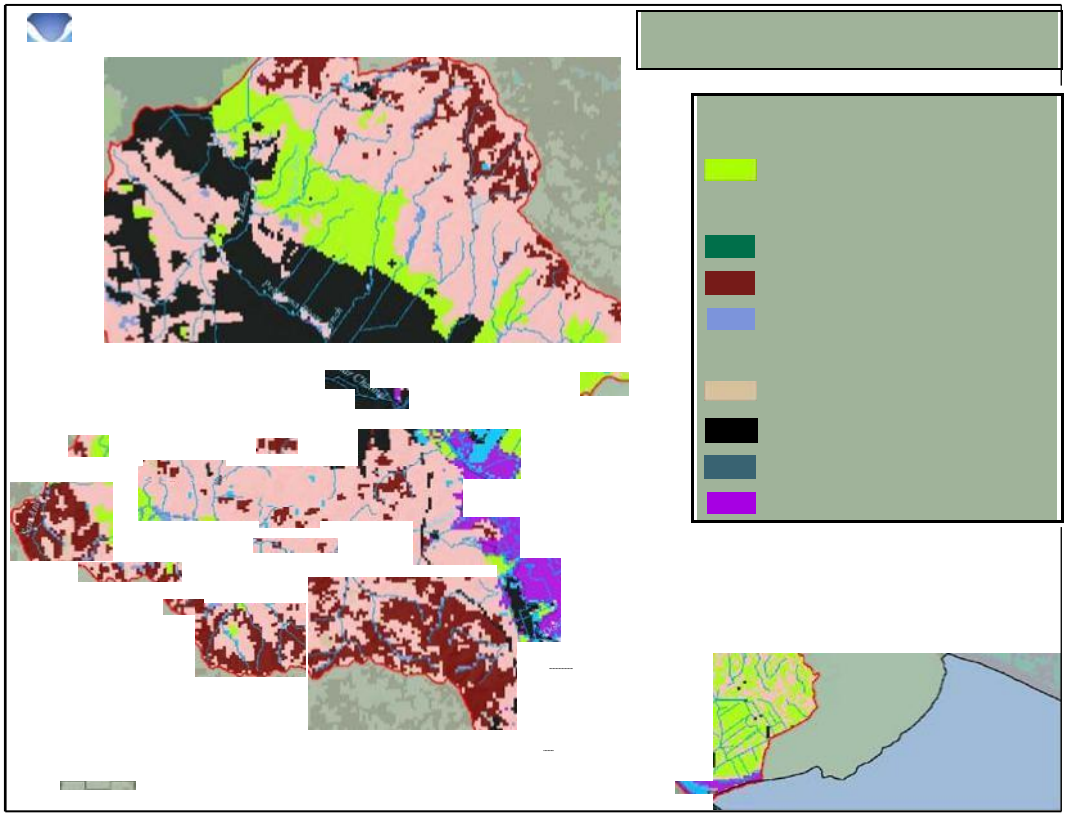
Recommendation ARS7-Assist landowners with developing projects to ensure water reliability.

CHAPTER 5: RIPARIAN PLANT COMMUNITY ENHANCEMENT

One purpose of the Petaluma River Watershed Enhancement Plan is to characterize the riparian plant community and identify opportunities for enhancement. This chapter is intended to be an overview of riparian conditions and to identify enhancement recommendations that can be implemented. 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.

The landscape within the Petaluma Watershed encompasses an area of great plant diversity and maintains a series of valuable biological characteristics. The complex network of tributaries feeding the Petaluma River and the slough itself play a significant role in maintaining the ecological systems of the region. Terrestrial vegetation types and riparian communities constitute an area of tremendous biodiversity, which provides habitat for a number of species. These vegetation types include varieties found in urban and agricultural areas, grasslands and oak savannahs, wetlands, vernal pools, riparian corridors, and both salt and brackish water marshlands. Promoting conservation of terrestrial communities within the watershed offers direct benefits for improving ecological health and water quality.

Map 5.1 Petaluma River Watershed Vegetation (NOAA, 2008)



PLANT COMMUNITY CONCERNS

In the early 1800s significant alterations to the landscape had begun as European agricultural practices took hold and California missions were established. Demands 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 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 in the watershed.

Approximately 26 miles of dense Valley Foothill Riparian (VRI) habitat remain intact within the watershed creating a landscape historically dominated by dense two-storied corridors. The strong overstory of mature live oak, black oak and California bay, in conjunction with a healthy understory of buckeye and big leaf maple, allow for an area of vital habitat for wildlife. Root systems stabilize streambanks with the support of small shrubs and groundcover.

The majority of creeks in the middle and lower reaches of the watershed have been altered or converted to moderate canopy cover and annual grasslands. These systems now portray a fragmented system with narrow widths and disrupted plant communities; only pockets of remnant vegetation remain. The removal of woody plant cover and shrubs leave streambanks unprotected and subject to increased erosional processes.

Exotic species are any organism including animals, plants, and microorganisms that historically are not native to a specific region. 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 other species occasionally leading to extinction. These species weaken the natural habitat functions becoming one of the leading causes of biodiversity loss in aquatic and terrestrial ecosystems. Through time these invasive species will outcompete and establish a dominant presence in the environment if not properly controlled or monitored.

Managing lands to improve carbon sequestration and soil nutrients to support diversity and encourage native plant populations is vital. With a degraded system the rate of non-native or invasive species increases greatly, thus by protecting microorganism habitat beneath the soil, with minimal disturbance regimes from tillage or compaction, implementation of beneficial grazing to encourage re-growth of plant structures, and allowing for effective biological decay of surface litter; will result in plant diversity and ecosystem health. Supporting deep rooted perennial grasses and forbs alongside strict grazing management will aid in the control of invasive species through time. Some exotic species were intentionally introduced to the state, while many other species become established accidentally.

Survey methods include an overview of riparian conditions was developed through a review of existing literature, inspection of photographs and maps, and field reconnaissance. Literature reviewed included the Restoration Design and Management Guidelines for the Petaluma River Watershed (Questa Engineering Corporation, et al., July, 1996) and historical and recent aerial photographs. Soil maps in the Soil Survey of Sonoma County, California (1972) and Soil Survey of Marin County, California (1985) were consulted to assist in analyzing potential or existing erosion hazards and to assess historical plant community conditions. To help identify changes in plant community boundaries and composition, aerial photographs from 1942 were compared to 1990 aerial ortho-photos from the Sonoma County Planning Department. Such comparisons are useful for evaluating the extent of floristic changes in natural habitat through time and to assist in predicting long-term trends and consequences from land use.

For the purpose of this report, vegetation was characterized as either Valley Foothill Riparian (VRI) or Annual Grassland (AGS) depending on the presence or absence of trees and shrubs.

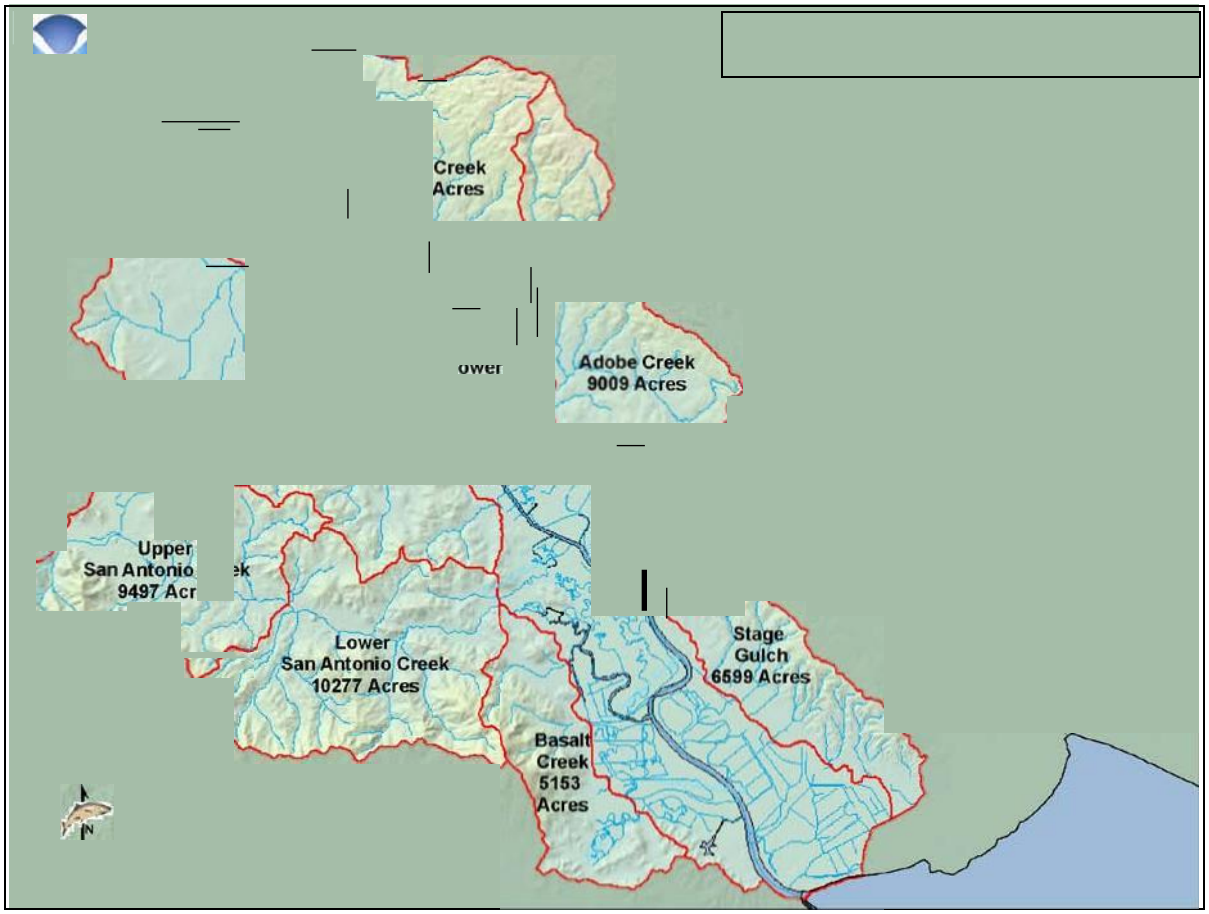
Table 5.1 Summary of Wildlife Habitat Relationship (WHR) Habitat Classifications

WHR Classification	**Size (for trees)** **Height (for grasses)**	**Canopy Cover Density (trees)** **Cover Density (grasses)**
Valley Foothill Riparian (VRI) Found in valleys bordered by low foothills and coastal plains. (See Appendix C for more information).	**4**: small trees (hardwood crown diameter of 30' - 45') **5 or 6**: Large or medium trees or a two-storied forest (hardwood crown diameter greater than 45')	**D**: Dense (60-100% of canopy is closed) **M**: Moderate (40-59% of canop closed) **P**: Open (25-39% of canopy is closed) **S**: Sparse (10-24% of canopy is closed)
Annual Grassland (AGS)	**1**: short herb (less than 12" when mature) **2**: tall herb (more than 12" when mature)	**D**: Dense (60-100% of ground covered **M**: Moderate (40-59% of groun covered) **P**: Open (10-39% of ground is covered) **S**: Sparse (2-9% of ground is covered)

Examples:
VRI 4M means that the site is classified as Valley Foothill Riparian with small trees and a moderate canopy cover. **AGS 1D** means that the site is classified as Annual Grassland and is densely covered with short grasses.

SPECIFIC RECOMMENDED ACTIONS BY SUBWATERSHED

Map 5.2 Petaluma River Watershed CalWater Planning Watersheds (NOAA, 2008).



Lichau Creek Subwatershed

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 Subwatershed

Willow Brook Creek subwatershed is located 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).

Lynch Creek Subwatershed

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 Subwatershed

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 Ielmorini 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.

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 Subwatershed

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 entirely 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.

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. 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.

Ellis Creek Subwatershed

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 of 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.

With the exception of 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 Creeks Subwatershed

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 Subwatershed

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 starthistle and broom.

Both Marin RCD and Southern Sonoma RCD (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.

Lakeville Subwatershed

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.

RECOMMENDED ACTIONS

Recommendation RE1- Revegetate high and medium priority riparian sites with cooperative landowners.

Recommendation RE2- Help landowners apply for cost share programs to implement stream enhancement plans

Recommendation RE3-Manage livestock access to the creeks, especially during the wet season and assist landowners to develop grazing plans

Recommendation RE4- Conduct community outreach and provide technical assistance to landowners to help manage and protect riparian areas.

Recommendation RE5 – Develop LandSmart ranch and farm water quality plans to document current and plan for future beneficial management practices.

CHAPTER 6: MARSHLANDS

The lower 12 miles (19 km) of the Petaluma River flows through the Petaluma Marsh and is the largest remaining salt marsh in San Pablo Bay. The marsh covers 5,000 acres (20 km^2) and is surrounded by approximately 7,000 acres (28 km^2) of reclaimed wetlands. The Petaluma wetlands that is connected to the river is one of the last remaining protected wetlands in the state of California and on the west coast. This chapter includes a description of the marsh habitat and historical impacts, management suggestions and a focus on special status species including recovery plan methods.

OVERVIEW

The US government has designated 13,000 acres in the Marsh as the San Pablo Bay National Wildlife Refuge. The San Pablo Bay Wildlife refuge, which lies along the north shore of San Pablo Bay in Sonoma, Solano, and Napa Counties, was created in 1974 to protect migratory birds, wetland habitat, and endangered species. The refuge includes open bay/tidal marsh, mud flats, and seasonal and managed wetland habitat and supports the largest wintering population of canvasbacks on the west coast, and protects the endangered salt marsh harvest mouse and the California clapper rail. Agricultural lands occupy almost half of the Marsh and are largely reclaimed lands that support oats, hay and grains, and cattle and sheep. Salt production is the largest industrial use of the marsh, covering approximately 20% of the area.

MARSHLAND DESCIPTION AND HISTORY

The Petaluma River Wildlife Area (PRWA) 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, which comprises the most northern extent of the proposed National Estuarine Research Reserve (NERR). Petaluma Marsh is 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.

The status of marshlands in the San Francisco Bay Delta Area has changed considerably. Conversion to agricultural and industrial/urban use, and water diversion and management (Marshall & Dedrick 1994) has changed the landscape dramatically. Nearly all of the lands within this area once were tidal salt marsh or tidal brackish marsh.

During the mid 1800s the tidelands bordering San Pablo Bay were "reclaimed" for farm land. Conversion of tidelands to farm land occurred under the Swamp Land Act of 1849 (modified in

1850 and 1860). Private individuals were offered land at no cost, provided that 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 storm water making it possible to farm productively. This Federal wetlands policy was reversed in 1988 when the "no net loss" of wetlands policy was adopted. 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, rain water flushed out the salts from the land and crops were planted. Currently, these lands are either private or publically owned and support local agricultural operations, infrastructure (i.e. roads) and important habitat and the levees require ongoing maintenance to prevent these lands from flooding. These agricultural baylands, especially portions that have seasonal ponds, provide habitat for several species of wildlife. Farmers that continue to produce crops in the bay lands may be able to improve wildlife habitat using a variety of management practices

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 a variety of local, state, and federal agencies including: Sonoma Land Trust, Sonoma County Agricultural Preservation and Open Space District, the US Fish and Wildlife Service, California Coastal Conservancy, the California Department of Fish and Game, the Point Reyes Bird Observatory. Also, there are large areas that are well suited to be managed as diked wetlands for shorebirds and waterfowl. The wetlands, waterways and grasslands surrounding the 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, California clapper rail, and salt marsh harvest mouse.

Restoring tidal marsh in this watershed would greatly enlarge 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 California clapper rail and the salt marsh harvest mouse. Restoring marsh at the periphery of the bay lands, where natural transitions to adjacent uplands 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 would provide important roosting and foraging habitat for shorebirds and waterfowl.

SPECIAL STATUS SPECIES

The tidal marshlands of the Petaluma River Wildlife Area support two species (California Clapper Rail and the Salt Marsh Harvest Mouse) that are listed as endangered by both the federal and the California State species protection laws. The Petaluma Marsh is part of the northern limits of the California Clapper Rail. Its distribution within the Petaluma Marsh extends upstream with increasing aqueous salinity during drought years. The site 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.

The California black rail *(Laterallus jamaicensis coturniculus*) is a scarce, rarely seen, year-round resident of saline, brackish, and freshwater emergent wetlands. California black rails are most commonly found in tidal emergent wetlands dominated by pickleweed *(Salicornia virginica*) 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. Rails eat insects, crustaceans, and other arthropods, as well as aquatic plant seeds.

Information on the historical 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. Today California black rails are found in San Francisco Bay, in Bodega Bay in Sonoma County, in Tomales Bay and Bolinas Lagoon in Marin County, and in Morro Bay in San Luis Obispo County. The black rail no longer breeds in coastal southern California. Population numbers have continued to decline since the 1970s. More than 80% of the remaining California black rails are 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 clapper rail is the loss and degradation of the 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 rail is loss of high marsh habitat that provides refuge areas from high tides. Lack of refuge areas has left rails 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).

California clapper rail

The California clapper rail *(Rallus longirostris obsoletus)* lives in coastal salt and brackish marshes and tidal sloughs. A year-round resident, the California clapper rail lives mostly in the upper to lower zones of coastal salt marshes dominated by pickleweed and cordgrass *(Spartina foliosa*); some birds live in coastal brackish marshes. The California clapper rail forages in the 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.

Historically, California clapper rails 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 in San Francisco Bay and Suisun Bay. South San Francisco Bay marshes continue to support the largest number of these rails in the state. In the Petaluma River watershed, clapper rails are resident and breed along the river as far north as Schultz Creek.

In the early 1980s, more than a decade after the California clapper 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 clapper rails were estimated to be in the Petaluma Marsh, 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, have depleted the California clapper rail population. Habitat loss also resulted from the dying out of marsh vegetation. 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 the bird's food supply. Predators to both clapper rails 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 clapper rail populations, and predator management is not being regularly practiced in the North Bay. The introduced horse mussel may also inadvertently kill clapper rails by trapping the bills or feet of birds that have stepped on or probed into the shell. The California clapper rail was listed as endangered by the state of California and under the federal ESA in 1970.

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. The mice's 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 as a result 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 baylands 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 effluents, pollution, flood control, and marsh erosion on existing populations and habitat.

RECOVERY PLANS

In 2010 the USFWS developed a Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California. The following is a list of ecosystem-level recovery methods from USFWS focused on tidal marsh conservation effort and monitoring of listed species.

Ecosystem-Level Recovery Strategies

"The following five ecosystem-level strategies are described further below:

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

  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 covered in this draft recovery plan.

  Conduct range-wide species status surveys/monitoring and status reviews for species covered in this draft recovery plan.

  Conduct research necessary to the recovery of listed species and long-term conservation of species of concern and other *tidal marsh* species covered in this draft recovery plan.

Improve coordination, participation, and outreach activities to achieve recovery of listed species and long-term conservation of species of concern." (USFWS, 2010).

The USFWS also created a Draft Recovery Unit for the San Pablo Bay evaluating the watersheds and marshlands surrounding and draining into the bay. The San Pablo Bay Recovery Unit for the California Clapper rail and the Salt marsh harvest mouse evaluates the potential for a species listed under the ESA to be downlisted or delisted. Considerations to population numbers, habitat parameters and timelines are accounted for in the recovery of the Clapper rail and Salt marsh harvest mouse for this region. Actions to recover a species successfully would by definition mean that the species no longer falls in the parameters stated under the ESA as either threatened or endangered. This also demands that there is enough viable habitat available (VHA)—well-developed and complex tidal marsh habitat—to support the species existence. The following table illustrates the information taken from the Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California:

Table 6.1 Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California—San Pablo Bay Recovery Unit

Marsh Complexes	CA Clapper rail- Downlist	CA Clapper rail- Delist	Salt marsh harvest mouse- Downlist	Salt marsh harvest mouse- Delist
China Camp to Petaluma River	Min. acreage: 2,500ac Recovery Unit target (10-yr mean)= 936 birds	Min. acreage: 2,500ac Min. Density in any yr: 0.09 birds/acre Recovery Unit target (10-yr mean= 1,248 birds	Min. acreage: 1,000 ac 2 VHAs 40% of VHAs with CE of 5.0 or greater AND 50% of VHAs with CE of 3.0 or greater Each VHA monitored twice with 2-5 yrs between efforts	Min. acreage: 1,000 ac 2 VHAs 75% of VHAs with CE of 5.0 or greater Each VHA monitored twice with 2-5 yrs between efforts
Petaluma River Marshes	Min. acreage: 2,500 ac Recovery Unit target (10 yr mean) 936 birds	Min. acreage: 2,500ac Min. Density in any yr: 0.09 birds/acre Recovery Unit target (10-yr mean= 1,248 birds	Min. acreage: 1,000 ac 3 VHAs 40% of VHAs with CE of 5.0 or greater AND 50% of VHAs with CE of 3.0 or greater Each VHA monitored twice with 2-5 yrs between efforts	Min. acreage: 1,000 ac 3 VHAs 75% of VHAs with CE of 5.0 or greater Each VHA monitored twice with 2-5 yrs between efforts

Petaluma River to Sonoma Creek	Min. acreage: 2,500ac Recovery Unit target (10-yr mean)= 936 birds	Min. acreage: 2,500ac Min. Density in any yr: 0.09 birds/acre Recovery Unit target (10-yr mean= 1,248 birds	Min. acreage: 1,000 ac 1 VHAs 40% of VHAs with CE of 5.0 or greater AND 50% of VHAs with CE of 3.0 or greater Each VHA monitored twice with 2-5 yrs between efforts	Min. acreage: 1,000 ac 1 VHAs 75% of VHAs with CE of 5.0 or greater Each VHA monitored twice with 2-5 yrs between efforts
Napa Marshes	Min. acreage: 2,500ac Recovery Unit target (10-yr mean)= 936 birds	Min. acreage: 2,500ac Min. Density in any yr: 0.09 birds/acre Recovery Unit target (10-yr mean= 1,248 birds	Min. acreage: 1,000 ac 12 VHAs 40% of VHAs with CE of 5.0 or greater AND 50% of VHAs with CE of 3.0 or greater Each VHA monitored twice with 2-5 yrs between efforts	Min. acreage: 1,000 ac 12 VHAs 75% of VHAs with CE of 5.0 or greater Each VHA monitored twice with 2-5 yrs between efforts

RECOMMENDED ACTIONS

Recommendation MH1- Restore large patches of tidal marsh along the entire shoreline of San Pablo Bay particularly near the mouths of sloughs and major streams.

Recommendation MH2- With willing landowners, establish managed marsh or enhanced seasonal pond habitat (especially for shorebirds) on agricultural baylands that are not restored to tidal marsh.

Recommendation MH3 Enhance riparian habitat along Petaluma River. Where possible, enhance marsh/upland transitions and provide buffers.

Recommendation MH4- Prepare and distribute information to the public about the habitat needs of these species and how watershed residents can help with recovery efforts.

Recommendation MH5- In agricultural areas**,** allow ponding in field depressions for shorebirds and waterfowl.

Recommendation MH6- In agricultural areas create small diked ponded areas adjacent to levees where possible

Recommendation MH7- In agricultural areas, encourage growth of vegetation along fence rows or field edges to provide habitat for small birds and mammals.

Recommendation MH8 –In agricultural areas, delay spring harvest of oat-hay as late as possible to avoid nesting waterfowl.

Recommendation MH 9- In agricultural areas, fence cattle from wetland areas during wet periods.

Recommendation MH 10- In agricultural areas, increase the practice of rotational grazing to encourage a more diverse grassland habitat.

CHAPTER 7: 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 thought to be caused by increased levels of carbon dioxide and other greenhouse gases in the Earth's atmosphere (EPA, 2012). This chapter includes a description of the effects of climate change on a larger scale, more locally in Sonoma County, and adaptation recommendations.

CLIMATE CHANGE IMPACTS IN CALIFORNIA

The consequences of climate change are projected to be substantial in California and to have far-reaching impacts to many ecosystems, agriculture, and infrastructure. California is already experiencing the effects of climate change, including warming temperatures, rising sea levels, longer fire seasons and shifts in precipitation. Wetlands – coastal, riparian, seasonal, or tidal – all stand to suffer some of the greatest and most immediate and observable impacts. The projected changes of greatest 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 with it 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, water quantity and quality impairments, invasive species, pest vectors and related diseases.

Changing temperatures are already starting to impact our communities in terms of personal health and energy, water and land use. This is because climate dictates:

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

Rates and patterns of commercial and residential energy use

How and where farmers can grow crops

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. The Regional Climate Protection Authority (RCPA), the Climate Protection Campaign (CPC), North Bay Climate Adaptation Initiative, California Climate and Agriculture Network, and their many partners, are looking to educate and provide resources to communities in Sonoma County and beyond about the many impacts that climate change may have on our economy and our environment, and strategies to adapt to these impacts. The County has adopted a Community Climate Protection Action Plan (CCAP) and many cities throughout the county have adopted green building programs and Land Use and Community Design Programs to address Climate Change.

Impacts to Biodiversity and Habitat

While climate change models have generated a wide range of projections, there is consensus that some ecosystems, particularly tidal wetlands, will be impacted more than others. Several factors make tidal wetlands sensitive to climate change. First, the rise in average global temperatures will influence the timing and degree of snow fall and ice melt, shifting temporal runoff patterns in watersheds supplied predominantly by mountain snowpack. Second, rates of sea-level rise are almost certain to increase over the next several decades. Sea-level rise will push sea water farther up into estuaries, increasing salinities in tidal ecosystems. Increases in sea level alone will account for losses of up to 22% of the world's remaining tidal wetlands. Moreover, the combination of sea level rise with reclamation and development infrastructure in coastal regions may result in the loss of up to 70% of coastal wetlands (Nicholls et al., 1999; Najjar et al., 2000; but see Hughes et al. 2000). Tidal marshes are likely to be particularly vulnerable to climate change impacts through these shifts in salinity and inundation patterns (Callaway, et al, 2007). Wetlands are also important in combating climate change and its impacts. Wetlands serve as carbon sinks, storing 20-30% of the world's soil-stored carbon (Cudmore, 2011). They also can help buffer the increased winter flooding and summer drought conditions that are predicted results of climate change by acting as sponges that trap storm water and release it slowly over time.

The predominant effects of climate change on terrestrial species will likely result from changes in vegetation communities. These changes are likely to include increases in the amount of oak, pine, chaparral, and montane hardwood vegetation, and a loss of conifer dominated vegetation. Snow-fed rivers and streams are likely to have less water, which may diminish the quantity and quality of wildlife habitat.

Floods and Sea Level Rise

One of the projected impacts of climate change is the increased likelihood of extreme floods capable of destroying streamside land, buildings, roads, and crops. Floods can be especially severe near the coast and the bay shoreline, where higher tides caused by sea level rise can push flood levels even higher. In California, Sonoma County is already the top recipient of repetitive flood damage payments and, in fact, has losses greater than those of the next nine communities combined, making it the county with the highest number of properties suffering repetitive flood losses west of the Rockies. In 2005, the most recent year for which data is available, 30% of Sonoma County's urban areas were in a high hazard area for flooding.

Sea level has risen approximately 7 inches over the last 100 years. Recent data from the Intergovernmental Panel on Climate Change 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. 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 the flood protection infrastructure (levees, ditches and pumps) is maintained.

Heat and Fire

Climate Change is predicted to create more frequent and prolonged droughts; leading to water shortages for people and nature. Droughts dry up streams, stunt or kill crops, harm wildlife, and cause people to pump more groundwater near streams. As the land gets drier, streamside forests and wetlands come under more pressure to provide water, recreation, and wildlife habitat. As the land dries out, the risk of fire increases. When a rain event occurs after an area has been burned there is the threat of increased erosion hazards washing soils off hillsides into roads, ditches, and streams creating increased water quality concerns.

Agricultural 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 weed, disease and pest shifts, and decreased crop yields, loss of chill hours for crops, and changing intensity and number of storms. Continued warming will create conditions unfavorable for production of many wine grape varieties in the future and may require farmers to change the cultivars they plant or move production further north and/or "upslope" to higher elevations.

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 and as such, hay producers grow specific crops and utilize methods for highest quality grain to meet local demands for livestock and equestrian feed and for high value milk, cheese, and meat products. This locally produced seed and grain feedstock contributes to the local agricultural economies supply loop by supporting local dairies and feed for grazing livestock. Local cultivation helps minimize the carbon and ecological footprint that would otherwise 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 challenges of maintaining levees for agricultural use and sea level rise in the vicinity will take agricultural acreage out of production.

There are a number of ways that agriculture benefits climate change and a variety of ways that farming practices could contribute to reducing future impacts. Farmland provides numerous additional benefits, including carbon sequestration, open space preservation, water absorption and filtration, and local food source. Agriculture and forestry offer the only currently available terrestrial 'sinks' of carbon dioxide. Among the soil management practices that have the greatest potential to sequester carbon are cover crops, perennial cropping, reduced synthetic fertilizer inputs, and conservation tillage. Composting and adding organic amendments have also resulted in increased carbon storage in soils. Increasing agricultural waste composting through anaerobic digesters and implementing methane digesters on dairies as an energy source for operation is a sustainable farming practice. Incorporating trees, shrubs or hedgerows into rangeland or farm

landscapes can also sequester carbon in significant quantities. Restoring forested lands can dramatically increase carbon stocks. 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 the potential to increase 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 utilizing synthetic fertilizers.

SONOMA COUNTY CLIMATE INITIATIVES

Actions to address the current and future impacts of climate change within Sonoma County have made great progress in the last decade. The Sonoma County Board of Supervisors since 2001 has become increasingly committed to creating solutions to reduce greenhouse gases and effectively steward the environment. As a leader in climate protection, the county has invested in renewable efforts and proposed planning to curb the effects of climate change. These efforts include projects, programs and action plans to guide the goals and timelines set forth by the Board of Directors.

The Regional Climate Protection Partnership is an alliance between the County, SCWA, and the nine cities within the County to coordinate, implement and manage a series of best practices methods; which are to be administered by the Sonoma County Transportation Authority (SCTA) and Regional Climate Protection Authority (RCPA). The RCPA was established through legislation in 2009 to guide and coordinate climate change efforts between the County's nine cities and numerous stakeholder agencies with the ultimate goal of reducing greenhouse gas emissions (GHG) throughout the region. Sonoma County partnered with the Climate Protection Campaign (CPC) in order to set an overarching greenhouse gas reduction target. This target projected the County to reduce emissions by the year 2015 to levels 25 percent below those calculated in 1990; a target which would be seen as one of the most demanding in the country (SCTA/RCPA,). The CPC aided the County in designing and publishing the Community Climate Action Plan (CCAP); final document found here: http://www.coolplan.org/ccap-report/CCAP_Final11-05-08.pdf. In 2008 the document was complete offering an array of solutions to meet the challenges of climate change and provide solutions to sustain our climate and environment. The County is continues developing partnerships to increase conservation and adaptation initiatives.

Below is a list from the CCAP illustrating design:

Organized by Sector (Solutions are presented in four different sectors):

- Electricity and Natural Gas (including water, wastewater, efficiency, and new construction)
  Transportation and Land Use
  Agriculture and Forests
  Solid Waste

Assessed solutions rationally (solutions were analyzed using four criteria):

- Significant, rapid GHG emission reductions
- Cost effective
- Under local control
- Politically feasible

RECOMMENDED ACTIONS

Recommendation CA1-In riparian areas encourage native vegetation at multiple heights: groundcover, shrubs, and trees.

Recommendation CA2- In riparian areas encourage a patchwork of habitats, such as a small grassy area near a dense shrubby area near a group of tall trees.

Recommendation CA3-In riparian areas leave old and dead trees in place if they do not threaten structures.

Recommendation CA4-Allow natural processes, such as flooding and laying down new layers of sediment.

Recommendation CA5 -In forestlands look out for pest insects and disease, invasive species, and dying trees. If you have questions, contact University of California Cooperative Extension Master Gardeners or a private arborist.

Recommendation CA6- Assist landowners to eradicate non-native pest insects, diseases, and invasive weeds.

Recommendation CA7-For wetlands complete large wetland restoration projects to serve as buffers to tidal flooding as well as sea level rise

Recommendation CA8 -For wetlands reduce development in low-lying areas, behind levees, or adjacent to the bay/coast and prevent or reduce other stressors that reduce the ability of the wetland ecosystem to respond.

Recommendation CA9- For wetlands identify and support projects that facilitate connectivity to marshes and wetlands prior to and as they are impacted by sea level rise

Recommendation CA10- For agriculture, provide technical and financial incentives for agriculturalists to transition management practices that are affected by climate change.

Recommendation CA11-For agriculture consider transitioning to organic practice on agricultural operations.

Recommendation CA 12- For agriculture consider incorporating trees, shrubs, and hedgerows into rangeland or farm landscapes to sequester carbon

Recommendation CA13- For agriculture consider soil management practices that sequester carbon

CHAPTER 8: FISH AND WILDLIFE RESOURCES

The Petaluma Watershed supports a strong diversity of fish and wildlife species. Due to the dynamic habitat of the estuary, wetlands and salt and fresh waters there are many diverse aquatic habitats. Fish and other wildlife are key ecosystem components. Restoration of a naturally functioning ecosystem with all its component elements is consistent with the Plan's goals of maintaining and improving water quality, riparian function, and habitat value. 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.

SPECIES AND WATERSHED HABITAT

The estuary serves as a migratory route and nursery area for Chinook salmon (*Oncorhynchus tshawytscha*), striped bass, and green sturgeon, American shad, and steelhead trout (*Oncorhynchus mykiss)*. 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, longfin smelt, Sacramento splittail, catfish, largemouth bass, black bass, crappie, and bluegill. Several other listed species are found within the Petaluma River watershed. Among the threatened species that have been documented in the watershed is the *Rana draytonii*, California red- legged frog.

A reduction in the quantity and quality of the watershed's habitat, limits its ability to support aquatic species and other wildlife. For example, the American badger—a species of concern —once inhabited all of northern California but have been gradually forced westward as development has spread. Badgers have been pushed from their historic grassland range by growth. As a part of the ecological balance, they predominantly prey on small rodents, eating squirrels (*Spermophilus*), rats, gophers (*Geomyidae*), moles (*Talpidae*) and voles (*Microtus*), and even rattlesnakes. They also prey on ground-nesting birds, such as the federally endangered bank swallow (*Riparia riparia*) and threatened burrowing owl (*Athene cunicularia*). In turn, they are preyed upon by golden eagles (*Aquila chrysaetos*), coyotes, and bobcats (*Lynx rufus*).

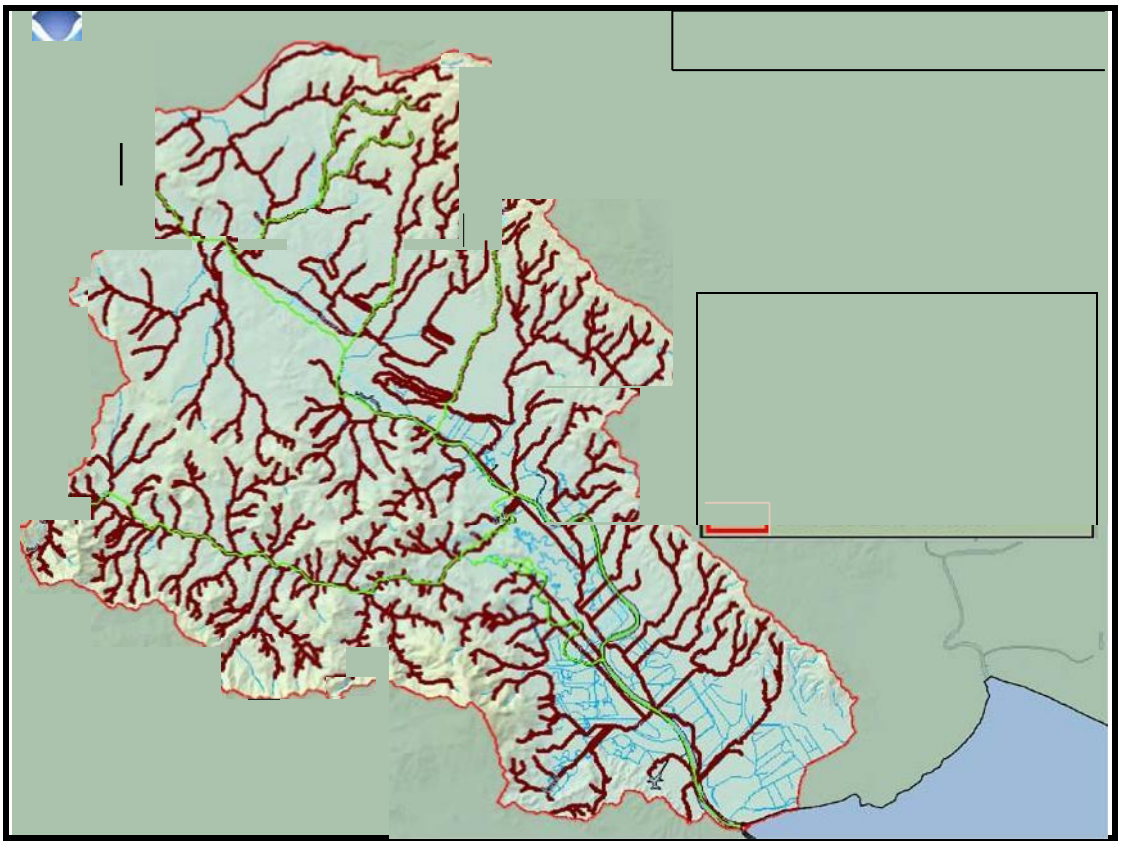
Of particular interest in the watershed, is the status of salmonid fish such as steelhead, which are found in the Petaluma watershed which utilize these systems. Steelhead in the Petaluma Watershed are part of the Central California Coast Distinct Population Segments (DPS) and are State and federally listed as threatened under the Federal Endangered Species Act.

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 supported Chinook, Chinook have been documented and are currently returning to the watershed. Genetic testing have not been done on Chinook, but genetic origins may conclude 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 point to the Feather River Hatchery in the Central Valley and this might be the case for Chinook that are located in the Petaluma system.

To date, it is unknown if these fish are successfully spawning or not and if there is a self sustaining population in the watershed. There needs to be more comprehensive monitoring to determine the status of these fish and the potential for habitat enhancement (Amanda Morrison, Personal Communication, May 29, 2013).

There is limited information available about the current and historic numbers of steelhead in the Petaluma River watershed and the status of Chinook. The California Department of Fish and Wildlife (CDFW) do not have records on historic or current populations of steelhead. Bill Cox, a biologist with CDFW, believes that historically steelhead were found in Lichau, Adobe, and San Antonio Creeks, and possibly in Lynch, Willow Brook, and Thompson Creeks. Other tributaries in the Petaluma River watershed were, and still are, too small and dry for steelhead.

Map 8.1 Petaluma River Watershed Steelhead Current vs. Historical (NOAA, 2008).



CONSERVATION EFFORTS: UNITED ANGLERS OF CASA GRANDE

The United Anglers of Casa Grande High School (UACGHS) was developed as an educational and valuable monitoring program in 1983. In 1993, the Casa Grande High School/United Anglers Fish Hatchery was established to rear and raise steelhead and Chinook. Through this program, students and program leads have been mainly conducting focused surveys in Lynch and Adobe

creeks. Monitoring has also been carried out on other stream reaches more sporadically based on landowner requests.

The students have observed steelhead in Adobe Creek, redds (the salmonid fish egg nests) in Willow Brook Creek just above the Highway 101 crossing, and fish at several other locations including Payran Street bridge to Lynch Creek confluence, Washington Street Creek, and the confluence of Lynch Creek. Of these creeks, Adobe Creek had the highest number of steelhead observations. Watershed residents have observed fish in Lichau, Adobe, and San Antonio Creeks. The first Chinook was observed in 1987 in Adobe Creek and are observed returning every year.

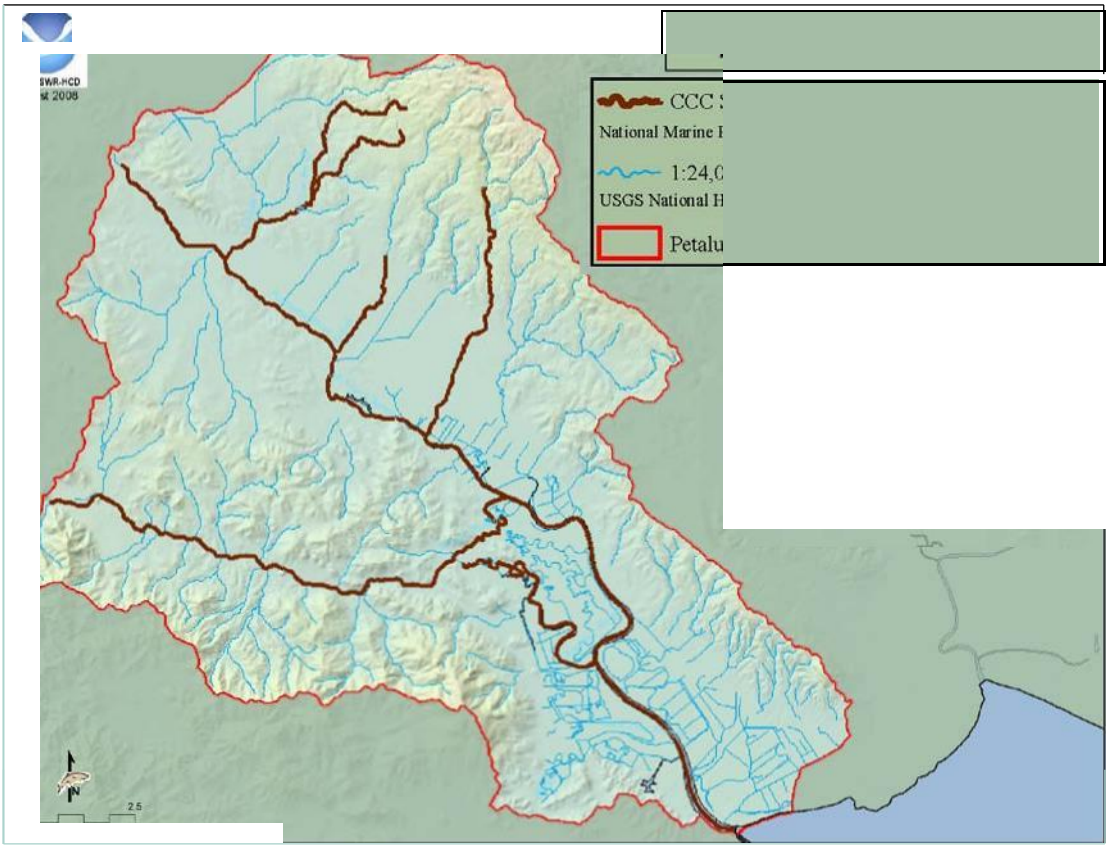
In spawner surveys conducted from 1987 to 2007 in Adobe Creek by the (UACGHS), the highest number of adult spawners observed during that span was 60 individuals (UACGHS 2003). In 2007 CDFW conducted watershed wide habitat assessments to documents habitat conditions. During these assessments, juvenile steelhead were observed in many of the streams surveyed. These surveys can be accessed at:

http://coastalwatersheds.ca.gov/portals/1/Watersheds/SanFranciscoBay/PetalumaRiverSubbasinDocuments/tabid/670/Default.aspx.

The Casa Grande Hatchery reared Chinook in the watershed from 1994-2010. Due to instruction from CDFW, the hatchery stopped rearing Chinook due to feedback from agencies that there is lack of habitat and no data on the genetic origins of the fish. No Chinook have ever been released in the Petaluma Watershed they were released in the San Francisco Bay. The hatchery has never reared or released steelhead for the Petaluma Watershed. Currently, all the steelhead being reared at the hatchery are for the Russian River Watershed (Hubacker, Personal Communication, June 5, 13). This is also because there is a lack of understanding of current habitat conditions and carrying capacity for steelhead.

Currently, NMFS, CDFW, UACGHS and other stakeholders are coordinating to conduct more watershed wide fish monitoring fill in our data gaps and develop abundance trends maybe through fin clips and pit tagging. This effort is in the beginning stage of development. Also, the groups CDFW and UACGHS are working together to resurvey the streams that were assessed in 2007 to confirm the presence of steelhead and to confirm habitat conditions (Amanda Morrison, Personal Communication, May 29, 2013). This increased monitoring is very critical to better understand the status of salmonids and how habitat conditions can be improved in high priority reaches. There is a need to better understand the viability and carrying capacity of steelhead and Chinook populations.

Map 8.2 Petaluma River Watershed Fish Distribution and Critical Habitat (NOAA, 2008).



HABITAT CONCERNS

Although the Petaluma Watershed historically may not have been considered a major salmonid system, the documented steelhead and Chinook in the system should not be discounted and more information is needed to know the current status and the potential for sustainable populations.

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

Major land modifications have resulted from increased urbanization and agriculture, road development, alterations to the estuary and flood plain and to the channel. These land changes have affected habitat conditions in many ways and have resulted in stressors that adversely affect salmonid habitat.

Some of the highest ranked stressors include:

Increased sediment transport and stream incision

Alterations to the estuary from straitening 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, water quality and lack of instream complexity including: spawning gravel, shelter and deep pools

Increased fish passage barriers

Increased water pollution from both urban and rural sources

RECOMMENDED ACTIONS

Recommendation FW1-Focus riparian restoration and erosion control efforts on tributaries that do, or potentially can, support steelhead and Chinook. These tributaries are Lichau, Adobe, San Antonio, and possibly Lynch and Willow Brook Creeks.

Recommendation FW2- Increase riparian canopy cover to 70% and install livestock exclusion fencing within key reaches of major tributaries.

Recommendation FW3-Work with CDFW, UACGHS and NMFS to conduct surveys for threatened species and species of concern to include but not limited to pond-breeding and stream-breeding amphibians throughout the watershed; and support on-going monitoring and survey efforts of salmonids and wildlife populations.

Recommendation FW4- Conduct genetic testing on the Chinook to understand origins and patterns.

Recommendation FW5- Conduct assessments of potential fish passage barriers and remove on priority streams.

Recommendation FW6- Rehabilitate and reclaim historic tidal wetland/slough estuarine habitat for rearing steelhead.

Recommendation FW7-Create more pool connectivity and increased summertime flow for steelhead and Chinook survival.

CHAPTER 9: WATER CONSERVATION

The availability of clean, freshwater is a key requirement for both human land uses and ecosystem function. The following chapter illustrates the needs for water conservation efforts on agricultural, rural and residential land-use areas.

CONSERVATION OVERVIEW

Water resources are a vital part of all ecosystem function, agricultural prosperity, community health, and economic livelihood. In Northern Coastal California's Mediterranean climate, water quantity can be a key limiting factor for all living things that depend on a watershed. As a limited natural resource, water is subject to impact from both abiotic and biotic processes. Conserving water supplies, managing stormwater runoff, and flooding events will aid in protecting water supplies. The purpose of water resources management techniques is to properly inform and guide landowners to engage in water smart conservation initiatives. Watershed planning method implementation promotes balanced solutions that satisfy environmental, domestic, and agricultural interests, while maintaining economic sustainability of the City to continue to meet future water demands.

Conserving water has become even more critical as the populations continue to steadily rise on a statewide, national and global scale. Senate Bill X7-7 was enacted in 2009, which would require all suppliers of water to increase water use efficiency standards of business. The legislation focuses primarily on two sectors: Urban Water Conservation and Agricultural Water Conservation. Department of Water Resources in conjunction with other state agencies must develop a standardized water reporting form under the bill to be applied to both sectors and all water agencies. Increasing the role of conservation is intended to result in meeting the water supply needs of all users. "In Sonoma County, a 500 square foot lawn needs about 2800 gallons of water each month, although many folks unnecessarily use up to 5000 gallons for that lawn. According to the Sonoma County Water Agency, here's how a three-person family in a single detached home uses about 150,000 gallons of water annually: 51% in the yard and mostly for lawn, 17% for toilet flushing, 15% for bathing, 11% for clothes washing, and the balance, 6% for all other household uses." (Metzger, 2009).

The Petaluma Watershed supports a variety of land uses that each demand water supplies at a broad range of intensities. Understanding these differences and 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 these land use categories and suggested water conservation efforts, but are not meant to be limited to only one land use.

AGRICULTURAL LANDS

Agricultural production includes but is not limited to dairy, cattle, row crops, vineyards, and orchards. Each of these uses demand healthy soil capacity and water supply to maintain a healthy landscape to yield productive supplies for market. The Sonoma County General Plan 2020 includes a policy to encourage and support conservation for agricultural activities that increase the efficiency crop irrigation, frost protection and livestock. There are methods applicable to landowners with farms or ranches that would aid in storing water, managing irrigation, planting for soil moisture conservation, implementing no-tillage practices, preserving crop residue, and monitoring well and groundwater levels which would support water conservation initiatives and store water for future use.

Focusing on water use efficiency is a necessary goal throughout California. Under the Senate Bill X7-7 the Agricultural Water Conservation sector demands that all agricultural water suppliers prepare and adopt agricultural water management plans by December 31, 2012. These plans will be updated by December 31, 2015 and every five years following. Other mandates on water suppliers are to measure the volume of water delivered to customers and develop regulations that the water suppliers may use to comply with the measurement requirement, pricing structure by quantity of water delivered, and create and implement supplementary water efficient management practices; to be initiated on or before July 31, 2012. In turn if these agricultural water suppliers to do not meet the requirements stated in this bill by 2013 they consequently become not eligible for state water grants or loans.

Methods of Conservation

Agricultural land owners have an opportunity to implement a variety of measures to help conserve water and reduce demand during water scarce periods. Incorporating reduced tillage practices and preserve crop residues on soil surface layers in order to improve water use and conservation for crop production. Croplands which are tilled regularly and between crop rotations are subject to increased soil moisture loss and ultimately erosion. Storing water in soil is fundamental to the health of soil cover and crop viability. Studies conducted by University of California, California Agriculture produced a peer-reviewed article, *No-Tillage and high-residue practices reduce soil water evaporation*, completed in 2012 provide valuable information to water conservation approaches.

Crop residues are a result of crop production as harvests leave remaining plant matter, often accumulating in the top soil (Mitchell J, 2012). Leaving residues to be reincorporated into the soil for nutrients and soil moisture retention is a primary goal of sustainable production in the agricultural industry. However, practices such as strip-tillage first remove all residues thus causing the soil layers to dry and warm simultaneously leaving soil vulnerable to erosion. Surface soil water content was found to be higher with less evaporation in areas with no-tillage. When evaluating these management techniques for water conservation the study found that in general preserving residue cover to reduce soil water evaporation rates compared to bare soils; however there is still much to understand about how we can evaluate the impacts of crop residue removal

and the creation of outcomes for sustainable rates of removal to better balance soil water concentrations. In addition, introducing cover crops in between productions can keep the soil permeable to uptake and infiltration. This will also help manage any runoff that would otherwise occur at greater rates if the soil was left barren.

Maintaining soil water content is also a passive frost protection method, as water in the soil layers support the soil's ability to absorb and even hold heat. Holding heat in the soil can reduce the severity of a frost event as the soil keeps low-lying air warmer for a longer period of time during cold seasonal periods of freezing weather.

Managing irrigation systems already in place on agricultural lands and open pasture can significantly support water conservation efforts. Firstly addressing the design and application of sprinkler systems is an effective approach to conserving water use. Implementing efforts to reduce sprinkler head discharge, determining the discharge rate of a sprinkler head and operating pressure can reduce the discharge rate as well as increasing application uniformity for efficient irrigation of crop lands (Schwankl, 2007).

Agricultural landowners can also benefit from implementing rain water storage projects that minimize water use from direct diversions or from shallow wells that are close or along a stream. Storing winter rain water that can be used for non-potable agricultural use is a viable method for conserving water during the dry, summer months when water is scarce.

URBAN AND RURAL RESIDENTIAL DEVELOPMENTS

Conserving water in your home and business is one of the most cost-effective and environmentally conscious methods to preserving water supplies. Urban water conservation management strategies have also been set on suppliers within the Senate Bill X7-7 creating an overall goal to reduce per capita urban water use by 20 percent as of December 31, 2020. In addition, a cut by 10 percent by December 31, 2015 is set to encourage the incremental steps toward the desired outcome. Coming effective 2016 urban retail water supplier who do not meet the standards set by the bill and the Department of Water Resources will not be eligible for state water grants or loans.

Water conservation initiatives within the City of Petaluma focuses on methods to best manage and reduce the use of water supplies in the urban boundary. A series of beneficial management practices (BPMs) to curb such demands from the city. As a member of the California Urban Water Conservation Council (CUWCC)—which was created to improve water conservation efforts statewide under a Memorandum of Understanding (MOU)—Petaluma annually submits BMP reports to the CUWCC. Within the Department of Water Resources and Conservation the City of Petaluma has developed a specific Water Conservation Plan. The purpose of the study was to evaluate and recommend the most cost effective water conservation plan, with an identified objective being to implement water conservation initiatives further than those recommended under the City's June 2006 Water Demand and Supply Analysis. The established Water Conservation Plan savings goal was based on the amount of additional potable water

required to meet buildout projections of Year 2025 demands. The proposed water conservation measures in addition to the City's existing water conservation programs, combined with the recycled water program will save approximately 714 million gallons of potable water on an annual basis.

The City of Petaluma General Plan states that they intend to use groundwater primarily for standby or emergency conditions where water delivered by SCWA and recycled water are not sufficient to meet demand. As of 2006 there are six active wells in the City and nine inactive wells. These existing wells will support the City in times where SCWA deliveries may be limited. Additional water conservation methods are being evaluated for applicability in the City to support the community and the environment alike. One of these alternatives is the continued development of recycled water. The Ellis Creek water recycling facility in Petaluma and replaced Petaluma's Hopper Street wastewater treatment plant, which was built in 1937. The plant operates 24 hours a day, seven days a week, combining natural wetland treatment processes and state-of-the art technology to provide recycled water to the city. It increases the capacity of average dry weather flow from 5.2MGD to 6.7MGD produces about 2,200 million gallons of disinfected recycled water annually, which is used to irrigate a vineyard, golf courses and 700 acres of agricultural land (Petaluma GP, 2025).

Methods of Conservation

Residents in urban and rural areas have a variety of water conservation measures applicable to their homes, businesses and other commercial properties. The City of Petaluma has devised a list of water conservation beneficial management practices (BMPs) to aid in the education and understanding of techniques to offer residents. Conservation tips include reducing irrigation to once a week, identify leaks, water between midnight and 6:00am to reduce evaporation rates and loss from wind, prevent and report water waste, cover pools and hot-tubs to reduce evaporation, use front-load washing machines, change shower heads, toilets, other facets to low flow appliances, and tune sprinkler systems regularly to reduce unnecessary water loss (Petaluma GP, 2025). Landscaping to reduce water use can be helpful to greatly decrease the amount of water put on planted areas. Xeriscaping is the process of planting with native drought tolerant species that are adapted to the regions climate which demand much less water to survive and still preserve a beautiful aesthetic. When watering the lawn or garden short cycles are more water efficient than on long period, this gives plants and the soil enough time to properly absorb water rather than having small standing pools. Another method to reduce water waste in the planted landscape is to create rain gardens to capture runoff and restore soil moisture and groundwater.

RECOMMENDED ACTIONS

Recommendation WC1- From the City of Petaluma General Plan 2025; implement the Water Conservation Plan that incorporates conservation measures beyond the beneficial management practices developed by the California Urban Water Conservation Council.

Recommendation WC2- Increase the role of water conservation and safe, beneficial re-use where water meets applicable regulatory standards for the intended use as a measure to improve water use efficiency and offset potable water demand for both urban and rural landowners.

Recommendation WC3- – Collaborate and seek funding for watershed-wide efforts to establish parameters of a multiple-benefit project involving elements of: water quality improvement, surface and groundwater storage, rainwater harvesting, use of recycled water, wetland restoration, and seasonal flood easements to allow continued agriculture.

Recommendation WC4- Develop a roof water catchment program and demonstration project for both residential and agricultural landowners.

Recommendation WC5- Provide resources to landowners on the benefits of restoring ground water and methods for increasing groundwater recharge in uplands areas through small landowners meetings.

Recommendation WC6- Outreach to agricultural producers to determine if there are opportunities increase water use or efficiency or implement alternative water source for the users.

Recommendation WC7- Implement urban and rural water conservation measures such as low-water landscaping, water saving appliances and fixtures, and graywater re-use.

CHAPTER 10: STORMWATER AND FLOOD CONTROL MANAGEMENT

Normal weather patterns for Northern California, where the majority of rainfall occurs between October and May, has precipitated a watershed approach to storm water management and active flood protection measures in the Petaluma River Watershed. Population growth experienced over the last two decades puts more people and property at risk during major storm events. During the rainy season, the Petaluma River regularly leaves its banks and spreads out into the floodplain. The response to the damaging flood events that occurred between 1982 -1998 and again in 2004-2005 have resulted in a coordinated approach by multiple agencies and the community at large. The Sonoma County Water Agency leads many of these efforts such as preparing *The Petaluma River Watershed Master Drainage Plan* to leading Zone 2A which guides the recommendations of the Zone 2A Flood Control Advisory Committee. The City of Petaluma, Army Corps of Engineers, San Francisco Bay Regional Water Quality Control Board, Environmental Protection Agency and many other entities are working collaboratively to address the rural and urban issues in managing surface water.

STORMWATER MANAGEMENT

Roofs and other impervious surfaces alter natural hydrology, increasing the volume and velocity of stormwater runoff. This has a variety of impacts including stream bank erosion and degraded wildlife habitat. Other unintended outcomes associated with accelerated stormwater runoff are potholes, damage to structures, beach closures, and in severe cases, land and mud slides.

For the past 50 years, the approach has been to direct runoff away from the property as quickly as possible using pipes and pavement. While largely effective, it is recognized that this approach only shifted problems downstream. Negative consequences of those methods include increased potential for flooding, damage to public and private property, stress on our water supplies, and degradation of our local waterways and habitats.

Sonoma County is taking comprehensive action to understand and manage storm water to minimize flooding, increase ground water recharge, and minimize the pollutants and sediment being added to our waterways. One important outcome of this comprehensive action is the development of the guidebook “Slow it. Spread it. Sink it!” which provides straight forward beneficial management practices that can help to protect and replenish groundwater resources, reduce erosion and pollution, while providing many other environmental benefits! “Slow it. Spread it. Sink it!” provides practical actions that can be implemented by rural and urban landowners. The principals of “Slow it. Spread it. Sink it!” are being applied to creek and stream restoration and enhancement projects throughout the Petaluma Watershed.

Stormwater Quality Impacts

Storm water and its associated water quality impacts have led to the listing of the Petaluma River on the 2002 Clean Water Act due to unacceptable levels of nutrients, pathogens, sediment, diazinon, and nickel. As per the mandated requirements of the Federal Clean Water Act, the City

of Petaluma developed a Stormwater Management Plan. These storm water systems are regulated under the National Pollutant Discharge Elimination System (NPDES) through Municipal Separate Storm Sewer System (MS4) permits. Petaluma's MS4 permit is being renewed as of July 2013. 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.

Rural runoff & Sedimentation

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 unleveed areas. 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 ACOE in 1933 removed over half-a-million cubic yards of sediment from the Petaluma River to improve its navigability. Since 1937, ACOE has dredged millions of cubic yards of deposited material from the river to maintain the navigable channel.

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 (SCWA, 1986).

FLOODING

Flooding is a serious concern in portions of the watershed. This chapter discusses historic and current flooding conditions, opportunities, constraints, and recommended actions with regard to flooding.

Historic and Current Flood Conditions

In the mid-1800's storm water 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. In the ensuing century, with settlement of the town of Petaluma and the surrounding areas, and the urbanization of the region since the 1950's, such overflow could no longer be tolerated. 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 2005, many problems still existed. 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 tributary area exceeds its capacity.

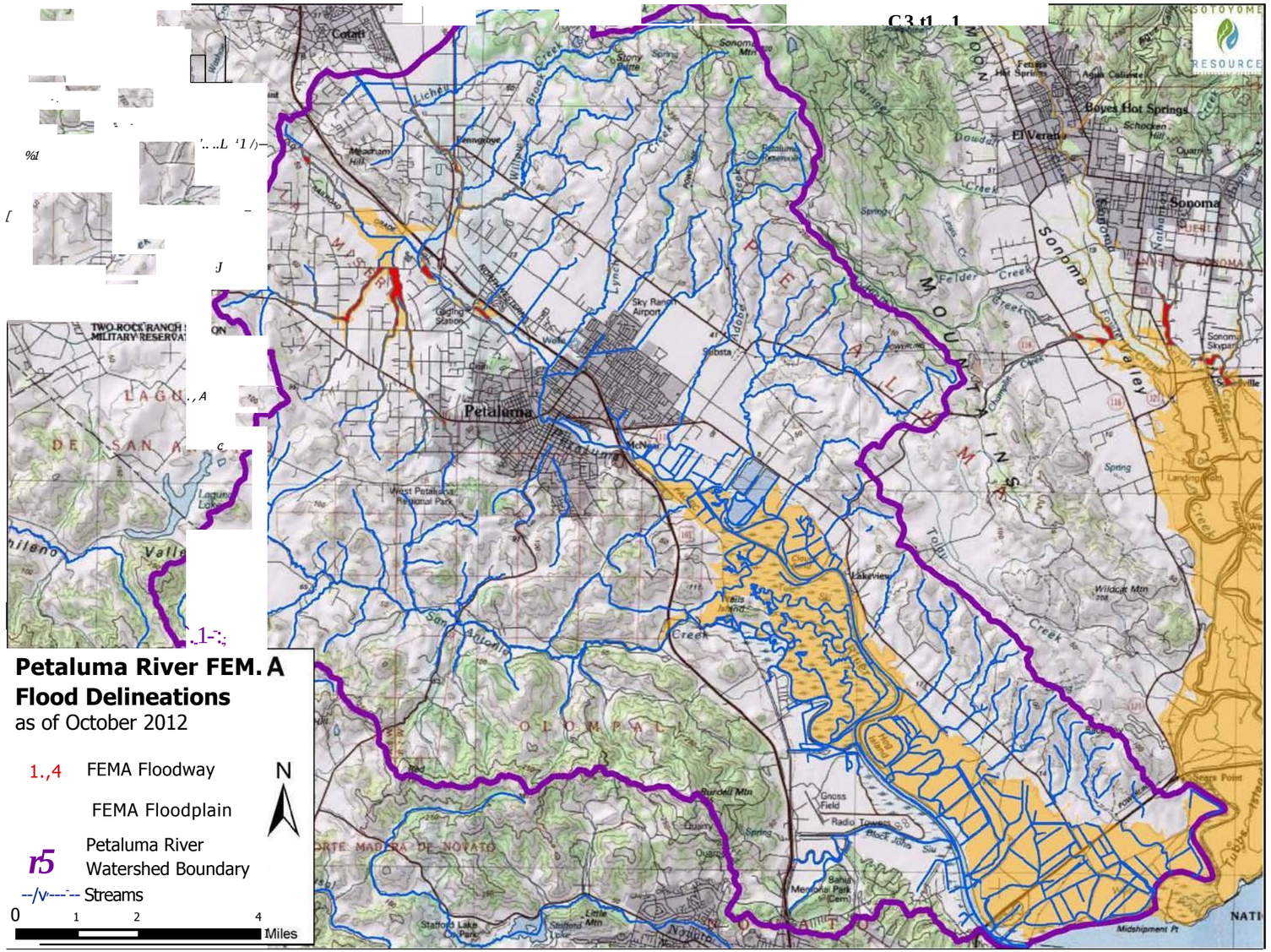
The Sonoma County Water Agency’s Master Drainage Plan describes in detail the climatic, hydrologic, and topographic factors, which contribute to the delineation of floodplains or flood prone areas. Specifically, the flood plain delineation closely approximates the base (100-year) flood elevation lines developed by the U. S. Army Corps of Engineers (ACOE) for the National Insurance Administration, Federal Emergency Management Agency’s Flood Insurance Rate Maps for the City of Petaluma and Sonoma County.

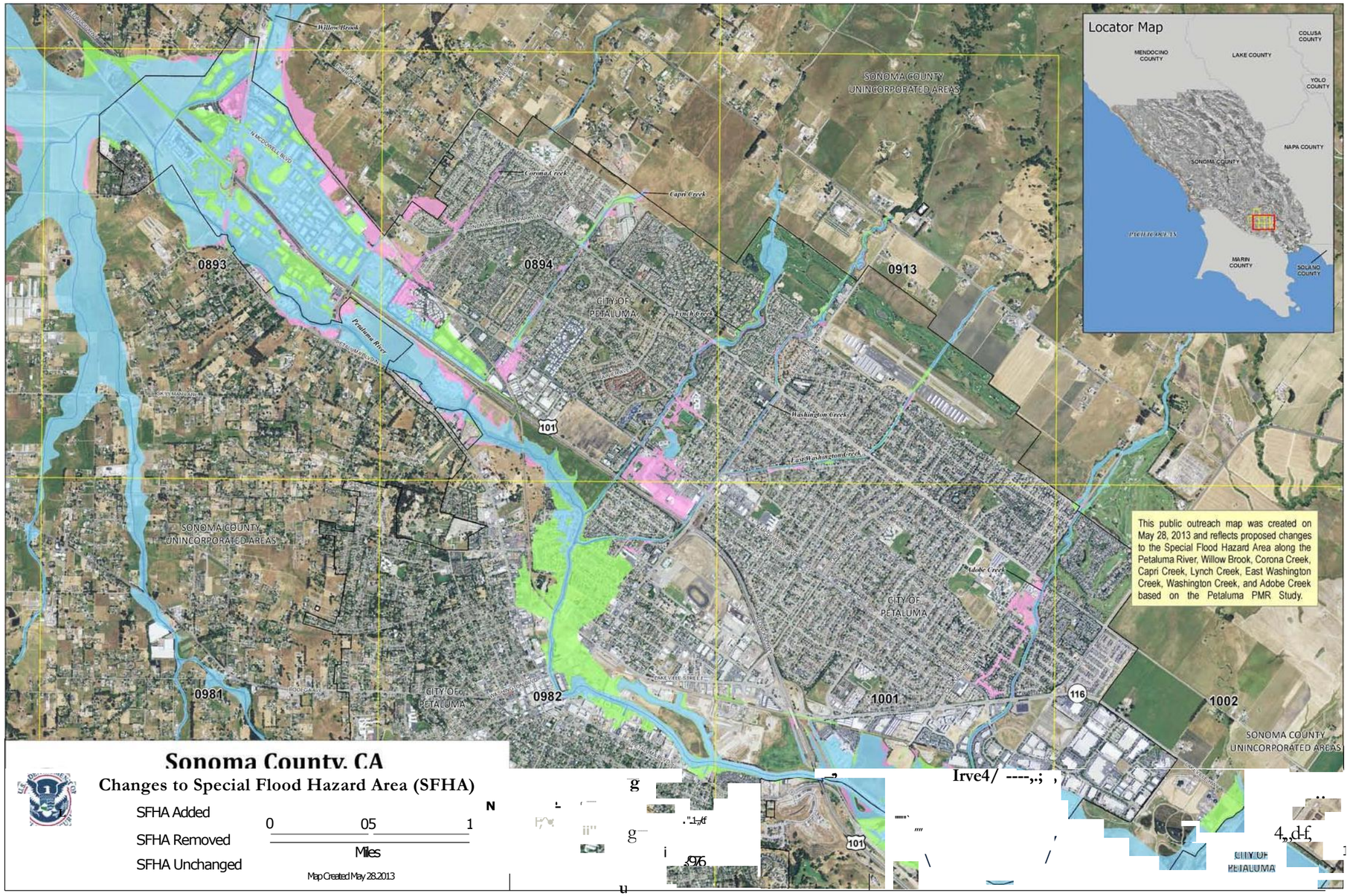
The term 100-year flood is a measure of water level rather than rate of occurrence therefore can happen any time. The term “100-year flood” is often used inconsistently and misunderstood by many people. The misinterpretation can foster a belief that if a 100-year flood occurs in any one year, then it 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 finite probability that the 100-year flood could occur in any year. Characteristic floods in the Petaluma River Basin are normally of short duration, lasting 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. 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.

Map 10.1 Petaluma River FEMA Flood Delineations as of October 2012.




Locator Map
COLUSA COUNTY
MENDOCINO COUNTY
LAKE COUNTY
YOLO COUNTY
NAPA COUNTY
SONOMA COUNTY
PACIFIC OCEAN
MARIN COUNTY
SOLANO COUNTY
SONOMA COUNTY UNINCORPORATED AREAS
0893
0894
0913
0981
0982
1001
1002
CITY OF PETALUMA
Willow Brook
Corona Creek
Capri Creek
Lynch Creek
Petaluma River
East Washington Creek
Washington Creek
Adobe Creek
MENDOCINO BLVD
PETALUMA BLVD
LAKEVILLE STREET
ROBLAR RD
101
116
This public outreach map was created on May 28, 2013 and reflects proposed changes to the Special Flood Hazard Area along the Petaluma River, Willow Brook, Corona Creek, Capri Creek, Lynch Creek, East Washington Creek, Washington Creek, and Adobe Creek based on the Petaluma PMR Study.
Sonoma County, CA
Changes to Special Flood Hazard Area (SFHA)
SFHA Added
SFHA Removed
SFHA Unchanged
0 05 1
Miles
Map Created May 28,2013
N

Historic and Current Flood Management

To adequately address downstream flooding, the Sonoma County Water Agency, City of Petaluma, and others are studying and developing 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 County Water Agency. 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. Residents within this Zone pay an extra tax to fund structural projects that will reduce flooding risks in this area. There is a seven-member Zone 2A Advisory Committee consisting of citizens who reside within the Zone and representatives from the City of Petaluma and Sonoma County. This committee is responsible for recommending budget priorities to the Board of Directors of the SCWA for inclusion in the Zone budget for each fiscal year. In November 1986 and again in 1996, extended in 2007 the electorate of Zone 2A authorized the levying of benefit assessments within these two zones for 10 years to augment funds received from general property taxes. Since 1986 these revenues have supplemented the property taxes received by Zones 2A.

The officially formed zones have 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 zones have also financed the flood protection operation and maintenance activities of the Agency.

SCWA Stream Maintenance Program

Stream maintenance activities support a proactive regional approach to flood protection and stream and wildlife habitat restoration. The Sonoma County Water Agency (SCWA) works in and around streams throughout the Petaluma Watershed, removing sediment and garbage and planting trees. SCWA 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 to provide shade 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 good water quality and habitat for wildlife. www.sonomacountywater.org.

City of Petaluma Flood Control Efforts

Petaluma has been working with the 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. The Petaluma Flood Control Project has taken steps to reduce flooding

to a level that FEMA can issue revised maps which can reduce the level of flood insurance required by landowners. In addition Petaluma developed their Floodplain Management Action Plan (FMP) which was updated in the fall of 2010 and sets forth recommendations and actions to be pursued through 2015. Petaluma's Floodplain Management Plan lays seeks to integrate their storm and flood management activities.
http://cityofpetaluma.net/pubworks/pdf/2010-floodplain-management-plan-final.pdf

cityofpetaluma.net/wrcd/flood-control.html

INTEGRATED APPROACHES TO FLOOD & STORMWATER MANAGEMENT

Local entities working in the Petaluma Watershed are taking integrated approaches to Flood and Storm Management. Projects are now designed to meet multiple watershed goals from reducing erosion by slowing storm water, improving groundwater recharge by spreading storm water into the floodplain, to implementing construction requirements for new homes which minimize storm runoff.

The Petaluma Floodplain Management Plan calls for the utilization of flood terraces adjacent to the 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 way. Augmentation of the river corridor floodplain to capture and transport additional surface flows. Slowing the storm flows, allowing ponding and recharge through pervious soils within the flood terraces, provides recharge benefits for shallow aquifers. Groundwater benefits infiltration of water from ponding and terracing improvements reduces the volume and velocity of downstream runoff.

This integrated approach is exemplified by the upcoming projects to be implemented by Petaluma and Southern Sonoma County (Sonoma) RCD through a recent grant funding by the Department of Water Resource Integrated Watershed Management Plan for the Bay Area. This project will link seven individual project sites in an effort to achieve the maximum benefit of flood reduction while addressing water and habitat quality. Project sites are located in the upper Petaluma River Watershed and extend from just north of the town of Penngrove along Lichau Creek down through the confluence with Capri Creek, and includes reaches on Lichau, Willowbrook, and Capri creeks as well as portions of the upper reach of the Petaluma River. Though these projects address flooding they will also increase channel stability and improve the overhead canopy, provide access to the historic floodplain, and dramatically reduce in the delivery of fine sediment to the channel which will enhance critical riparian and upland habitat.

Petaluma Flood Impact Reduction, Water & Habitat Quality, Recreation, Phase IV
http://bairwmp.org/projects/petaluma-flood-impact-reduction-water-habitat-quality-recreation-phase-iv/.

The SCWA is presently developing the Upper Petaluma River Watershed Project (Project) in collaboration with RMC Water and Environment in order to provide regional flood mitigation and groundwater recharge benefits within the Upper Petaluma River Watershed. Currently in the initial scoping phase this project intends to study and ultimately implement projects that meet the following objectives for flood hazard reduction: groundwater recharge, water quality, waters supply, system sustainability, ecosystem improvements, support agricultural preservation, enhance undeveloped land, and other associated benefits of improved water quality and quantity. Flood hazard reduction and groundwater recharge are the projects core objectives; to improve management of stormwater that contributes—directly or indirectly—to reduce flood hazard potential as well as increase the beneficial recharge of groundwater.

RECOMMENDED ACTIONS: STORMWATER

Recommendation SM1- 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 SM2- Support the goals and practices of the City of Petaluma Storm Water Management Plan

Recommendation SM3- Support planning measures that control development to appropriate locations, preserve open space and agricultural lands.

Recommendation SM4- Utilize land management practices and develop LandSmart ranch and farm water quality plans.

RECOMMENDED ACTIONS: FLOODING

Recommendation FM1- Implement the City of Petaluma's Floodplain Management Plan and support the completion of the Petaluma Flood Control Project

Recommendation FM2-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 FM3- 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.

Recommendation FM4- Implement projects that provide flood protection, habitat enhancement, groundwater recharge, and where feasible, passive recreation.

CHAPTER 11: WATER QUALITY

Water quality in the Petaluma River Basin is under the jurisdiction of the State Water Resources Control Board and its San Francisco Bay Region 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. Initial amendments to the Water Quality Control Plan were adopted in 1982, 1986, and 1995, with 16 additional amendments adopted between 2005 and 2011. The most current proposed amendment under development is the Stream and Wetland Protection Policy.

WATER 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 both natural and man-made waterways. The Petaluma River is influenced by tidal action from the bay and receives little fresh water 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 the 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 Resources Control 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.

The Petaluma River has been designated as a "water quality limited" segment in the 1982 amended Water Quality Control Plan. In the Water Quality Control Plan, a segment of the River basin can be classified as "effluent limited" if water quality objectives are met after the application of effluent limitations. If water quality objectives are not met, even after application of effluent limitations on point sources, the segment is then classified as "water quality limited" and additional control of non-point sources of pollutants would be needed to meet water quality objectives.

Monitoring water quality of the Petaluma River has been performed by the Regional Water Quality Control Board since mid-1970. Major concerns were dissolved oxygen (DO) readings below minimum standards, with coliform bacteria and unionized ammonia sometimes exceeding maximum standards. Additional field biological studies were conducted and a subsequent report was issued 1981 in conjunction with the City of Petaluma's Wastewater Management Plan. In 1982, the State Water Resources Control Board (SWRCB) reported that "dissolved oxygen and

nutrient problems persist (in the Petaluma River) producing seasonal fish kills."

More recently California Assembly Bill 982 (Water Code Section 13192; Statutes of 1999) required that the State Water Resources Control Board (SWRCB) assess and report on State water monitoring programs and prepare a proposal for a comprehensive surface water quality monitoring program.

The SWRCB proposed to restructure the existing water quality monitoring programs into a new program, the Surface Water Ambient Monitoring Program (SWAMP). This program consists of statewide environmental monitoring focused on providing the information needed to effectively manage the State's water resources.
SWAMP is designed to be consistent, cooperative, adaptable, scientifically sound, and to meet clear monitoring objectives. It will also facilitate reporting and categorizing of the State's water quality under Sections 305 (b) and 303 (d) of the federal Clean Water Act.

SWAMP has conducted statewide monitoring through the SWRCB and regional monitoring through the Regional Water Quality Control Boards. Currently, both the statewide component and the regional components are being redesigned. SWAMP in the San Francisco Bay Region included:

Monitoring watersheds to assess water quality impacts and establish regional reference sites; and

Monitoring edible fish for contaminant levels in reservoirs and coastal areas where people catch and consume fish.

Five years of watershed monitoring have been completed, 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 performed in the RMP determines spatial patterns and long-term trends in contamination through sampling of water, sediment, bivalves, bird eggs, and fish, and evaluates toxic effects on sensitive organisms and chemical loading to the Bay. The program combines RMP data with data from other sources to provide for 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 different benefits to the people of the state. These beneficial uses define the resources, services, and qualities of these 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, 2007).

Designated beneficial uses in the Petaluma River Watershed are numerous and include: Cold Water Habitat, Estuarine Habitat, Fish Migration, Preservation of Rare and Endangered Species, Fish Spawning, Warm Water Habitat, Wildlife Habitat, Water Contact Recreation, Non-Contact Water Recreation, and Navigation. These beneficial uses are defined in the Basin Plan as follows:

Cold Water Habitat

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

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

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

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.

Fish Spawning

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 Water Habitat

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

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

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

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.

Navigation

Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

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 amount 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 considered to be impaired for five pollutants: sediment, pathogens, nutrients, diazinon, and trash.

Water Quality Data

The goal of SWAMP in the San Francisco Bay Region has been to monitor and assess watersheds in the Region using a weight-of-evidence approach based on measurement of physical, chemical, and biological water quality parameters. Data developed in this program are intended to be used for evaluating watersheds for 305b reporting and 303d listing. Specific objectives of the monitoring program are to develop new data to evaluate beneficial use protection; measure water quality indicators and stressors to characterize spatial and temporal trends; determine relationships between water quality indicators, specific stressors and land use, including water management; identify reference sites; and evaluate monitoring tools. Due to a reduction in regional SWAMP funding, future plans are to meet these objectives in collaboration with other watershed monitoring programs.

Summary of Petaluma River Watershed SWAMP Monitoring Results

The Petaluma River watershed is heavily influenced by historic and current poultry and dairy farming, and has a substantial urban area within the city of Petaluma and adjacent communities. The tidal influences extend many miles up the slough, through highly channelized agricultural areas and tidal marshes.

Thirteen sites were sampled for benthic macroinvertebrates and physical habitat in the Petaluma River watershed. Benthic macroinvertebrate assemblages in the mainstem Petaluma River and several tributaries (Washington Creek, Ellis Creek) were in poor condition (i.e., highly disturbed), while other tributaries showed evidence of low levels of disturbance (e.g., Adobe Creek) or moderate levels of disturbance (e.g., San Antonio Creek).

A total of 20 water samples were collected in the Petaluma River watershed for analysis of conventional water quality characteristics in 2003. Seven of these samples were collected during the winter, 7 in the spring, and 6 in the dry season.

Temperature and dissolved oxygen benchmarks were exceeded in a little more than 50% of the deployments, there were frequent exceedances of criteria for nutrients and bacteria and minor chronic toxicity effects, but there were no exceedances of organics or trace metals benchmarks in water. The sediment had only one TEC exceedance, for nickel which is part of the natural geology, and one chronic effect in the Hyalella test. Nutrient concentrations throughout the Petaluma River watershed frequently exceeded nitrogen criterion, regardless of season, and all samples exceeded total phosphorus criterion.

The Petaluma River watershed had some exceptionally low DO values for aquatic life. All sites monitored in the summer were below the minimum concentration for cold-water habitat (7 mg/L), as well as the 7-day minimum (all below 1 mg/L) and median percent saturation (all below 20 percent). In the spring, only Adobe Creek had DO levels above minimum and median threshold values, and even then, it was below the recommended 7-day spawning minimum of 11 mg/L (however this benchmark may not be relevant in April).

All pH levels met guidelines, except one station on San Antonio, which had a winter range of values greater than 1 pH unit, suggesting excessive photosynthesis. Closer inspection reveals the sudden decrease in pH and DO was coincident with an increase in temperature and depth and a decrease in specific conductance. USGS flow data indicates a flow increase from 3 to 50 cfs at the same time: likely a rain event, especially since similar patterns of increase in depth and decrease in specific conductance are evident in data from the other sites at the same time.

RECOMMENDED ACTIONS

Recommendation WQ1-Encourage the City of Petaluma and urban landowners to implement practices to reduce pollutants from entering the water way.

Recommendation WQ2-Encourage rural residential landowners and agricultural producers to implement beneficial management practices to improve stream health.

Recommendation WQ3-Implement management actions to reduce erosion and sediment from entering streams.

Recommendation WQ4- Assist residents in working with the Counties on well and septic installation and management to maintain or improve ground and surface water quality.

Recommendation WQ5- Due to current habitat conditions, investigate the possibility of using Adobe Creek as an 'urban reference site.

Recommendation WQ5- Investigate the possibility of using Adobe Creek as an 'urban reference site.'

Recommendation WQ6- Increase flow monitoring to better interpret water quality data.

Recommendation WQ7 – Develop LandSmart ranch and farm water quality plans and implement beneficial management practices to decrease pathogen and nutrient loads.

CHAPTER 12: SEDIMENT SOURCES AND IMPACTS

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 chapter 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 a gully or streambank washout.

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 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 in rural areas, 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 independent of it.

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 removal of vegetation.

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 of 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—the rate at which rainfall enters the stream channels.

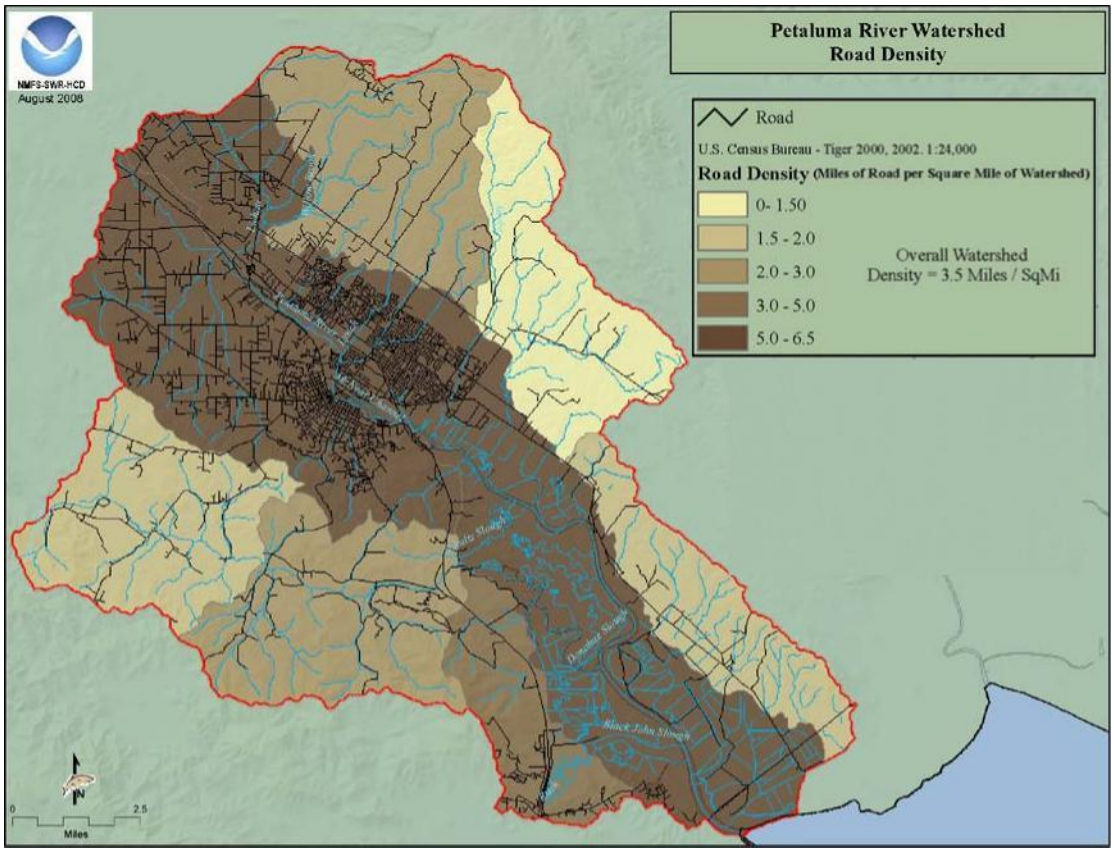
Local bank erosion can also occur from an obstruction, such as a fallen tree that pushs water into a streambank, or from excessive subsurface flow, such as an overly watered lawn or a poorly placed rain gutter.

Roads

Poorly designed roads are a chronic source of sediment. Typical road-related erosion problems include improper road sloping, inadequately 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.

Map 12.1 Petaluma River Watershed Road Density (NOAA, 2008).



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 uses and management that occurred 100 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 what is happening with 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 land stewardship.

As part of a report prepared by Prunuske Chatham, Inc. (PCI) with SSRCRD, 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 12.1 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

Non Point Sources

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, 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 unleveed areas. 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 ACOE in 1933 removed over half-a-million cubic yards of sediment from the Petaluma River to improve its navigability. Since 1937, ACOE has dredged over three million cubic yards of deposited material from the river to maintain the navigable channel.

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 (SCWA, 1986).

RECOMMENDED ACTIONS

Recommendation SSI1- Concentrate erosion control activities in the high priority sub-watersheds of Willow Brook, Lynch, Adobe, Ellis, and San Antonio Creeks.

Recommendation SSI2- Seek funding and cost share programs for landowners in the upper watershed for installation and maintenance of erosion control measures.

Recommendation SSI3-Manage livestock access to creeks and gullies, especially in the wet season.

Recommendation SSI4- 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 SSI5- Maintain drainage ditches, spillways, culverts, etc. to avoid overtopping and delivery of sediment to the streams.

Recommendation SSI6 - Improve upstream waterways for flood and sediment control by planting native species.

Recommendation SSI7- Assist landowners and pursue funding to repair eroding banks, install riparian fencing and revegetation and implement LandSmart ranch and farm water quality plans.

CHAPTER 13: 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.

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.

In 1987, an amendment to the CWA directed the NPDES program to address non-point source (NPS) pollution through a phased approach. NPS pollution does not have a specific origin or discharge location but is considered to be general surface runoff containing pollutants from streets, parking lots, construction sites, homes, businesses and many other sources.

- Phase I of the NPDES permit program began in 1990 and applied to construction sites disturbing 5 or more acres of soil and municipalities with populations equal to 100,000 or more.

  Phase II of the NPDES permit program became effective on March 10, 2003 and applied to construction sites disturbing between 1 and 5 acres of soil and municipalities with populations between 10,000 and 100,000.

NPDES is a federally mandated program that is implemented and enforced locally. Currently, all construction sites disturbing 1 or more acres of soil must obtain an NPDES General Permit from the State Water Resources Control Board (SWRCB). The County of Sonoma has obtained Municipal Separate Storm Sewer System (MS4) permits from the North Coast Regional Water Quality Control Board (NC RWQCB) and the San Francisco Bay Regional Water Quality Control Board (SFB RWQCB).

The Industrial Storm Water 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 Storm Water 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 storm water pollution are described. The General Industrial Permit requires that an annual report be submitted each July 1.

The ten categories covered under the Industrial Storm Water General Permit include:

1. Facilities subject to storm water 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 storm water.

The City of Petaluma upgraded its wastewater treatment facilities and the Ellis Creek Water Recycling Facility began treating wastewater in 2009. The facility treats about 5 million gallons of wastewater each day. In the winter time, highly treated wastewater is introduced back into the Petaluma River. During the summer, the recycled water is introduced into the City's recycled water system and used for irrigation of agricultural lands, two golf courses, and a vineyard. The City annually produces about 708 million gallons of recycled water. The City is currently subject to the following discharge prohibitions under order number R2-2011-0003 of the SWRCB:

GENERAL PERMIT

Applicants of construction projects disturbing 1 or more acres of soil are required to file for coverage under the State Water Resources Control Board (SWRCB), Order No. 99–08–DWQ, National Pollutant Discharge Elimination System (NPDES) General Permit No. CAS000002 for Discharges of Storm Water Runoff Associated with Construction Activity (General Permit). 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 Storm Water Pollution Prevention Plan (SWPPP). The SWPPP should contain a site map which shows the construction site perimeter, existing and proposed buildings, lots, roadways, storm water 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 storm water runoff and the placement of the BMPs. Agricultural construction related to reservoirs, access avenues and structures are still subject to the General Permit requirement.

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

Municipalities are required to obtain Municipal Separate Storm Sewer Systems (MS4s) Permits which regulate storm water discharges. MS4 permits are issued by Regional Water Quality Control Boards (RWQCB) and are usually issued to a group of co-permittees encompassing an entire metropolitan area. Since Sonoma County has two major watersheds regulated by two RWQCBs, we have two MS4 permits.

One municipal permit is a Phase I MS4 Permit for municipalities serving more than 100,000 people and is administered by the North Coast RWQCB. The County of Sonoma is a co-permittee with the City of Santa Rosa and the Sonoma County Water Agency 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 other municipal permit is a Phase II General MS4 Permit for municipalities serving between 10,000 and 100,000 people and is administered by the San Francisco Bay RWQCB. The County of Sonoma is a co-permittee with the Sonoma County Water Agency for the Phase II boundary which includes the unincorporated areas near the cities of Petaluma and Sonoma.

UNDERGROUND STORAGE TANKS

In EPA Region 9, the Underground Storage Tanks Program Office (USTPO) works to prevent leaks from USTs, clean up contaminated sites, and redevelop formerly contaminated sites into beneficial use. They oversee state UST/LUST programs and partner closely with tribes and Pacific island territories. The program has direct implementation over tribes and island territories. Several tribes and territories in Region 9 have their own UST programs and staffs which work cooperatively with EPA to oversee and regulate UST facilities on their lands. Over the last two decades, EPA and its partners closed over 1.5 million substandard tanks that were corroding and leaking petroleum into groundwater; cleaned up more than 300,000 petroleum leaks; and reduced the number of new releases from a high of over 66,000 in 1990 to roughly 12,000 in 2003. Today, tank systems are much less likely to leak and cause significant environmental problems.

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 Resources Control 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, were 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.
CERCLA:

established prohibitions and requirements concerning closed and abandoned hazardous waste sites;
provided for liability of persons responsible for releases of hazardous waste at these sites; and
established a trust fund to provide for cleanup when no responsible party could be identified.

The law authorizes two kinds of response actions:

- Short-term removals, where actions may be taken to address releases or threatened releases requiring prompt response.
  Long-term remedial response actions, that permanently and significantly reduce the dangers associated with releases or threats of releases of hazardous substances that are serious, but not immediately life threatening. These actions can be conducted only at sites listed on EPA's National Priorities List (NPL).

CERCLA also enabled the revision of the National Contingency Plan (NCP). The NCP provided the guidelines and procedures needed to respond to releases and threatened releases of hazardous

substances, pollutants, or contaminants. The NCP also established the NPL.CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) on October 17, 1986.

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.

RECOMMENDED ACTIONS

Recommendation PS1 – Implement beneficial management practices to decrease pollutant loading from urban and suburban stormwater.

Recommendation PS2 – 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 PS3 – Comply with all conditions of municipal NPDES permits for stormwater and sewer systems.

Draft Petaluma Watershed Enhancement Plan

SECTION 3. IMPLEMENTATION

CHAPTER 14: PLAN IMPLEMENTATION

The management plan is intended to be implemented over a 10-year timeframe and will be reviewed and updated as needed during that time. A complete review and update of the Plan should commence at the end of the 10-year period. The vision, goals, objectives, and policies of the Plan are well established, though the recommended actions are designed to be revised and updated as appropriate, thus providing some flexibility over the course of plan implementation. This chapter provides a framework for implementing the recommended actions defined in the previous chapters.

MANAGEMENT ACTIONS

Table 14.1 summarizes the management actions, the timing of planned implementation, and the chapter of this plan in which the actions are described in detail. The information provided in the table can be used in conjunction with the more detailed management actions described in the previous chapters and associated appendices. Each recommended action will be included in one or more of the following:

- **5-Year Actions** include many tasks that are required to build the groundwork for future on-the-ground implementation, such as monitoring and assessment.

- **10-Year Actions** are follow-up on tasks or monitoring related to actions initiated in the 5-Year period. 10-year actions also include tasks that are expected to be ongoing in the long-term, such as regulatory compliance.

- **As-Needed Actions** will be carried out in order to achieve the goals of this plan and accomplish specific recommended actions.

IMPLEMENTATION OF THE DRAFT PETALUMA WATERSHED ENHANCEMENT PLAN

Table 14.1 Schedule for Implementing Recommended Actions

Recommended Actions[1]	Description	Chapter	Date	Status	Potential Partners
As-Needed Actions					
Outreach and education –	Landowner participation and involvement is critical for the successful implementation of the recommended actions. The RCD understands the importance of trust between landowners and the agencies working in the watershed. Close coordination is important so that the community understands how the various agencies work together. Additionally, this plan is a living document, and continued landowner and stakeholder input into the plans and its recommendations is essential to keeping the plan current and effective.	All	2013-2023	Ongoing	SRCD; SCWA; UACGHS; NRCS; FPR; UCCE
5-Year Actions					
WQ6	Increase flow monitoring to better interpret water quality data.	11	2013-2017	Needed	CEMAR; CDFW; UACGHS; NMFS; SRCD
FW4	Conduct surveys for species of concern throughout the watershed; and support instream monitoring and survey efforts of salmonid and wildlife populations.	8	2013-2017	Ongoing	CEMAR; CDFW; UACGHS; NMFS;SRCD
RE4	Conduct community outreach and provide technical assistance to landowners to help manage and protect riparian areas.	5	2013-2018	Ongoing	NRCS; SRCD; MRCD
SSI1	Concentrate erosion control activities in the high priority sub-watersheds of watershed tributaries.	12	2013-2018	Needed	CDFW; NMFS; NRCS;SRCD
WQ1	Encourage implementation of practices to reduce pollutants from entering the water way. *See Chapter 13.*	11	2013-2018	Needed	City of Petaluma
WQ2	Encourage rural residential landowners and agricultural producers to implement beneficial management practices to improve stream health. *See Chapter 4.*	11	2013-2018	Needed	NRCS;SRCD;MRCD
WQ3	Implement management actions to reduce erosion and sediment from entering streams. *See Chapter 12.*	11	2013-2018	Needed	NFFS;CDFW; NRCS;SRCD;M

					RCD
WQ4	Assist residents in working with the Counties on well and septic installation and management to maintain or improve ground and surface water quality.	11	2013-2018	Needed	Count of Sonoma, City of Petaluma
WQ5	Investigate the possibility of using Adobe Creek as an 'urban reference site.'	11	2013-2018	Needed	SCWA; CDFW; RCD
FM1	Implement the Floodplain Management Plan; support the completion of the Petaluma Flood Control Project.	9	2013-2018	Ongoing	City of Petaluma
FM2	Participate in local stream maintenance & storm drain improvement projects.	9	2013-2018	Ongoing	SCWA; City of Petaluma
FM3	Support erosion and sediment control efforts such as the development of LandSmart ranch and farm water quality plans and implement beneficial management practices to decrease sediment loads.	9	2013-2018	Ongoing	UCCE; NRCS; CDFW; SRCD
SM1	Assist individual rural and urban landowners to install "Slow It, Spread It, Sink It!" practices. *See Chapter 9 and 10.*	10	2013-2018	Ongoing	SCWA; City of Petaluma;SRCD
SM2	Support the goals and practices of the Storm Water Management Plan.	10	2013-2018	Ongoing	City of Petaluma; SCWA; SRCD
SM3	Support planning measures that control development to appropriate locations, preserve open space and agricultural lands.	10	2013-2018	Ongoing	SLT;SCAPOSD
SM4	Utilize land management practices and develop LandSmart ranch and farm water quality plans. *See Chapter 4.*	10	2013-2018	Ongoing	UCCE; NRCS
WC2	Increase the role of water conservation and safe, beneficial re-use where water meets applicable regulatory standards.	9	2013-2018	Needed	SCWA; City of Petaluma
WC3	Collaborate and seek funding watershed-wide on water conservation efforts.	9	2013-2018	Needed	SCWA; City of Petaluma;NRCS;SRCD; NOAA
WC4	Develop a roof water catchment program and demonstration project for both residential and agricultural landowners.	9	2013-2018	Needed	SCWA; City of Petaluma;SRCD

WC5	Provide resources to landowners on the benefits of restoring ground water and methods for increasing groundwater. recharge in uplands areas through small landowners meetings.	9	2013-2018	Needed	SCWA; City of Petaluma;SRCD
WC6	Outreach to determine opportunities to increase water use or efficiency or implement alternative water source for the users.	9	2013-2018	Needed	SCWA; City of Petaluma;SRCD
FW1	Focus riparian restoration and erosion control efforts on tributaries that do, or potentially can, support steelhead and Chinook. *See Chapter 5.*	8	2014-2017	Ongoing	NRCS; CDFW; UACGHS; NMFS;SRCD
10-Year Actions					
ARS1	Provide education and technical services to help ranchers and growers understand and comply with applicable agricultural regulations.	4	2013-2023	Ongoing	NRCS; Ag Commissioner;SRCD
ARS2, RE5	Develop LandSmart ranch and farm water quality plans to document current and plan for future beneficial management practices.	4, 5	2013-2023	Ongoing	DFW; SCC; NOAA; NRCS
ARS3	Prevent and control soil erosion, and enhance soil quality. *See Chapter 12.*	4	2013-2023	Ongoing	NRCS; SCWA
ARS4	Improve water use efficiency of irrigation and frost protection systems. Explore alternative water sources for these uses.	4	2013-2023	Ongoing	NRCS; UCCE
ARS5	Manage grazing to protect and enhance soil quality, plant communities and water quality.	4	2013-2023	Ongoing	DFW; SCC; NOAA; NRCS
ARS6	Conduct outreach about minimizing the impact of animal waste	4	2013-2023	Ongoing	NRCS, UCCE
ARS7	Assist landowners with developing projects to ensure water reliability	4	2013-2023	Ongoing	NRCS
CA1	In riparian areas encourage native vegetation at multiple heights: groundcover, shrubs, and trees.	7	2013-2023	Ongoing	DFW; NOAA; NRCS; UCCE
CA2	In riparian areas encourage a patchwork of habitats and install plant species with climate changing adaptability	7	2013-2023	Ongoing	NRCS; UCCE
CA3	In riparian areas leave old and dead trees in place if they do not threaten structures.	7	2013-2023	Ongoing	DFW
CA4	Allow natural processes, such as flooding and laying down new layers of sediment.	7	2013-2023	Needed	DFW
CA5	Assessment of pest insects and disease, invasive species,	7	2013-	Needed	UCCE

	and dying trees in forestlands		2023		
CA6	Assist landowners to eradicate non-native pest insects, diseases, and invasive weeds	7	2013-2023	Ongoing	UCCE
CA7	For wetlands complete large wetland restoration projects to serve as buffers to tidal flooding as well as sea level rise	7	2013-2023	Ongoing	SCC;SLT; USACE
CA8	For wetlands reduce development in low-lying areas, behind levees, or adjacent to the bay/coast and prevent or reduce other stressors that reduce the ability of the wetland ecosystem to respond.	7	2013-2023	Ongoing	SLT; DFW;SCC
CA9	For wetlands identify and support projects that facilitate connectivity to marshes and wetlands prior to and as they are impacted by sea level rise	7	2013-2023	Ongoing	SLT;SCC
CA10	For agriculture provide technical and financial incentives for agriculturalists to transition management practices that are affected by climate change.	7	2013-2023	Ongoing	UCCE; NRCS
CA11	For agriculture consider transitioning to organic practice on agricultural operations.	7	2013-2023	Ongoing	UCCE; NRCS
CA12	For agriculture consider incorporating trees, shrubs, and hedgerows into rangeland or farm landscapes to sequester carbon	7	2013-2023	Ongoing	UCCE; NRCS; WCB
CA13	For agriculture consider soil management practices that sequester carbon	7	2013-2023	Ongoing	UCCE;NRCS
FW2	Increase riparian canopy cover to 70% and install livestock exclusion fencing within key reaches of major tributaries.	8	2013-2023	Ongoing	UCCE; NRCS
FW4	Conduct genetic testing on the Chinook to understand origins and patterns.	8	2013-2023	Needed	NMFS; DFW
FW5	Conduct assessments of potential fish passage barriers and remove on priority streams.	8	2013-2023	Ongoing	NFWF; CDFW; SCWA
FW6	Rehabilitate and reclaim historic tidal wetland/slough estuarine habitat for rearing steelhead	8	2013-2023	Ongoing	WCB;SCC;SLT
FW7	Create more pool connectivity and increased summertime flow for salmonids	8	2013-2023	Needed	NMFS; CDFW
FW8	Monitor and investigate groundwater and surface water interactions	8	2013-2023	Needed	CEMAR;DFW;NMFS
WC1	From the City of Petaluma General Plan 2025; implement the Water Conservation Plan	9	2013-2023	Ongoing	City of Petaluma; SCWA
WC7	Implement low-water landscaping, water saving appliances and fixtures, and graywater re-use.	9	2013-2023	Ongoing	SCWA; City of Petaluma
FM4	Implement projects that provide flood protection, habitat enhancement, groundwater recharge, and where feasible, passive recreation	10	2013-2023	Ongoing	SCWA; City of Petaluma
WQ7	Develop LandSmart ranch and farm water quality plans and implement beneficial management practices to decrease	11	2013-2023	Ongoing	UCCE;NRCS

	pathogen and nutrient loads.				
PS1	Implement beneficial management practices to decrease pollutant loading from urban and suburban stormwater.	13	2013-2023	Ongoing	City of Petaluma ; SCWA
PS2	Maintain septic systems based on State Water Board and Sonoma County PRMD requirements and guidelines.	13	2013-2023	Ongoing	County of Sonoma
PS3	Comply with all conditions of municipal NPDES permits for stormwater and sewer systems.	13	2013-2023	Ongoing	City of Petaluma Petaluma /County Sanitation District
SSI4	Provide educational and technical assistance for "do-it-yourself" erosion control, small farm and pasture management.	12	2013-2023	Ongoing	UCCE; NRCS
SSI5	Maintain drainage ditches, spillways, culverts, etc. to avoid overtopping and delivery of sediment to the streams.	12	2013-2023	Ongoing	City of Petaluma; NRCS;SCWA
SSI6	Improve upstream waterways for flood and sediment control by planting native species.	12	2013-2023	Ongoing	SCWA; NRCS; DWF
SSI7	Assist landowners and pursue funding to repair eroding banks, install riparian fencing and revegetation and implement LandSmart ranch and farm water quality plans.	12	2013-2023	Ongoing	NRCS; UCCE; DFW
ML1	Restore large patches of tidal marsh along the entire shoreline of San Pablo Bay particularly near the mouths of sloughs and major streams.	6	2013-2023	Ongoing	SCC;SLT;WCB; SCAPOSD
ML2	With willing landowners, establish managed marsh or enhanced seasonal pond habitat (especially for shorebirds) on agricultural baylands that are not restored to tidal marsh.	6	2013-2023	Ongoing	DFW; USFWS USACE
ML3	Enhance riparian habitat along Petaluma River. Where possible, enhance marsh/upland transitions and provide buffers.	6	2013-2023	Ongoing	DFW; USFWS ; NOAA
ML4	Prepare and distribute information to the public about the habitat needs of these species and how watershed residents can help with recovery efforts.	6	2013-2023	Ongoing	USFWS ;FPR; UCCE
ML5	In agricultural areas allow ponding in field depressions for shorebirds and waterfowl.	6	2013-2023	Ongoing	USFWS USACE
ML6	In agricultural areas create small diked ponded areas adjacent to levees where possible.	6	2013-2023	Ongoing	DFW;USACE;
ML7	In agricultural areas, encourage growth of vegetation along fence rows or field edges to provide habitat for small birds and mammals.	6	2013-2023	Ongoing	NRCS; UCCE; USFWS

ML8	In agricultural areas, delay spring harvest of oat-hay as late as possible to avoid nesting waterfowl.	6	2013-2023	Ongoing	UCCE; NRCS
ML9	In agricultural areas, fence cattle from wetland areas during wet periods.	6	2013-2023	Ongoing	NRCS; USFWS ;UCCE
ML10	In agricultural areas, increase the practice of rotational grazing to encourage a more diverse grassland habitat.	6	2013-2023	Ongoing	UCCE; NRCS
RE3, SSI3	Manage livestock access to the creeks, especially during the wet season and assist landowners to develop grazing plans.	5, 12	2013-2023	Ongoing	NRCS; UCCE
SSI2	Secure funding to implement erosion control measures, mainly in the upper watershed, and help landowners apply for cost share programs.	12	2013-2023	Ongoing	NMFS; DFW; NRCS;SRCD
RE2	Secure funding to implement stream enhancement plans and help landowners apply for cost share programs.	5	2013-2023	Ongoing	NRCS;SRCD;MRCD
RE1	Revegetate high and medium priority riparian sites with cooperative landowners.	5	2013-2023	Ongoing	DFW; NOAA; NRCS;SRCD

[1] Actions defined in Section 2 Chapters 4-13; codes correspond to listed recommended actions.
ARS=Agricultural /Rural Sustainability; RE=Riparian Enhancement; ML=Marshlands; FW=Fish and Wildlife; WC=Water Conservation; SM=Stormwater Management; FM=Flood Management; WQ=Water Quality; SSI=Sediment Sources/Impacts; PS=Point Source Pollution; CA=Climate Adaptation

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 times 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 a given 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; an outflow from a river out of a lake.

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 particular 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 - Rain water and melting ice that flows on the earth's surface into nearby streams, lakes, wetlands, and reservoirs.

Salmonid - Any species of a genus of Pacific Ocean fishes from the salmon or trout family that can breed in rivers and stream tributaries to the North Pacific.

Sheet erosion - The removal of a fairly 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) does support a prevalence of such vegetation under normal circumstances.

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