Sonoma Resource Conservation District

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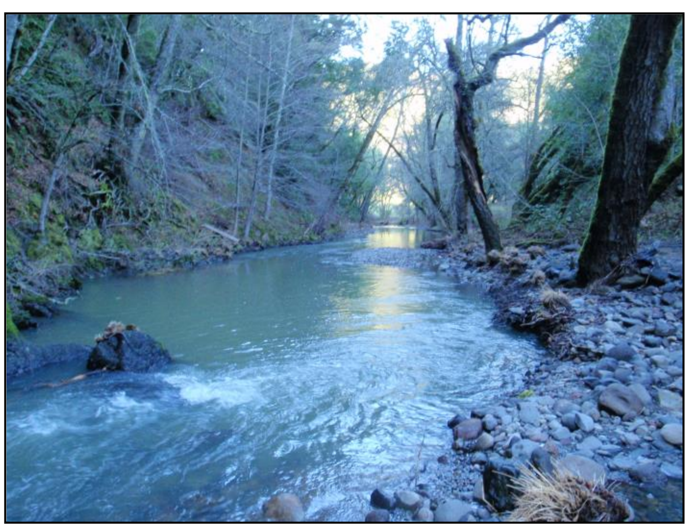
Maacama and Upper Mark West Creek Integrated Watershed Management Plan

March 2015



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Prepared By:

Sonoma Resource Conservation District

Kara Heckert, Executive Director

Playalina Bojanowski, Resource Planner

Anya Starovoytov, Resource Planner

Kevin Cullinen, Project Manager

This Plan follows the US EPA's nine elements of an effective watershed plan. Its compilations consisted of data gathering and general watershed scoping that occurred as part of the previous watershed planning efforts, performed in the Maacama Creek watershed in 2004 and the Upper Mark West watershed in 2008 (Marcus/Sotoyome RCD, 2004; Sotoyome RCD, 2008) as well as inclusion of reports and studies that were completed after the time of these plans and assessments, and data collected from many scientific field surveys and monitoring efforts.

Acknowledgements

The Sonoma Resource Conservation District (SRCD) gratefully acknowledges the dedication and hard work of SRCD staff members and stakeholders who contributed toward the completion of the *Draft Maacama and Upper Mark West Creek Integrated Watershed Management Plan (WMP).* Contributors and reviewers include Sarah Nossaman, and Steven Swain, University California Cooperative Extension, Matt Deitch, Center for Ecosystem Management and Restoration, Drew Loganbill, Natural Resources Conservation Services, Sierra Cantor, Gold Ridge RCD, Derek Acomb, California Department of Fish and Wildlife, Wendy Eliot and John McCaull, Sonoma Land Trust, and Lisa Micheli, Pepperwood Preserve.

The WMP could not have been completed without the long term involvement and participation of many rural and agricultural landowners who have allowed access to their properties for monitoring and stream assessments, and other surveys, which provided valuable information for current on-the ground conditions as well as important historical perspectives on the land use and natural resources in the watersheds. The WMP is a living document and the RCD will continue to seek ongoing input from the landowner community and our many partners to create common goals for watershed health and multiple lands use.

EXECUTIVE SUMMARY

ACKNOWLEDGEMENTS 2

EXECUTIVE SUMMARY 2

ACRONYMS 5

SECTION 1. INTRODUCTION AND BACKGROUND 7

CHAPTER 1. INTRODUCTION 8

BACKGROUND AND PURPOSE OF THE WATERSHED MANAGEMENT PLAN 8

WATERSHED GOALS 9

STAKEHOLDER GROUPS 12

CHAPTER 2. WATERSHED BACKGROUND 14

REGIONAL SETTING 14

CULTURAL RESOURCES 19

HISTORY 20

LAND USE 23

GEOLOGY 27

SOILS 31

FISH AND WILDLIFE 33

WATER RESOURCES 37

WATER QUALITY 43

INSTREAM AND RIPARIAN HABITAT 49

SEDIMENT SOURCES 49

FORESTRY AND VEGETATION RESOURCES 51

CLIMATE VARIABILITY 55

SECTION 2. MANAGEMENT AND RECOMMENDATIONS 57

CHAPTER 3. WATER RESOURCES 58

CHAPTER 4. WATER QUALITY 66

WATER QUALITY CONCERNS 66

CONSERVATION AND ENHANCEMENT RECOMMENDATIONS 72

CHAPTER 5. INSTREAM AND RIPARIAN HABITAT 76
FISH MONITORING AND SURVEYS 76
FOCAL SPECIES AND HABITAT 78
RIPARIAN CORRIDOR ORDINANCE 79
FISH PASSAGE 80
SURVEYED STREAM HABITAT CONDITIONS AND CONCERNS 82
RECOMMENDED ACTIONS 90
CHAPTER 6. SEDIMENT SOURCES AND IMPACTS 93
EROSION PROCESSES IN MAACAMA AND MARK WEST WATERSHEDS 93
ROAD ASSESSMENTS AND IMPLEMENTATION TECHNIQUES 98
ROAD RELATED SEDIMENT SOURCE ASSESSMENTS 99
COMPLETED ROAD ASSESSMENTS AND IMPLEMENTATION 100
RECOMMENDED ACTIONS 103
CHAPTER 7. AGRICULTURAL AND RURAL LAND PRESERVATION 105
AGRICULTURAL BACKGROUND 105
AGRICULTURAL SUSTAINABILITY 105
CONSERVATION PLANNING 106
CONSERVATION EASEMENTS 107
THE WILLIAMSON ACT 108
RURAL RESIDENTIAL 108
RECOMMENDED ACTIONS 109
CHAPTER 8. FOREST LAND PRESERVATION 111
BACKGROUND 111
CONDITIONS AND CONCERNS 111
RECOMMENDED ACTIONS 116
CHAPTER 9. CLIMATE VULNERABILITY AND ADAPTATION 118
CLIMATE VARIABILITY IMPACTS 118
CLIMATE PREDICTIONS AND CONCERNS 122

SUMMARY 124
RECOMMENDED ACTIONS 124
SECTION 3. IMPLEMENTATION 127
CHAPTER 10. PLAN IMPLEMENTATION 128
PLAN LIMITATIONS 128
CHAPTER 11. SUPPLEMENTAL INFORMATION 137
REFERENCES 137

Appendices

Appendix A – Web Soil Survey Soil Erosion Ratings

Appendix B – California Natural Diversity Database Map (updated March 2015)

Appendix C – Basin Plan Beneficial Uses for Surface Water

Appendix D – CDFW Stream Surveys

Appendix E – Sonoma County Hazard Mitigation Map – Historical Fires

Appendix F – Climate Variability Data Tables

ACRONYMS

ABAG	Association of Bay Area Governments
BMP	Best Management Practice
CAL FIRE	California Department of Forestry and Fire Protection
CASGEM	California Statewide Groundwater Elevation Monitoring
CCAP	Community Climate Action Plan
CDFW	California Department of Fish and Wildlife (formerly known as CDFG: CA Department of Fish and Game)
CEMAR	Center for Ecosystem Management and Restoration
CESA	California Endangered Species Act
CEQA	California Environmental Quality Act
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CPC	Climate Protection Campaign
CWD	Climatic Water Deficit
CWQ	Clean Water Act
DO	Dissolved Oxygen
DWR	California Department of Water Resources
ESA	Endangered Species Act
FMWW	Friends of the Mark West Watershed
GHG	Greenhouse gas
GSA	Groundwater Sustainability Agency
HU	Hydrologic Unit
LWM	Large wood material
NBCAI	North Bay Climate Adaptation Initiative
NCRWQCB	North Coast Regional Water Quality Control Board
NEPA	National Environmental Policy Act
NFWF	National Fish and Wildlife Foundation
NMFS	National Marines Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	Non-Point Source
NRCS	Natural Resources Conservation Service
PRMD	Permit & Resource Management Department

PWA	Pacific Watershed Associates
RCPA	Regional Climate Protection Authority
RRCSCBP	Russian River Coho Salmon Captive Broodstock Program
RRMAP	Russian River Monitoring and Assessment Program (UC Cooperative Extension)
SCA	Streamside Conservation Area
SCAPOSD	Sonoma County Agricultural Preservation and Open Space District
SCWA	Sonoma County Water Agency
SCTA	Sonoma County Transportation Agency
SGMA	Sustainable Groundwater Management Act
SLT	Sonoma Land Trust
SMART	Sonoma Marin Area Rail Transit
SOD	Sudden Oak Death
SRCD	Sonoma Resource Conservation District
SSP	Species of Special Concern
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UCCE	University of California Cooperative Extension
USEPA (EPA)	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WDMP	Water Demand Management Plan
WMP	Watershed Management Plan
WQO	Water Quality Objective

Sonoma Resource Conservation District

Maacama Creek and Upper Mark West Watershed Management Plan

SECTION 1. INTRODUCTION AND BACKGROUND

CHAPTER 1. INTRODUCTION

BACKGROUND AND PURPOSE OF THE WATERSHED MANAGEMENT PLAN

A Watershed Management Plan is an important tool for any group looking to improve their local rivers or streams. Put simply, a Watershed Management Plan identifies water quality and other natural resource problems in your watershed, proposes solutions, and creates a strategy for putting those solutions in action. Watershed Management Plans take a long-term, comprehensive approach, which has proven to be successful. Like a road map directing you from the start to finish of your effort, a watershed management plan helps you create a strategic, targeted plan for making changes in your watershed. Resource Conservation Districts throughout the State have a long history of supporting planning at the watershed level as an effective tool that can be used to develop an understanding of the impact of human activities on ecosystems and actions that can be taken to improve those impacts.

This plan covers both the Maacama and the Upper Mark West watersheds, high priority areas for fish and wildlife habitat and forest and plant communities, agriculture, and rural land in Russian River Watershed. These watersheds are rich in biodiversity and provide homes for hundreds of plant and animal species. This region is recognized globally as a biodiversity "hotspot," and it features species representative of California's coastal, interior, northern and southern climates which converge in rich mosaic of plant communities. (Pepperwood Preserve, 2015). These watersheds are recognized for their important role in providing terrestrial and aquatic fish and wildlife habitat and connectivity that extends beyond the watershed boundaries in three regional conservation plans: the Conservation Lands Network, the Critical Linkages: The Bay Area and Beyond, and the Mayacamas Connectivity Report (Bay Area Open Space Council, 2011; Science and Collaboration, 2013; Merelander et al, 2010). In addition both watersheds has been identified as a high priority stream for preservation and restoration by a number of regional, state, federal and local agencies. The Association of Bay Area Governments (ABAG), a comprehensive planning agency for the San Francisco Bay region, has identified the Upper Mark West watershed as a priority conservation area based on regional significance, and urgency of protection.

An integrated approach for this planning document was selected given the proximity of these watersheds to each other, the similarities in their geology and other natural resources, similar habitat degradation of for fish and wildlife species and their habitats, and water quality and streamflow, and the clear distinction in population and land uses in the rest of the Mark West Watershed. This watershed plan is structured to discuss both watersheds in an integrated format and also aims to highlight where there are key differences between the watersheds.

Since the 1940s, the Sonoma RCD (SRCD) has supported many conservation-oriented projects and programs to enhance and protect lands in the Maacama and Upper Mark West watersheds. Through decades of cooperative collaboration, SRCD has formed productive, long-standing relationships with the agricultural and rural community. Given SRCD's proven commitment to protecting both the ecological integrity and economic productivity of the watershed's natural resources, we felt well positioned to produce this document and to facilitate the cooperative process on which it is based.

The RCD endeavors to use the draft management plan as a framework to engage the Maacama and Upper Mark West community and agricultural producers to develop a plan that meets multiple goals. Local people play active roles in protecting our watersheds. Local knowledge and expertise is invaluable for development of local goals and long term objectives. Because the planning process is an ongoing work in progress, these goals will be reviewed and adapted as we continue to move forward. It is ultimately hoped that this plan will lead to improved community understanding, interest and leadership in watershed stewardship and will provide a structure for continued input from and dialogue between all watershed stakeholders.

WATERSHED GOALS

The Maacama and Upper Mark West Watershed Management Plan (WMP) provides descriptions of current watershed conditions and identifies needs and assessments that aid in achieving the Plans goals and objectives.

Goal 1: Water quality conditions that meet the needs for all beneficial uses
Goal 2: Stream flows that supports fish and other aquatic organisms at all life stages
Goal 3: Surface water and groundwater supplies within the watershed are managed to support resident's quality of life, agriculture, and ecosystem needs
Goal 4: Aquatic and riparian habitats are assessed, protected, and restored
Goal 5: Upland habitats are resilient and biologically diverse with intact ecosystems
Goal 6: Landowners are supported in their efforts to live on the land and produce agricultural products while conserving and protecting natural resources
Goal 7: Forestlands are protected and maintained to promote health and vigor while reducing the risk of wildfire.
Goal 8: Ecosystems and agriculture have increased resiliency to climate variability

Table 1.1 below links watershed goals with indicators that demonstrate whether or not the goals are being attained, potential sources of impact that could be altered to attain the goals, and management objectives to help achieve the goals. The goals and objectives of this Plan may be revised as more data is gathered and effects of management actions become better understood.

Table 1.1 Watershed goals and indicators

Goal	Indicator	Potential Source of Impact	Management Objective
Water Quality conditions that meet the needs for all beneficial uses	Dissolved Oxygen; Temperature; Turbidity; Streambed Composition; Benthic Macroinvertebrates; Riparian Vegetation; Instream Habitat Structure; wetlands and floodplains; Fish Passage	Destabilized streambanks; removal of riparian vegetation; modified drainage pathways; gully erosion; rural roads. High turbidity levels and aggradation of stream channels raises water temperature; sediment loads alter streambed composition; removal of riparian vegetation; fish passage barriers; depletion of floodplains and wetlands	Stabilize and revegetate stream corridors; mitigate erosion from gullies and rural roads; investigate and treat significant sediment sources, conduct stream habitat typing; remove fish passage barriers; increase instream habitat structure and complexity; restore floodplains and wetlands
Surface water and groundwater supplies within the watershed are managed to support resident's quality of life, agriculture, and ecosystem needs	Groundwater and surface water supplies available for residential, municipal, and wildlife needs; Stream flow reliability for salmonids	Depletion of groundwater supplies; stream diversions; groundwater pumping from streamside wells; rainfall pattern and storm intensity changes due to climate variability	Increase year-round stream flows; Improve water security for landowners through water storage projects; Protect springs and seeps;

Goal	Indicator	Potential Source of Impact	Management Objective
Promote native biodiversity in upland habitats and critical habitat linkages	Extent and condition of native plant communities; connectivity of critical habitat linkages/corridor	Invasive species; development and infrastructure	Identify areas for permanent protection through fee purchase, conservation easements and restoration investments.
Restore and protect forest health	Levels of Sudden Oak Death infection; frequency and magnitude of forest fires	Spread of Sudden Oak Death pathogen; modification of forest structure and composition	Perform surveys for species of concern; protect critical habitats identified through surveys; survey forested properties to identify pest or disease problems; encourage proper forest management to decrease risk of wildfire while protecting habitat and migratory pathways.
Landowners are supported in their efforts to live on the land and produce agricultural products while conserving and protecting natural resources	Loss of agricultural lands and depletion of production	Over use of resources, lack of management, regulation, climate change	Encourage management of working landscapes to promote productivity and healthy lands Identify properties appropriate for conservation easements that support agricultural uses Conduct landowner outreach and education

Goal	Indicator	Potential Source of Impact	Management Objective
Ecosystems, and agriculture have increased resiliency to climate variability	Reduction of agricultural land productivity; Increased crop damage and yield impacts from extreme weather events such as drought, fire, or flooding	Over-use of resources, lack of adaptation to changes in annual climate patterns	Provide the local community with information regarding anticipated climate variability and ways to adapt; continue to perform research to assess impacts from climate change on a local/watershed scale.

STAKEHOLDER GROUPS

Community outreach is an important part of the development and implementation of any watershed management plan. The SRCD understands the need for agencies, watershed groups and landowners to coordinate to meet common watershed goals. Below is a list of the numerous stakeholder groups working on conservation concerns in the Maacama and Upper Mark West watersheds:

Federal

National Fish and Wildlife Foundation (NFWF)

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

Natural Resource Conservation Service (NRCS)

State

California Department of Forestry and Fire Protection (CAL FIRE)

California Department of Fish and Wildlife (CDFW)

State Water Quality Control Board

University of California Cooperative Extension-Russian River Coho Salmon Captive Broodstock Program (RRCSCBP)

County

Sonoma County Regional Parks

Sonoma County Agricultural Preservation and Open Space District (SCAPOSD)

Regional

Regional Water Quality Control Board, Region 1 - North Coast (NCRWQCB)

Local

Audubon Canyon Ranch

Friends of the Mark West Watershed (FMWW)

LandPaths

Maacama Watershed Alliance

Pepperwood Preserve

Russian River Coho Water Resources Partnership (Partnership)

Sonoma Land Trust (SLT)

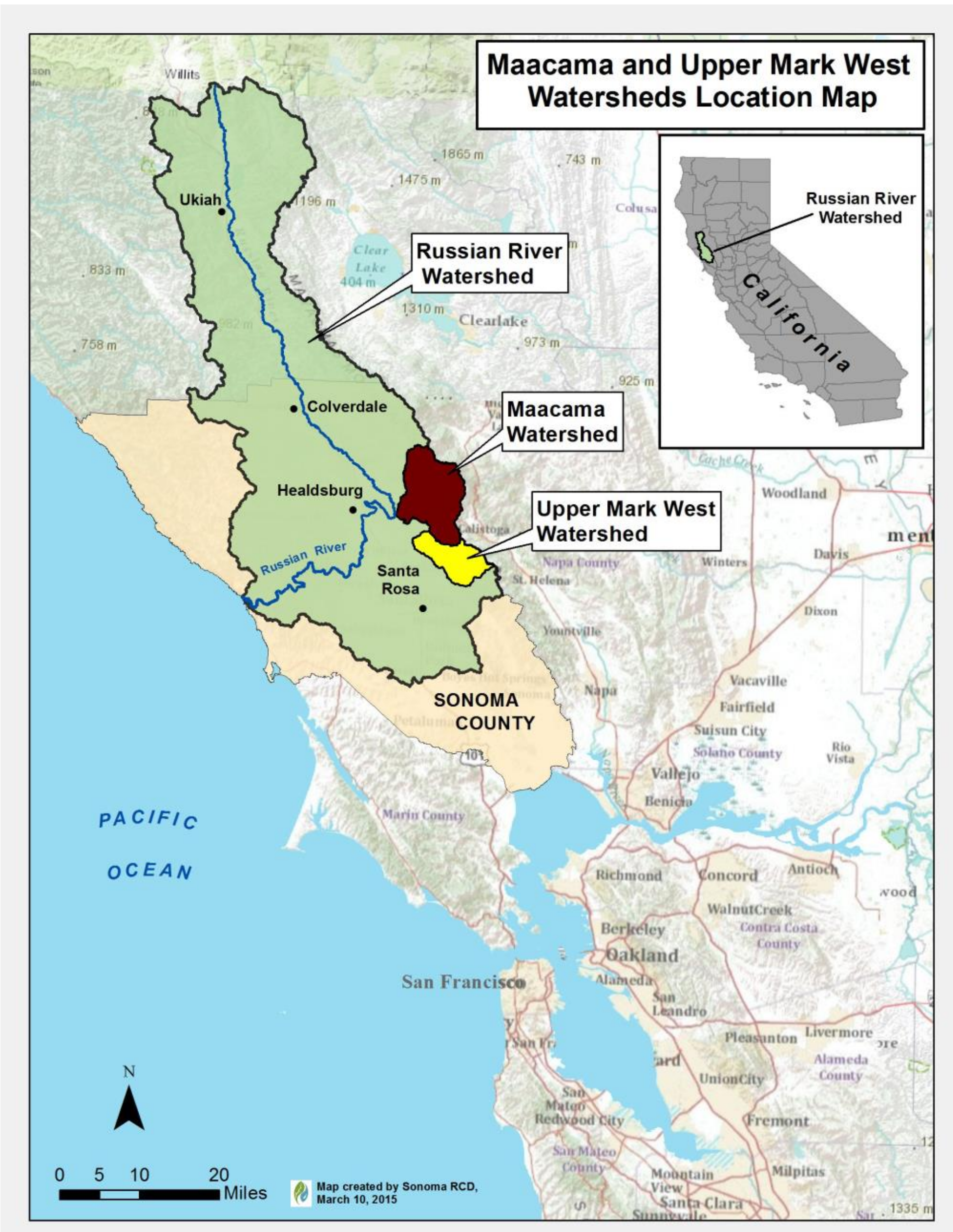
Sonoma Resource Conservation District (SRCD)

CHAPTER 2. WATERSHED BACKGROUND

REGIONAL SETTING

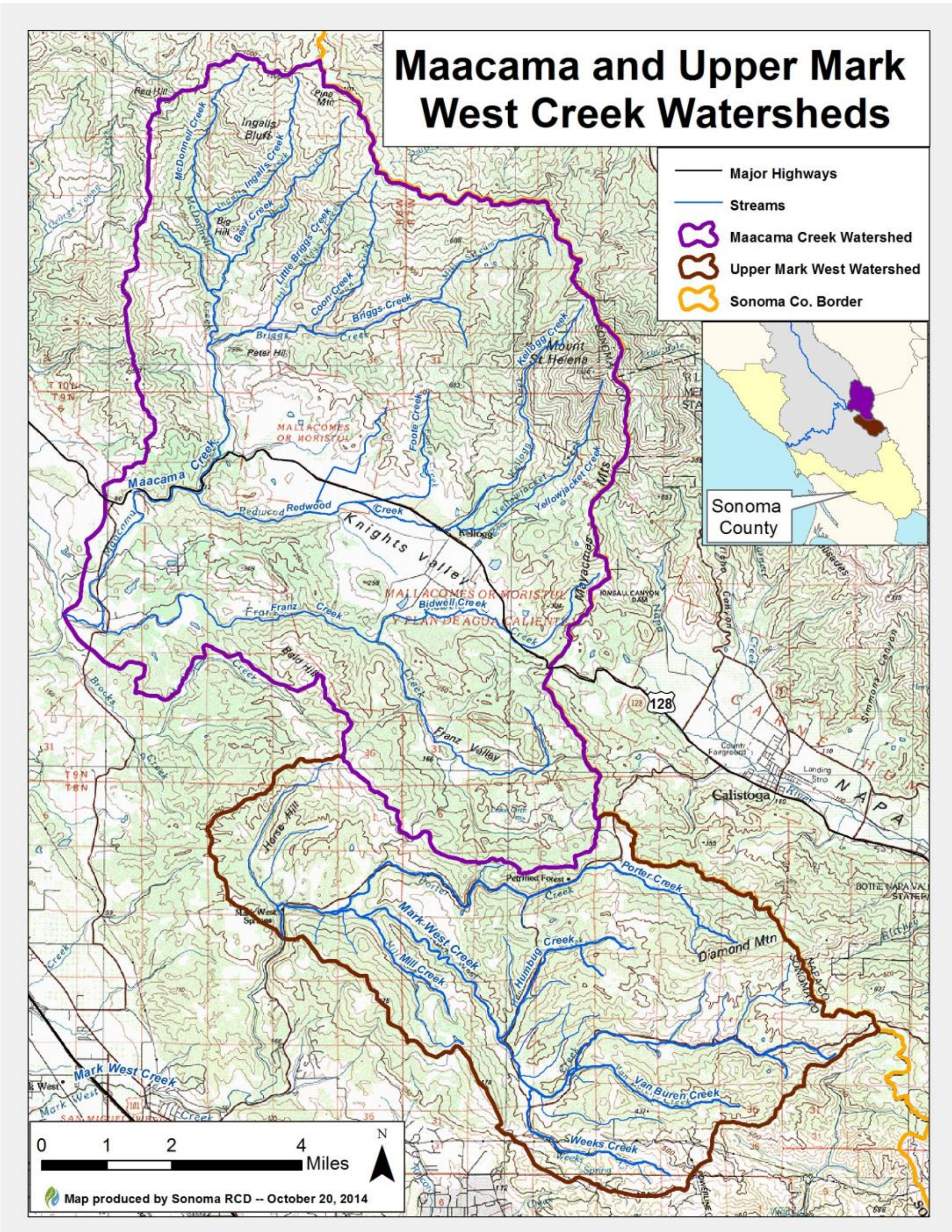
The Maacama and Upper Mark West watersheds are located in central Sonoma County approximately 60 miles north of San Francisco and lie to the east of the Highway 101 corridor.

Figure 2.1 Regional context map of Maacama and Upper Mark West watersheds



Both the Maacama and Upper Mark West watersheds are bordered by the Mayacamas mountain range and the Napa County line to the east. The Maacama Watershed is bordered by Alexander Valley to the northwest and the Upper Mark West watershed to the south, followed by the Laguna de Santa Rosa watershed. These watersheds are located east of the cities of Santa Rosa, Windsor, and Healdsburg.

Figure 2.2 Maacama and Upper Mark West watershed boundaries



Maacama Creek and its tributaries drain a basin of approximately 69 square miles, which is predominantly made up of two separate drainage basins. Franz Creek, with its tributary Bidwell Creek, meets Maacama Creek less than a mile from its confluence with the Russian River. The Franz Creek watershed covers approximately 23 square miles. The other main drainage basin includes Knights Valley and its tributary creeks - Redwood, Kellogg, McDonnell, and Briggs Creek, which form Maacama Creek. This basin covers approximately 46 miles. The confluence of Maacama Creek and the Russian River is about 3 miles east of Fitch Mountain, or about 4.5 miles east of the City of Healdsburg. Table 2.1 lists the primary sub-basins of this watershed and their respective size and Figure 2.3 shows the boundaries of the sub-watersheds.

Figure 2.3 Maacama Creek sub-watersheds

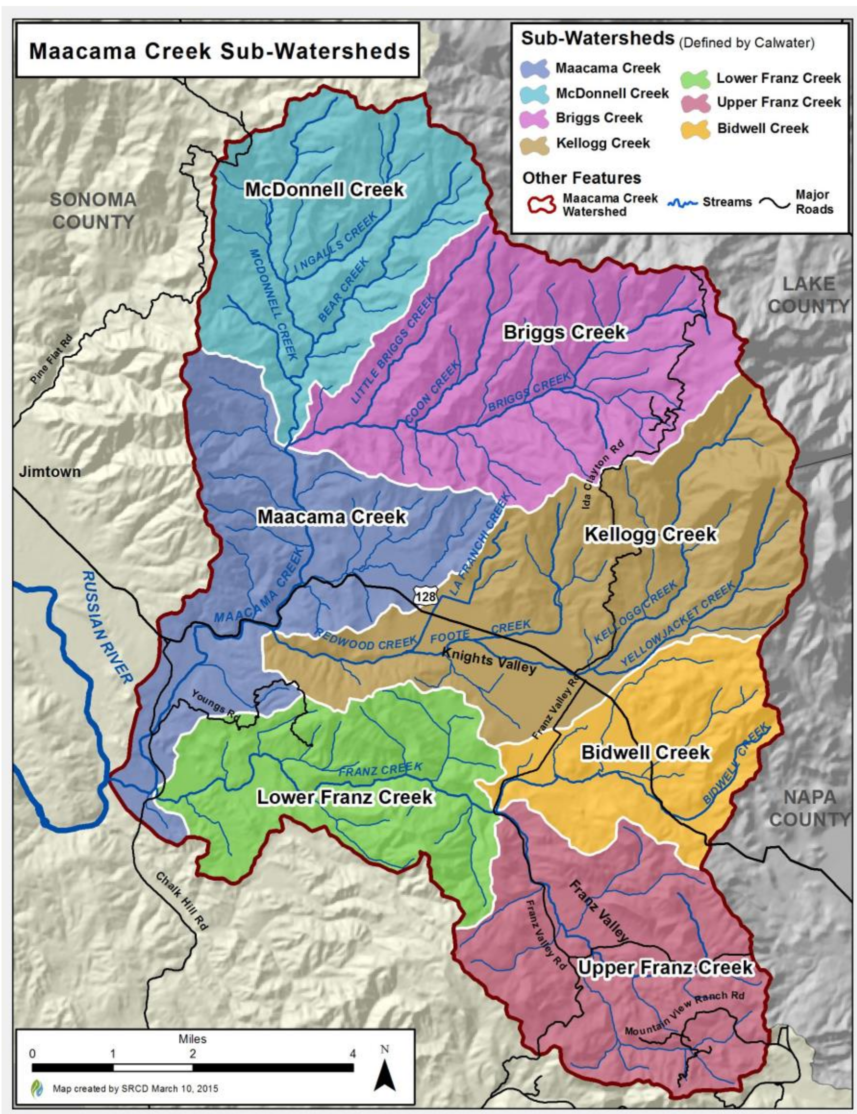


Table 2.1 Sub-basins of the Maacama Creek watershed (as defined by CalWater)

CalWater Sub-basin	Watershed Area (sq. mi.)	Primary Stream Length (miles)	Unnamed Tributary Length (miles)
McDonnell Creek [a]	9.52	13.42	9.46
Briggs Creek [b]	12.39	13.53	20.5
Kellogg Creek [c]	13.71	18.1	13.39
Maacama Creek	10.54	7.1	19.5
Bidwell Creek	6.14	4.84	7.62
Upper Franz Creek [d]	9.54	5.15	14.57
Lower Franz Creek	7.86	5.6	14.1
Total Maacama Watershed	**69.7**		

a McDonnell Creek sub-basin includes Bluegum (1.47 mi), Bear (3.43 mi), and Ingalls (3.02 mi) Creeks

b Briggs Creek sub-basin includes Little Briggs (3.17 mi) and Coon (2.86 mi) Creeks

c Kellogg Creek sub-basin includes Yellowjacket (3.64 mi), Foote (2.82 mi), La Franchi (2.53 mi), and Redwood (4.49 mi) Creeks

d Upper Franz Creek encompasses the sub-basin of Franz Creek located upstream of the confluence with Bidwell Creek

The overall Mark West watershed drains approximately 57 square miles of land, and includes approximately 27 miles of blue line streams. Mark West Creek joins the Laguna de Santa Rosa about five miles upstream of the Laguna's confluence with the Russian River.

Although not an official designation, the SRCD breaks Mark West into upper and lower watershed areas roughly at the Mark West Spring Lodge, along Porter Creek Road due to a change in the geology, hydrology, degree of urbanization, and ecology between these areas. The Upper Mark West watershed encompasses 34 square miles of the watershed and includes the upper reaches of Mark West Creek, as well as Humbug, Mill, Porter, Van Buren, and Weeks Creeks, and many smaller tributaries. Table 2.2 lists the primary sub-basins of this watershed and their respective size and Figure 2.4 shows the boundaries of the sub-watersheds.

Figure 2.4 Upper Mark West Creek sub-watersheds

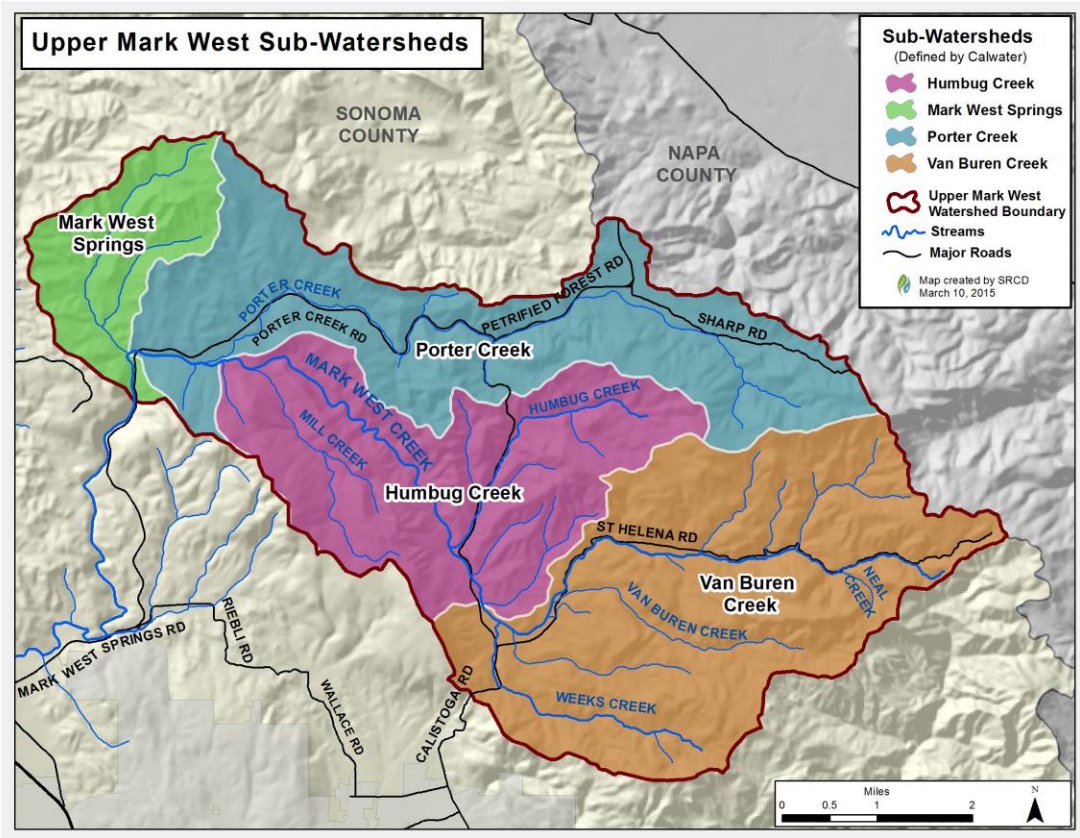


Table 2.2 Sub-basins of the Upper Mark West Creek watershed (as defined by CalWater)

CalWater Sub-basin	Watershed Area (sq. mi.)	Primary Stream Length (miles)	Unnamed Tributary Length (miles)
Mark West Springs Creek [a]	3.03	-- [d]	--
Humbug Creek [b]	8.45	3.25	--
Van Buren Creek [c]	12.4	6.4	--
Porter Creek	9.73	8	--
Total watershed	**33.61**		--

a Mark West Springs Creek sub-basin includes Horse Hill Creek (3.4 mi)

b Humbug Creek sub-basin includes Mill Creek (2.3 mi)

c Van Buren Creek sub-basin includes Weeks Creek (3.4 mi)

d -- : Data was not readily available

The landscape across both watersheds consists of a mosaic of different habitat types including chaparral, coniferous forest, hardwood forests, grasslands and riparian habitat with varying elevations. The landscape topography within the Maacama watershed ranges from 140 feet at the confluence of Maacama Creek and the Russian

River up to 4,343 feet at Mt. Saint Helena Peak. Elevations within the Upper Mark West watershed range from about 440 feet at the confluence with Horse Hill Creek up to about 2,200 feet at the headwaters in the Mayacamas mountain range. Both watersheds are located within the Russian River watershed Hydrologic Unit and the Middle Russian River Hydrologic Sub-Basin, as classified by CalWater 2.2a.

CULTURAL RESOURCES

The Maacama and Upper Mark West watersheds are rich in historic cultural resources. The Maacama watershed was once home to the Ash-o-chi-mi tribe, also called the Wappo people, who lived in villages mostly near streams, and subsisted as hunter gatherers. Wappo territory was bordered by the Coast Miwok and Pomo peoples. Because of their location, the Wappo had access to both obsidian and shells, which were very valuable trade commodities. Their extensive processing of these materials into trade goods left behind many artifacts in this watershed.

The Wappo used two primary trails for their travel – one that extended from Knights Valley over the Ida Clayton Ridge on the east and along the Russian River Valley on the west and another that extended from Napa Valley on the south through Knights Valley and to the Alexander Valley/Geysers area on the north.

The Upper Mark West watershed was occupied by three tribal units of the Southern Pomo – the Kataictemi, the Konhomtara, and the Bitakomtara (Leonard Charles and Associates, 2013). The Bitakomtara occupied the area east of Laguna de Santa Rosa, roughly from Cotati to Mark West Creek, Porter Creek, and to the east in the Mayacamas Mountains (Leonard Charles and Associates, 2013). The Pomo settlements typically consisted of large, permanent villages with nearby seasonal camps and task-specific sites. Although no permanent village sites have been documented within the Upper Mark West watershed, evidence of tribal activity (such as bedrock mortars) has been observed along Porter Creek.

The Wappo and Pomo people were heavily impacted by Mexican colonization, the Gold Rush, and the influx of settlers following the passage of the Homestead Act. By the 1900 census, the Wappo population had declined from an estimated 1,000 in 1770 to less than 100 within this area. According to one local newspaper account, all members of the Wappo tribe had left Knights Valley by 1872 (Russian River Flag, 1875).

HISTORY

<u>Maacama Watershed</u>

As part of the Mexican era, Knights Valley and Franz Valley were part of the 17,740-acre Rancho Mallacomes, or Moristal y Plan de Agua Caliente, granted to Jose Santos Berryesa in 1843. Berryesa built an adobe home in Mallacomes Valley and used the area as a hunting preserve. Following California statehood, Berryesa sold his Rancho to several different Americans. Thomas Knight purchased 8,328 acres of Berryesa's land for $10,000 in 1853 and eventually Mallacomes Valley was renamed Knights Valley. Following the purchase, Thomas Knight planted vineyards, peach and apple orchards, and wheat on the valley floor. Knight also built a sawmill on Kellogg Creek. Berryesa also sold a portion of his rancho to William Eliot. Eliot's land encompassed most of Franz Valley.

In 1861, Calvin Holmes purchased a large area of Knights Valley. Holmes and his wife, Emma, built a large Victorian mansion in the valley that still stands today, planted wheat in the valley and grazed sheep in the hilly grasslands. Holmes also grew winegrapes that were hauled to Napa Valley Vintner, Charles Krug. Agricultural operations gradually developed in other areas of the valley and included properties such as the McDonnell Ranch, with 2,000 acres of hay, corn, vegetables, orchards and cattle and the Steele Brothers, who ran a 7,000-acre ranch that produced hay, wheat, barley, and corn. The McDonnell Ranch was also known for its recreational uses, such as fishing and bathing in its year-round creeks. The Steele Brothers also operated a water-powered lumber mill in the valley most likely on Briggs, Kellogg or Yellowjacket Creeks. Many of the creeks in the Maacama watershed are named for these early settlers.

In what became known as Franz Valley, William Eliot attempted to operate a water-powered grist mill and raise wheat in the valley. However, water flows were insufficient on Franz Creek to power the mill. The next set of owners, Blair and Woods, logged all of the redwoods from the valley and surrounding hills in the 1850s. The Franz family purchased the valley in 1857, built a home and brought in cattle.

One of the largest industries in this area in the 1870s through early 1900s was mining. Knights Valley, western Lake County and northern Napa County were part of the Mayacamas Mining District, the second largest in California, with a focus on quicksilver or mercury production. The largest mine in the region was the Great

Western Mine, located on the Sonoma County/Lake County line, partly in the headwaters of the Maacama Creek watershed. The Great Western Mine opened up in 1873 and operated until 1909 (California State Mining Bureau 1918). The Great Western Mine included extensive tunnels and shafts extending to a depth of 750 feet and was reached from Knights Valley and Kellogg by the Ida Clayton Road.

The development and operation of a mine as large as the Great Western Mine involved a number of resources. The mine shafts and underground workings were constructed with large timbers from coniferous trees, which likely came from the Maacama Creek watershed as most of the local coniferous forest is uphill from the Great Western Mine (Marcus/Sotoyome RCD, 2004). This sawmill is likely to have been located on upper Briggs Creek, which is also named Mill Stream on some maps. The Great Western Mine operated its greatest number of furnaces in the 1880s. Over this operation period, an average of 5 to 10 million tons of ore per year were mined, burned and dumped, requiring thousands of large timbers and close to 100,000 cords of wood. Mercury frequently escaped the furnaces in the fumes and remained in the slag, affecting local vegetation.

While the Great Western Mine was the largest mine near the Maacama Creek watershed, the Helen, Mirabel and other mines were located in close proximity and likely also harvested timbers and cordwood in the Maacama watershed. In addition, two mines in the Kellogg area, the Yellowjacket and Ida Clayton (also named the Oakland Mine) operated for a number of years and required timbers and cordwood. The effects of mining, combined with logging for other uses, land clearing for grazing and growing crops would have created the first major human-made changes in the Maacama Creek watershed (Marcus/Sotoyome RCD, 2004).

Another major vegetation shift, in the vegetative composition in grassland areas, has occurred since European settlement. The Spanish began grazing cattle in this area in the early 1800s. The native perennial bunchgrasses that would have typically grown within the Maacama Creek watershed do not respond well to intense grazing. Over time, annual European grasses introduced with cattle grazing replaced the perennial natives. These two types of grasses are fundamentally very different. Native perennial grasses are adapted to California's summer drought with dense and deep root systems and summer dormancy and bunchgrasses form a thick mat on hillsides and provide a high level of soil erosion control. By contrast, the European grasses are annuals that germinate with the first rains, grow quickly, flower, set seed and then die back during the summer drought. The annuals have a less vigorous root system due to their short life cycle (Marcus/Sotoyome RCD, 2004).

Upper Mark West Watershed

William Marcus West was granted 6,663-acres of land in the late 1800's by his cousin-in-law, General Mariano G. Vallejo, between Mark West and Santa Rosa Creeks (Leonard Charles and Associates, 2013). When West arrived in this area, he established a hacienda, post office, trading post, and developed Mark West Springs as a resort destination (Leonard Charges and Associates, 2013). In the mid-1800s, the local economy in this area was significantly dependent on mining of silver and mercury, agriculture, and hot springs located around Calistoga.

Around 1850s, reports of gold in the Russian River brought a new influx of new settlers into this area (Leonard Charles and Associates, 2013). However, the search for gold quickly dissipated and more focus was directed to mining quicksilver, which was abundant in smaller mines throughout the Mayacama Mountains, as noted above.

Historical Notes by Calvin Ares (1973), Pomo, highlight additional details about the interaction of Native Americans and early settlers in Upper Mark West watershed:

"Since human life is dependent on water, people have settled along streams where there is an abundance of plant and animal life. So it was with the Mark West Creek.

The first known people to live along the Mark West Creek were the Southern tribe of the Pomo Indian Nation, who called the creek "Potiquiyome." Each tribal group depended on the plant and animal life in an area covering 1 or 2 watersheds. During this time, the creek remained virtually unchanged. The few Pomo people living in the watershed led a simple life, using few resources and wasting very little. We, in this century, have much to learn from this early way of life.

When the white settlers came they brought a different culture, based on private ownership of land and water and we began to exert a very different influence on the creek. In 1890 the Spanish Governor of California granted 6,660 acres along the creek to a man named Mark West. Here, with abundant water and fertile soil, Mark West established a rancho where he grew wheat, barley, corn and beans, built a grist mill and raised cattle for meat and hides. Most of the Indians were pushed to the rugged hills or died of diseases that the white settlers brought. The remainder were coerced into working on the rancho. Logging was done on nearby hills to provide lumber for the growing Bay area. Remains of huge redwood stumps along the creek indicate that at one time there were dense forests along the creek. Clearing fields for crops and lumbering began to effect the quality of the creek.

The Gold Rush brought many people to California and some settled in the Mark West Creek area. Many of the stone walls and the original Porter Creek road were built by Chinese laborers who emigrated during this time.

The Homestead Act of the 1860's brought more people to the area where they took up farming and grazing. In the upper watershed sheep and cattle were grazed. In the lower watershed orchards, vineyards and hops were planted and the land use patterns that we see today took root. During the early part of the last century the creek was very different from what it is today. People who have lived along the creek for 50-60 years tell of deep swimming holes that have long since disappeared. The fish were so thick, they say, you could walk across their backs. Some people attribute the cause of the changes in the creek primarily to road building. Others believe that all the water being pumped out for both the irrigation of grapes and home use is drying up the creek. Prunes, which were the major crop for many years, didn't require the heavy irrigation that grapes now require. In Post WWII Years, agriculture has given way to increasing residential development."

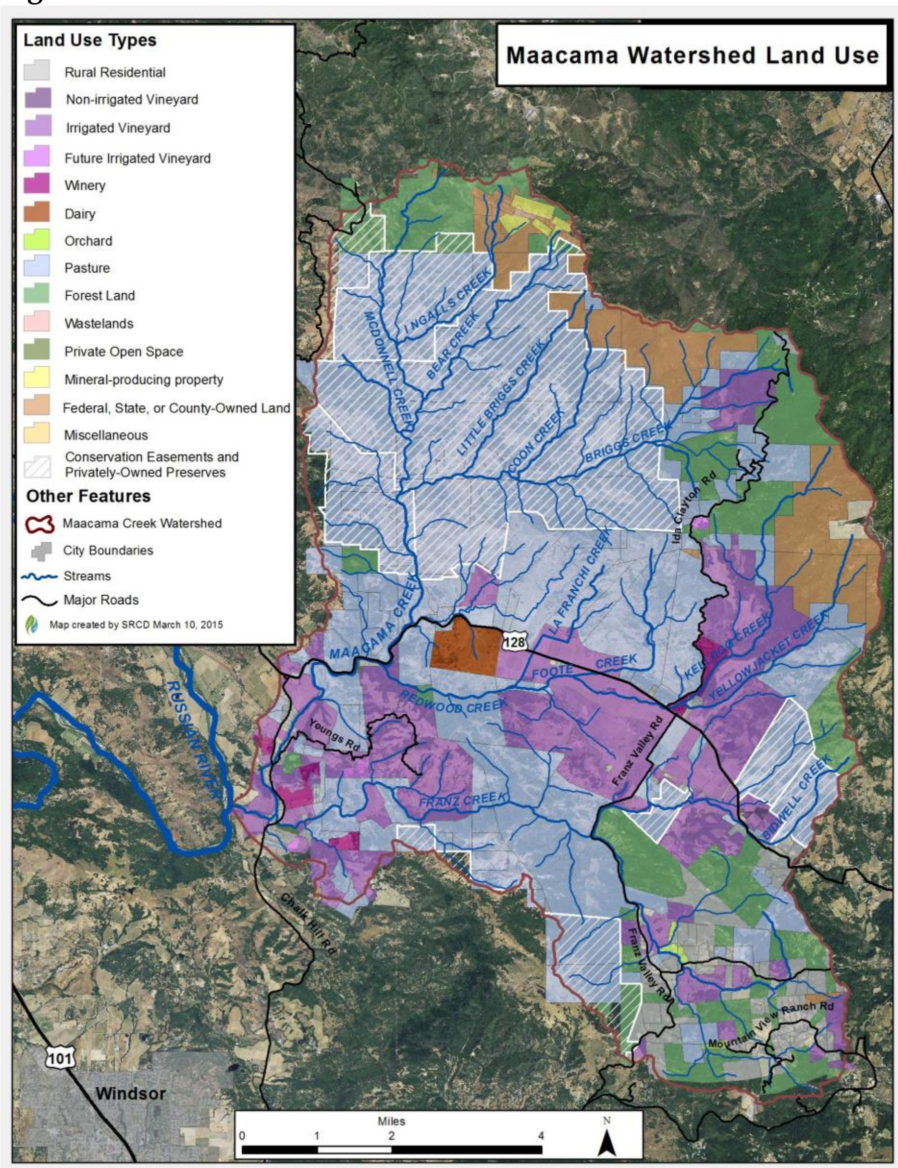
LAND USE

Both the Maacama and Upper Mark West watersheds are dominated by rural and agricultural land, most of which is privately owned (greater than 90% of each watershed). Both watersheds also contain multiple open space properties owned by either state or federal entities as well as fee title or easement properties held by the Sonoma Land Trust, the Sonoma County Agricultural and Preservation Open Space District, and the Audubon Canyon Ranch that have some, but limited public access (refer to Land Use maps below).

The Upper Mark West watershed includes other lands with recreational and educational opportunities through the Pepperwood Preserve, Land Paths, Safari West, and the Mayacamas Golf Club. Also, in Upper Mark West watershed, the Sonoma County Regional Park is expected to take ownership in 2015 of several parcels currently held by the Sonoma County Agricultural and Preservation Open Space District that will be open to the public for recreational use. There are no incorporated cities or towns within either watershed.

The Knights and Franz Valleys, located within the Maacama watershed, have been occupied by agricultural properties encompassing vineyards and cattle ranching since the late 19th century. Many parcels in Maacama Creek watershed and particularly in the upper portions of the watershed have a long history of ranching and have been passed on in that land use through multiple generations on one family.

Figure 2.5 Land uses in the Maacama watershed



*Data shown is based on Sonoma County land use records from 2014

As shown in Table 2.3 below, among current land uses in this watershed, nearly half is categorized as grazing/rangelands. Vineyards occupy approximately 20 percent of the Maacama watershed. Rural residential land use encompasses only 5 percent of the Maacama Creek watershed and is predominantly concentrated in the Upper Franz Creek area and around lower Maacama Creek. Figure 2.5 shows the distribution of land uses across this watershed.

Table 2.3 Current watershed land uses (by acreage and percent of watershed area)

Land Use	Maacama Creek Watershed		Upper Mark West Watershed	
	acres	%	acres	%
Agricultural	32,917	74%	7,358	34%
Vineyards	8,872	20%	1,214	6%
Grazing/Rangelands	23,646	53%	6,009	28%
Forest Land	5,539	12%	7,461	35%
Rural Residential	2,134	5%	4,828	22%
Total Watershed Area	44,644 acres (appx 69 mi)		21,507 acres (appx 34 mi)	

*Data shown is based on Sonoma County land use records from 2014

Agricultural acres include vineyards acres plus grazing acres, orchards, and livestock operations

Vineyard acres include vineyards (irrigated and non-irrigated), wineries with vineyards, and land being converted to vineyards

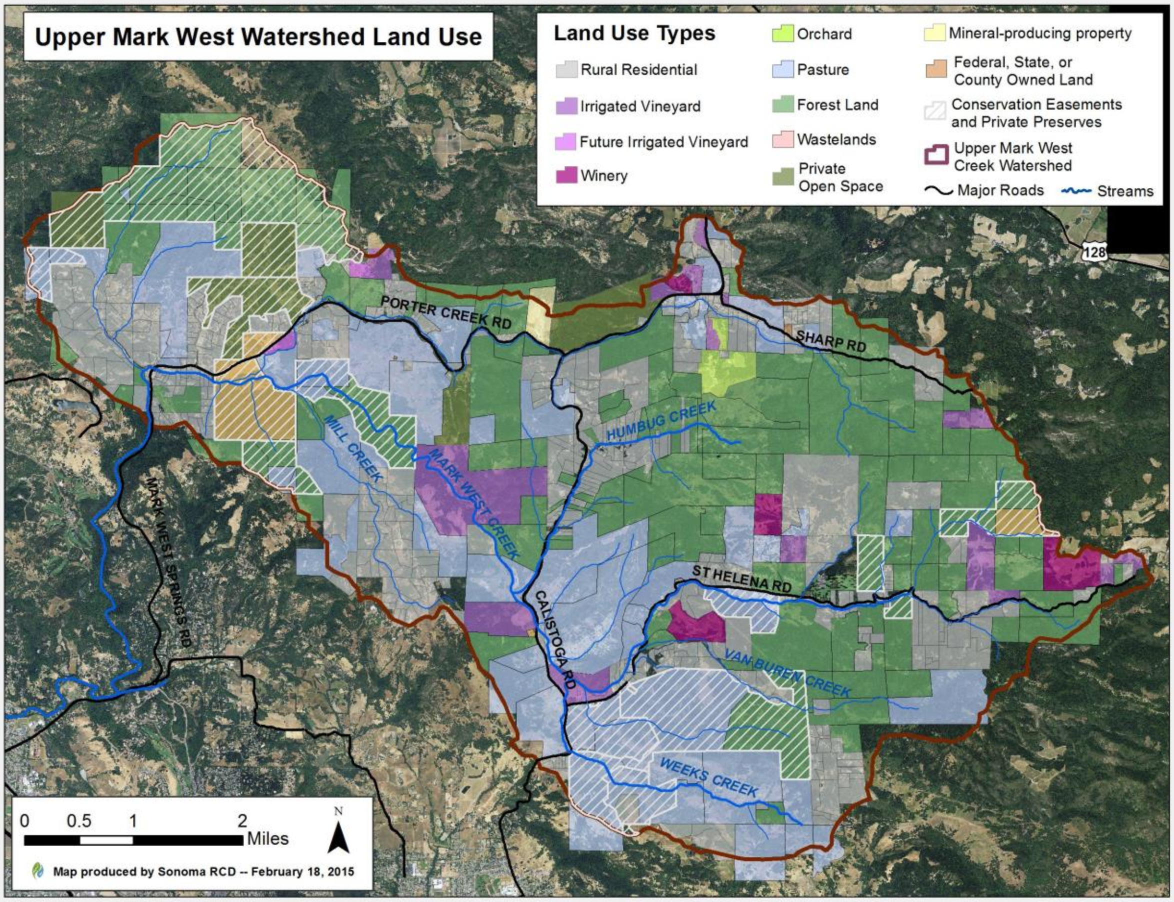
Grazing acres include land designated as pasture

Forest Land acres include land designated as Hardwoods and Chaparral

Rural Residential acres include land designated as rural residential or single-family dwelling

During the late 19th century, land uses in the Upper Mark West watershed were largely focused around ranching and timber harvest. These land uses are still in place today, though to a lesser degree. Agricultural properties encompass 74 percent of the Maacama Creek watershed and 34 percent of the Upper Mark West watershed. Consistent with trends throughout the county, vineyard development also increased over the latter part of the 20th century. Today's land use patterns include high occurrence of forest and chaparral (35 percent of the overall land use) and rural residential properties (22 percent). Rangeland and vineyard land uses are more limited, as compared to the Maacama watershed, occupying nearly 30 percent and 6 percent of the watershed, respectively. The distribution of land uses across the Upper Mark West watershed are shown in Figure 2.6 below.

Figure 2.6 Land uses in the Upper Mark West watershed



*Data shown is based on Sonoma County land use records from 2014

A distinguishing feature of the Maacama watershed is the frequency of larger parcels (100 acres or greater) that have not been sub-divided, particularly in upper portions of this watershed. These large land holdings are unique to the Maacama Creek watershed area and can provide valuable opportunities for habitat enhancement due to the lack of fragmentation. The Sonoma County General Plan designates much of the Maacama Creek watershed for resources and rural development with 200- and 320-acre minimums in the upper watershed and 120-acre minimums in the lower watershed. Franz Valley area is designated for both land intensive agriculture, diverse agriculture with 40- or 100-acre minimums and rural residential with 20- and 30-acre minimums. Other areas along Franz and Maacama Creeks are designated for land intensive agriculture at 20-acre minimums. Both hillside vineyard and rural residential developments are allowable under most of the designations for most areas of the watershed. Table 2.4 below shows the distribution of parcel sizes within Maacama watershed.

Although there are some larger parcels in the Upper Mark West (56 parcels with total area greater than 100 acres), two-thirds of the parcels within this watershed consist of smaller (less-than 10 acres) properties that predominantly consist of rural residential or forest land uses. The majority of the Upper Mark West Creek watershed is designated for rural residential, with 1- to 20-acre minimums. Other areas within the watershed are designated for resources and rural development with 20- to 320-acre minimums and for diverse agriculture, with 10- to 60-acre minimums. Many of the smaller residential parcels in the Upper Mark West watershed are located along major streams, which can pose challenges for implementing restoration projects on a large scale.

Table 2.4 Parcel size distribution in Maacama and Upper Mark West watersheds

	Number of Parcels	
Parcel Size (acres)	**Maacama Creek Watershed**	**Upper Mark West Watershed**
0 - 10	206	652
10 - 20	100	130
20 - 50	138	124
50 - 100	64	58
100 - 200	57	37
200 - 500	35	19
> 500	16	0
> 1,000	4	0

*Data shown is based on Sonoma County land use records from 2014

GEOLOGY

Geologically, Sonoma County is bisected by the San Andreas Fault. To the west, on the tip of Bodega Head, are ancient continental rocks formed far to the south and moved north at least 335 miles by the fault. To the east of the fault lies the Franciscan Complex; oceanic rocks mixed by faulting as ocean floor slid east under the edge of the continent. Both areas are covered by a thin mantle of more recent rocks formed in shallow seas, beaches, volcanoes and rivers. Recent sharp uplift and ongoing river erosion has sculptured the scenery (Wright 1998).

Maacama Creek Watershed Geology

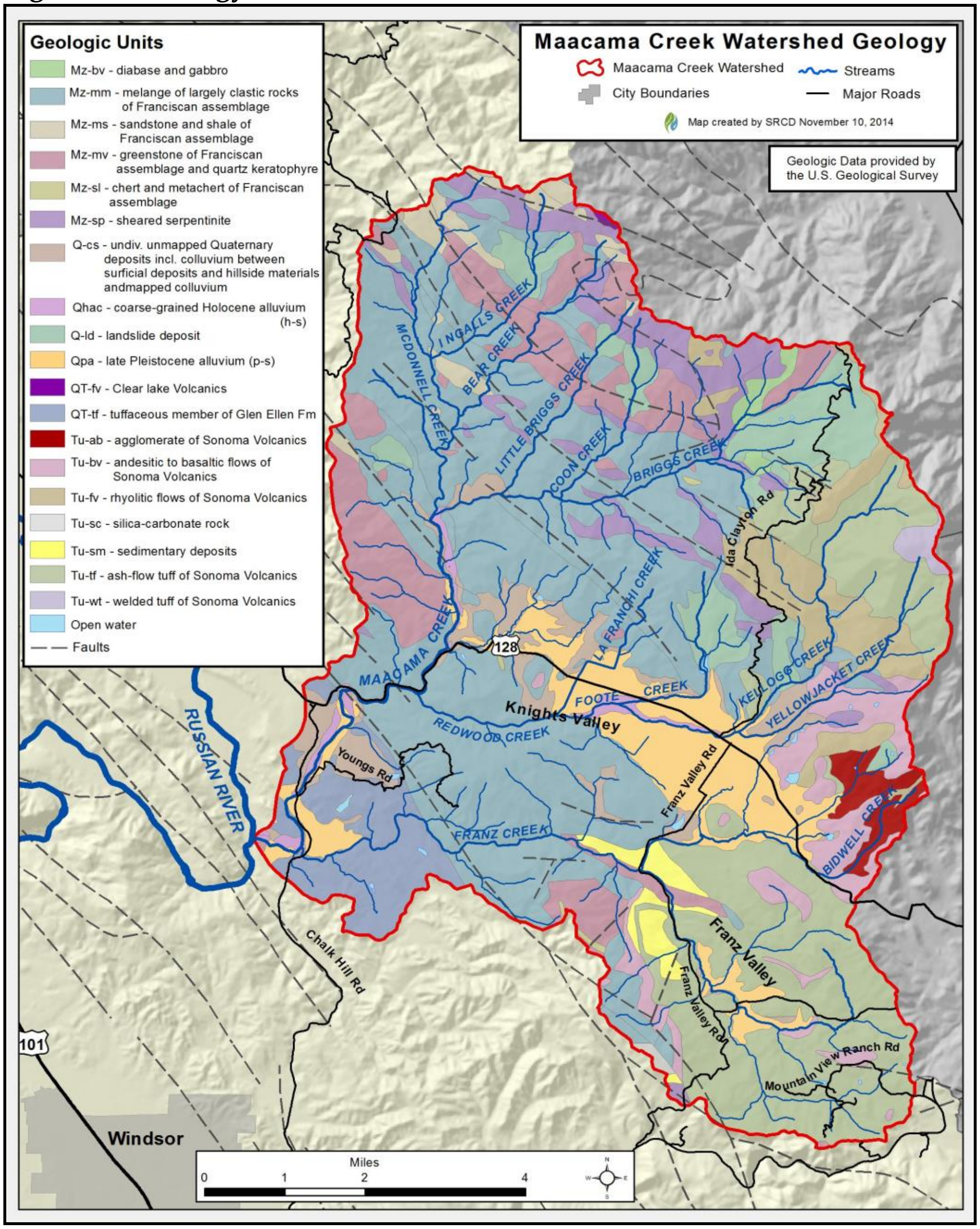
Within the Maacama watershed the Maacama Fault system dissects the watershed. The northern section of the watershed, encompassing Briggs and McDonnell Creek, consists of Franciscan Formation with outcrops of ultramafic serpentine rock and is marked by a series of unnamed faults. Redwood Creek and its tributaries Kellogg and Yellowjacket Creeks, and Franz Creek and its tributary Bidwell Creek, drain a watershed area of Franciscan Formation, Sonoma Volcanics, as well as the alluvium of Knights and Franz Valleys. The Glen Ellen/Huichica Formation occurs on the western area of Franz and Maacama Creek watersheds. Figure 2.7 shows the distribution of geologic formations across the watershed.

The Franciscan Formation is former ocean floor that has been uplifted and deformed from tectonic activity along the coastal ranges. Franciscan Formation is a heterogeneous mixture of different rock types within a matrix of clay and silt. This mixture is often termed the Franciscan Mélange. Franciscan Formation is known for its shattered rocks, high levels of instability and extreme landslides. Franciscan Formation is the basement rock for much of the Maacama Creek watershed and dates from 150 to 195 million years ago.

Sonoma Volcanics lies on top of the basement of Franciscan Formation. Sonoma Volcanics dates to 3 to 8 million years ago during a period of active volcanism. Sonoma Volcanic rock was created by a volcanic field stretching towards Fairfield and north of Calistoga, encompassing 300 square miles. This area of active volcanism has now moved north to the Geysers and Clear Lake Volcanics. The Sonoma Volcanic Formation is made up of basalt and andesite lava flows along with ashflow tuffs. Sonoma Volcanics are not as landslide-prone as Franciscan Formation and often contain springs.

Ultramafic serpentinized rock occurs along faults in the watershed. Serpentine rock typically is extruded along fault lines. Serpentine soils have very high levels of magnesium and low levels of calcium. Only specialized plants species are able to grow on serpentine soils.

Figure 2.7 Geology of the Maacama watershed



Glen Ellen/Huichica Formation is a relatively young formation on top of the Franciscan Formation basement. Glen Ellen/Huichica Formation consists of sandstone, siltstone and pebble conglomerate deposited by streams and rivers and later uplifted by tectonic activity. The Glen Ellen/Huichica Formation is shallow, easily eroded and landslides are often present.

The main stem of Maacama Creek crosses the Maacama Fault near its confluence with Redwood Creek. Both Maacama and Franz Creek show clear lateral displacement along the Maacama Fault. This fault creates a divide between the

Franciscan Formation and the Glen Ellen/Huichica Formation in the downstream area of the watershed.

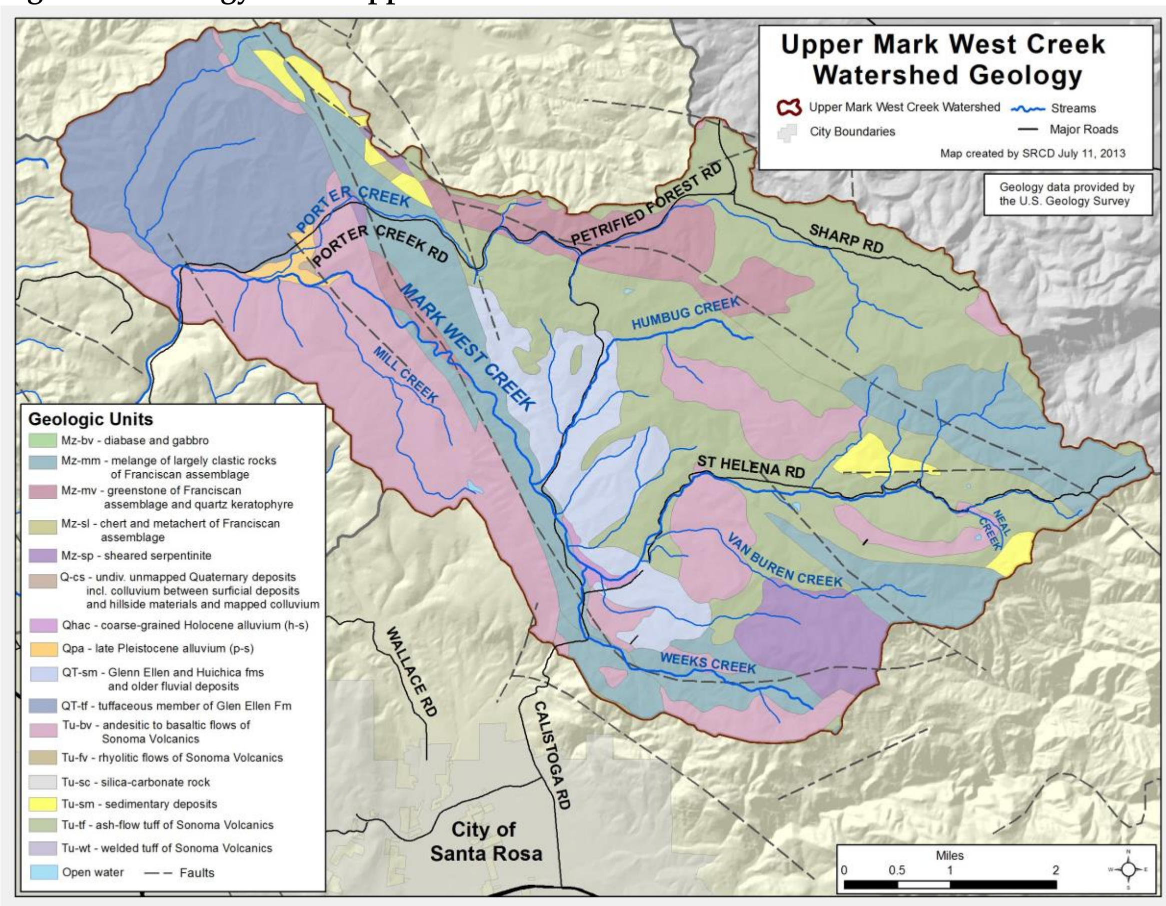
The Franz and Knights valley, which are major features of the Maacama Creek watershed, both follow the northwest/southeast alignment of the Maacama fault zone (see Figure 2.7 for fault line distribution). Knights Valley is a pull-apart basin similar to the Alexander Valley to the northwest and to the Calistoga Valley to the southeast. Note that the Alexander Valley, Knights Valley and the Calistoga Valley are all on a northwest-southeast trending line that is roughly parallel to the San Andreas Fault system. This line of pull-apart basins cuts across the Maacama Creek watershed dividing it into three different physiographic regions.

The Maacama Fault is one of the numerous faults associated with the San Andreas riff zone and numerous accounts highlight the effects of the 1906 earthquake on the Maacama Fault. The epicenter of the 1906 earthquake was located in the Point Reyes area on the San Andreas Fault and caused a massive landslide on Maacama Creek where it crosses the Maacama Fault.

Upper Mark West Creek Watershed Geology

The geology of the Upper Mark West watershed is comprised of the Coastal Belt Franciscan Complex, Glen Ellen Formation, and Sonoma volcanics. The Coastal Belt Franciscan Complex consists of undifferentiated and erodible mélange, with large blocks of varying lithology. These blocks result in the common rolling hill topography observed across this watershed. The Glen Ellen Formation is highly erodible due to the unconsolidated nature of the fluvial and lacustrine sediments that comprise it (PWA, 2008). Figure 2.8 shows the distribution of geologic formations across the watershed.

Figure 2.8 Geology of the Upper Mark West watershed



According to the United States Geological Survey (USGS), the Mark West area is underlain by Mesozoic rocks of the Franciscan Complex, the Coast Range ophiolite, and the Great Valley sequence, considered here to be the pre-Tertiary basement of the northern Coast Ranges. These rocks are overlain by a complexly interstratified and mildly to moderately deformed sequence of Pleistocene to late Miocene marine and non-marine sedimentary and largely sub aerial volcanic rocks. These rocks and unconformably overlying, less-deformed Holocene and Pleistocene strata are cut by the active right-lateral Healdsburg and Maacama Fault Zones (McLaughlin et al, 2004).

SOILS

A review of the Sonoma County Soil Survey found a variety of soil types in the Maacama and Upper Mark West watersheds (see Figure 2.9 and 2.10, respectively). The erosion hazard ratings are moderate to high for many of the soils in these watersheds and runoff is medium to rapid. Soil erosion ratings maps and reports were generated through the United States Department of Agriculture (USDA) Web Soil Survey website and are provided in Appendix A.

Figure 2.9 Soil types in the Maacama watershed

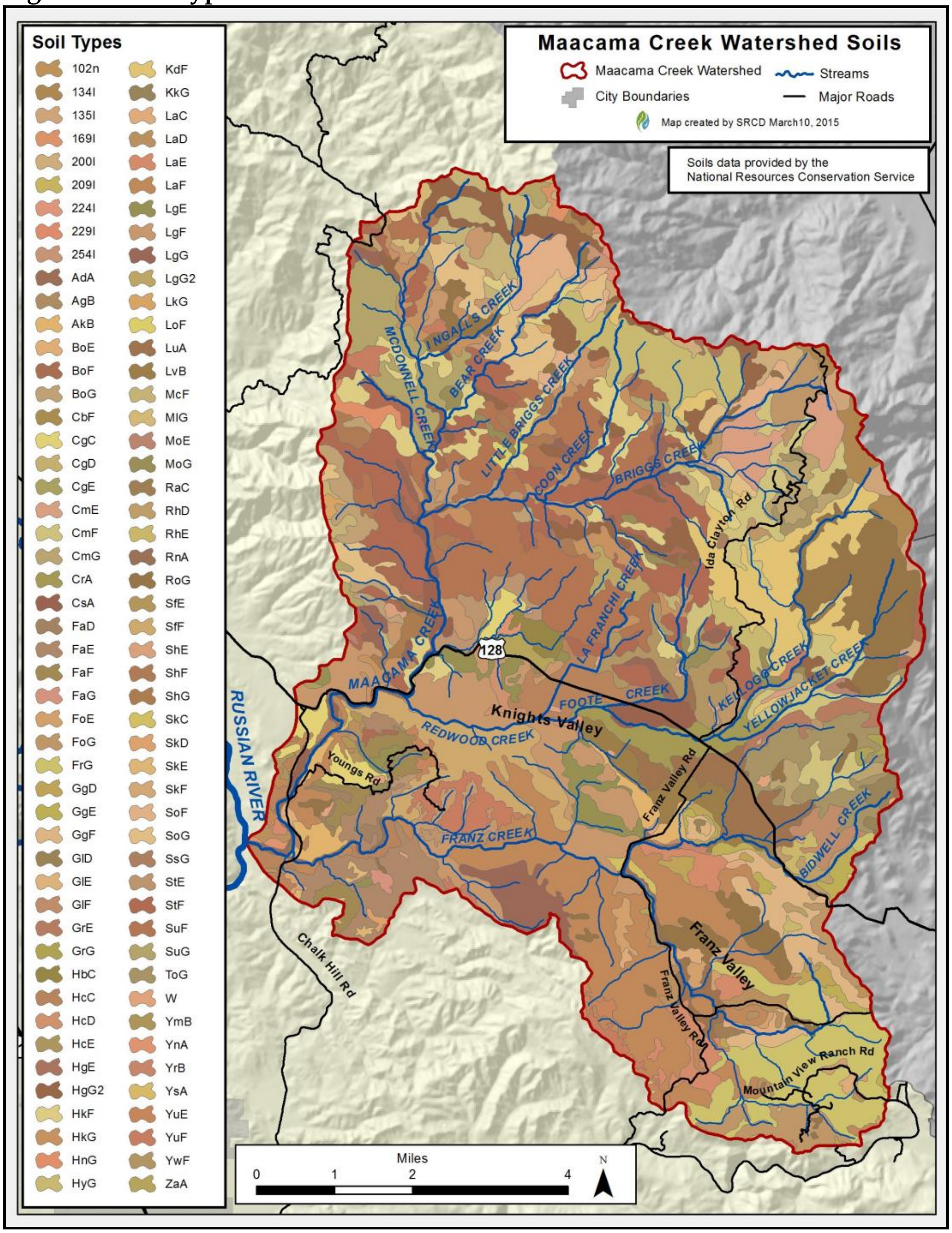
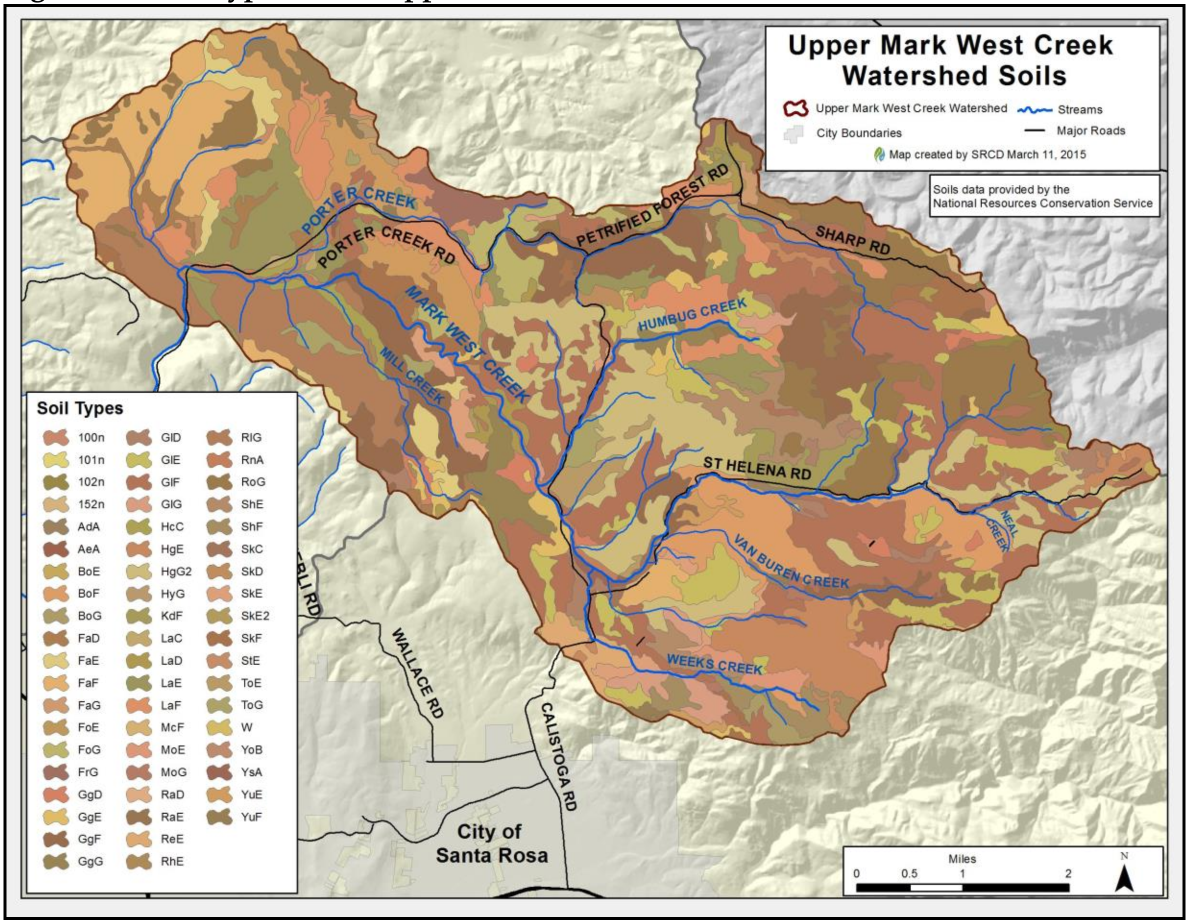


Figure 2.10 Soil types in the Upper Mark West watershed



FISH AND WILDLIFE

Habitat for fish and wildlife in both watersheds has been relatively impacted by the history of timber harvest and land development. Only a small portion of the forest remains as old-growth habitat, and stream habitat for fish has been degraded through contributions of sediment and reduction in stream flows due to an increased water demand for other uses. However, these watersheds provide habitat and breeding grounds for a variety of important species, some of which are threatened or endangered due to habitat loss and impairment.

Threatened and Endangered Species

In California, special-status plants and animals include those species that are afforded legal protection under the federal and California Endangered Species Acts (ESA and CESA, respectively) and other regulations. Consideration of these species must be included during project evaluation in order to comply with the California Environmental Quality Act (CEQA), in consultation with State and federal resources agencies, and in the development of specific management guidelines for resource protection.

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. California Department of Fish and Wildlife (CDFW) also has the authority to list Species of Special Concern (SSC), which 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.

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. List 1A consists of plants presumed to be extinct in California. List 1B includes plants that are rare, threatened or endangered in California and elsewhere. List 2 consists of plants that are rare, threatened or endangered in California, but more common elsewhere. It is mandatory that species on lists 1A, 1B and 2 be evaluated in order to comply with CEQA.

Both the Maacama and Upper Mark West watersheds provide habitat for many species that are listed as threatened, endangered, species of special concern, and species listed on CNPS lists. A California Natural Diversity Database (CNDDB) search was completed for the Maacama and Upper Mark West watershed boundaries to produce a list of endangered animal and plant species located in these watersheds. A figure showing the distribution of animal and plant species listed on these lists is provided in Appendix B.

Aquatic Habitat

The Russian River watershed once supported a highly prized anadromous fishery that ranked only behind the larger Klamath, Eel and Sacramento River systems. The historic fishery included three species of salmon – coho (*Onchorhynchus kisutch),* Chinook (*O. tshawutscha),* and pink salmon (*O. gorbuscha*) as well as one of the world's largest populations of steelhead trout (*O. mykiss*). Pink salmon are now extirpated from the system while the coho salmon is listed as endangered and Chinook and steelhead are listed as threatened under the Federal Endangered Species Act. Although habitat within Maacama and Upper Mark West Creeks and their tributaries has historically been good for these species, the amount of good habitat, for both spawning and rearing, has been steadily declining.

In addition to coho, steelhead, and Chinook, other fish species using habitat within these watersheds include the sculpin (*Cottoidea*), California roach (*Lavinia symmetricus*), threespine stickleback (*Gasterosteus aculeatus*), Tule perch (*Hysterocarpus traski*), Sacramento sucker (*Catostomus occidentalis occidentalis*), bluegill (*Lepomis macrochirus*), fathead minnow (*Pimephales promelas*), pacific lamprey (*Lampetra tridentate*), sacramento pikeminnow (*Ptychocheilus grandis*), and hardhead minnow (Bauer, 2015).

The California freshwater shrimp (*Syncaris pacifica*) is a federally endangered species endemic to Marin, Sonoma and Napa Counties (US Fish and Wildlife Service, 1998). The shrimp, a native crustacean, currently occupies 23 coastal streams in this area including Bidwell Creek, a tributary to Franz Creek (US Fish and Wildlife Service, 2007) in the Upper Mark West Watershed. These shrimp are typically found in low elevation (less than 380 feet), low gradient streams (generally less than 1%) (USFWS 1998). The habitat usually consists of perennial freshwater or intermittent streams with perennial pools with undercut banks, exposed roots, and overhanging vegetation or woody debris.

Population declines of California freshwater shrimp have occurred due to many factors including deterioration or loss of habitat resulting from water diversion, impoundments, agricultural and rural development, flood control activities, timber harvesting, migration barriers, and water pollution.

A variety of amphibian and reptile species, including the state and federally listed CA red-legged frog (*Rana draytonii*) and the foothill yellow-legged frog (*Rana boylii*) and the specie of special concern, the northwestern pond turtle (*Actinemys marmorata marmorata*), depend upon natural and man-made ponds or reservoirs, small-pond depressional wetlands, low-gradient, low-velocity streams and riparian areas within these watersheds for breeding and rearing habitat. The non-native American bullfrog (*Lithobates catesbeianus),* also occurs in both watersheds and can be a direct threat to native amphibians. Diverse riparian areas also provide habitat for other state and federally listed species as well as migratory corridors for a variety of wildlife.

Status of Salmonid Populations and Habitat

Prior to 2010-2011, annual observations of returning coho salmon to the Russian River were under 20 fish. Since local biologists have been using pit tag estimates starting in 2010-2011, coho returns are annually in the low hundreds. Since 2011, increases in adult returns have correlated with the increased release of juvenile coho through the Broodstock Program but return numbers can also vary due to ocean conditions, weather patterns, and many other factors that affect survival. Also, although limited effectiveness monitoring has been conducted, there has been an increased effort by local agencies and stakeholders to implement habitat enhancement and flow recovery projects to improve coho survival. It is projected that, coho returns of approximately 10,000 is needed for a sustainable population in the Russian River (UCCE, 2015).

Maacama Creek and Upper Mark West watersheds both support populations of steelhead trout and coho and Chinook have been observed in the Maacama watershed in recent years. Specifically, evidence of Chinook spawning was documented in mainstem Maacama Creek in the winter of 2014-15 (UC Sea Grant), while coho salmon juveniles were observed in Redwood Creek in 2011 (brood year 2010 – UC Sea Grant). The presence of juvenile coho documented through UC Sea Grant snorkel surveys and SCWA's smolt trap indicate that coho adults returned to spawn in Mark West Creek in 2010-11, 2011-12 and in 2012-13 (UC Sea Grant).

There is increased effort and coordination between many resource agencies, watershed groups, landowners and stakeholders for increased monitoring in order to determine presence of these species and to strategically develop habitat enhancement projects in high priority stream reaches. Refer to Chapter 5, Instream and Riparian Habitat, below for further details on monitoring efforts and presence of salmonids.

Terrestrial Habitat

The Southern Mayacamas Mountains have been identified as an important zone of ecological convergence, extending along the northeast portion of the Maacama and Upper Mark West watersheds. This habitat zone connects to other important ecological regions and provides habitat and migratory paths for a variety of species (SCWA, 2010). Dense vegetation along riparian corridors is vital to promote migration, particularly of large animals, and measures should be taken to preserve these areas and enhance them to develop a more connected network of wildlife corridors. The current threats to habitat connectivity include fragmentation associated with urban and agricultural development, including fencing, replacement of native species by invasives and non-natives, disruption of natural water cycles, pollution of air and water, and the potential impacts of climate change (SCWA, 2010).

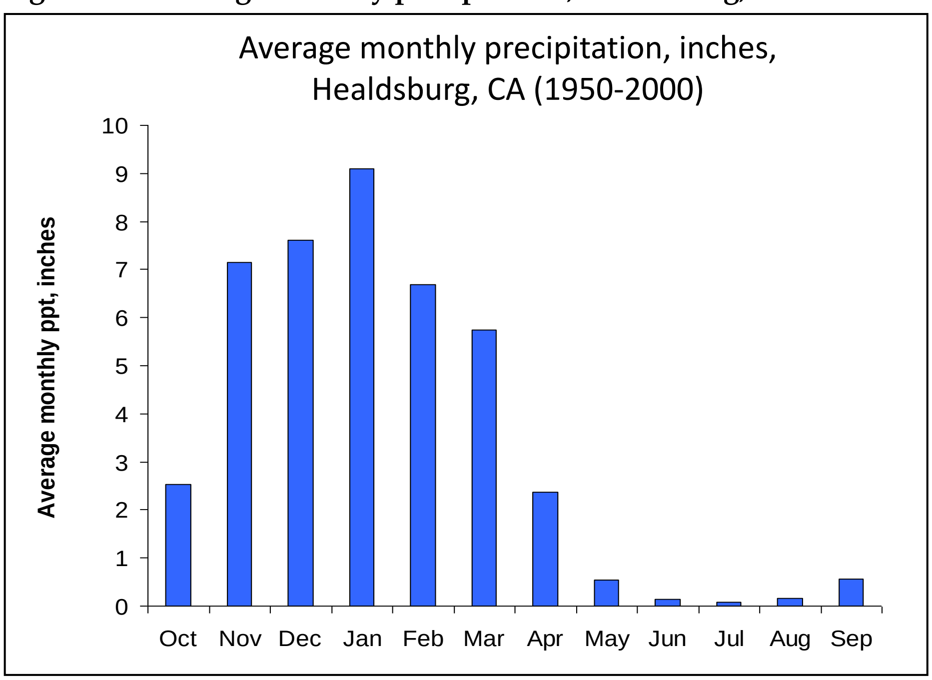
Because the forest habitat may provide limited complex structure or species diversity, affecting habitat niches, the number of species present and the number of individuals of most species may be limited. However, if appropriate habitat conditions are present, most wildlife species commonly found in coniferous forest in northwestern Sonoma County as well as oak woodland habitats, could be present in the Maacama or Upper Mark West watersheds or in adjacent watersheds.

WATER RESOURCES

Precipitation

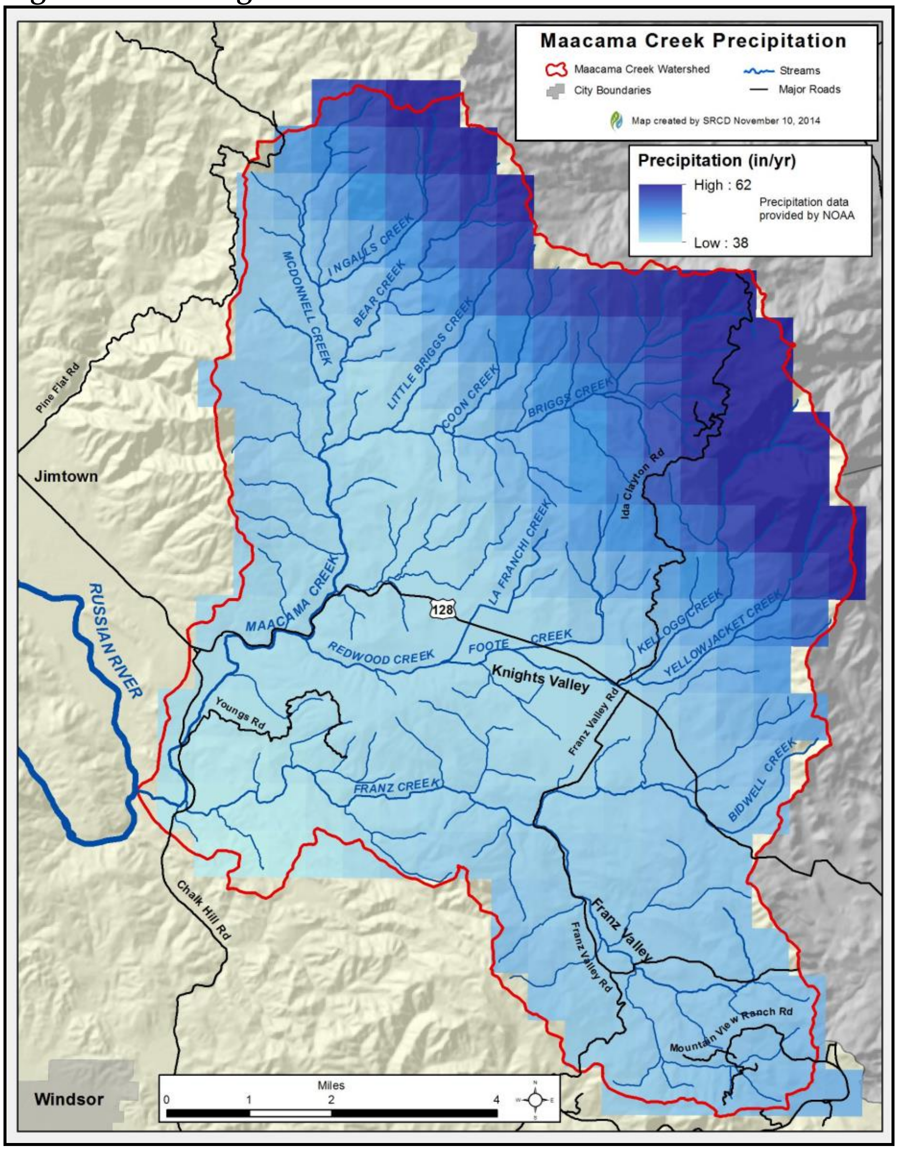
The climate patterns of the Maacama and Upper Mark West watersheds are characteristically Mediterranean with cool to warm, dry summers and cool, moist winters. Precipitation occurs almost exclusively as rainfall (i.e., snowfall is very rare) and mostly during wet winters. On average, 95% of annual precipitation falls in October through April, with only 5% falling in May through September (see Figure 2.11 below).

Figure 2.11 Average monthly precipitation, Healdsburg, California



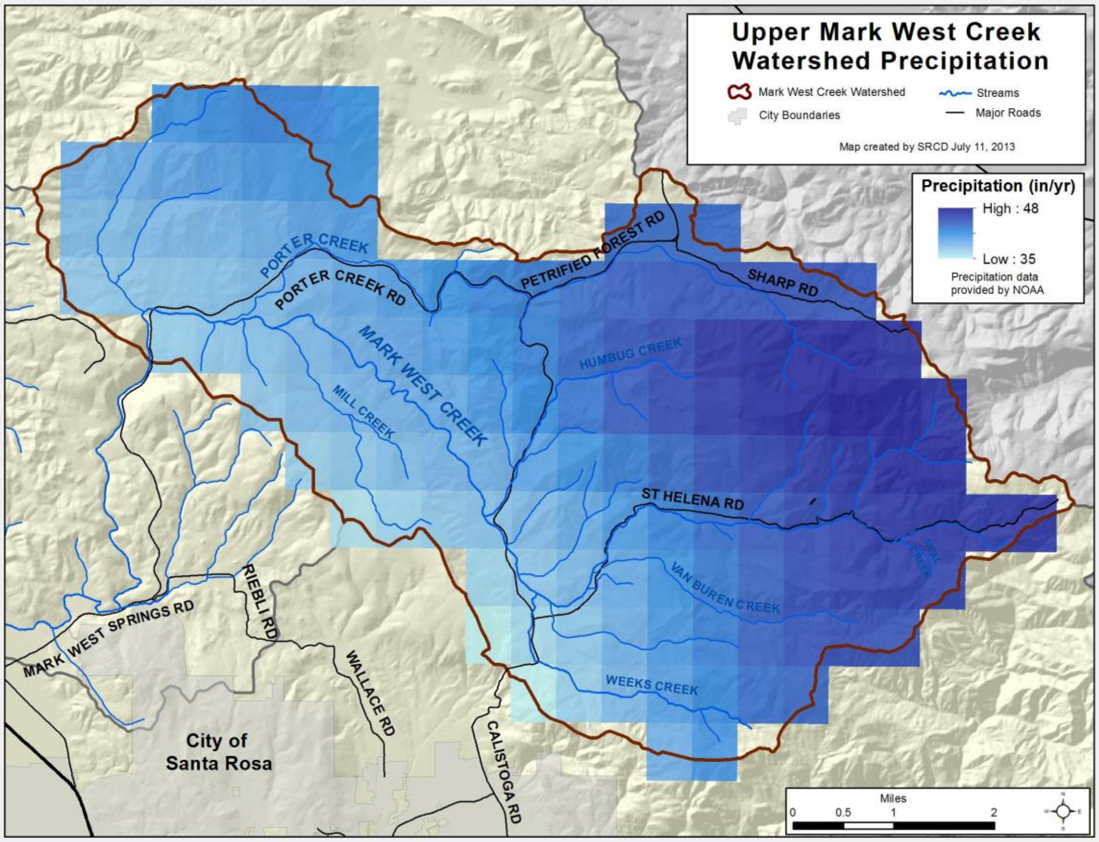
Precipitation amounts vary throughout these watersheds due to diverse topography and elevations and rainfall amounts are typically lower in the western area of these watersheds and higher in the more mountainous eastern parts.

Figure 2.12 Average annual rainfall in Maacama watershed



The PRISM spatial data set of rainfall (developed by Oregon State University, widely considered a standard for rainfall analysis in the Western United States) indicates that the average rainfall amounts across Maacama Creek watershed can range between 38 and 62 inches of rainfall in a typical year (see Figure 2.12).

Figure 2.13 Average annual rainfall in Upper Mark West watershed



The data indicates that the average rainfall amounts across Upper Mark West Creek watershed can range between 35 and 48 inches of rainfall in a typical year (see Figure 2.13).

Groundwater – Maacama Watershed

The Department of Water Resources (DWR) describes the Knights Valley groundwater basin, located in the lower portion of the Maacama Creek watershed, as follows:

> "The Knights Valley groundwater basin is a northwest trending structural depression in the Coast Ranges approximately 35 miles north of the San Pablo Bay. The Knights Valley groundwater basin averages approximately 6 miles in length from its northwestern boundary near the confluence of Briggs Creek and McDonnell Creek to its southeastern margin near the town of Kellogg. The basin is approximately one mile in width. Alluvial contacts with consolidated beds of non-water bearing sediments, of Jura-Cretaceous age generally form the basin

boundary (DWR 1975). Tributaries to the Russian River including Maacama Creek drain the Knights Valley groundwater basin. The annual precipitation ranges from less than 40 inches in the southwest to more than 44 inches in the northeast (USDA 1972).

Water Bearing Formations:

Younger Alluvium: The younger alluvium of Holocene age is the principal water bearing formation of the Knights Valley groundwater basin. It consists of unconsolidated deposits of clay, silt, sand, and gravel generally formed as floodplain deposits. lts total thickness ordinarily ranges from 30 feet to 150 feet (DWR, 1975). Well yields are usually adequate for most domestic uses and the water is generally of excellent quality (DWR, 1975).

Sonoma Volcanics: Isolated outcrops of the Sonoma Volcanics of Pliocene age are found at the valley margin to the south and southeast. The Sonoma Volcanics are composed of interbedded tuff, tuff breccia, agglomerate, andesitic and basaltic flow rocks. Yields are highly variable and unpredictable usually associated with fractures in the deposits (DWR, 1975).

Recharge Areas: Natural recharge occurs principally as infiltration from streambeds that exit the upland areas within the drainage basin and from direct percolation of precipitation that fails on the basin floor."

Groundwater-Upper Mark West Watershed

DWR includes the Upper Mark West watershed as part of the Santa Rosa Plain Groundwater Basin. Although the Glen Ellen Formation is an important groundwater source in the Santa Rosa Plain Groundwater Basin, its capacity to produce groundwater in the Upper Mark Creek Watershed is limited and most of the aquifers are within zones in the Sonoma Volcanics containing open and interconnected fractures (Giblin and Associates 2003a, USGS, 2014). The low permeability of the Franciscan Complex, which underlies the Sonoma Volcanics and Glen Ellen Formations, along with the two faults in the region, act as barriers to groundwater movement. Groundwater recharge, which is a function of the amount and intensity of rainfall, slope, and soil permeability, was estimated by Giblin and Associates (2003);

potential recharge area is limited to the area of volcanic rock and fractured inclusions within the Franciscan Complex. (SMPMP DRAFT, 2009).

The Franz Valley Specific Plan (SCCES, 1979) classifies the Upper Mark West watershed as an area of marginal water availability, and requires proof of water to build in some areas of the watershed. In 2000, the Sonoma County Permit and Resource Management Department hired Kleinfelder and Associates to prepare a pilot study of groundwater resources in several water-scarce areas of the county. One of these areas was within the middle Mark West watershed, bounded on the southwest corner by Mark West Springs Road 1 ¼ miles North of Highway 101, on the northwest corner by the intersection of Mark West Springs Road and Leslie Road, on the northeast corner near the intersection of Foothill Ranch Road and Wallace Road, and on the southeast corner at the southeastern edge of the Fountaingrove Golf Course.

The findings of this investigation concluded that availability of water in the aquifers of this area, composed primarily of fractured Sonoma Volcanics, is unpredictable (Kleinfelder, Inc. 2003). The study shows that depth to water in new wells increased by around 100% from the 1940s to the 1990s. However, there is a marked difference between this increase in depth to water and the 2000% increase in residential development over the same period. The researchers hypothesized that the effects of increased residential water demand in this area have been buffered by groundwater recharge. However, there was no evidence of water availability problems within the study area.

In 2012-2014 Stakeholders representing all aspects of the community developed a Groundwater Management Plan for the Santa Rosa Plain Groundwater Basin. The Plan, adopted by the County Board of Supervisors in October 2014, began the implementation phase in early 2015 by starting a variety of monitoring and data collection activities. The Plan is a living document that can adapt to changing conditions. Plan implementation is structured to encourage an open, collaborative and cooperative process for groundwater management activities guided by the Basin Advisory Panel and a Technical Advisory Committee.

In 2014 California adopted the Sustainable Groundwater Management Act (SGMA). This Act requires all medium and high priority groundwater basins as designated by DWR to form a local Groundwater Sustainability Agency (GSA) by 2017. The Santa

Rosa Plain is a medium priority basin. The GSA will have until 2022 to develop a sustainable groundwater management plan. The plan requires that the basin will be in compliance with DWR's definition of sustainable groundwater use within 20 years.

Surface Water

In coastal California watersheds such as the Maacama and Upper Mark West Creeks, rainfall is the principal driver of hydrologic processes, with streams generally responding quickly with elevated streamflow, after rainfall occurs (CEMAR, 2015). When rainfall ends, streamflow then gradually subsides until the next rainfall event. These streamflow and rainfall dynamics in turn define instream conditions throughout the year (CEMAR, 2015). Additionally, the volcanic geology in the upper portions of the Mark West watershed affects water temperatures by seeping cold groundwater into surface water throughout the summer months.

Increases in water demand during periods of low flow will typically result, as it has in upper Mark West Creek and areas of Maacama, in surface flow becoming intermittent in response to extraction of both surface and groundwater. In addition, increased water use can also result in less water volume available to dilute the concentration of pollutants or attenuate the high summer water temperatures, both of which drastically affect the quality and availability of aquatic habitat.

Water Needs

In both the Maacama and Upper Mark West watersheds, irrigated agriculture and rural residences are two of the predominant forms of water use and those water needs are typically met through water storage in small reservoirs (CEMAR, 2015) and by private water supply wells. Vineyards, depending on location, may require water for both irrigation and frost protection, which can often require larger quantities of water but for a limited amount of time. Domestic needs include landscape irrigation and household water uses. Wineries and other commercial operations, although limited within this watershed, also contribute to the water demand of this region, requiring water for barrel and equipment cleaning, commercial business activities, and dish washing.

Understanding water resources and water needs and balancing these needs for multiple, and diverse uses, is a complex undertaking in both watersheds. To date there are a variety of different agencies and private landowner groups collecting stream flow data and private studies evaluating water demand for specific needs or geographical area. There is no comprehensive approach to water management and there is a need for more information and a collaborative approach among all stakeholders around water management. What is understood is that with frequency of drought, and increasing temperatures, it is critical for the livelihood of the local economy and ecology that water be managed wisely and with a variety of innovative management tools.

WATER QUALITY

Water quality refers to the physical, chemical and biological characteristics of water. Water quality information can be used to assess the safety of surface water for a variety of beneficial uses ranging from drinking water, contact recreation, and aquatic wildlife habitat requirements. Water quality is often framed in context of measureable concentrations of contaminants (see below for more information on beneficial uses).

Water quality is determined and affected by a complex web of chemical, physical and biological processes. A wide range of human activities can affect water quality in ways that aren't always obviously related. The impacts to water quality from human activities in the surrounding watershed depend on the type of activity, its timing, location, duration and intensity. Each type of activity affects the watershed and contributes a set of pollutants to the stream system. The concentration of pollutants varies by season, by day, and sometimes from hour to hour. Water quality impacts are related to watershed function and ability to ameliorate pollutants (i.e. warm water related to spring flow connection and riparian cover). This can make it difficult to measure water quality and increases the necessity of building a data record over time to assess how different conditions affect water quality.

Temperature

Temperature affects water chemistry and the functions of aquatic organisms. It has influences on the amount of oxygen that can be dissolved in water, the rate of photosynthesis by algae and other aquatic plants, the metabolic rates of organisms, and the sensitivity of organisms to toxic wastes, parasites and diseases, and timing of reproduction, migration, and aestivation of aquatic organisms.

Temperature is also an important environmental factor for aquatic habitat and at times is the determining factor for species assemblages. For example, as waterways that were historically cool become warmer, cold water fish can be replaced by species better suited to warmer conditions. Protection and restoration of the cold freshwater habitat is imperative to restoring coho and steelhead fisheries in Maacama and Upper Mark West watersheds since temperature is an important factor in activity level and physiological processes at all stages of the salmonid life cycle (see Table 2.5 below).

Timing of upstream migration is also dependent upon temperature as well as flows. Coho salmon enter the Russian River between November and January, with most spawning occurring in December. Steelhead enter the river between December and April, with most spawning occurring from January through March (Coey et al. 2002). Summer water temperatures are critical for the survival and health of all salmonid species that may enter the Maacama or Upper Mark West Creek watersheds.

Table 2.5 Water Temperature (°C) Criteria for Life Stages of Steelhead and Coho (Thompson and Larsen 2004, Coey et al. 2002, McEwan and Jackson 1996, KRIS Web 2011)

Adults				Juvenile Rearing		
Species	**Migration**	**Spawning**	**Incubation**	**Preferred**	**Optimum**	**Lethal**
Coho	4.44 – 9.44	4.39 – 9.39	4.39 – 13.28	11.78 – 14.61	9 – 15.6	26
Steelhea	7.78 – 11.11	3.89 – 9.39	8.89 – 11.11	7.28 – 15.56	10	24.11

Dissolved Oxygen

Dissolved oxygen (DO), the amount of oxygen gas present in water and available to aquatic organisms, is critical for all aquatic life, just like oxygen in air is essential to terrestrial organisms. DO is one of the most important parameters to measure to assess the health of aquatic environments. DO is added to water through diffusion from air, turbulence, and photosynthesis of aquatic plants. It is removed through respiration of aquatic organisms, the biological oxygen demand associated with the decomposition of organic material, and other chemical reactions that use oxygen. Additionally, DO passes from the water to the air in response to changes in atmospheric pressure, temperature, or salinity. More dissolved oxygen can be held in cold water, under greater pressure, and at lower salinity. DO levels are extremely variable and can change with time of day, weather, and temperature. For example, excess nutrients in an aquatic system generally lead to aquatic plant and algal growth, the presence of which can cause diurnal fluctuations in DO concentrations. Photosynthetic processes under daylight conditions can artificially increase the DO concentration, creating super-saturated (>100% saturation) conditions, while oxygen levels drop at night due to consumption during the respiration and bacterial breakdown of the plants and algae (aka Biological Oxygen Demand).

The DO monitoring summarized in Chapter 4, Water Quality, was taken via instantaneous or "grab" sampling, which captures the conditions only at the time sampling is conducted. Continuous dissolved oxygen monitoring, which tracks the daily and seasonal variations and allows for a more thorough assessment of stream health is more desirable, particularly during the summer and fall when temperature tends to be high and streamflow is low. Understanding the effects of isolated pool conditions on DO levels is vital for streams that become intermittent during any part of the year since streamflow generally disconnects at riffles, thereby eliminating the main mechanism for introducing DO to surface water.

Dissolved oxygen levels can range from 0–18 milligrams per liter (mg/l), but most aquatic ecosystems require at least 5–6 mg/L to support a diverse biological assemblage. When the concentration of DO is greatly reduced, the ability of aquatic organisms to acquire oxygen through their gills for respiration is impaired, potentially leading to chronic effects such as reduced growth, increased susceptibility to disease, or reduced reproductive success or death.

Macroinvertebrate species sensitive to decreasing DO levels include mayfly nymphs, stonefly nymphs, caddisfly and beetle larvae, all which are a food source for salmonids. As DO levels decrease, these pollution-intolerant organisms are replaced by pollution-tolerant worms, snails and fly larvae. A decrease in DO is often an indication of an influx of an organic pollutant (GRRCD, 2010). If DO concentrations fall below 3 to 4 mg/L, fish species such as salmon can experience physiological stress. However, many aquatic organisms can recover from short periods of low DO availability. The optimal DO level for salmonids is 9 mg/l with a level of 7-8 mg/l considered acceptable and 3.5-6 mg/l considered poor. DO levels below 3.5 mg/l are likely to be fatal to salmonids; levels below 3 mg/l are stressful to most vertebrates and other forms of aquatic life. Conducting benthic macroinvertebrate sampling is another recommendation for future monitoring efforts as the macroinvertebrate assemblages present in a stream give insight into water and habitat quality conditions over time.

Water Quality Objectives from the North Coast Regional Water Quality Control Plan (Basin Plan 2011) set a minimum dissolved oxygen level at 7.0 mg/l with a 7.5 mg/l monthly mean (90% Lower Limit) and 10.0 mg/l monthly mean (50% Lower Limit) for the Russian River Hydrologic Unit (HU), which encompasses both the Maacama and Upper Mark West Creek watersheds. DO objectives were developed to protect the five beneficial uses related to the preservation and enhancement of fish: marine habitat (MAR), inland saline water habitat (SAL), warm freshwater habitat (WARM), cold freshwater habitat (COLD), and spawning, reproduction, and/or early development (SPWN).

Most water quality monitoring is conducted via grab sample and subsequent chemical analysis. Grab sampling takes a snapshot of the water quality conditions occurring at that particular spot at that particular time. Water quality sampling can be designed to take a number of instantaneous samples over time to examine trends in water quality, decline or improvement, and potentially catch a pollution event when it occurs. Water quality is only one piece of the puzzle of evaluating stream health. Many things can influence the health of a creek and its ability to sustain sensitive species (see Table 2.6).

Table 2.6 Partial list of habitat characteristics and their function in maintaining sensitive aquatic species, such as the highlighted anadromous salmonids. Adapted from NMFS, 2007.

Habitat	Characteristic	Function
Water quality	Temperature, dissolved oxygen, conductivity, chemical pollution	• Mortality • Growth • Toxicity/sub-lethal effects
Water quantity	Low flow, high velocity	• Mortality • Competition • Predation • Interactions with water quality (i.e. dilution)
Substrate quality	Sedimentation, substrate size	• Spawning • Incubation • Macroinvertebrate production
Geomorphology (i.e. pools and riffles)	Cover material (e.g. large woody debris, boulders), depth, gradient	• Flow refugia • Shelter from predators • Sediment traps and substrate sorting • Nutrient reservoirs • Macroinvertebrate production

		• Spawning • Oxygenation
Riparian corridor, extent and health	Canopy, vegetation type, vegetation amount	• Water temperature (shade) • Nutrient sources (invertebrate production • Source of large woody debris • Physical buffer and filter for sediment and chemical pollution from surrounding uplands

It is important to note that water quality analysis only provides information about the constituents analyzed for so it can only answer the questions that are being asked. Due to the procedural difficulty (transport, holding times, etc.) and the expense of many chemical analyses, most water quality monitoring programs analyze for a few common chemical and physical parameters such as Temperature, pH, DO, Conductivity and concentrations of common pollutants of concern such as nutrients, pesticides, metals, oil and grease, etc. These basic parameters are utilized as screening tools or water quality indicators (i.e. high conductivity or high/low pH levels can indicate the presence of pollutants) and can trigger the need for more specific sampling to identify the pollutant of concern.

Beneficial Uses for Surface Water

Beneficial uses describe existing and potential uses of water within a waterbody. The State and Regional Water Quality Control Boards are responsible for designating and protecting these beneficial uses in all waters of the state. The Water Quality Control Plan for the North Coast Region (Basin Plan; NCRWQCB, 2011) designates a list of existing beneficial uses for the Geyserville HSA, which encompasses the Maacama Creek watershed, and the Mark West HSA, which encompasses the Upper Mark West Creek watershed. Beneficial uses of these two watersheds include Municipal and Domestic Supply (MUN), Agricultural Supply (AGR), Groundwater Recharge (GWR), Warm Freshwater Habitat (WARM), Cold Freshwater Habitat (COLD), Wildlife Habitat (WILD), Rare, Threatened, or Endangered Species (RARE), Migration of Aquatic Organisms (MIGR), and Spawning, Reproduction, and/or Early Development (SPWN). For the full list of designated beneficial uses, refer to Appendix C.

The Federal Clean water Act (CWA), Section 303(d), recognizes two types of water pollution: pollution discharged by *point sources* and pollution discharged by *nonpoint* *sources*. Point sources include water treatment plants, factories, and other "discernible confined discrete conveyances." Nonpoint source (NPS) pollution is dispersed throughout a watershed and includes pathogens, bacteria, metals, nutrients or pesticides delivered to water bodies in stormwater runoff. NPS pollution also includes sediment discharged to water bodies from roads, streambanks, gullies, and sheet and rill erosion. The insidious nature of nonpoint source pollution is that the individual pollutant contributions may be small, but their combined effects can significantly impact aquatic health. Identifying that a pollutant is present in a stream is the first step to identifying the relative impact, source of the pollutant and the potential for stemming its input. The main mechanism for pollutants entering both the Maacama and Upper Mark West creeks and their tributaries is through NPS inputs (see Table 2.7 below). NPS inputs are pollutants that arise from a number of places throughout a watershed. The leading pollution concerns for the Maacama and Upper Mark West watersheds consist of sediment and increasing water temperatures, which cause impairments that are further exacerbated by the reduction in stream flows that has been more frequently observed throughout these watersheds.

Table 2.7 Potential Sources of Sedimentation and Increased Water Temperature (NCRWQCB 2010)

Pollutant/Stressor	Potential Nonpoint Sources
Sediment/Siltation	Agriculture Irrigated Crop Production Specialty Crop Production Agriculture-storm runoff Agriculture-grazing Silviculture Construction/Land Development Highway/Road/Bridge Construction Land Development Hydromodification Channelization Dam Construction Upstream Impoundment Flow Regulation/Modification Habitat Modification Removal of Riparian Vegetation

Pollutant/Stressor	Potential Nonpoint Sources
Water Temperature	Hydromodification Upstream Impoundment Flow Regulation/Modification Habitat Modification Removal of Riparian Vegetation Streambank Modification/Destabilization Nonpoint Source

INSTREAM AND RIPARIAN HABITAT

The sustainability of salmonid populations in the Russian River watershed depends upon a variety of factors, including habitat conditions. During each life stage, an individual salmonid requires a specific set of environmental conditions to succeed. The lack of any essential habitat requirements are known as "limiting factors." Limiting factors are defined as environmental conditions that, if at sub-optimal levels, will prevent an organism from reaching its full biotic potential. Anadromous steelhead and coho salmon have specific habitat requirements for each of their lifestages (i.e. clean, well-aerated gravels for spawning and hatching; deep, well-shaded pools for rearing and resting; and unimpeded channels for migration). Other requirements include adequate supplies of cool, clean, oxygenated water and food. Degradation of one or more of the salmonid habitat factors can lead to population stress and eventual localized extinction.

SEDIMENT SOURCES

The processes and rates of erosion occurring in a watershed combined with the mechanisms by which the eroded material is transported dictate the volume and rate the eroded sediments will be delivered to a stream network. Gravel and sediment recruitment is a natural function of a stream system but land management practices can have a great effect on erosion rates and the mechanisms that lead to the sediment delivery to a stream. Historically Maacama and Mark West Creeks delivered sediment derived from their steep upper reaches to the low-gradient alluvial plains, located further downstream, at a slow but steady rate, as a naturally-occurring process. The sediment transport rate of tributary networks across both watersheds would have been at a relative balance with the sediment inputs. Occasional large erosion events such as a landslide or debris flow, resulting from a large but infrequent storm event, would also contribute sediment into the system. These large erosion events were likely the primary catalysts to significant alterations in the morphology of the stream networks.

In the last 150 years, human activity has made significant changes to the landscape in both Maacama and Upper Mark West watersheds in the form of land cover and stream channels. Logging, forest conversion to agriculture, and residential development has taken place over large areas of the watershed, increasing storm runoff and sedimentation. Formerly undeveloped native timberlands, grasslands, and scrub have been converted for a variety of uses including vineyards, orchards, cattle grazing, and rural residential development. This alteration to the landscape has created a significant increase in bare compacted soils and impervious surfaces, such as roads and rooftops, significantly increasing runoff volumes and rates as well as erosion and transport of fine sediments. The increased runoff leads to increased peak discharge of Maacama and Mark West Creeks and their tributaries and has altered sedimentation rates and overall geomorphology of the stream networks. In combination, these factors have caused dramatic changes in the types and rates of erosion in the watershed with consequences for both stream channel form and aquatic habitat quality.

Sediment Impacts on Aquatic Health

The impacts of fine sediment in a stream system are significant. Besides the unappealing aesthetic of a very turbid stream, there are very serious affects to aquatic habitat quality, particularly for salmonids. Fine sediment pollution has been shown to negatively affect salmonids on multiple levels. It has been demonstrated that fine sediments severely impact incubation success of salmonid embryos (Reiser and White 1988). Female salmonids create a nest in the substrate of stream by using their tails to winnow away fine sediments from an area while leaving larger gravels in place to lay their eggs among. However, fine sediment eventually finds its way back into the redd by the "pulling" of water downward through the redd. Redds are constructed in such a way to create down-welling through it to bring oxygen rich water into contact with incubating eggs and to remove metabolic wastes (Kondolf, 2000). This down-welling also brings with it fine sediments that are drawn into the redd even at times when high water velocities would prevent deposition on the gravel surface. Therefore, suspended sediments that would normally get carried out to the bay or get deposited in fringe, low velocity areas work their way down through the redd. These sediments oftentimes form a seal above the egg pocket (the actual location of egg deposition) thus sealing off the eggs for effective metabolism (Chapman, 1988). Increased fine sediments may also have the effect of decreasing the production of macroinvertebrates that are an important food source for fry, juveniles, and smolts which can lead to reduced growth rates. It may also result in gill abrasion and overall reduced feeding success (MacDonald, 1991). Sediment sources and impacts within the Maacama and Upper Mark West watersheds are discussed further in Chapter 6 below.

FORESTRY AND VEGETATION RESOURCES

Forestland vegetation in the Maacama and Upper Mark West watersheds is typical of the North Coast Mediterranean vegetation types. Where temperatures are relatively high and precipitation and soils are shallow, oak woodlands and chaparral-associated plants predominate. In the cooler and wetter areas, soils are deeper, and mixed evergreen forest and oak woodland communities occur. Redwood and Douglas fir dominate in cooler, moister areas, whereas hardwood evergreens, such as tan oak, madrone, live oak, and bay occur on well-drained slopes. Northern oak woodland type of vegetation can be observed on southern exposures and the edges of the mixed forest. Oregon and black oak and Manzanita dominate here, while coniferous trees are scarce. Much of the grassland in the watershed has developed on land cleared of hardwoods and conifers for grazing.

Maacama Watershed

A variety of vegetation types, including coniferous forest, hardwood forest, mixed hardwood/coniferous forest, chaparral, grassland and riparian forest cover the Maacama Creek watershed. The distribution of vegetation is summarized in Table 2.8 and Figure 2.14 below.

Figure 2.14 Vegetative cover across Maacama watershed

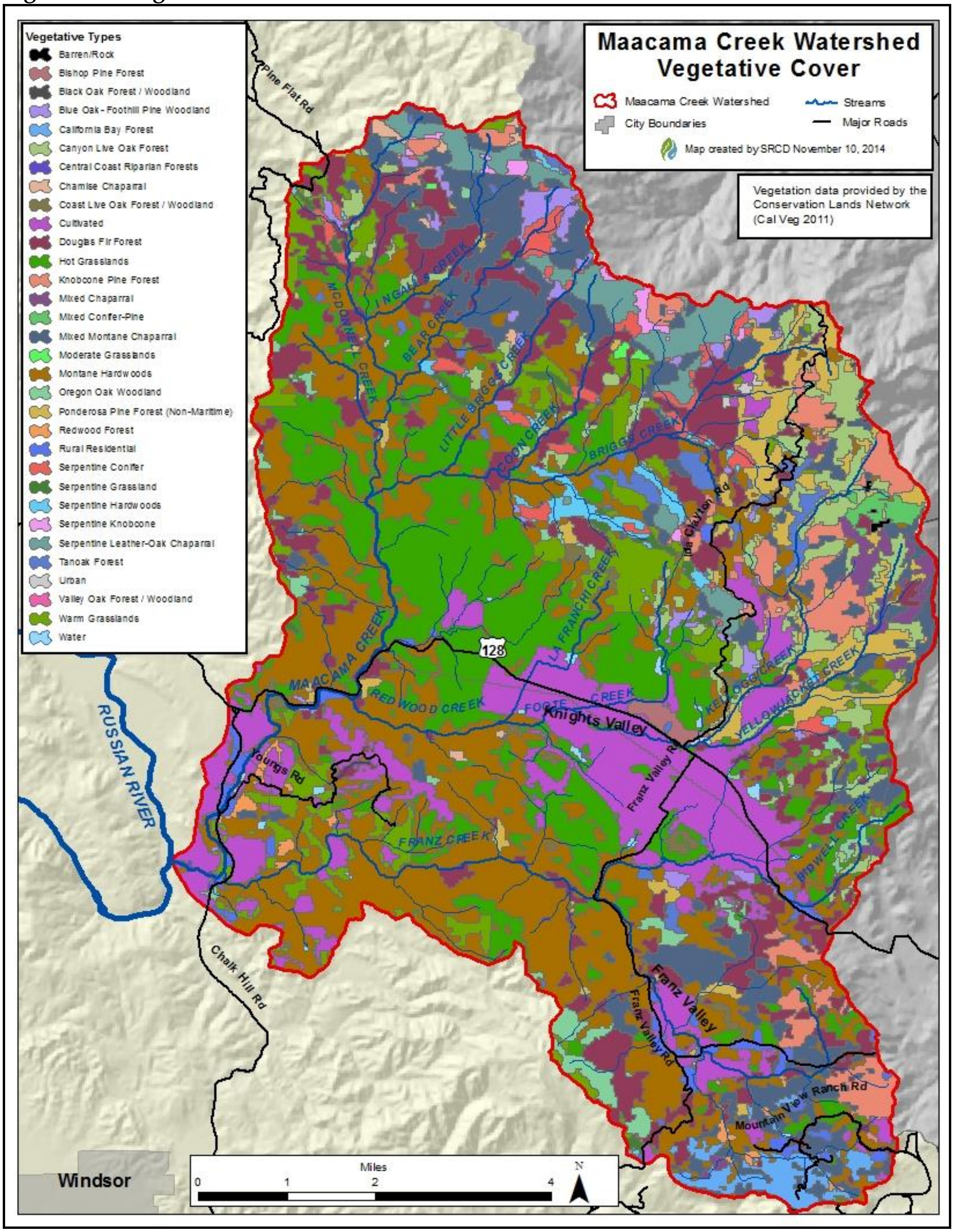


Table 2.8 Vegetation Types in the Maacama Watershed

Vegetation Type/Land Use*	Acres	Square Miles
Chaparral	5,235	8.18
Coniferous Forest	6,106	9.54
Hardwood Forest	16,346	25.54
Mixed Hardwood/ Coniferous Forest	1,760	2.75
Rangeland/Grassland	10,323	16.13
Cropland	3,667	5.73
Urban	12.8	0.02
Barren (rocky peak of Mt. St. Helena)	19	0.03

Table derived from the Maacama Creek Watershed Assessment (Marcus/Sotoyome RCD, 2004)
* This information was created from satellite imagery, which does not record features less than 30 meters and 2.5 miles in extent and therefore some features are not included.

Additionally, a delineation of the extent and density of riparian forest was completed as part of the Maacama Creek Watershed Assessment for all sections of major creeks with unconfined and partially confined channels (Marcus/Sotoyome RCD, 2004). The findings from that assessment are summarized in Table 2.9 below. High to medium density vegetation exhibits a closed canopy over the creek channel. Medium to low density vegetation has gaps in the canopy. Low density vegetation has scattered trees along the channel and little to no closed canopy.

Table 2.9 Riparian Forest Delineation on Unconfined/Partially Confined Channels from 2000 Aerial Photographs of the Maacama Creek Watershed

Sub-basin	Vegetation	Acres
McDonnell	Medium to Low	23.2
Briggs	High to Medium	29.9
Maacama	High to Medium	139.8
	Medium to Low	14.5
Kellogg	High to Medium	35,9
	Low	56.4
Bidwell	High to Medium	35.9
	Low	2.7
Lower Franz	High to Medium	72.3
Upper Franz	High to Medium	41.2

Table derived from the Maacama Creek Watershed Assessment

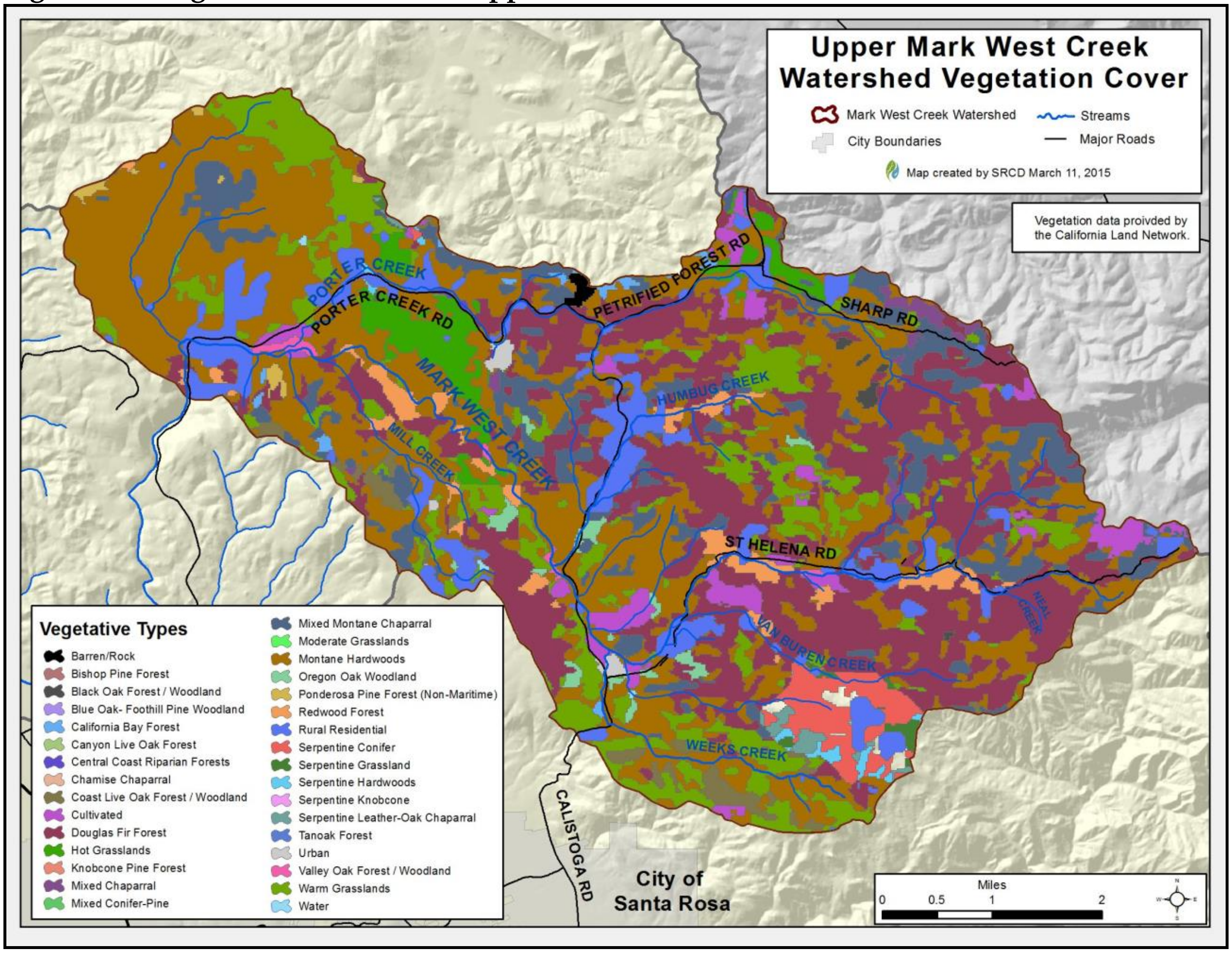
Upper Mark West Watershed

Vegetation within the Upper Mark West watershed consists primarily of meadows and forested areas. Meadows are composed of a mixture of native and non-native grasses and herbs such as *Avena* spp. (oat grass), *Festuca* spp. (fescue), *Elymus* spp. (wild rye), and *Lolium* spp. (wild rye). The forest canopy consists of *Pseudotsuga menziesii* (Douglas-fir) and *Lithocarpus densiflorus* (tan-oak). This canopy shelters an understory of *Polystichum munitum* (sword fern), *Toxicodendron diversilobum* (poison-oak), and *Corylus cornuta* (hazelnut). Transition areas between meadows and forests generally include the shrubs *Baccharis pilularis* (coyote brush), *Ceanothus cuneatus* (buck brush), and *Rubus discolor* (Himalayan blackberry), while riparian zones generally support *Sequoia sempervirens* (redwood) and *Acer macrophyllum* (bigleaf maple) with occasional *Umbellularia californica* (bay laurel). Refer to Table 2.10 and Figure 2.15 below for a distribution of vegetation types.

Table 2.10 Vegetation Types in the Upper Mark West Watershed

Vegetation Type/Land Use*	**Acres**	**Square Miles**
Chaparral	2043.3	3.2
Coniferous Forest	6294.4	9.8
Hardwood Forest	7639.7	11.9
Mixed Hardwood/ coniferous Forest	404.6	0.6
Rangeland/Grassland	2948.3	4.6
Cropland	568.0	0.9
Urban	1552.4	2.4
Barren (Rock)	41.7	0.1
*Source: Conservation Land Network 2011		

Figure 2.15 Vegetative cover across Upper Mark West watershed



The SCAPOSD and the SCWA are also currently in the process of mapping vegetation across Sonoma County, through the Sonoma Veg Map program. In the first two years of this five-year program, this program has produced countywide LiDAR data and orthophotography that is freely available at sonomavegmap.org. The continued mapping effort will provide accurate, current inventory of the County's landscape features, ecological communities, and habitats in order to facilitate good planning and management for watershed protection (sonomavegmap.com, accessed on 3/26/2015).

CLIMATE VARIABILITY

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 increasing levels of carbon dioxide and other greenhouse gases (GHGs) in the Earth's atmosphere (EPA, 2013).The consequences of climate change are projected to be substantial 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. The projected changes of greatest concern are: increased weather variability, 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 the cumulative effect of any combination of these factors is also of concern. Other stressors include the development and fragmentation of open spaces, water quantity and quality impairments, invasive species, pest vectors and related diseases.

Chapter 9, Climate Vulnerability and Adaptation, provides a discussion of the projected effects of climate change in Sonoma County, potential vulnerabilities within the Maacama and Upper Mark West watersheds, and recommendations for adaptation measures that can reduce impacts.

Sonoma Resource Conservation District

Maacama Creek and Upper Mark West Watershed Management Plan

SECTION 2. MANAGEMENT AND RECOMMENDATIONS

CHAPTER 3. WATER RESOURCES

This section provides a brief summary of current monitoring efforts and recommendations for Maacama and Upper Mark West watersheds. In addition, links are provided throughout this section to resources and studies that contain additional data for these watersheds.

Maacama Creek Watershed – Monitoring

Since 1956, hydrologic data in Maacama Creek has been collected by multiple sources in the Maacama Watershed. Several rainfall gauges, managed by the National Climatic Data Center (NCDC), and two USGS stream flow gauges collected data historically within this watershed. Rainfall data from six NCDC rainfall stations in and near the Maacama Creek watershed was collected and analyzed. Because of climate change and varying precipitation patterns, current rainfall and stream flow data needs to be analyzed to better understand current conditions and rainfall levels.

Stream Flow Monitoring

One USGS gauge, staged on Maacama Creek downstream of Briggs Creek, operated between water-years 1961 and 1981 and was re-established by USGS in 2013. A second USGS gauge was staged along Franz Creek, near Kellogg Creek, and was active between 1956 and 1976 water-years.

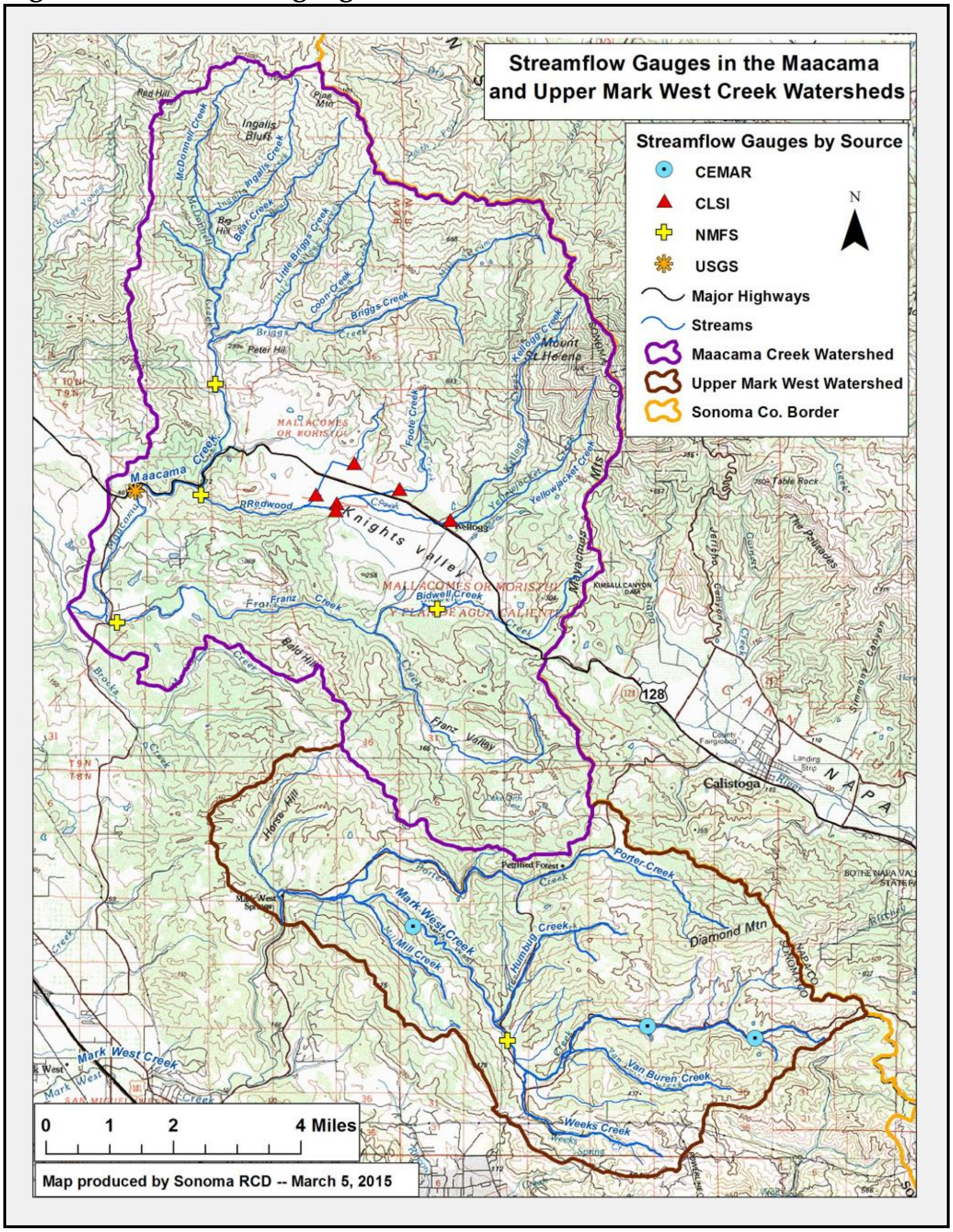
A full list of current and historical data collected at these locations can be viewed online at:

Maacama Creek
http://nwis.waterdata.usgs.gov/ca/nwis/inventory/?site_no=11463900&agency_cd=USGS

Franz Creek
http://nwis.waterdata.usgs.gov/ca/nwis/inventory/?site_no=11463940&agency_cd=USGS&amp

In addition to the USGS gauges, data was collected in 2004 and 2005 by Matthew Deitch from eight stream flow gauges. Two of the stations monitored by Dr. Deitch were located in the vicinity of the two discontinued USGS gauge locations. Refer to Figure 3.1 for a distribution of current flow gages in Maacama Creek watershed. The California Land Stewardship Institute has also installed six additional streamflow gauges in 2015 on Redwood Creek and its tributaries.

Figure 3.1 Streamflow gauge locations across both watershed



NMFS has been collecting data from 4 stream flow gauges in the Maacama watershed since 2010 with a summary report that can be found at:

http://www.ncriverwatch.org/wordpress/wp-content/uploads/2012/03/CoastalwrkshpYoseConf.pdf

NMFS is in the process of synthesizing data collected from 2012-2014. A data report will be completed sometime during 2015.

Groundwater Monitoring and the CASGEM Program

Groundwater monitoring in Sonoma County is also performed through the California Statewide Groundwater Elevation Monitoring (CASGEM) program, which is a statewide groundwater elevation monitoring program mandated by the State Legislature in 2009. The CASGEM program is designed to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. To achieve that goal, the amendment requires collaboration between local monitoring entities and Department of Water Resources (DWR) to collect groundwater elevation data.

The intent of the CASGEM program is to establish a permanent, locally-managed program of regular and systematic monitoring in all of California's alluvial groundwater basins in order to improve the management of California's groundwater resources. DWR's role is to coordinate the CASGEM program, to work cooperatively with local entities, and to maintain the collected elevation data in a readily and widely available public database.

The Sonoma County Water Agency acts as the lead for the CASGEM program and coordinates with other monitoring entities like RCDs and volunteers to gather the groundwater elevation data on wells twice a year. The SRCD is a monitoring entity for the CASGEM program in three groundwater sub-basins that include the Lower Russian River, Dry Creek, and Alexander Valley sub-basins.

There are currently five groundwater monitoring wells in the Maacama Watershed, which reside in the Knights Valley groundwater sub-basin and the southern portion of the Alexander Valley sub-basin. One well is located within the Upper Mark West watershed, also residing in the southern portion of the Alexander Valley sub-basin. Each of these wells are monitored by other agencies not associated with the SRCD. More information regarding this groundwater monitoring program can be found at: http://www.water.ca.gov/groundwater/casgem/

Maacama Creek Watershed – Documented Conditions

Based on the USGS flow gauge data, Franz Creek appears to be seasonal in nature and, although it does not dry up every year, it becomes intermittent in most years. Flow appeared to be more consistent at the Maacama Creek gauge location. However, trends in the data suggested that flow may be reduced in years when rainfall is slightly below average. Periods of zero discharge were shown to typically occur in August, September, or October at both monitoring locations.

The hydrologic data from other flow monitoring efforts found many of the less than 2 percent slope, unconfined stream reaches within the Maacama Creek watershed did not have consistent summertime stream flow (Marcus/Sotoyome RCD, 2004). While reservoirs, water diversions and groundwater use have probably increased since the 1960s, it is not clear if these reaches of the creek system are highly impacted by water development or may have naturally been intermittent with significant sub-surface flow. The results also suggest that upper portions of the major Maacama Creek tributaries may have reaches of perennial stream flow that may be a limiting factor for salmonids.

The work completed to date did not include a detailed analysis of the relationship between stream flow and upstream water diversions. Therefore, it is unknown whether water diversions in the Maacama Creek watershed have affected the records analyzed during these sampling periods. It is recommended that a more detailed study be undertaken to understand the relationship between water diversions and summer stream flow and salmonid rearing habitat within this watershed.

Upper Mark West Creek Watershed – Monitoring

According to several rainfall models and historical reports, annual precipitation in the Mark West Creek watershed can vary between 40 and 65 inches per year in an average water-year and approximately 20 to 25 inches of rainfall in a dry year (CEMAR, 2015). The data also suggests that the upper portions of the watershed tend to be wettest.

Flow and hydrology conditions have been studied consistently in Mark West Creek since 2012 with the installation of five streamflow gauges by the Russian River Coho Water Resources Partnership (Partnership) and with one gauge installed by NMFS. The report on the NMFS gauge is listed above in the Maacama Watershed section. Refer to Figure 4.1 for a distribution of current flow gages in this watershed.

Continued flow monitoring has provided critical data about understanding both the natural and unnatural influences of flow conditions and has helped determine where there are data gaps. This flow monitoring has been coupled with monitoring salmonids to better understand flow thresholds and how habitat, gradient and other factors affect flow conditions (for more on fish monitoring efforts refer to the Instream and Riparian Habitat discussion in Chapter 6). Based on this understanding, actions are identified to address low flow thresholds that will improve water reliability for both humans that rely on water resources and for salmonids and other aquatic species.

In the Mark West Watershed, like the other project watersheds, improving low flow conditions is one of the most critical limiting factors to supporting sustainable populations of coho. Information collected by the Partnership has helped to been to develop alternative water system projects to improve stream flow.

In addition to the monitoring that has been carried out through the Partnership, a Report on the Hydrologic Characteristics of Mark West Creek (dated November 14, 2014, updated January 28, 2015) was completed by Center for Ecosystem Management and Restoration (CEMAR, 2015). The findings of this report, as well as monitoring data collected by the Partnership, are summarized below and is available online at: http://www.cemar.org/publications.html.

Upper Mark West Creek Watershed – Documented Conditions

The CEMAR study of Upper Mark West Creek documented low streamflow conditions in Mark West Creek but did not observe many of the characteristic fluctuations associated with streamflow diversions typically produced by human water needs. Mark West Creek maintained consistent flow even through the dry conditions in 2013. The report suggested that this may be a result of the unique Sonoma Volcanic surface geology in much of the watershed, which produces base flow even through the summer months. The report also noted that while some development occurred along the upper reaches of Mark West Creek (including houses and wells) groundwater pumping to meet residential needs did not appear to have a noticeable impact and, unlike direct instream diversions, there were no irregular fluctuations in water level in Mark West Creek during the summer study period. The report noted that alternatively, groundwater pumping was likely resulting in reduced base flow. Groundwater pumping to meet agricultural needs may also affect base flow, especially if wells are located in bedrock fractures that would otherwise provide base flow in the summer.

Shifting water demand from the dry season to the rainy season (whereby water is stored in winter for use in summer) is becoming a more widespread method to benefit salmon and steelhead populations and meet agricultural and residential water needs. The CEMAR report found that the amount of water that falls as rain and leaves as streamflow in the Upper Mark West watershed greatly exceeded the amount of water needed for human use. The report estimates that 260 acre-feet of water are needed to meet human water needs (agricultural, residential, and industrial), and a typical, normal-year rainfall over the Upper Mark West watershed is 34,500 acre-feet (discharge is approximately 17,300 acre-feet).

The report noted that agricultural and residential land uses will likely benefit from water catchment using off-channel irrigation ponds or storage tanks filled with rain water or water pumped in the wet season as an alternative to groundwater pumps or streamside wells. Implementing these types of projects would keep more water in the stream during the dry season while increasing water security during dry months. Refer to Chapter 7, Agricultural and Rural Sustainability for more on this topic.

In the future, additional data may be needed to learn more about the tributaries of Mark West Creek, in particular Humbug Creek and Van Buren Creeks, to determine current conditions and feasible actions to improve streamflow and water reliability for landowners.

Frost Protection on Vineyards

In spring of 2008, juvenile salmon were found dead or stranded after severe dry and cold weather caused many growers to simultaneously draw water from the Russian River system for frost protection. NMFS biologists extrapolated from the number of fish that had been found that several thousand had died in total. In 2011, the State Water Board issued new rules on using and reporting use of Russian River water. Grape growers challenged the rules, which led to three years of legal battles. In October of 2014 the California Supreme Court issued a final settlement in favor of the State Water Board. The new rules required growers in Sonoma and Mendocino counties who use water from the Russian River, its tributaries, and water considered hydraulically connected through wells for frost protection to submit a Water Demand Management Plan (WDMP) to the State Water Resources Board by February 1st, 2015. Diversions during the frost season, March 15 through May 15, must be covered by a WDMP. The regulation is designed to protect fish when large amounts of water are diverted at one time from the river system during frost events. Farmers are prohibited from diverting or pumping water from the Russian River system during the frost season without an approved plan. A grape grower or farmer can meet the requirements by filing an individual WDMP with the state or by joining an existing group, such as the Russian River Watershed Conservation Council, which was established to assist growers in complying with the regulation. The State Water Board encourages group plans, which will be less costly for individual growers.

The Sonoma County Vineyard and Orchard Frost Protection Ordinance requires the registration of all vineyard and orchard frost water protection systems in the Russian River Watershed with the Sonoma County Department of Agriculture (the Agricultural Commissioner).

- Systems need to be registered before they are used;
- Registrations must be amended within 30 days following any change to the vineyard or orchard sprinkler frost protection system or the owner/operator;
- Frost protection systems using treated waste/recycle water are included in the county registration program; and
- Registration is only required for systems within the Russian River Watershed.

RECOMMENDED ACTIONS

Recommendation WR1 – Further evaluation of summertime stream flow in tributaries to Maacama Creek and Upper Mark West Creek to help prioritize restoration actions in stream reaches that are capable of providing adequate year-round salmonid habitat.

Recommendation WR2 - Evaluate the relationships between summertime flows in low slope channels and water storage, diversions, and groundwater pumping that occurs nearby, particularly in areas along Franz Creek and Bidwell Creek.

Recommendation WR3 - Evaluate the limitations posed by low summertime flows in Maacama Creek to migrating salmonids.

Recommendation WR4 - Outreach to landowners where multiple small diversions are impacting stream flows on a larger scale, both in Maacama and Upper Mark West watersheds.

Recommendation WR5 – Provide resources to landowners, through small landowner meeting, on the benefits of restoring groundwater and methods for increasing groundwater recharge in uplands areas.

Recommendation WR6 - Outreach to agricultural and rural landowners to identify opportunities for increase water use efficiency or implementation of alternative water supply systems such as rainwater catchment or off stream storage ponds, through SRCD's LandSmart ® Water Resource Program and the Russian River Coho Water Resources Partnership Program.

Recommendation WR7 - Coordinate with foresters and landowners with forest land to help improve forest health and better understand the role of upland forests in groundwater recharge and flow regimes.

Recommendation WR8 – Continue existing streamflow monitoring networks and increase monitoring in high priority areas.

Recommendation WR9 - Continue the California Statewide Groundwater Elevation Monitoring Program (CASGEM) to document groundwater conditions in the region.

Recommendation WR10 - Continue encouraging broad, multi-agency participation in the Counties Groundwater Management Planning efforts.

CHAPTER 4. WATER QUALITY

As discussed in Chapter 2, the leading water quality concerns for the Maacama and Upper Mark West watersheds consist of sediment and increasing water temperatures. Although sediment and higher water temperatures occur naturally in these systems, the increasing amount of sediment delivery and cumulative effects of warming temperatures are detrimental to aquatic organisms that rely on these watersheds for habitat. These water quality impacts are further exacerbated by the reduction in stream flows, which is discussed further in Chapter 3 - Water Resources, above.

WATER QUALITY CONCERNS

The SRCD implemented the Russian River Watershed Monitoring and Assessment Program (RRMAP) in Maacama and Mark West watersheds between 1998 and 2012 (formerly called the Russian River Creek Stewardship Program). Field monitoring conducted under the RRMAP included:

- Continuous stream temperature data collection using data loggers deployed in May or June through October
- Ambient water quality measurements (instantaneous temperature, dissolved oxygen, pH, conductivity), conducted in late summer in conjunction with temperature data logger field checks in selected tributaries

The data collected through this program was documented in annual or biannual reports completed since 1998 and is summarized below.

Temperature Monitoring

Analysis of temperature regimes for tributaries of the Russian River watershed is valuable for scientific understanding and for responsible conservation management. For conservation management, a goal is to protect natural resiliency of stream ecosystems by maintaining sufficient spatial variability of riparian canopy structure, along with surface and subsurface flow conditions, to provide a desirable spectrum of temperature regimes. Sufficient temperature variability can buffer or help ameliorate cumulative impacts of urbanization, extreme climate events, and climate change, thereby protecting habitat for aquatic organisms.

Temperature is an important water quality parameter since it directly influences the amount of dissolved oxygen that is available to aquatic organisms. Elevated water temperatures have a deleterious effect on several fish species in streams, as described above. Temperature in the Russian River tributaries is considered one of the most critical barriers to the survival of salmonid populations, second only to sediment. Water quantity and temperature are critical to all life stages of salmonids, and of particular importance to their summer rearing life stages in the Mediterranean climate of the Russian River watershed.

The RRMAP has provided a scientifically comprehensive tool to gather detailed site-specific information about the temporal and spatial variability of water temperature regimes throughout the focused watersheds. While more work is needed to understand each of the tributary's long-term temperature patterns, data collected to date can be used to identify vulnerabilities to the health of the streams ecosystems. The ability to understand stream water temperature regimes is needed for diverse applications ranging from basic scientific study of ecosystems to pragmatic conservation planning and management to mitigate impacts of rural residential and agricultural development and climate change.

The continuous temperature monitoring stations were selected to represent summer refugia habitat or the presumed best available summer habitat, the deepest pools, adjacent to coldwater seeps when possible, that were most likely retain surface flow and buffer warm weather temperatures. The water temperature data collected included continuous measurements from May to October at 30 minute intervals; the data was analyzed for: the daily minimum; the daily maximum; the moving average of the weekly average temperature over a 7-day period; the maximum weekly average temperature (MWAT), the moving average of the weekly maximum temperature over a 7-day period; the maximum weekly maximum temperature value (MWMT); the daily range in temperature, and the number of continuous hours water temperatures exceeded 21.1°C (70°F). These analyses give an indication of whether the pool at the monitoring station can support salmon and steelhead trout rearing throughout the monitoring period. The collected data was then extrapolated to assess the stream reach between the temperature monitoring stations. The average weekly monitoring data along with the three daily measurements (minimum, median and maximum), give an indication of the seasonal temperature conditions at each monitoring station and whether temperatures met the Water Quality Objective (WQO) for the Cold Freshwater Habitat beneficial use.

Table 4.1 below summarizes the thresholds or water quality objectives for dissolved oxygen, pH, water temperature and conductivity to better understand target goals for salmonid health and water quality standards.

Table 4.1 Water Quality Objectives by Parameter.

Parameter (reporting units)	Water Quality Objectives	Source of Objective
Dissolved Oxygen (ppm)	≥7.0	Basin Plan Objective for Cold Water Fish
pH	≥6.5 or ≤8.5	General Basin Plan objective
Water Temperature (°C)	≤21.1°C	USEPA (1999) 20-22 range, supported by Sullivan (2000)
		Basin Plan Objective for Cold Water Fish
Conductivity (uS)	None established	N/A

Used in previous RRMAP analyses by Laurel Marcus and Associates, the temperature WQO of <21.1°C (70°F) was selected based on a number of factors including research findings indicating that annual maximum temperatures exceeding 21°C show a >10% reduction from maximum growth of steelhead (Sullivan et al, 2000). Findings from another study showed that "behavioral changes included decreased foraging and increased aggressive behavior as pool temperature reached approximately 22°C" (Nielsen et al, 1994; Carter, 2006). While the 21.1°C threshold is likely sub-lethal, it is acknowledged that the stressful impacts of sub-lethal temperatures on salmonids are cumulative and positively correlated to the duration and severity of exposure. To address this, the threshold temperature data was combined with exposure duration information for each temperature monitoring station.

Water Quality Conditions - Maacama Creek Watershed

The SRCD has been collecting monitoring data on a reach in the lower Maacama Creek watershed since 1999, which drains an area of approximately 44 square miles. The lower channel reach of Maacama Creek has a wide active channel and low summer stream flows, which often go subsurface and result in intermittent summer flow conditions. This lower portion of Maacama Creek is considered a naturally warm water system.

In subsequent years, additional monitoring reaches have been added to assess habitat conditions in the upper reaches of Maacama Creek as well as on its tributaries. Five to seven monitoring reaches, comprising 15 stations, have been established on lower , mid and upper Maacama, lower and upper Redwood, Kellogg and Bidwell Creeks, depending on variability of funding and landowner access between monitoring years. Over the course of the monitoring effort, additional stations were added to better geographically represent the watershed and to better understand the temperature and habitat variability throughout the watershed.

Water temperatures in mainstem Maacama Creek remain consistently warm. Temperature conditions often meet or exceed water quality objectives under isolated pool conditions, however other water quality parameters such as dissolved oxygen and pH may be unsuitable for sensitive aquatic species under these conditions. Low flow and isolated pool conditions often result in lower sustained water temperatures throughout the summer and fall due to the lack of warm water flowing into the pool. If there is a sufficient volume of water in the isolated pool, and/or a cold water input into the pool, coupled with a high percentage of canopy coverage (<80%), the pool can often attenuate high air temperatures and meet cold water temperature water quality objectives. Water temperature data collected in 2011 and 2012 shows that water temperatures in Maacama Creek typically remain consistently warm, even in stream reaches with adequate canopy cover. The findings suggest that since warm water conditions persist despite high percentages of canopy cover it is likely that water temperatures are warming upstream and/or that remaining surface water flows are too shallow to attenuate solar inputs. Generally, water temperatures were consistently coolest and most often met WQOs in the upper tributaries, demonstrated by data in upper Maacama, Redwood/Kellogg and Bidwell Creek reaches.

Given these findings, flow recovery appears to be the most vital priority for habitat enhancement in Maacama Creek. Flow recovery efforts should be conducted in conjunction with riparian conservation and enhancement priorities. There is a need to expand the flow gauging effort in Maacama and Redwood Creek watersheds to conduct additional flow monitoring in order to calibrate a flow rating curve and continue to quantitatively measure the flow deficit. A related monitoring recommendation is to conduct wet/dry mapping throughout the watershed, since intermittent flow conditions are not thoroughly represented through in situ gauges.

During low flow years (as seen in 2008 and more recently) additional impacts associated with low stream flows were documented including the disconnection of in-stream cover such as roots and undercut banks from surface water as the pool recedes. Efforts have been made to point out the various data sets for aquatic habitat areas that have been compromised by the physical conditions. The stations that retain water throughout the season have been identified to show that these are the data sets that represent persistent aquatic habitat that can be evaluated as year-round aquatic habitat and compared to previous data.

Again, it is important to note that all the temperature monitoring stations selected are based on their high habitat quality and the probability that they will retain surface water throughout the summer and fall months. Even though in 2011 and 2012 conditions slightly improved, many of the stations monitored through this program have not retained surface water during past drought years, 2009 and prior. The lack of surface water may be the most significant impact to the availability and quality of aquatic habitat. Most of the areas monitored through the SRCD RRMAP have continually shown good water quality, but under conditions that result in very little aquatic habitat persisting throughout the summer and fall months, the presence of habitat is the limiting factor for the survival of aquatic organisms.

In addition to temperature monitoring, bioassessment monitoring and benthic macroinvertebrate sampling was conducted on the lower Maacama Creek reach in 2008. The findings from this sampling indicated good conditions and suggested typically warm summer stream conditions. Several pollution sensitive species were present but no organisms intolerant of warm water were observed. The observed macroinvertebrate populations also suggested nutrient-rich stream conditions in this portion of Maacama Creek. The findings suggested that less warm-water tolerant macroinvertebrates may be present in this stream reach in winter and spring but do not persist through the summer months, due to warmer water conditions. The reports recommended continued and expanded sampling of benthic macroinvertebrates in Maacama Creek in order to better document seasonal water quality and aquatic habitat variability in this stream reach.

Water Quality Conditions - Upper Mark West Creek Watershed

The RRMAP water quality monitoring reaches within the Upper Mark West Creek watershed were located upstream of the Mark West Springs landmark, or Mark West Lodge, and upstream of the Horse Hill Creek confluence, draining an area of approximately 30 square miles. Depending on variability of funding and landowner access between monitoring years, five- to eight temperature loggers were deployed and managed in Mark West Creek through the RRWAP and data was utilized from gages managed through the Partnership.

The water quality conditions vary, but in general, areas along upper Mark West and along Saint Helena Road have been documented with very stable and cool water temperatures that remained below the 21.1°C threshold. This may be an indication that shade, provided from adequate canopy cover throughout these reaches, is sufficient to reduce high summer water temperatures. Also, these conditions may be a result of the volcanic geology and the presence of perennial springs that feed Mark West with cold water even in summer months.

In contrast, the reach of Mark West Creek closer to the confluence with Porter Creek has demonstrated more inconsistent water temperature conditions with average water temperatures in most years sampled exceeding the 21.1°C threshold by the second week of June. Temperature loggers have typically been located above and below the confluence of Porter Creek and data collected indicates that water temperature below the confluence has typically been lower. This suggests that the continuous input of cooler water flowing, surface and/or subsurface, from Porter Creek throughout the summer decreases temperature levels below the confluence of Porter Creek and Mark West Creek. Precipitation trends have also played a vital role in flow conditions at Mark West Creek: in 2009-2010 there was an increasing trend in low flow conditions. The same reaches exhibited continuous flows in 2011 and 2012 due to increased precipitation.

Limited water quality data is available for the Mark West Creek tributaries including Weeks, Humbug and Van Buren Creeks. Weeks Creek was monitored from approximately 2008-2012.

Along Weeks Creek, canopy cover was documented as low but the presence of natural springs helped to keep water temperatures low. Based on monitoring data collected, many shallow pools were present and, at times, pool depth was insufficient to keep the data logger submerged.

In addition to water temperature monitoring, bioassessment surveys were performed in one to two locations every two years, starting in 2006. Bioassessment data from 2008 suggested good but warm summer stream conditions in Mark West Creek. The benthic macroinvertebrate species documented during this sampling suggests that varied conditions exist across different monitoring locations in this creek, some suggesting higher organic material presence and stronger riparian cover. Another monitoring site, located approximately seven miles further upstream showed a more diverse macroinvertebrate community in monitoring data from 2006, suggesting relatively high quality habitat, cobble dominated stream channel conditions, and good riparian cover. Also, within this reach there are many seeps and springs contributing to cooler water temperatures. Both reaches had a diverse and mature riparian corridor although the lower reach is a lower gradient with more exposed stream channel. The upper reach is surrounded by rural residential parcels and the lower reach is adjacent to primarily livestock grazing. The findings from both reaches of Mark West Creek suggest that a diverse and mature riparian corridor is able to effectively buffer any potential nutrient and sediment inputs but that the lower reach had less macroinvertebrate species perhaps due to less channel cover and impacts from grazing.

CONSERVATION AND ENHANCEMENT RECOMMENDATIONS

The SRCD approaches enhancement from the perspective of watershed function. While many of the enhancement efforts in the Russian River watershed are focused on salmonid recovery, the watershed is home to a vast array of sensitive species, both aquatic and terrestrial. Past, current, and future SRCD projects take a watershed approach that addresses the interaction between land use impacts in upslope areas and its potential impacts on aquatic habitats. Therefore many SRCD projects focus on upslope sediment reduction through rural road improvement and riparian corridor enhancement to restore the riparian functions ranging from canopy cover, bank stabilization, sources of large woody debris, and terrestrial habitat for invertebrates, amphibians, reptiles, birds, and mammals, including humans. This watershed approach also extends to the alternative water source development and water conservation efforts underway to improve streamflow and water supply reliability for agricultural and rural residential landowners, a vital priority for climate adaptation in light of local climate projections (North Bay Climate Adaptation Initiative. 2013). Outreach and education continue to be critical tools that connect land managers to the utilization of best management practices and ultimately watershed improvement.

Over the last five to ten years, there has been concern from landowners and residents in the Maacama and Upper Mark West watersheds regarding a trend of significant stream flow decreases and low stream flows over the critical summer months being a potential barrier to cold water fish presence.

Even though conditions slightly improved in 2010, the fact that many of the stations monitored through this program did not retain surface water similar to past drought years (2009 and prior) makes it clear that the lack of surface water was the most significant impact to the availability and quality of aquatic habitat. Most of the areas monitored through the SRCD RRMAP, which as described above were generally located in the best available habitat, have continually shown high water quality, but under conditions that result in very little aquatic habitat persisting throughout the summer and fall months the presence of habitat, let alone high quality habitat, is the limiting factor for the survival of aquatic organisms. Given this, summer months pose the greatest challenge for water quality. Low flow conditions result in less water volume available to dilute the concentration of pollutants or attenuate the high summer temperatures, both of which drastically affect the quality and availability of aquatic habitat. Temperature increases and an absence of habitat may limit survival of juvenile salmonids in the watershed. Because these factors are so closely related, efforts to increase summer flow are likely to have a beneficial effect on water temperature and DO concentrations. (Refer to *Chapter 3, Water Resources* for more information).

Efforts in Mark West Creek continue to focus on restoring flows and maintaining the existing high water quality. The need remains for alternative water sources and conservation opportunities to be explored and implemented. Maintenance and enhancement of the riparian corridors of Maacama and Upper Mark West Creeks and their tributaries is critical to the persistence of flow and water quality, as well as a source of large woody debris. Particularly under the critically low flow conditions experienced in the past several years, pool habitat is vital and should be protected wherever possible. Fine sediment sources should continue to be assessed and restored to improve the quality of both spawning and rearing habitat. Refer to *Chapter 6, Sediment Sources and Impacts* for more information. These watershed scale conservation approaches will continue to be a high priority action for the SRCD for several years to come.

The SRCD continues to collaborate with other local agencies, organizations and landowners to pursue off-stream water storage and water conservation efforts, as well as stream flow monitoring in both the Maacama and Upper Mark West watersheds. Pending funding availability, the SRCD continues to identify tools and incentives for agricultural and rural residential land uses to conserve water during the critical late summer and early fall months.

Another critical habitat feature that contributes to high summer habitat value in both Mark West and Maacama tributaries including Bidwell, Kellogg and Yellowjacket Creeks is the volcanic geology and the associated springs present throughout the upper watersheds. These springs should be protected and managed to maintain and connect this important summer water source.

RECOMMENDED ACTIONS

Recommendation WQ1 – Conduct bioassessments, as an indicator of aquatic habitat quality, throughout both watersheds.

Recommendation WQ2 – Collect total suspended solids (TSS) data during periods of high flow and turbidity to better understand the duration of impairment in both watersheds.

Recommendation WQ3 – Continue ambient water quality monitoring to document ongoing changes in stream conditions within both watersheds.

Recommendation WQ4 - Expand flow gauging efforts in Maacama and Redwood Creeks to conduct additional monitoring in order to calibrate a flow rating curve to quantitatively measure the flow deficit.

Recommendation WQ5 - Perform a wet/dry mapping program to record and quantify areas that retain surface flow in late summer.

Recommendation WQ6 - Implement best management practices to decrease sediment loads and storm runoff and improve rural road development and maintenance.

Recommendation WQ7 - Protect natural springs throughout the Upper Mark West watershed and upper portions of the Maacama watershed that are vital sources of clean and cool water, particularly in the summer months.

Recommendation WQ8 - Pursue funding for studies and implementation projects through the Wildlife Conservation Board's California Stream Flow Enhancement Program to stabilize and improve flow recovery.

CHAPTER 5. INSTREAM AND RIPARIAN HABITAT

Characterization of habitat conditions in the Maacama and Upper Mark West watersheds is primarily based on stream surveys conducted from CDFW, NMFS, RCD, UCCE, and other past reports and studies completed in these watersheds. Maps providing locations of reaches and surveyed sites as well as stream inventory report can be found in Appendix D.

FISH MONITORING AND SURVEYS

Fish monitoring and habitat quality surveys have been carried out since 1953 in both Maacama and Upper Mark West watersheds periodically by CDFW and, in later years, ground-truthed by NMFS, UCCE, and the SRCD. Stream surveys conducted by CDFW indicate that coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*) are present within Maacama Creek and Upper Mark West Creek with steelhead also being observed in some of their tributaries. As shown in Appendix D, numerous surveys performed between 1953 and 2012 have identified steelhead in several Maacama Creek tributaries, including McDonnell Creek, Franz Creek, and Kellogg Creek. Coho salmon were detected in Maacama and Redwood Creeks in 1993, 1994, and again in 2001, when CDFW collected juvenile coho salmon from Redwood Creek for their coho salmon broodstock program, and most recently in 2011.

CDFW also reports that, through 1983, hatchery steelhead were transferred into Mark West Creek. A 1983 stream survey of Porter Creek noted historical observations in 1974 of juvenile steelhead from the mouth to the headwaters of Porter Creek. In a 1997 habitat inventory of tributaries to Mark West Creek, CDFW staff noted steelhead in Mill Creek and Van Buren Creek. During the implementation of an instream habitat enhancement structure project in 2001, CDFW staff observed coho salmon in Mark West Creek (Derek Acomb, personal communication, December, 2001). Wild coho salmon were also observed in 2001 by CDFW during a snorkel survey and most recently in the fall of 2011 during multiple surveys conducted by UCCE/California SeaGrant and CDFW.

In addition to CDFW, monitoring has been carried out in both Maacama and Upper Mark West watersheds by UC, through the Russian River Coho Salmon Captive Broodstock Program (RRCSCBP). The RRCSCBP is working to supplement the wild

Russian River coho population in the hope of restoring it to a sustainable size. Since 2001, a collaborative partnership including the US Army Corps of Engineers, the National Oceanic and Atmospheric Administration Fisheries Service, the California Department of Fish and Wildlife, the Sonoma County Water Agency, and the UCCE/California SeaGrant Extension Program has been breeding coho salmon from local genetic stock at the Warm Springs Hatchery and releasing them as juveniles into streams with historical coho presence in the Russian River watershed, including Mark West Creek. To date, no coho have been released in Maacama but coho have been released annually in Mark West since 2011 (UC, 2015). A total of 9,047 juvenile coho salmon were released into Mark West Creek and 4,047 released into Porter Creek in the 2011 – 2012 release year. The 2012 – 2013 release year included 19,775 juvenile coho released into Mark West Creek and 400 released into Porter Creek (RRCSCBP, 2015).

Monitoring efforts originally focused on a small number of tributaries but have since expanded to include select streams in the Maacama and Mark West watersheds. Mark West Creek has been snorkeled annually since 2011 in order to document spawning success. UC also began conducting regular spawner surveys in Mark West and Porter Creeks in the winter of 2014-2015. In addition, the Sonoma County Water Agency (SCWA) has been operating a downstream migrant smolt trap on the mainstem of Mark West Creek each spring since 2012. The presence of juvenile coho documented through UC snorkel surveys and SCWA's smolt trap indicate that coho adults returned to spawn in Mark West Creek over the winters of 2010-11, 2011-12 and 2012-13 (UC, 2015). Juvenile coho were not observed in Mark West Creek in summer of 2014, a survey year when juvenile coho were only observed in very low numbers in four of the 32 streams surveyed. This was likely due to the documented drought conditions, which had a significant, negative impact on coho production that year (UC, 2014).

Another key effort in the Upper Mark West watershed has been the Russian River Coho Water Resources Partnership (Partnership), a group of six organizations established to implement the National Fish and Wildlife Foundation (NFWF) Keystone Initiative for coho salmon in the Russian River. The Partnership was developed in 2009 and works in five focal watersheds where federal and state recovery plans identified water management as critical to restoring coho salmon: Dutch Bill, Green Valley, Mill, Mark West, and Grape Creeks. Across Mark West Creek, the Partnership installed a network of five year-round streamflow gauges in the drainage network to collect stream and tributary-specific streamflow data, which has been essential for improving understanding of individual and cumulative impacts on streamflow and fish habitat locally, and for evaluating the feasibility of proposed management practices and projects.

Additional monitoring information has been gathered from the Sonoma County Water Agency, as part of the "Russian River Basin Steelhead and Coho Salmon Monitoring Program Pilot Study", who conducted electrofishing on Mark West Creek from 1999 to 2001. Four selected sampling reaches of Mark West Creek were electrofished, the reaches extended from the Mark West/Laguna de Santa Rosa confluence to the headwaters near Diamond Mountain. The study concentrated on population estimates, observed fish densities and species (particularly steelhead) composition percentages. Mark West Creek was selected as part of this study, in part due to the historical presence of coho salmon (SCWA, 2002). The study reach that extended from Mark West Springs to just downstream of the St. Helena Road crossing had a species composition of Sculpin (52%), California Roach (33%), Steelhead (12%) and Lamprey Ammocoete (3%). The study reach, which extended from just downstream of the St. Helena Road crossing to the headwaters of Mark West Creek had a population of 100% steelhead.

Monitoring in the Maacama system has been less extensive. UC conducted a snorkel survey of Redwood Creek in 2012 and 2014 but did not observe any coho salmon. The first formal monitoring effort began with the advent of the Coastal Monitoring Program (CMP, a CDFW-sponsored joint effort between UC and SCWA), which led to regular spawner surveys of Maacama and Redwood Creeks in the winter of 2014 – 2015. UC and SCWA have plans to continue conducting regular adult and juvenile surveys on select reaches of Maacama and Redwood Creeks through the CMP, as funding allows (UC, personal communication, February, 2015).

FOCAL SPECIES AND HABITAT

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 for the Maacama and Upper Mark West watersheds. Several listed species are found within both watersheds, as described in Chapter 2 above.

Instream and riparian habitat levels for each of these species vary throughout Maacama and Upper Mark West watersheds. Variations in food availability and stream temperature affect growth rates of salmonid within a stream and also between different streams (USFWS, 1983). High winter flows increase salmonid emigration and may effect smolt production (Giannico and Healey, 1998). Large wood material (LWM) directly improves fish habitat and the quantity of woody material and density of habitats have been strongly associated with salmonid overwintering survival (Quinn and Peterson, 1996). LWM is especially effective in pools since a pool with significant amounts of large wood is preferred by salmonids over a pool without it. Submerged large wood with a rootwad attached provides especially good cover for fish. The presence of large wood in fast water areas such as riffles and rapids creates a physical barrier around which water must flow, thus reducing water velocity. Decomposition of large wood in the stream serves as an energy source for the growth of microorganisms, which in turn are fed upon by macroinvertebrates, the main food source for salmonid fry. Many macroinvertebrate species spend part of their life cycles on large wood substrate. Greater accumulations of large wood trap gravel and create new channels, especially during periods of high flow. This increases the diversity and complexity of fish habitat.

Riparian habitats are the plant communities growing along a stream, river or other body of water and interface with land and water. These habitats are essential for healthy stream systems for aquatic species and to help maintain the viability of surrounding communities. Riparian habitats also interface with upland plant communities that play an important role in the health of the stream system and associated riparian habitat. Riparian corridors are made up of the riparian habitat and associated stream, river, creek and floodplain. In this Plan riparian corridors are used to describe the specific management area to implement practices to maintain and improve riparian functions and health (USDA, 2011).

Healthy riparian corridors help reduce the adverse effects of flooding by allowing for increased changes in flow, reducing erosion, and improving stream bank protection. In addition riparian corridors improve water quality by reducing temperatures and filtering out excess nutrients from agricultural and urban runoff entering the stream. Healthy riparian corridors, which provide key habitat to many different types of terrestrial plant and animal species, also provide a long term source of large wood material which is critical for salmonids and other aquatic species. Lastly, riparian corridors provide essential habitat linkages for wildlife movement.

RIPARIAN CORRIDOR ORDINANCE

The Riparian Corridor Ordinance, approved in 2014 by Sonoma County Board of Supervisors, is an implementation measure of the stream protection policy included in the County's General Plan. This ordinance establishes agricultural setbacks in order to protect and enhance riparian corridors and their functions along designated streams (PRMD, Ordinance No. 6089). The ordinance requires agricultural operations that extend into the agricultural setback area (defined as a Streamside Conservation Area or SCA within the ordinance) to follow best management practices (BMPs) identified by the Agricultural Commissioner's office in order to reduce potential impacts from their land uses to the riparian corridor and adjacent stream channels. The BMPs prescribed for the setback area include perimeter and erosion control techniques such as vegetative berms, straw bales or silt fences, prescribed grazing, grassed waterways, fencing, and cover crops. A full list of BMPs for grazing and agricultural cultivation within the riparian corridor can be found on the Agricultural Commissioner's website: http://sonomacounty.ca.gov/Agricultural-Commissioner/

FISH PASSAGE

Habitat quality is influenced not only by the physical habitat available in a given reach of stream, but also the accessibility of that habitat. Natural stream features such as log jams, as well as man-made structures such as dams, weirs, and culverts, are all instream barriers that potentially prevent or inhibit the natural movement of aquatic species. Maintaining conditions within the stream that provide hydrological and structural barriers to fish habitat can be a limiting factor in their recovery. Enhancing habitat without ensuring free access will not benefit special status species.

In both Maacama and Mark West watersheds some work has been done to better understand the impacts of fish barriers in these watersheds. Some of these efforts are associated with large-scale Russian River studies and assessments done by CDFW and private consultants. Based on findings included in these assessments the following is a list of identified barriers that may need further study in order to determine their impact on fish passage:

- Mill Creek (tributary to Mark West) – multiple barrier issues were identified as part of a 2013 CDFW survey. According to this report, it is recommended that access for migrating salmonids should be assessed at all road crossings and dams. Multiple barrier sites were documented, associated with the Cresta Road Bridge, an upstream ford crossing, and a dam site.

- Porter Creek (tributary to Mark West Creek) – a complete barrier for juveniles and partial barrier for adults has been identified where Porter Creek crosses under Calistoga Road in a twin box culvert. A study and designs to address this barrier, funded by CDFW, have been completed with the expectation that this project will be funded and implemented in the future.
- Weeks Creek – a complete barrier has been identified at Weeks Falls as part of a CDFW assessment.
- Mark West Creek – a waterfall located below the St. Helena Road bridge crossing may impede migration during some portions of the year. CDFW is anticipating assessing this site in the summer of 2015.
- Maacama Creek – a concrete ford previously identified as a barrier is currently being evaluated by CDFW. The study is expected be completed by spring 2015.
- Yellowjacket Creek – several dams and natural waterfall barriers have been documented approximately three miles upstream of the confluence with Kellogg Creek. Additional assessment may be necessary to better understand the impact on fish passage and to identify recommended actions.
- Kellogg Creek – a natural waterfall blocks fish passage in the area upstream of the confluence with Redwood Creek. Several migration barriers have also been previously identified on Kellogg Creek, which are filled with sediment but likely act as salmonid migration barriers at certain flow regimes. Additional assessment may be necessary to better understand potential impact from these barriers.
- Van Buren Creek – an undermining road culvert on St. Helena Road is preventing fish passage. Details have been assessed as part of the Russian River Stream Crossing Inventory Report (Taylor and Associates, 2003).

Additional details about fish passage barriers described above can be found in CDFW stream surveys provided in Appendix D.

Surveyed Stream Habitat Conditions and Concerns

In the Maacama and Upper Mark West watersheds, the riparian habitat is generally characterized by the following trees and shrubs: California Bay, (*Umbellularia californica),* big leaf maple (*Acer macrophyllum),* white alder (*Alnus rhombifolia),* willow (*Salix* spp.*),* coast redwood (*Sequoia sempervirens),* Douglas-fir (*Pseudotsuga menzieii),* spicebush (*Calycanthus occidentalis),* wild and cultivated grape (*Vitis sp.),* Oregon ash (*Fraxinus latifolia*), live oak (*Quercus agrifolia),* and black oak. There are also a variety of grasses, herbs, sedges and rushes that make up the herbaceous layer of the riparian corridor. These plant assemblages integrate with upland plant comminutes that typically include mixed conifer forests, oak woodlands, grasslands and chaparral habitat in the upper areas of the watersheds.

For most salmonid stream bearing systems, canopy coverage of 75-80% or greater is considered sufficient to provide enough shade and cover. Based on past CDFW stream surveys described below and more recent observation during various surveys and monitoring efforts, there are stream segments within both watersheds where canopy and riparian buffer width can be improved or enhanced.

Below are summaries of instream and riparian conditions within the Maacama and Upper Mark West watersheds, based on the findings from CDFW stream surveys, monitoring carried out by UCCE, NMFS, SRCD, and feedback from local landowners.

Maacama Creek Watershed

The Maacama Creek watershed is made up of several sub-basins including:

- McDonnell Creek sub-basin (includes Bluegum, Bear, and Ingalls Creeks)
- Briggs Creek sub-basin (includes Little Briggs and Coon Creeks)
- Kellogg Creek sub-basin (includes Yellowjacket, Foote, and Redwood Creeks)
- Maacama Creek sub-basin
- Bidwell Creek sub-basin
- Upper Franz Creek sub-basin
- Lower Franz Creek sub-basin

McDonnell, Bluegum, Bear, and Ingalls Creeks

Stream surveys were last conducted in this sub-basin by CDFW in 1996 (Marcus/Sotoyome RCD, 2004). These surveys found juvenile steelhead in all four creeks and generally good habitat, with the exception of McDonnell Creek. The surveys identified a lack of riparian canopy, high water temperatures, and high siltation in the channel of McDonnell Creek. These findings are consistent with the higher erosion potential within this drainage, spring-fed creeks, and the effects of long-term cattle grazing on deciduous riparian trees. Recommendations from the stream surveys included the addition of riparian exclusionary fencing and revegetation of the riparian corridor along the channel of McDonnell Creek and in various areas along Ingalls and Bear Creeks, which lacked good riparian cover. To date, in Maacama, UC has completed spawner surveys in winter 2014-2015 and conducted snorkel surveys in the lower reaches of Redwood Creek in 2012 & 2014 but have not completed habitat surveys (UC, 2015). More recently, landowners in this area of the watershed have expressed concerns regarding increased sediment loads that may be impeding fish passage and water quality (personal communication with various landowners, SRCD, 2015).

Briggs, Little Briggs, and Coon Creeks

Stream surveys were last conducted in this sub-basin by CDFW in 1996 (Marcus/Sotoyome RCD, 2004). Juvenile steelhead were found in all three creeks at that time and were also documented in Briggs Creek during three prior surveys, conducted in 1973, 1982, and 1984. The 1996 survey also noted a lack of riparian canopy in lower portions of Briggs Creek and Little Briggs Creek as well as relatively high water temperatures in those parts of the sub-basin. Upper Briggs Creek and Coon Creek were noted to have good riparian cover and cool water temperatures. Recommendations from the stream surveys included implementation of actions to reduce siltation, restricting cattle grazing and revegetating the riparian corridor along Briggs and Little Briggs Creeks.

Kellogg, Yellowjacket, Foote, and Redwood Creeks

Stream surveys for this sub-basin were conducted by CDFW on Kellogg and Yellowjacket Creeks in 1973 and on Foote Creek in 1998 (Marcus/Sotoyome RCD, 2004). NMFS also conducted a stream assessment survey on Foote Creek and Redwood Creek in 2007. The completed CDFW surveys rated the habitat in both creeks as excellent for steelhead. However, a fish barrier (several dams and natural waterfalls) was documented in Yellowjacket Creek, approximately 3 miles from its confluence with

Kellogg Creek. High siltation levels were also documented along Foote Creek. Survey recommendations included exclusionary fencing to reduce livestock impacts on the riparian corridor and revegetation to increase cover. In 2007, NMFS noted continuous stream flow and observed juvenile steelhead in Foote Creek. Their survey documented portions of the stream being artificially channelized through levees and rip-rap and several locations where over-steep banks are incising and contributing sediment, particularly near the Highway 128 crossing (NMFS, 2007). Two passage barriers, a flashboard dam and a head cut forming near a wet crossing, were also documented.

A survey that is documented to have been completed on Redwood Creek in 1997 was not readily available for review (However, other CDFW maps documented moderate (65 to 70 degrees F) temperatures and relatively low embeddedness levels along Redwood Creek.

An additional stream survey was completed by CDFW on Redwood Creek in 2001 (CDFG, 2001). The survey indicated elevated summer water temperatures, particularly in the Knight's Valley area where riparian cover was noted to be low. The survey also noted good spawning and pool conditions but inadequate pool shelter and riparian canopy cover. Recommendations from the stream surveys included increasing large woody debris, exclusion fencing for livestock, riparian revegetation, and implementation of actions to reduce siltation. The 2007 NMFS survey noted continuous stream flow and the presence of juvenile steelhead and steelhead redds. The survey noted that riparian was very sparse in some areas, consisting mainly of habitat restoration plantings that were recently implemented (NMFS, 2007). The survey also documented minor, naturally-occurring erosion sites as well as failing stream banks, in the upper portions of the surveyed stream segment, where cattle were accessing the creek from adjacent pastures. In other portions of this sub-watershed, where vineyard areas dominated the adjacent landscape, Redwood Creek was noted to be channelized through levees and deeply incised in some areas (NMFS, 2007). The NMFS findings indicated that, with a lack of instream structures or deep pools, these portions of Redwood Creek are likely to experience high velocity flows that would impede adult upstream migration during high flows, while shallow depths would limit passage during low-flow conditions. Head cuts associated with two wet crossings, as well as livestock fencing crossing the stream in two locations were documented as potential partial passage barriers in Redwood Creek (NMFS, 2007).

It should be noted that restoration actions have been taken within this reach however, there was low project success along Redwood Creek in Knights Valley. Past Knights Valley, Redwood Creek begins to flow within a more forested canyon that becomes steeper towards the confluence with Maacama Creek. Exclusion fencing for livestock is recommended within areas of this reach. Certain areas may also be in need of increased instream complexity but there is limited access within portions of this reach.

Maacama Creek

Stream surveys were completed by CDFW in this sub-basin in 1953, 1962, 1965, 1973, and 1996 (Marcus/Sotoyome RCD, 2004). A follow-up survey was performed by NMFS in 2007. A historical survey conducted in 1965 found 6.5 miles of good to excellent habitat in Maacama Creek. The 1973 survey identified 5 miles of good quality habitat and both surveys documented cool water temperatures (52 to 64 degrees F). The 1996 survey found low numbers of steelhead juveniles along with numerous warm water fish. The survey also noted poor and degraded habitat conditions, inadequate riparian canopy, warm water, and high siltation across Maacama Creek. The findings suggest that Maacama Creek may have experienced both a major input of sediment from its tributaries and a reduction in summer flows between 1973 and 1996. The NMFS survey indicated continues stream flows, juvenile steelhead observed in the majority of the stream segment surveyed as well as steelhead redds and one adult steelhead. The survey noted that several private residences are located immediately along the top of the stream bank in the area upstream of Chalk Hill Road bridge. The stream banks in this area were documented to be high and steep. Based on visual observations documented in the survey reports, these portions of the banks appear to have failed and been repaired in the past (NMFS, 2007). A partial passage barrier in the form of a dam and wet crossing, located on a ledge outcrop (low flow passage barrier) were also documented.

Bidwell Creek

Stream surveys were completed by CDFW in this sub-basin in 1964, 1976, 1983, 1996, and 1998 The surveys found few juvenile steelhead but a greater number of warm water fish. An adult spawning survey conducted in 1998 found six adults and four redds (Marcus/Sotoyome RCD, 2004). The 1996 survey found relatively dense riparian canopy and relatively cool water temperatures in all of Bidwell Creek. High siltation levels were documented in the most downstream sections of the confined channel. Sediment deposition was assumed to be higher in this section of Bidwell Creek due to a backwater condition created during flood flows as Bidwell meets the confined channel of Franz Creek. The observed conditions indicate a need for a reduction of sediment sources upstream of this confluence.

Upper and Lower Franz Creek

Stream surveys were completed by CDFW in this sub-basin in 1958, 1973, 1983, and 1997 (Marcus/Sotoyome RCD, 2004). A follow-up survey was also conducted by NMFS in 2007. The 1973 survey documented about half of the creek as dry but with an abundance of native warm water fish and a few steelhead. An adult spawning survey found one red and one adult steelhead (date unknown). The 1997 survey found juvenile steelhead as well as warm water fish. Water temperatures were noted to be cool in isolated pools that remain once the creek becomes intermittent. All of Lower Franz Creek and the downstream section of Upper Franz Creek were found to have high siltation levels. These creek areas (along with lower Bidwell Creek) appear to be subject to backwater conditions in floods, are low in slope, and were probably heavily impacted by major floods and fires that occurred in 1964 and 1965 in this area (refer to Chapter 8, Forest Lands, for discussion of historical fires). The surveys also indicated low level of riparian canopy on most of Franz Creek, with the exception of one partially-confined area where coniferous forest remains. High water temperatures were documented every else beyond this one well-shaded area.

The 2007 NMFS survey indicated discontinuous flow in the lower portions of Franz Creek and continuous flow further upstream, where juvenile steelhead were observed (NMFS, 2007). The report also noted observations of minor sediment contributions from erosion occurring where cattle are accessing the stream and wet crossings are present.

The survey also documented former erosion sites along a portion of the stream where Franz Valley Road runs closely along it and has caused washouts of portions of the stream bank. Two potential low flow passage barriers were also documented – a wet crossing with a head cut and a concrete foundation bridge crossing (NMFS, 2007).

Given the lack of adequate habitat in most of this sub-basin, CDFW records indicate that steelhead juveniles have been transferred from Franz Creek to other creeks with better rearing habitat in 1959 as well as annually between 1960 and 1964, and between 1966 and 1971.

<u>Upper Mark West Creek Watershed</u>

The Upper Mark West Creek watershed is made up of several sub-basins including:

- Mark West Springs Creek sub-basin (includes Horse Hill Creek)
- Porter Creek sub-basin
- Humbug Creek sub-basin (includes Mill Creek)
- Van Buren Creek sub-basin (includes Weeks Creek)

<u>Mark West Creek and Horse Hill Creek</u>

There were no readily available CDFW stream surveys for Upper Mark West Creek (the CDFW surveys were only Mark West Creek west of Highway 1). Also, to date UC's monitoring has been limited to snorkel surveys (3 years) and spanner surveys (1 year) of main stem Mark West and small sections of Porter Creek. Habitat surveys have not been conducted.

Horse Hill Creek which flows into Mark West, which was surveyed in 1997 (CDFG, 2006c). The survey did not observe any undercut banks nor small or large woody debris that could provide shelter and noted a lack of shelter. The survey also documented shallow pool depths and a lack of low gradient riffles that would provide good refugia and spawning habitat. The dominant substrate was documented as 100% silt/clay/sand. No fish were observed during the survey. A thin or nearly absent riparian buffer was documented in areas with livestock, agriculture, and urban development. Water temperature was not measured during this survey but was a recommendation for future stream assessment efforts. Other recommendations included a sediment source assessment, taking action to reduce sediment loads, and increasing the riparian canopy.

Porter Creek

A stream survey was completed by CDFW in this sub-basin in 1996 (CDFG, 2006d). The findings from this survey indicate elevated stream temperatures, above the threshold stress level (65 degrees F) for salmonids. The majority of the stream pools were observed to be shallow and lacking in adequate pool shelter. The riparian canopy was generally documented to be low and in need of improvement. The pool shelter observed was provided primarily by root masses, boulders, undercut banks, and terrestrial vegetation. The report also noted good spawning habitat with gravel or small cobble substrate. However, high sediment levels were noted to likely inhibit salmon spawning in several reaches. Recommendations in the report included adding more log and root wad cover, increasing frequency and quality of deep pools, increasing the riparian canopy cover (particularly with larger trees that can also contribute woody debris), and educating landowners regarding the importance of instream large woody debris to prevent removal.

These recommendations may be needed more within areas of Porter Creek closer to the confluence of Mark West Creek where there is more suitable spawning habitat and where the stream is less confined by Porter Creek Road. Also, there may be increased landowner participation within this area.

Humbug Creek and Mill Creek

A stream survey was completed on Humbug Creek by CDFW in 1996 (CDFG, 2006a). The survey documented stream temperatures at the threshold stress level (65 degrees F) for salmonids. However, the report noted that temperatures would need to be monitored for a longer period of time through the summer months to make further conclusions about impacts to salmonids. Deep pools were present but less frequently than recommended for good habitat. Pool shelter was rare and typically provided by undercut banks, boulders, and bedrock ledges. However, the substrate consistent predominantly of cobbles and the survey showed minimal impact from fine sediment, which suggest good spawning habitat. The report recommended increasing log and root wad cover across this sub-basin, removal of flashboard dams to improve fish passage, increasing riparian canopy to lower water temperature, and educating landowners about the importance of instream woody debris to prevent removal.

A 1997 stream survey performed by CDFW encompassed Mill Creek, which is part of the Humbug Creek sub-basin (CDFG, 2006c). This survey found only six of the 22 pools identified had a depth of two feet or grater (preferred depth for salmonids). Shelter in pools was infrequent and typically provided by root masses, boulders, undercut banks, and small woody debris. Spawning habitat was identified as poor, due to lack of gravel or small cobble substrate. The reported noted good riparian cover. The survey noted that steelhead, sculpin, and California newts were observed in Mill Creek during the survey and that recorded water temperatures were adequate for salmonids. The report recommended additional temperature monitoring for longer periods within the summer months to better understand the typical thermal regime.

An additional survey in Mill Creek, performed by CDFW in 2012, documented good stream temperature conditions for salmonids. However, the report noted that temperature monitoring throughout the summer months would be necessary to draw conclusions about habitat suitability in this creek (CDFW, 2013a). The survey also noted that only four of the 28 pools observed contained depths greater than two feet and recommended installation of in-stream structures to increase or deepen pool habitat. The report also recommended projects designed to improve the amount of suitable spawning gravel, an evaluation of fish passage barriers, installation of livestock exclusion fencing in areas where livestock access the creek, and utilization of bio-engineering to re-establish floodplain benches and a defined low flow channel.

<u>*Van Buren Creek and Weeks Creek*</u>

A 1997 CDFW stream survey looked at both Van Buren Creek and Weeks Creek, which is a part of the Van Buren Creek sub-basin (CDFG, 2006c). The Van Buren Creek survey identified some water temperatures above the threshold stress level (65 degrees F) for salmonids. Additional temperature monitoring was recommended to better understand the typical thermal regime. The survey also identified 45 pools, predominantly consisting of scour pools. However, only five of the 45 total pools had a depth of two feet or more. The dominant pool shelter types included boulders, bedrock ledges, root masses, and undercut banks. Spawning habitat was documented as poor, due to the lack of gravel or small cobble substrate in low gradient riffles that were observed. Riparian cover was documented as very good. Steelhead and roach were observed in the creek during the survey. An undermining road culvert on St. Helena Road was documented as a fish passage barrier.

The Weeks Creek survey identified only one low gradient riffle but with good spawning substrate and one of the five pools identified had a depth of two feet or more. Pool shelter was typically provided by boulders, root masses, undercut banks, and large woody debris. The riparian canopy cover was also documented to be poor. However, recorded water temperatures were in the favorable range for salmonids. The report noted that further temperature monitoring is recommended to better understand the typical thermal regime. No fish were observed in Weeks Creek during the survey.

An additional survey was performed by CDFW on Weeks Creek in 2012 (CDFW, 2013b). The observations in 2012 reflected findings from the 1997 survey: relatively shallow pools but good quality spawning substrate for salmon and steelhead. The 2012 survey recommended temperature monitoring throughout the summer months and more extensive biological sampling, in order to further assess habitat quality in this stream. It also recommended installing structures to increase or deepen pool habitat and to map and rate sediment sources and take measures to control those sources.

RECOMMENDED ACTIONS

Recommendation RI1 – Encourage livestock landowners to install riparian fencing to improve vegetative cover and reduce impacts to stream banks, particularly in Upper Maacama Creek, portions of Redwood Creek, Porter Creek, and Mark West Creek.

Recommendation RI2 – Provide resources to landowners about the benefits of large wood in streams.

Recommendation RI3 – Develop and implement instream enhancement projects in areas with less-than adequate cover and scour for anadromous species.

Recommendation RI4 – Target outreach and conservation projects in high priority reaches for fisheries enhancement.

Recommendation RI5 – Study fish passage and migration and the influence of backflow from the Russian River at the low reach of Maacama Creek.

Recommendation RI6 – Install instream structures in reaches of Redwood Creek, reaches of Porter Creek towards the confluence of Mark West Creek, and within Mark West Creek where landowner interest allows.

Recommendation RI7 – Install structures to decrease channel incision and recruit spawning gravel, in order to trap, sort, and expand redd distribution in streams across both watersheds.

Recommendation RI8 – Continue to conduct targeted outreach and coordinate with local agencies to assess high priority reaches and areas lacking habitat information, such as Porter Creek, reaches along Mark West Creek, Humbug Creek, Franz Creek, upper Maacama Creek, and portions of Redwood Creek, in order to develop site-specific treatments.

Recommendation RI9 – Secure funding to implement the high-priority, multi-purpose riparian enhancement projects and help landowners to apply for cost share programs to improve riparian corridors.

Recommendation RI10 – Increase riparian canopy cover with targeted plantings along the stream segments where shade canopy is not at adequate levels and where elevated water temperatures have been documented in stream surveys, particularly in McDonnell, Briggs, Maacama and Upper/Lower Franz Creeks in the Maacama Creek watershed and Horse Hill, lower reaches of Porter, Humbug, and Weeks Creeks in the Upper Mark West watershed.

Recommendation RI11 – Encourage near-stream riparian planting to provide bank stability and serve as a buffer against agricultural, grazing, and urban runoff.

Recommendation RI12 – Conduct surveys for species of concern, such as pond-breeding and stream-breeding amphibians throughout both watersheds.

Recommendation RI13 – Continue Broodstock Program monitoring and survey efforts of salmonid populations.

Recommendation RI14 – Assess and prioritize known fish barriers to identify those that exclude access to known quality fish habitat.

Recommendation RI15 - Remove identified barriers to fish migration in coordination with willing landowners and resource agencies.

Recommendation R16 –Promote programs that provide financial incentives, such as conservation easement programs, for riparian area protection and potential payments for other ecosystem services.

CHAPTER 6. SEDIMENT SOURCES AND IMPACTS

EROSION PROCESSES IN MAACAMA AND MARK WEST WATERSHEDS

Chronic and Episodic Erosion

Sediment delivery from road surfaces and cutbanks is defined as *chronic* when it occurs continuously during rainfall events that produce surface runoff. Generally 50 to 70 percent of sediment volume from roads originates from chronic sources and is usually less expensive to treat.

Sediment delivery is defined as *episodic* when it occurs as soils fail in response to storm events or other triggers. The delivery from a site may occur once, or in pulses over an indeterminate time period. Stream crossing washouts, road-related landslides, and gullying can produce episodic sediment delivery.

Surface Erosion

Surface erosion processes, which fall into the chronic erosion category, are relatively small scale erosion processes that can be broken down into rainsplash, sheet and rill erosion. These are processes that can take place over broad areas with bare soils or overall lack of cover.

Rain drops that fall directly upon bare soils will have a splash effect, which is called *rainsplash* and is defined as the impact of rain drops on the soil surface. Rainsplash only occurs if rain falls with sufficient intensity to allow the kinetic energy of the raindrops to detach and move soil particles a short distance. In many cases, particles may only be moved a few centimeters, however, if rain fall begins to concentrate, these particles are then easily transported by sheet erosion.

Sheet erosion is the transport of materials overland in broad extremely shallow flows rather than in defined channels or rills. A more or less uniform layer of fine particles is removed from the entire surface of an area, often times from a disturbed area such as plowed fields or unsurfaced roads, where there is a lack of vegetative cover.

As sheet flow coalesces it will form into *rills* which are small channels generally categorized as measuring less than 1 ft x 1 ft in cross-sectional area (Flosi et al., 2006). Rill erosion has the ability to transport large volumes of material delivered to them from the previous processes and can also expand as contributing flow increases thus increasing the total amount of material in transport.

As mentioned above, surface erosion in the form of chronic lowering of dirt and gravel roads that are hydrologically connected to stream crossings make up the majority (often over 70 percent) of sediment contribution to streams when looking over a ten-year or longer time period. Chronic road surface erosion accounted for 80 to 84 percent of all road related erosion in the Maacama watershed, and accounted for 61 to 85 percent of all road related erosion in the Upper Mark West watershed.

Some road surface erosion is inevitable due to the regular process of vehicles loosening and pulverizing roadbed materials (dirt and gravel) into fine dust particles during the dry season and then having those fine materials wash away during the first rains. However, there is often preventable road surface erosion that occurs due to improper shaping and draining of road surfaces. Rural and ranch roads are often insloped towards a ditch along the cutbank of the road. While this may be appropriate in some areas, it concentrates water thereby giving the water more erosive power. Additionally, when the ditch has an insufficient number of drainage structures such as ditch relief culverts to relieve its water-carrying burden, the ditch can incise and then transport that eroded sediment to the nearest stream crossing. Road surfaces may also be graded flat with no slope towards or away from the cutbank in which case the water from rain events will be forced to drain down the road surface itself leading to rilling and eventually gullying of the road surface, if left untreated.

The typical recommendations provided by Pacific Watershed Associates and the CDFW, for reducing road surface erosion from rural roads, is to outslope road surfaces and have regular permanent drainage structures, such as rolling dips, to allow water to shed off the road in a sheet flow fashion at regular intervals to route water to a stable infiltration or drainage area and prevent it from concentrating.

Gullies

A gully is created when the process of rilling grows to larger features measuring greater than 1 ft x 1ft in cross sectional dimension (Flosi et al., 2006). Gullies can become very large features that transport significant amounts of sediment from erosive hillslopes to a stream network. They can form from the coalescing of rills or be caused by concentrated drainage exiting a roadbed or culvert. This concentrated flow creates a new linear erosion feature where there was no drainage feature before. These features have the ability to stabilize on their own or can continue to erode and become significant features on a hillslope contributing large volumes of material to a stream depending on soils, slope gradient, and water input. They contribute sediment to the waterway by transporting materials already in solution at the head of the gully and by expanding in size, thereby contributing more materials from eroding banks of the gully.

In the Maacama watershed, gullies were associated with less than half of identified road-related sediment source assessment sites, among properties assessed to date. The majority of gullies in both cases were a result of insufficient rock armoring at fill crossing sites, which led to gully formation on the outboard edge of the road at the point where water drains off the road bed and onto the fillslope. Other major causes for gullies were due to plugged culverts and the associated diverted streams, poor road surface drainage on steep roads, and from in sufficient armoring at ditch relief culvert outlets.

In the Upper Mark West watershed, gullies were associated with 1/5 to 1/4 of identified road-related sediment source assessment sites, among properties assessed to date. In some locations observed, long and poorly drained road approaches were the main cause of gully formation, while poorly sized or plugged culverts and the associated diverted streams were the main causes of gullies on the other assessed property. In both watersheds, the majority of gullies acted as direct conduits for transporting road-related sediment to streams.

Channel Incision

Stream channel incision is defined as the lowering of the stream bed over a period of time. A "stable" stream is in a dynamic equilibrium when, over a decadal time scale, sedimentation processes are balanced so that the channel, while changing locally, maintains the same average morphological character. The morphology of a stream depends on two independent variables; runoff and sediment yield. These act in concert to determine channel depth, cross section, and grade. Boundary conditions include the valley slope, geology, resistance, soil type, and vegetation and may also include man-made controls such as dams, bridges, and water take from the creek for agriculture or other uses. Changes in sediment load, flow regime, and boundary conditions can disrupt the balance resulting in a creek that undergoes rapid morphological changes. When long-term stream erosion exceeds sedimentation, channel incision occurs.

Channel modification, including confinement and straightening of the channel, often leads to incision. Other causes for channel incision include reduced sediment transport due to upstream dams, increased peak flows caused by residential development, cover alterations in a watershed, and the removal of wood from a stream channel.

In general, channel incision accounted for less than 5% of sediment source assessment sites and was not observed as a major source of erosion on the assessed properties of Maacama and the Upper Mark West watersheds. The channel incision that was observed was due to the large outflows of a dam's spillway on an Upper Mark West property. The spillway's overflows have incised the channel below the spillway down to a bedrock layer which will likely halt further incision, but bank erosion may occur due to the over-steepened sides of the channel below the spillway if left untreated.

More assessment and fluvial geomorphologic analysis is needed to determine the full extent of non-road related stream incision and bank erosion on the main creeks and their tributaries in both watersheds.

Mass Wasting

Mass wasting, a form of episodic erosion that can be triggered during large storm events, can include landslides, earth flows, slumps, rock falls, and other events where large volumes of earth and rock are transported downslope, sometimes reaching stream systems. Roads can often be the causes of landslides in steep areas and are discussed in more detail below.

In the Maacama watershed, no active mass wasting was observed on the two assessed properties due to road activity. There was evidence of two past landslides on one property which may have delivered sediment to the nearby by stream, but these features have since stabilized and do not appear to be actively eroding.

In the Mark West Watershed, no road-related landslides where observed, but a deep seeded landslide was observed on one property. More assessment and analysis is needed to determine the full extent of mass wasting events on the main creeks and their tributaries in both watersheds.

Roads

Sediment delivery to stream channels from roads and road networks has been extensively documented, and is recognized as a significant impediment to the health of salmonid habitat (Harr and Nichols, 1993; Flosi et al., 1998). Reasons given for the detrimental effects of roads include the fact that the slopes at which most roads are built tend to inhibit the natural dispersal of water thereby concentrating runoff and creating gullies and landslides. In addition, road networks have created drastic changes in the natural drainage patterns of the watershed through increasing the amount of impervious surfaces and diverting water to follow roads rather than natural patterns.

Roads are a major source of erosion and sedimentation on most managed forest and ranch lands. Compacted road surfaces increase the rate of runoff, and road cuts intercept and bring groundwater to the surface. Ditches concentrate storm runoff and can transport sediment to nearby stream channels. Culverted stream crossings can plug, causing fill wash outs or gullies where the diverted streamflow runs down nearby roads and hillslopes. Roads built on steep or unstable slopes may trigger landsliding which can also deposit sediment in stream channels. Filling and sidecasting (the act of placing material on the hillslope to increase road width) increases slope weight, road cuts remove slope support, and construction can alter groundwater pressures, all of which may trigger landsliding. Unstable road or landing sidecast materials can fail, often many years after they were put on steep hillslopes. Lack of inspection and maintenance of drainage structures and unstable road fills along old, abandoned roads can also result in soil movement and sediment delivery to stream channels (Weaver and Hagans, 1994).

The compacted impervious surfaces that roadbeds create across a watershed actively capture and transport hillslope drainage down their lengths due to road insloping or the existence of inboard ditches that transfer flow. These conduits transport fine sediments derived from the road surface, the exposed cutbank of the road, and the inboard ditch itself, and may deliver it to stream channels. As mentioned previously, this form of road erosion is categorized as chronic because it is a steady and on-going process.

Stream crossings on road networks require careful design and maintenance to ensure longevity. Classically, stream crossings, particularly culverted crossings, have been under-designed and poorly constructed. Culverts are regularly too small to handle peak flows of the streams they are installed to convey, they are installed too shallow making them subject to plugging, and the crossings are designed in a way that, in the case of the culvert being overwhelmed, the stream will flow down the roadbed rather than staying within its natural channel. This diversion of a stream can lead to extreme erosion in the form of gullying or landsliding where the flow exits the road and finds its way back into the channel. As mentioned previously, this erosion process is categorized as episodic and can lead to significant pulses of sediment being delivered to a stream system.

ROAD ASSESSMENTS AND IMPLEMENTATION TECHNIQUES

Unlike many watershed improvement and restoration activities, erosion prevention and "storm-proofing" of rural, ranch, and forest road systems has an immediate benefit to the streams and aquatic habitat of a watershed. It helps ensure that the biological productivity of the watershed's streams is minimally impacted by future road-related erosion, and that future storm runoff can cleanse the streams of accumulated coarse and fine sediment, rather than depositing additional sediment from managed areas (Weaver and Hagans, 1994).

An evaluation of road density across the Maacama watershed sub-basins was performed as part of the Maacama Creek Watershed Assessment. Many of the roads present within this watershed are associated with historical logging and mining operations. The findings from that evaluation are shown in Table 6.1 below.

No in-depth evaluation of road density has been completed for the Upper Mark West watershed, but Pacific Watershed Associates (PWA) estimates that there are just over 80 miles of unsurfaced roads within this watershed. Gaining access to properties within both of these watersheds to assess the road networks is a significant first step in understanding what erosion processes are occurring and what impacts they may have on the in-stream conditions.

Table 6.1 Frequency of Roads within the Maacama Watershed Sub-Basins

Maacama Watershed Sub-Basin	Total Amount of Roads (miles)	Amount of Road on >30% slope (miles)	Ratio of Road Frequency (per square mile)
McDonnell Creek	36.4	16.9	3.82
Briggs Creek	67.7	30.7	5.47
Kellogg Creek	61.2	17.1	4.16
Bidwell Creek	33.8	7.1	5.51
Upper Franz Creek	53.3	14.6	5.59
Lower Franz Creek	37.8	11	4.8
Maacama Creek	48.8	12.1	4.63

Table derived from the Maacama Creek Watershed Assessment

ROAD RELATED SEDIMENT SOURCE ASSESSMENTS

The purpose of a road-related sediment source assessment is to identify and quantify road-related erosion and sediment delivery to streams, and present a prioritized plan-of-action for cost-effective erosion prevention and erosion control for the road system. The majority of properties assessed in the two watersheds have been through competitive grants rounds where the SRCD contracts with PWA. Since 2014, the SRCD has also been able to assess and complete basic road inventories for agricultural properties as part of their newly-developed LandSmart® planning program (refer to Chapter 7, Agricultural and Rural Preservation for additional discussion about LandSmart).

Depending on the future land-use needs that a landowner or property manager may have, two different techniques of drainage improvements may be utilized: upgrading or decommissioning. Upgraded roads are kept open, and are inspected and maintained regularly. Their drainage structures should be designed to accommodate the 100-year peak storm flow. Conversely, properly decommissioned roads are closed and no longer require maintenance. Whether through upgrading or decommissioning, the goal of storm-proofing is to make the road as "hydrologically invisible" as possible, that is, to reduce or prevent future sediment delivery from the road to the local stream system (Weaver and Hagans, 1994).

COMPLETED ROAD ASSESSMENTS AND IMPLEMENTATION

Maacama Watershed

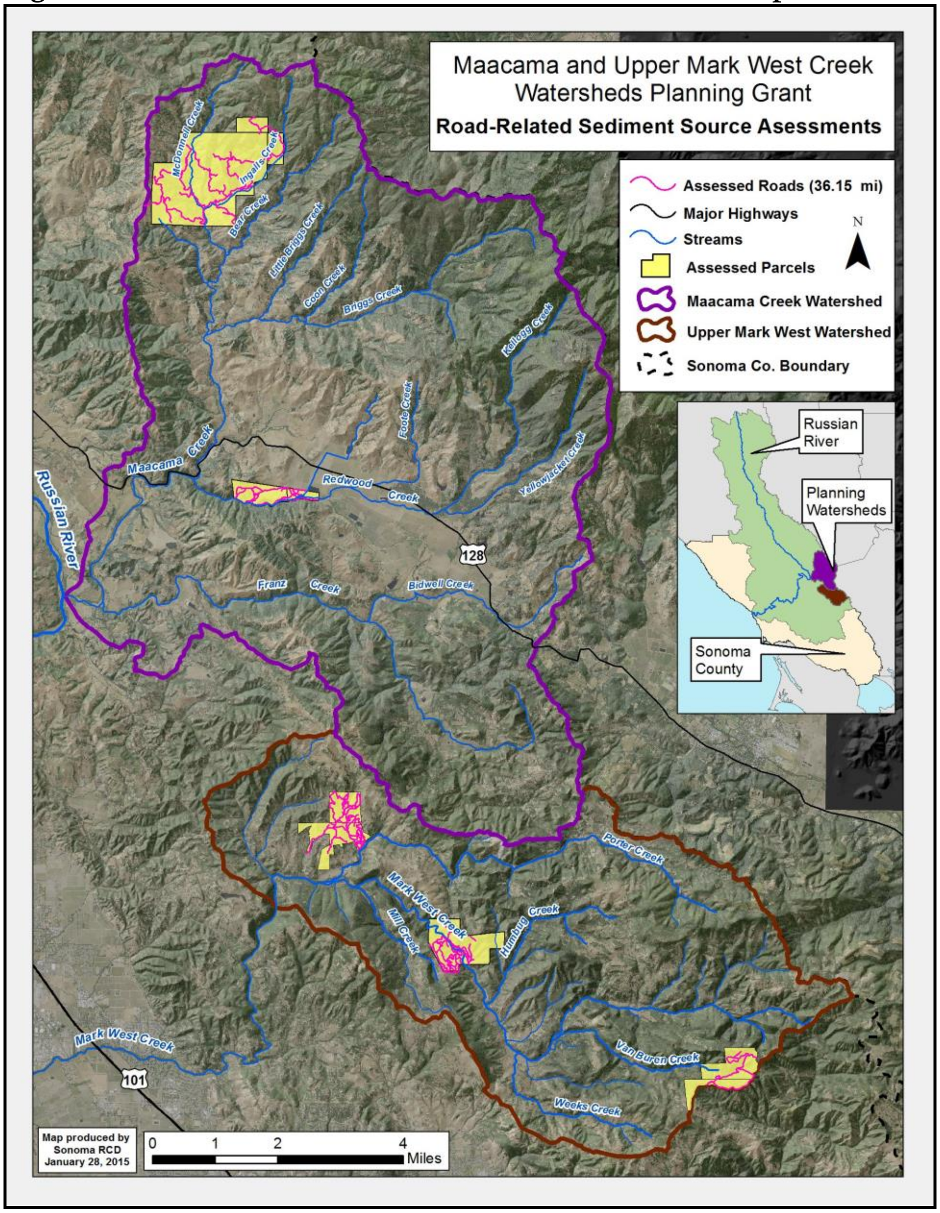
The SRCD and PWA have assessed a small subset of roads in the Maacama watershed for erosion and sediment delivery to streams. The recently assessed areas include 13 miles of roads in the McDonnell and Ingalls Creek subwatersheds in 2011 and 4.5 miles of roads along a middle reach of Redwood Creek near the confluence of La Franchi Creek assessed during 2014 and 2015 (See Figure 6.1 below). A summary of the sediment source assessment findings are presented in Table 6.2 below.

Outreach regarding future sediment source assessments should be conducted to additional high priority landowners within Maacama watershed, particularly within the Briggs Creek and Franz Creek sub-watersheds.

Table 6.2 Road-related sediment source assessments performed during the period of this grant

Watershed	Miles of Roads Assessed	# of SSA Sites Recommended for Treatment	Chronic Erosion	Episodic Erosion	Total Potential Sediment Savings
Maacama Creek	13.2	65	5,406	1,281	6,405
Maacama Creek	4.5	36	2,710	635	3,345
Mark West Creek	9.3	80	3,595	1,320	4,915
Mark West Creek	5.85	31	3,160	1,980	5,140
Mark West Creek	3.3	6	319	57	376
Totals	**36.15**	**218**	**15,190**	**5,273**	**20,181**

Figure 6.1 Road-related sediment source assessments completed across both watersheds



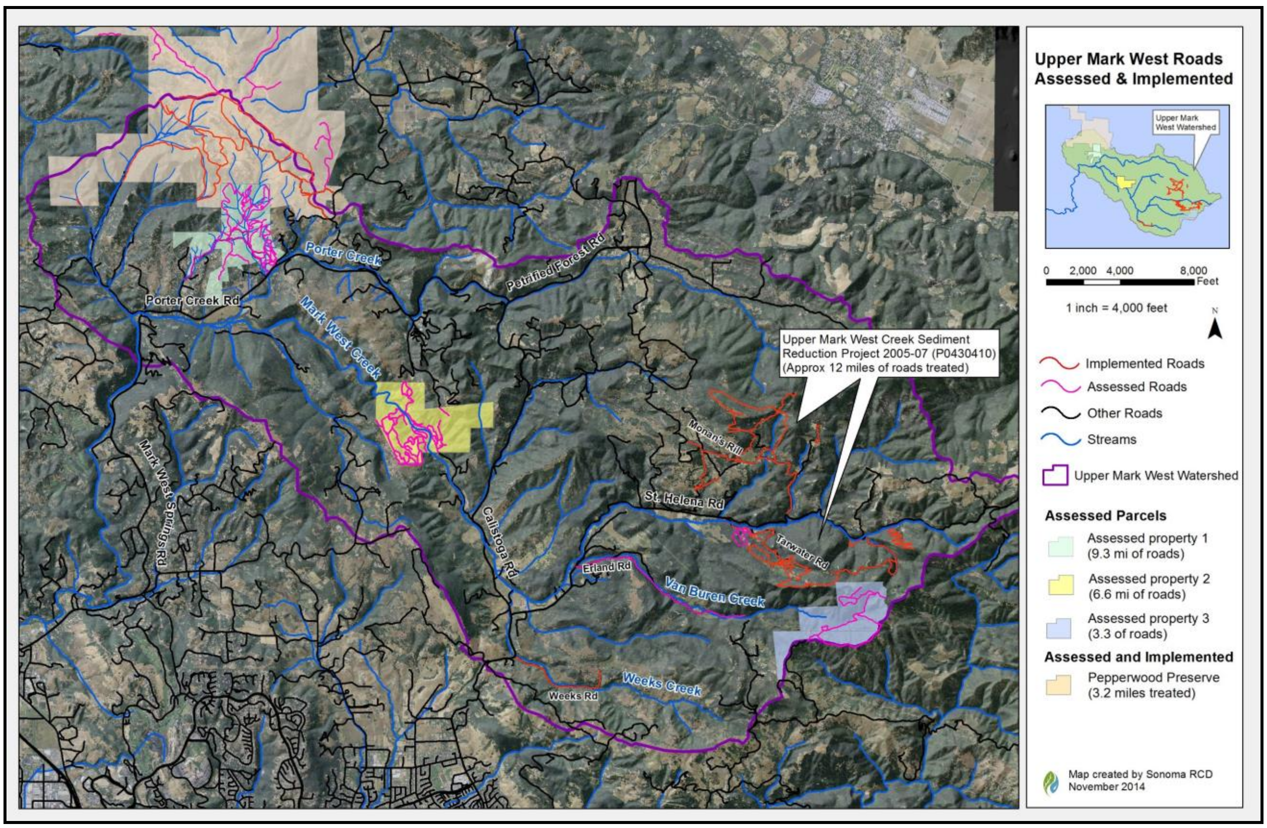
Upper Mark West Watershed

PWA, under contract with the SRCD, completed three sediment source assessments in the Upper Mark West watershed prior to 2010. These assessments focused on rural roads, including Tarwater Road, Mattei Road, the Monan's Rill complex of roads, Lone Pine Road, Cleland Road, Erland Road, Phillips Road, and the roads encompassed within the Pepperwood Preserve (See Figure 6.2). These assessments included approximately 25 miles of unpaved roads, representing approximately 31% of all unpaved roads in the Upper Mark West watershed, according to PWA estimates. The most common erosion problems found by PWA in the watershed were: 1) erosion at or associated with stream crossings (from several possible causes); 2) gully erosion on hillslopes below ditch relief culverts; and 3) road surface and ditch erosion.

Of the 25 miles assessed by PWA, 11.9 miles of road were improved between 2006 and 2007 under a grant awarded to the Sonoma RCD by the California Department of Fish and Game (now California Department of Fish and Wildlife, CDFW) and involved the coordination of over 70 landowners. This project resulted in a savings of over 14,000 cubic yards of sediment.

SRCD coordinated the improvement of another 3.16 miles of roads on Pepperwood Preserve in 2013, funded by the City of Santa Rosa, saving an estimated 3,195 cubic yards of sediment from entering the Mark West watershed. (See Figure 6.2).

Figure 6.2 Roads assessed and implemented in Upper Mark West watershed



More recently, SRCD coordinated with PWA to complete the assessment of an additional 18 miles of unpaved roads in 2014 at three separate properties, bringing the total percentage of assessed roads in the watershed up to 53%.

Outreach regarding future sediment source assessments should be conducted to additional high priority landowners within the Upper Mark West watershed, in particular, along the mainstem of Mark West Creek, from Alpine Rd to the intersection of Calistoga Rd and St. Helena Rd as well as and in the Porter Creek sub-watershed, to properties upstream of the intersection of Porter Creek Rd and Franz Valley Rd.

Other Assessment Considerations

In addition to the maintained unpaved roads in the watershed, there are many miles of un-inventoried driveways, access roads, skid roads and abandoned roads that have the potential to deliver sediment to streams as well. A comprehensive inventory of unmaintained roads in both watersheds is needed to more accurately describe road-related erosion. Additionally, non-road related sediment sources need to be inventoried to assess their contribution to sediment loads, and to plan for future control of these sources Lastly, suspended sediment and flow data is needed to determine instream loads and compare these with identified upslope sediment yields.

No systematic assessment or modeling of surface erosion has been conducted for the Maacama and Upper Mark West watersheds, but it is likely that the timber harvesting and the process of converting native woodlands for orchards, vineyards, and mining has increased surface erosion over historical levels. Large agricultural areas are generally designed to drain water rapidly which leads to increased rates of storm runoff, thereby resulting in higher peak storm flows in the creeks and higher rates of erosion. This results in increased delivery of surface erosion to the creeks and can lead to increased scour and incision of the stream channels. More in depth assessment is needed of these other possible sediment sources to determine their overall sediment contribution to Maacama and Upper Mark West watersheds.

RECOMMENDED ACTIONS

Recommendation SSI1 – Conduct in-depth hydrologic and geomorphic assessments in both watersheds, to better understand the geomorphic condition.

Recommendation SSI2 – Conduct a road development history study utilizing historical aerial imagery in the Upper Mark West watershed.

Recommendation SSI3 – Use findings from historical road development research to identify areas with concentrations of historical roads where to prioritize outreach and future road sediment source assessments.

Recommendation SSI4 – Utilize historical roads data along with current 2014 LiDAR data to map all rural roads within both watersheds.

Recommendation SSI5 – Conduct a multi-phased series of road sediment source assessments on high priority road networks in order to develop prioritized sediment reduction plans for these watersheds.

Recommendation SSI6 – Continue to assess and inventory farm and ranch roads on agricultural properties in high priority areas through the LandSmart® planning program.

Recommendation SSI7 – Prioritize and implement road sediment reduction plans resulting from existing sediment source assessments.

Recommendation SSI8 - Conduct a landslide/mass wasting historical study using aerial photographs. Utilize the study to assess if the identified erosion features are naturally occurring or are due to management practices.

Recommendation SSI9 – Conduct field visits, in tandem with the historical study, to 20 percent of the mapped erosion features to assess study accuracy.

Recommendation SSI10 – Encourage landowners with current management-induced mass-wasting occurring to adapt land management practices to reduce or stabilize landslides and bank erosion, through bioengineering techniques, wherever feasible.

CHAPTER 7. AGRICULTURAL AND RURAL LAND PRESERVATION

Supporting rural landscapes and sustainable agriculture in the Maacama and Upper Mark West watersheds is critical in preserving the local economy, community development, cultural history, and ultimately ecosystems that so many species rely on.

AGRICULTURAL BACKGROUND

Farms and ranches are a vital part of the history and culture of the Russian River Watershed. Vineyards are one of the major land uses in the Russian River Watershed. Sonoma County ranks 6th in the state and 34th in the nation in agricultural productivity and the county recognizes that agriculture is an important economic, social, and historic resource and has taken measures to protect it (Sonoma County PRMD, 2008).

AGRICULTURAL SUSTAINABILITY

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. Stewardship of natural resources on agricultural lands includes preservation and rehabilitation of ecological processes such as groundwater recharge, pollutant sequestration, pollination services, and nutrient sequestration. Agricultural lands, when sustainably and responsibly managed, can provide numerous ecosystem services to local fish and wildlife and watershed community residents including pest control, pollination, carbon sequestration, and water retention.

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.

Grazing-based agriculture can be very important in maintaining grasslands, including many native grass and wildflower species, as well as the wildlife they support. It can also create challenges to sustaining healthy streams and rivers. Most agricultural landowners have high quality habitat on their property, while others may need assistance to improve this resource. Managing manure, protecting riparian areas from trampling and excessive browsing, controlling soil compaction and invasive weeds, and even maintaining a network of year-round roads to reach livestock are part of the ongoing work of good stewardship.

As with all agricultural producers, grape growers also need to plan and manage vineyards to protect natural resources. Crop cultivation can have impacts on the surrounding watershed from replacing native vegetation, potentially exposing soil to erosion, fragmenting wildlife ranges, and changing the amount and timing of storm runoff.

CONSERVATION PLANNING

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

The purpose of a conservation plan is to develop a document 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 are designed to be working documents that are revised as needed. These plans are typically kept on-site where it is available for easy reference and updating. There are a variety of conservation programs available to farm and ranch owners that can assist in the identification of BMPs and restoration activities needed on their properties. Two examples of these programs in the Maacama and Upper Mark West watersheds are:

LandSmart®

LandSmart is a regional conservation program offered by the SRCD, and neighboring RCDs to assist landowners with improving their agricultural operations by minimizing erosion and impacts to water quality from their operations. The LandSmart® program assists vineyard and ranch owners with completing comprehensive farm and ranch plans, conservation project prioritization, designs, project funding, CEQA compliance, permitting, and project oversight. This program also offers educational workshops about agricultural BMPs.

Fish Friendly Farming®

Fish Friendly Farming is a farm plan certification program developed by Laurel Marcus and Associates (now California Land Stewardship Institute) and the Sotoyome RCD (now Sonoma RCD) in 1999, for vineyard properties. The program is designed to help agricultural landowners restore fish and wildlife habitat and improve water quality around their operations. The program has also expanded to include farm planning on ranch properties.

CONSERVATION EASEMENTS

A Conservation Easement is a voluntary legal agreement between a landowner and a land trust (or government agency) which restricts the use of a particular property in order to protect its conservation values. Conservation Easements are used to achieve a variety of conservation purposes, including open space preservation, agricultural preservation, and natural resource protection. The Conservation Easement is recorded in the form of a Grant Deed and is binding on successive owners of the property in perpetuity. In other words, it is forever. 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, 2008).

A Conservation Easement is tailored for each specific property based on the common preservation goals of the landowner and the holder of the easement. For example, Conservation Easements may prohibit development on scenic landscapes; prohibit non-agricultural uses on agricultural land; restrict timber harvests to sustainable levels over forest land; or require that land be kept “forever wild” on natural areas. One of the primary purposes of a Conservation Easement is to maintain larger parcels intact, in order to decrease fragmentation of wildlife habitat, agricultural lands and natural resources. Therefore, most Conservation Easements prohibit further subdivision of the property.

In some instances, development may be permitted within a specific building envelope. For example, on a large parcel that could be subdivided into many lots, the Conservation Easement may restrict development to one single home site. Or, on agricultural land, buildings and facilities necessary to the agricultural use of the property may be permitted. Unless desired by the landowner, Conservation Easements generally do not provide public access to the property.

A Conservation Easement is an excellent tool for families who wish to keep their land intact to pass on to the next generation. Landowners retain title to the land and continue to occupy and use the lands under the terms of the Conservation Easement. A subsequent owner would also be obligated to use the lands under the terms of the Conservation Easement.

Both the Sonoma County Agricultural Preservation and Open Space District and the Sonoma Land Trust (SLT) hold several conservation easements on agricultural and rural properties within the Maacama and Upper Mark West watersheds. In 2014-2015, SLT have noted an increase in inquiries from landowners in both watersheds regarding possible conservation easement opportunities.

THE WILLIAMSON ACT

The Williamson Act, known formally as the California Land Conservation Act of 1965, was established to preserve agricultural and open space lands by discouraging conversion to urban uses. The Act establishes a contract between private landowners and counties or cities to voluntarily restrict land use activities to agricultural and compatible open-space uses in exchange for reductions in tax obligations. About 300,000 acres of agricultural land are under Williamson Act contracts across Sonoma County (Sonoma County PRMD, 2008).

RURAL RESIDENTIAL

A limited amount of rural residential development is concentrated in the Upper Franz Creek and lower Maacama Creek areas within the Maacama watershed. Parcels in this area are generally smaller in size (less than 10 acres) compared to those in other portions of the Maacama watershed. Although several large vineyard and ranch properties are present in the Upper Mark West watershed, the majority of this watershed is rural residential, along with some smaller hobby gardens, orchards, or vineyards.

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. Also, many rural residential parcels are smaller in size than large ranch lands and pose a challenge for restoration work because often, to address a stream reach and have a larger benefit, many landowners must be engaged and willing to participate.

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 6, Sediment Sources and Impacts*). Management practices to reduce sedimentation from roads are available from many sources. A list of additional resources for implementing management measures on rural and agricultural lands will be developed upon further stakeholder feedback.

RECOMMENDED ACTIONS

Recommendation AR1 – Provide educational, technical, and financial services to help growers and ranchers in understanding and complying with applicable agricultural regulations.

Recommendation AR2 – Develop LandSmart farm water quality plans to document existing stewardship and plan for future beneficial management practice implementation.

Recommendation AR3 – Prevent and control soil erosion from working lands, through implementation of best management practices.

Recommendation AR4 – Improve water use efficiency of irrigation and frost protection systems. Explore alternative water sources for these uses.

Recommendation AR5 – Enhance soil quality through managed grazing, improved tillage and fertilization practices, and avoidance of land disturbance during wet-weather periods.

Recommendation AR6 – Conduct outreach about minimizing potential of animal waste runoff occurring from confined livestock areas and watering facilities near waterways, manure and fertilizer application, and silage storage.

Recommendation AR7 – Promote farming techniques that increase carbon sequestration, increase water holding capacity, protect soils, and buffer production from climate extremes.

Recommendation AR8 – Assist landowners with developing projects to ensure water reliability through increasing water storage capacity or developing a reliable water supply for rural and agricultural uses.

Recommendation AR9 – Connect agricultural landowners with programs such as conservation easements and Farm Bill programs that provide additional capital to support agricultural land values and conservation of rural properties.

Recommendation AR10 – Work with local land conservation organizations such as SCAPOSD and SLT to promote conservation easements and habitat enhancement projects on agricultural and rural properties.

Recommendation AR11 – Encourage landowners to minimize, wherever possible, fencing and other incompatible management practices that disrupt migration through wildlife corridors and riparian areas located on their properties.

CHAPTER 8. FOREST LAND PRESERVATION

BACKGROUND

Forests help conserve and enrich the environment in several ways including water and air quality enhancement, protection from soil erosion, and providing wildlife habitat. For example, forest soil soaks up large amounts of rainfall. It thus prevents the rapid runoff of water that can cause erosion and flooding. In addition, rain is filtered as it passes through the soil and becomes ground water. This ground water flows through the ground and provides a clean, fresh source of water for streams, lakes, and wells. Forest lands occupy approximately 12 percent of the Maacama watershed and approximately 35 percent of the Upper Mark West watershed.

CONDITIONS AND CONCERNS

Current concerns in relation to forest health in the Maacama and Upper Mark West watersheds include increased wildfire threat, decrease of health, vigor and productivity in timber species, and the spread of Sudden Oak Death (SOD). The majority of the forested area within these watersheds is identified as 'High' or 'Very High' Fire Hazard Severity by CalFire. The lack of forest management in much of the watershed has created overstocked forests resulting in a dense understory that provides the potential for stand replacing wildfire through the abundance of fuel load and ladder fuels. Overstocked forests also inhibit regeneration and growth of seedlings as well as degradation of wildlife habitat, particularly for raptor species that thrive in open spaces for hunting. Invasive species is a growing concern and French broom is one particular invasive that is becoming abundant and an increasing concern for forest landowners.

Forest stand improvement practices such as thinning, pruning, forest slash treatment, and fuel breaks are beneficial to decrease overall wildfire hazard. These practices decrease fuel load and ladder fuels, improve wildlife habitat, and promote optimal growth potential for desirable species. Timber harvest and pre-commercial thinning can also be beneficial for the same reasons. Addressing invasive species and competing vegetation by hand, mechanically, or with chemical treatment are beneficial forest management practices. Tree planting is often conducted to improve stand composition of timber species, increase tree species diversity, improve riparian canopy cover, and revegetate areas with tree loss from SOD.

Mortality and Snags

Timber inventories completed within these watersheds recorded standing dead trees, or snags, and downed woody debris. It found very large numbers of snags, predominantly Douglas fir, madrone, laurel, and tanoak. Conifer diameters tended to be much higher than hardwoods, and their condition generally much less decayed (Max, 2007). Beneficial forest management of the forested areas in these watersheds could include allowing snags to develop or snag creation in groups, maintenance of dense stands, and continued development of significant downed woody debris. While this will improve naturally over time, important wildlife and soil elements for habitat may be increased by gradual thinning and snag creation. Typically, one to two snags per acre is adequate for wildlife habitat.

Fire

Fires are a large part of the natural ecosystem in the area surrounding the Maacama and Upper Mark West Creeks as well as the surrounding watersheds. Fires act to clean out the brushy understory of a forest as well as take out dead and dying trees. Many plant species in this region are well adapted to fire and several plant and tree species rely on fire for regeneration and benefit from the reduction of competing vegetation. Several large wildfires have historically swept through these watersheds, including the PG&E # 10, Porter Creek, Hanly, Silverado/Morrison, and Ida Clayton fires. Figure 2.9 from the Sonoma County Hazard Mitigation Plan, included in Appendix E, shows the geographic extent of fires that have occurred in and around these watersheds between 1939 and 2004. In 1964 and 1965, the Hanly and PG&E # 10 fires burned a large portion of the Maacama watershed. The Hanly fire burned a total of 55,000 acres, within the Maacama watershed and beyond, and became the largest fire in the region's recorded history (Marcus/Sotoyome RCD, 2004). The other documented fires generally impacted smaller portions of these watersheds (less than 10%).

Historically fires were ignited naturally by lightning strikes and by anthropogenic means as a way to manage the resources on the land. In the last century the fire regime has changed dramatically with the implementation of an effective fire suppression program. The current fire regime and development in rural areas has resulted in increasing amounts of funding to suppress fire and to address adverse effects resulting from fire. Much of the forests are now overstocked with horizontal and vertical continuity that poses risk for destructive canopy fire. This fire suppression and lack of forest management has created a more dense and brushy condition than would naturally develop in the region. This has also resulted in sensitive ecosystems to be encroached upon by more resilient and vigorous species such as Douglas firs encroaching on meadows and oak woodlands. (Loganbill, D. Anecdotal Evidence. 2013).

Insects

In Sonoma County forests, insect attacks generally occur in scattered small areas. For Douglas fir, build-up of insect populations to the point of significant damage is generally associated with trees that have blown down, logging slash, or are damaged from fire, all of which provide a favorable habitat for insects. Bark beetles cause major damage to California forests, boring tunnels into inner bark and cambium to lay eggs; hatching larvae bore additional galleries as they mature, and the process repeats, sometimes several generations within a single year.

Generally beetles are specific to one particular species of tree, though some may infest several types, and severe infestations weaken and often kill the tree or whole stands of trees. Two bark beetles that attack Douglas fir are the Douglas fir beetle (*Dendroctonus pseudotsugae)* and the Douglas fir engraver (*Scolytus unispinosus)*. Older, stressed Douglas firs are more successfully attacked by bark beetles. Bark beetle attack symptoms generally include the upper parts of beetle-infested trees fading first from the deep green to light green, then yellow, and finally to red. The top alone may be killed or the entire tree may be affected. Other less noticeable initial signs of bark beetle attack can include boring dust from entry holes through the bark or pitch tubes exuding from entrance holes. Infested trees with living bark beetles should be cut down and removed, burned or debarked. Maintaining the vigor and health of a forest stand along with good management and sanitation practices is typically the best defense (Max, 2007).

Douglas Fir Diseases

There are a number of diseases which may cause the root crown or lower trunk rots (also called "butt rots") of Douglas fir. White pocket rot, also called red ring rot, (commonly in the literature as *Phellinus pini* or *Fomes pini,* but recently reclassified as *Porodaedalia pini*) is a common and destructive heart rot which normally attacks trees through roots and open wounds, fire and lightening scars (Swain, personal communication 2015). Red brown rot, also called red cubicle rot, *(Phaeolus schweinitzii)* similarly attacks just the butt of the tree.

Black stain root disease *(Grosmannia wagneneri,* commonly in literature as *Leptographium wageneri* or *Ophiostoma wageneri)* has been found on Douglas fir in Sonoma County, infecting the roots of trees of all ages where it spreads throughout the sapwood of the root system, root crown, and lower bole, causing a visible decline in the tree crown, reducing terminal growth, needle production, and eventually causing tree death.

Occurrences of conks are common with *Phellinus* and appear occasionally with other fungi. Annosus root disease (*Heterobasidion annosum)* can be found in Douglas fir, coast redwood, madrone, and manzanita. This fungus enters on cut surfaces or through root contact making thinned stands especially vulnerable. Trees weakened by fungus diseases are more susceptible to beetle attack. Common points of infection for these fungi are branch stubs, wounds, and fire scars (Max, 2007).

Redwood Diseases and Insects

Some insects that attack redwood are the flat-headed borer *(Anthraxia aeneogaster)* and the round headed borers *(Callidium sempirvirens, C. pallidum, Leptura obliterate, Preonius Californicus)*, and the redwood bark beetle *(Phloesinus sequoia)*. Redwood pocket rot *(Poria sequoia)* is a large brown pocket rot of the butt and trunks, commonly on old trees.

Sudden Oak Death

Sudden Oak Death (SOD) is a disease caused by the pathogen *Phytophthora ramorum.* It is established in the Maacama and Upper Mark West watersheds, with six laboratory confirmations having been obtained for trees in the Porter Creek and Franz Valley Road regions, eight more in the Calistoga and St. Helena Rd. regions, and at least 70 more lab confirmations, as of February 2015, coming from further south in the Maacama watershed. A number of long-term research plots have been established (mostly on private property) in these watersheds by UC, Cal State, and affiliated research organizations. Data from these sites suggest that sudden oak death has elevated mortality levels on coast live oak (*Quercus agrifolia*) and black oak trees (*Q. kelloggii*) over historical levels, and has severely depleted mature tanoak (*Notholithocarpus densiflorus*) stocks throughout this area.

Symptoms of infection vary by tree species. Coast live oak, black oak, and tanoak typically develop trunk cankers, the symptoms of which are deep burgundy colored droplets oozing from the bark, which are sticky when fresh, and smell vaguely of old wine barrels when the viscous liquid is rubbed between the fingers. Symptoms on bay laurel (*Umbellularia californica)* and other foliar hosts are much more subtle, being mostly small black leaf spots. However, these foliar hosts are responsible for the natural spread of the disease. It moves from leaf to leaf on foliar hosts in cool wet weather, infecting oaks when spores happen to land on their trunks. The disease is not known to spread from infected oaks to other trees (tanoak is an exception, and can spread the disease, which in part seems to account for its high mortality rate). Infected and dead coast live oak and black oak trees therefore present little risk for spreading the disease. However, a risk still exists and while infected materials should remain on site, dead and dying oaks should not be the focus of disease management. For more information refer to: http//:www.suddenoakdeath.org.

Because the disease spreads in cool, wet conditions, warm dry winters present little opportunity for the disease to infect new hosts. However, small pockets of disease seem to persist in some geographical regions during warm, dry winters. Predicting exactly where the disease will persist in inland locations such as the Maacama and Upper Mark West watersheds is difficult, but some infected areas may become disease free after several years of below average rainfall.

Work done by Margaret Metz and Maia Beh (Rizzo lab, UC Davis) in the Big Sur region after the Chalk, Big Basin, and Pfeiffer fires suggest that forests infested with *P. ramorum* respond differently than uninfested forests in some cases, notably that fire risk is increased for a brief period of time where dead trees remain standing. However, this is balanced by somewhat reduced risk on plots that have had disease for longer periods of time, as on these plots there are lower levels of standing fuels. Thus, for homeowners and property managers on sites with significant SOD infestation, regular monitoring of forest conditions is critical for keeping fire risk at acceptable levels, particularly as it relates to the amount of standing dead and ladder fuels.

The impact of infection by *P. ramorum* on foliar hosts is generally small, as trees drop infected leaves within a year or so and sprout new ones. In contrast, oaks and tanoaks die more quickly than one might expect from the disease alone (hence the “sudden” in the name sudden oak death). This is because when the disease attacks the conductive tissue in the tree trunks, it causes the tops to starve for water. This, in turn, attracts beetles that are adapted to hunting drought stressed trees. Two of the primary beetles that attack oaks are the oak bark beetle, *Pseudopityophthorus pubipennis*, and the ambrosia beetle, *Monarthrum scutellare* and *M. dentiger*. Attacks by these beetles greatly hasten the rate at which infected trees die. Once the tree has significant amounts of dead tissue on the trunk, it may be colonized by a decay fungus that resembles round balls of charcoal stuck to the outside of the bark. This organism, *Annulohypoxylon thouarsianum*, decays the outer sapwood of the tree, which is critical for the structural stability of the tree. Appearance of this fungus on significant portions of the oak's trunk is normally an indication of its imminent failure.

SOD is a federally quarantined organism and off-site movement of infected materials should be discouraged. Movement of infected materials out of the quarantine zone (currently Marin, Sonoma, southern Mendocino, and a small portion of Lake County) is prohibited.

Madrone Die Back

Madrone is subject to leaf and twig diseases, notably blister blight *(Exobasidium vaccinii)* and madrone foliage blight (*Mycosphaerella arbuticola).* These foliage diseases thrive in cool, wet weather, but normally symptoms subside with the onset of warm, dry weather, and seldom cause lasting damage. While it is not uncommon to see trees with dead leaves in the fall season, the trees generally come back the following year. More seriously, madrone canker *(Nattrassia mangiferae*) and/or madrone twig blight (*Botryosphaeria dothidea)* can kill trees, if given enough time. Madrone mortality due to these diseases is generally due to overcrowding in the forest, and either mechanical bark injury or sunscald. For more information, refer to: http://extension.oregonstate.edu/sorec/sites/default/files/ec1619-e.pdf

Forest Health

Sanitation is important in maintaining good forest health. Lopping of slash and quick decomposition of dead trees in logging operations and in thinning practices will reduce disease and insect vectors. Most diseases spread through wounds, fire scars or cut surfaces, and infected trees are much more prone to insect attack in a weakened or otherwise stressed condition.

Recommended Actions

Recommendation FP1—Evaluate the presence and quantity of critical forest habitat elements, such as snags and downed wood, during project planning. Protect these features and increase their abundance, where necessary, to provide better wildlife forest habitat.

Recommendation FP2—Perform surveys for species of concern to assess current population status, protect existing populations, and to target restoration actions to recover populations.

Recommendation FP3—Where species of concern are identified, any occupied sites should be protected by implementing noise and disturbance restrictions within minimum distances of nest sites or occupied areas.

Recommendation FP4—Complete an entomology and pathology study of large forested properties within these watersheds to assess, diagnose, and plan treatment practices for suspected pest and/or disease problems.

Recommendation FP5—Encourage landowners to develop Forest Management Plans that act to decrease the potential for wildfire by reducing stocking rates, clearing invasive species, establishing shaded fuel breaks, and establishing fire crew access into forested properties.

Recommendation FP6– Work with local preservation agencies such as SCAPOSD and SLT to promote conservation easements on high priority forest lands in both watersheds.

CHAPTER 9. CLIMATE VULNERABILITY AND ADAPTATION

CLIMATE VARIABILITY IMPACTS

Changing temperatures are already starting to impact local communities, including within Maacama and Upper Mark West watersheds, in terms of personal health and energy, water, and land use due to the close connection between climate and the following factors:

- 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.

Impacts to Biodiversity and Habitat

While climate change models have generated a wide range of projections, there is consensus that some ecosystems will be impacted more than others. 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.

Flooding and Extreme Rain Events

One of the projected impacts of climate change is the increased likelihood of extreme floods, capable of destroying streamside land, buildings, roads, and crops. In California, Sonoma County is already the top recipient of repetitive flood damage payments and is a county with the highest number of properties suffering repetitive flood losses west of the Rockies (PRMD, 2011). 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.

Climate models are highly variable in predicting long-term precipitation trends, with some models showing a decline in precipitation, up to 9% less than the 20th century average (by the 2091-2100 time interval), while others project increases of up to 14% above the 20th century average (Micheli et al, 2012). In contrast to long-term temperature projections, precipitation is not driven by varying greenhouse gas emissions scenarios and is more closely tied to other factors incorporated into the models. However, one notable observation from all projections is a trend towards unprecedented wet and dry periods that are more dramatic than variability that has been historically observed.

Variability in precipitation is tied to an increased future variability in runoff, recharge, and stream discharge (Micheli et al, 2012). Hydrologic models also predict a reduction in early and late wet-season runoff for the 21st century, which would result in a potentially extended dry season. In scenarios with increased future rainfall, precipitation also appears to be more concentrated in mid-winter months and may lead to an increased risk of flooding during that time (Micheli et al, 2012).

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 an increased threat of erosion from soils washing off hillsides into roads, ditches, and streams and creating increased water quality concerns (North Bay Climate Adaptation Initiative, 2013).

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 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 (Climate Action Team, 2010). Continued warming will create conditions unfavorable for production of many currently planted 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.

There are a number of ways that agriculture can play a role in climate change adaptation and a variety of ways that farming practices could also contribute to reducing future impacts. Farmland provides numerous additional benefits, including carbon sequestration, open space preservation, water absorption and filtration, and a local food source. Agriculture and forestry offer the only currently available terrestrial 'sinks' of carbon dioxide. Soil management practices that have the greatest potential to sequester carbon include cover crops, perennial cropping, reduced synthetic fertilizer inputs, and conservation tillage. Composting and adding organic amendments have also resulted in increased carbon storage in soils. 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 (CalCAN, 2011).

Sonoma County Climate Initiatives

The state of California and the county of Sonoma are recognized leaders in climate change research and adaptation strategies. Since 2001, the Sonoma County Board of Supervisors has been increasingly committed to creating solutions to reduce GHGs 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 development of projects, programs, and action plans to guide the goals and timelines established 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 then to be administered by the Sonoma County Transportation Authority (SCTA) and the 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 GHG emissions throughout the region.

Sonoma County partnered with the Climate Protection Campaign (CPC) in order to set an overarching GHG reduction target. This target was defined as a reduction of County-wide GHG 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, 2013). To aid local government agencies in achieving this goal, CPC developed the Community Climate Action Plan (CCAP), which was finalized in 2008 and offered an array of solutions to meet the challenges of climate change (copy available at http://www.coolplan.org/ccap-report/CCAP_Final_11-05-08.pdf). In addition, many cities throughout the County have adopted green building programs and land use and community design programs to address climate change concerns.

The County has continued to develop programs and partnerships to increase conservation and adaptation initiatives among local governments, businesses, and private landowners. County-wide GHG emissions inventory data, completed in 2009, showed a general decrease of emissions to 4.28 million metric tons of carbon dioxide. However, additional decreases will be necessary in order to achieve the reduction goal of 2.7 million tons of carbon dioxide (25 percent below 1990 levels). Transportation as well as residential and commercial electricity use were shown to be the highest contributors to GHG emissions in the 2009 analysis (SCTA/RCPA, 2015). County efforts in the recent years have largely focused on reducing building GHG emissions through the Countywide Retrofit Program, which was established in 2009. The ongoing construction of the Sonoma Marin Area Rail Transit (SMART) system, which is slated to begin operations in late 2016, will be key in reducing GHG emissions in the transportation sector. The RCPA is also working with stakeholders from city planning departments, PG&E, and CPC to track emissions data to estimate current progress towards the identified reduction goal (SCTA/RCPA, 2015).

Several local agencies and non-profits have also initiated projects to assess the potential impacts to local ecosystems from climate change. The Conservation Lands Network has been actively working on identifying the mosaic of interconnected habitats throughout the Bay Area and developing a regional biodiversity conservation plan in order to guide conservation practitioners, policymakers, regulators, funder, planners, and landowners about the highest priority areas and wildlife linkages that need to be protected and how climate variability will play a role in making these linkages and habitats even more vital in the future.

Many impacts of climate change are currently unknown, but various models have been developed based on historical weather patterns that can extrapolate current conditions and project climate trends into the future. Pepperwood Preserve, located in the Upper Mark West Creek watershed, is currently modeling potential future climate scenarios for several Sonoma County and nearby watersheds in partnership with the North Bay Watershed Association and the North Bay Climate Adaptation Initiative (NBCAI). NBCAI is a group of natural resource managers, scientists, policy makers, educators and private stakeholders formed during the 2009 State of the Laguna Conference. Participants include experts and community leaders from a range of natural resource science and management fields critical to understanding the climate adaptation challenge and options for action. The group's mission is to respond to climate change on a local scale and collaborate to implement effective climate adaptation strategies that sustain ecological and human communities of North Bay watersheds (SCWA, 2010). Preliminary findings from their model analyses are described below.

CLIMATE PREDICTIONS AND CONCERNS

Current model simulations project that California will retain a Mediterranean weather pattern, with cool wet winters and hot dry summers. However, most climate models project a warming of about 0.5 to 2.0 degrees Celsius over the next 30-year timeframe, the standard unit of measure in climate modeling, within this century and another 1.5 to 4.5 degrees Celsius increase in the next 30-year timeframe (Cayan et al, 2006; Cayan et al, 2008). In response to the warming, models also predict that the frequency, magnitude, and duration of heat waves will increase and would be likely to occur across a wider window seasonally (June through September). Alternatively, freezing spells are predicted to decline across even areas where they are currently common, such as the Russian River watershed (Mastrandrea et al, 2009).

Values for maximum and minimum temperatures, precipitation, runoff, and climatic water deficit from climate predictions for Maacama and Upper Mark West watersheds are shown in Figures 9.1 and 9.2 below and, in more detail, in Tables A1.1 and A1.2 in Appendix F. Climatic Water Deficit (CWD) is an integrated measure of seasonal water stress and aridity. It identifies the additional amount of water that could have been evaporated if it were freely available. It is calculated as a cumulative sum over the dry season. Increased CWD is an indicator of higher water stress for vegetation, aridity for the region, and a greater risk of fire.

The tables compare the 30-year time periods identified as a baseline (1951 – 1980), the recent 30-year period (1981 – 2010), and data for three future 30-year periods (2011 – 2039, 2040 -2069, and 2070 – 2099), projected through four separate climate models. The models used for this analysis are categorized as follows:

- GA2 – lower precipitation and higher (business-as-usual) emission scenario
- GB1 – lower precipitation and lower (mitigation achieved) emission scenario
- PA2 – higher precipitation and higher (business-as-usual) emission scenario
- PB1 – higher precipitation and lower (mitigation achieved) emission scenario

The trends in climate change data are consistent across both the Maacama and Upper Mark West watersheds and therefore, they are discussed jointly below. As the data indicates, all four models predict a general trend of increasing maximum and minimum temperatures in the decades ahead. Precipitation is predicted to decrease or be variable in models GA2 and GB1 and to increase in models PA2 and PB1, with future precipitation potentially declining to as much as 23% lower or up to 13% higher than the baseline conditions documented between 1951 and 1980. The data highlights the current drought trends that are being experienced, with precipitation decreases between 0.4% and 2% shown in the 1981 – 2010 time period. Runoff appears to generally parallel predicted changes in precipitation, with runoff amounts decreasing at times of predicted low precipitation and increasing when precipitation is projected to increase (see Appendix F for runoff model data).

The data from all four modeled scenarios show an upward trend in CWD, even under "wetter" climate scenarios, which is predominantly a driver of the timing of precipitation. Rainfall is predicted to occur during times that do not align with the periods of greatest water need for vegetation and streams flows, which occur in the hotter, dryer summer months. The runoff projections indicate that the additional rainfall received during predicted wet periods would be lost through runoff. These projections further emphasize the importance of rainwater catchment systems and increasing the amount of rainwater storage and groundwater recharge that may occur at times of high rainfall (L. Micheli, personal communication).

Summary

The predicted changes in climate patterns are expected to generate a wide array of impacts including an increased demand for surface and groundwater supply, electricity demand, reduced water quality, heat waves, flooding, and increases in wildfire frequency. Competition for water among aquatic habitat, agricultural, and drinking water needs is also likely to increase. While many of the noted impacts will occur on a larger scale, beyond the boundaries of this watershed management plan, some of the impacts to rural residential water supply, agriculture, and salmonid habitat are likely to be relevant to resource management decisions in both the Maacama and Upper Mark West watersheds. Current modeling efforts should be utilized to make resource management decisions today that will allow for more resilience among the residents, businesses, and wildlife that coexist in both watersheds.

Recommended Actions

Recommendation CV1 – Continue development of climate modeling tools to assist local resource agencies and local businesses and landowners with understanding potential impacts from predicted climate variability.

Recommendation CV2 – Develop projects to increase water storage capacity and a reliable water supply for rural, agricultural, and municipal uses.

Recommendation CV3 – Research and develop opportunities for groundwater recharge across both watersheds.

Recommendation CV4 – Continue to monitor and document climate trends on a local scale to evaluate accuracy of modeled climate scenarios.

Recommendation CV5 – Promote farming techniques that increase carbon sequestration, increase water holding capacity, protect soils, and buffer production from climate extremes.

Figure 9.1: Climate projections for Maacama Creek watershed

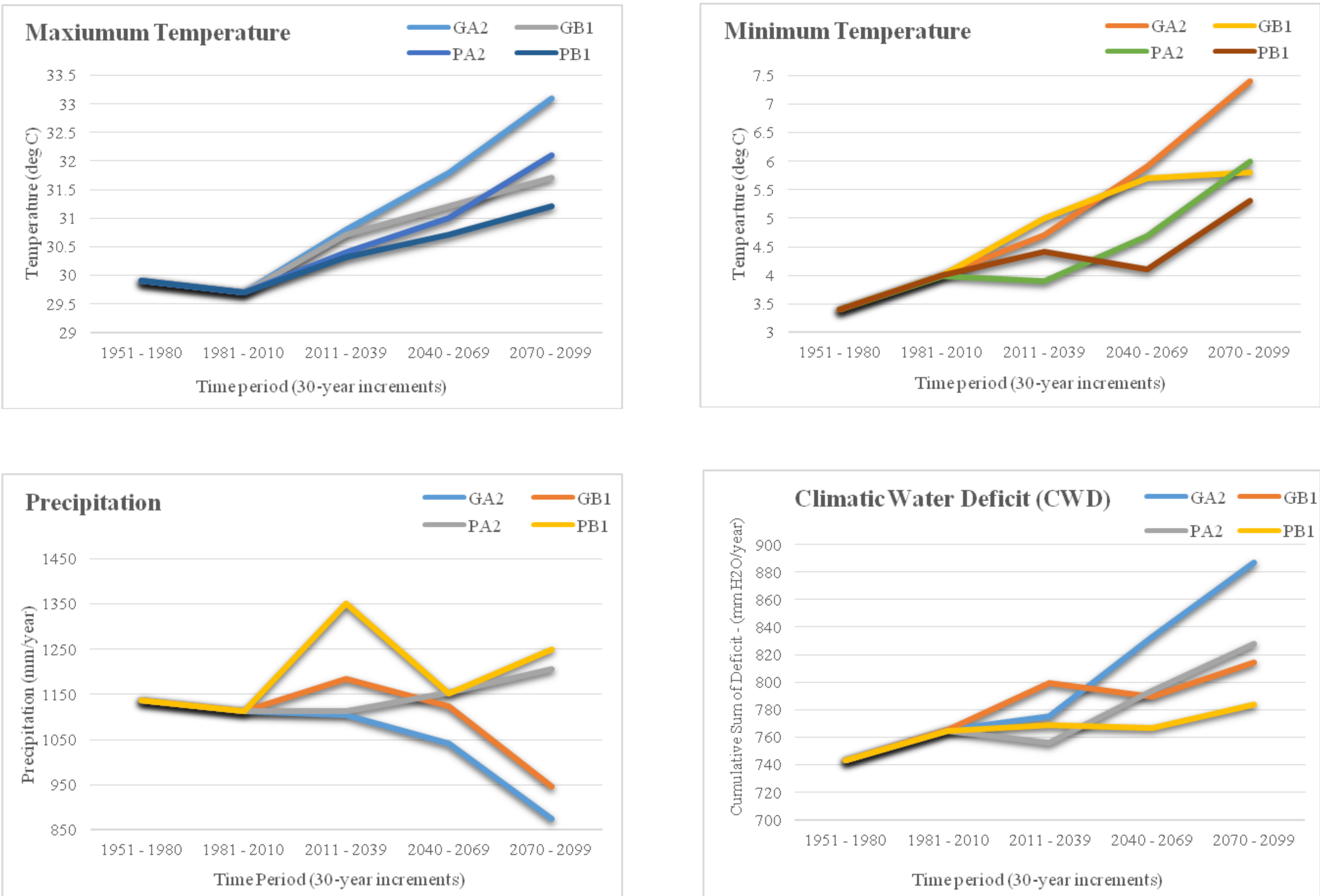
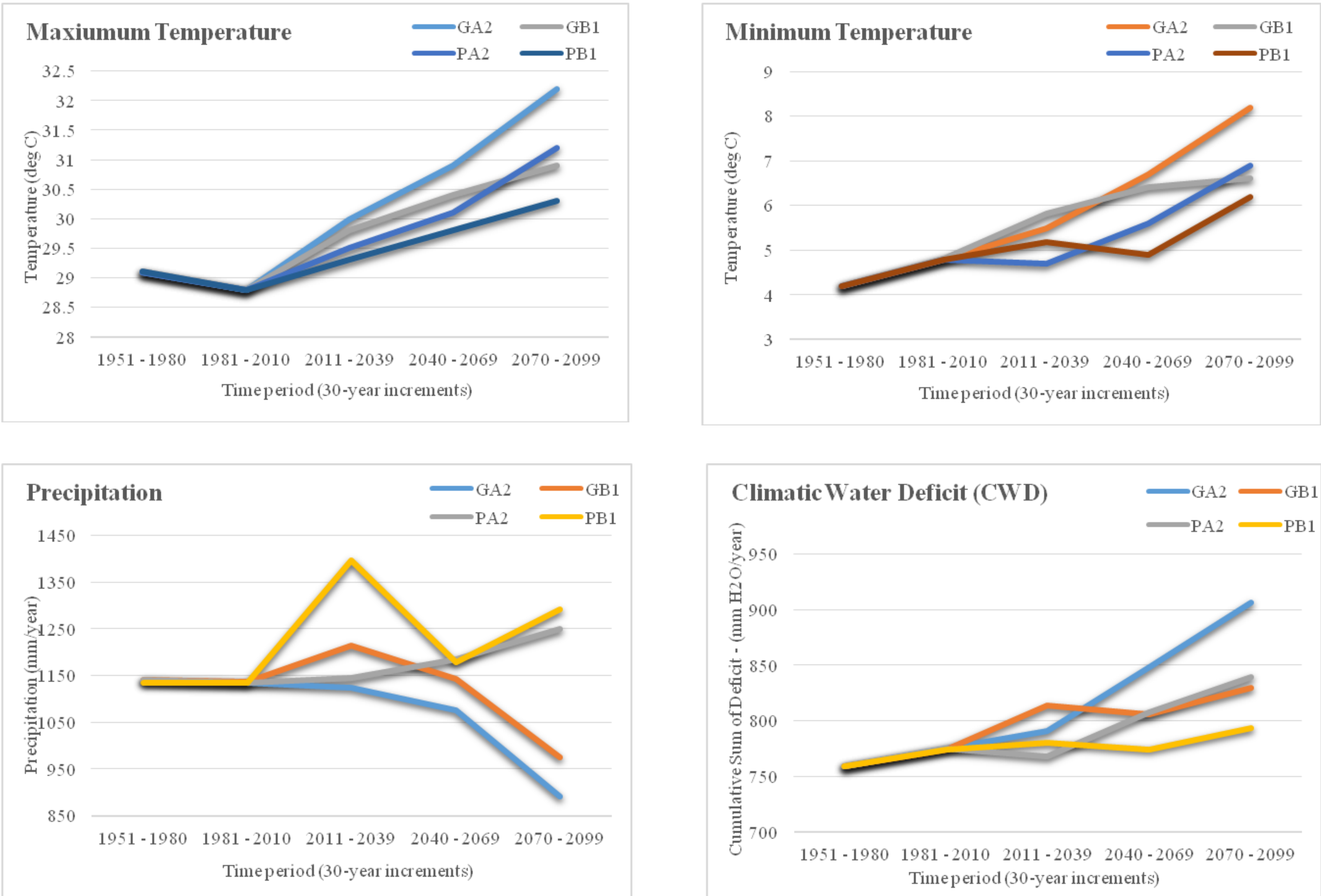


Figure 9.2 Climate projections for Upper Mark West Creek watershed



Sonoma Resource Conservation District

Maacama Creek and Upper Mark West Watershed Management Plan

SECTION 3. IMPLEMENTATION

CHAPTER 10. PLAN IMPLEMENTATION

The management plan is intended to be implemented over a 10-15 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 10-15 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 summary of recommendations and guidance for implementing the recommended actions defined in the previous chapters.

PLAN LIMITATIONS

This plan represents the most current data available regarding the Maacama and Upper Mark West watersheds; it has been developed using existing literature and data from field investigations conducted during the past several years. In spite of every effort to develop a comprehensive and accurate plan, there are funding, time, and data constraints. With greater funding, more field assessments would have been possible. These assessments would provide a greater understanding of riparian processes and impacts from past and present human activities. Additional field data would provide a more thorough understanding of the watershed and greater certainty when prioritizing projects for implementation. While recognizing these constraints, it is important to recognize that this plan is intended to be a “living document.” This plan is the first iteration of a plan intended to enable all willing landowners to improve land use practices, ameliorate legacy impacts, restore riparian function, and restore watershed function to improve salmonid and other wildlife habitat.

Table 10.1 Identified management actions for plan implementation

Recommendation	Actions
Water Resources and Quality	
Water Supply Resilience	***AR4*** – Improve water use efficiency in irrigation and frost protection systems. Explore alternative water sources for these uses. ***AR8, CV2*** - Assist landowners with developing projects that ensure water reliability through increasing water storage capacity or developing a reliable water supply for rural and agricultural as well as municipal uses. ***WR5***– Provide resources to landowners, through small landowner meetings, on the benefits of restoring groundwater and methods for increasing groundwater recharge in upland areas. ***WR6*** – Outreach to agricultural and rural landowners to identify opportunities for increase water use efficiency or implementation of alternative water supply systems such as rainwater catchment or off stream storage ponds, through SRCD's LandSmart ® Water Resource Program and the Russian River Coho Water Resources Partnership Program.
Streamflow Analysis	***WR1*** - Further evaluation of summertime flow in tributaries of Maacama Creek and Mark West Creek to help prioritize restoration actions in stream reaches that are capable of providing adequate year-round salmonid habitat. ***WR2*** – Evaluate the relationships between summertime flows in low-slope stream channels and water storage, diversions, and groundwater pumping that occurs nearby, particularly in areas along Franz Creek and Bidwell Creek. ***WR3*** – Evaluate the limitations posed by low summertime flows in Maacama Creek to migrating salmonids.

Recommendation	Actions
Streamflow Analysis	***WR4*** - Outreach to landowners where multiple small diversions are impacting stream flows on a larger scale, both in Maacama and Upper Mark West watersheds. ***WR8*** - Continue existing streamflow monitoring networks and increase monitoring in high priority areas. ***WQ4*** - Expand flow gauging efforts in Maacama and Redwood Creeks to conduct additional monitoring in order to calibrate a flow rating curve to quantitatively measure the flow deficit. ***WQ5*** - Perform a wet/dry mapping program to record and quantify areas that retain surface flow in late summer. ***WQ7*** - Protect natural springs throughout the Upper Mark West watershed and upper portions of the Maacama watershed that are vital sources of clean and cool water, particularly in the summer months. ***WQ8*** - Pursue funding for studies and implementation projects through the Wildlife Conservation Board's California Stream Flow Enhancement Program to stabilize and improve flow recovery.
Groundwater Recharge	***WR7*** - Coordinate with foresters and landowners with forest land to help improve forest health and better understand the role of upland forests in groundwater recharge and flow regimes. ***WR9*** - Continue the California Statewide Groundwater Elevation Monitoring Program (CASGEM) to document groundwater conditions in the region. ***WR10*** - Continue encouraging broad, multi-agency participation in the Counties Groundwater Management Planning efforts. ***CV3*** - Research and develop opportunities for groundwater recharge in both watersheds.

Recommendation	Actions
Water Quality Monitoring	***WQ1*** - Conduct bioassessments, as an indicator of aquatic habitat quality, throughout the watersheds. ***WQ2*** - Collect total suspended solids (TSS) data during periods of high flow and turbidity to better understand the duration of impairment in both watersheds. ***WQ3*** - Continue ambient water quality monitoring to document ongoing changes in stream conditions in both watersheds.
Pollutant Reduction	***AR6*** - Conduct outreach to landowners about minimizing potential of animal waste runoff occurring from confined livestock areas and watering facilities near waterways, manure and fertilizer application, and silage storage. ***WQ6*** - Implement best management practices to decrease sediment loads and storm runoff and improve rural road development and maintenance.
Instream and Riparian Habitat	
Riparian Area Enhancement	***RI1*** - Encourage livestock landowners to install riparian fencing to improve vegetative cover and reduce impacts to stream banks, particularly in the Upper Maacama Creek, portions of Redwood Creek, Porter Creek, and Mark West Creek. ***RI11*** - Encourage near-stream riparian planting to provide bank stability and serve as a buffer against agricultural, grazing, and urban runoff. ***RI9*** - Secure funding to implement high-priority, multi-purpose riparian enhancement projects and help landowners to apply for cost share programs to improve riparian corridors.

Recommendation	Actions
Riparian Area Enhancement	***RI10*** - Increase riparian canopy cover with targeted plantings along stream segments where shade canopy is not at adequate levels and elevated water temperatures have been documented in stream surveys, particularly in McDonnell, Briggs, Maacama, and Upper/Lower Franz Creeks in the Maacama watershed and Horse Hill, lower reaches of Porter, Humbug, and Weeks Creeks in the Upper Mark West watershed. ***RI16*** - Promote programs that provide financial incentives, such as conservation easement programs, for riparian area protection and potential payments for other ecosystem services.
Improve Fish Passage	***RI14*** - Assess and prioritize known fish barriers to identify those that exclude access to known quality fish habitat. ***RI15*** - Remove identified barriers to fish migration in coordination with willing landowners and resource agencies. ***RI5*** - Study fish passage, migration, and the influence of backflow from the Russian River at the low reach of Maacama Creek.
In-Stream Habitat Enhancement	***RI2*** - Provide resources to landowners about the benefits of large wood in streams. ***RI3*** - Develop and implement instream enhancement projects in areas with less-than adequate cover and scour for anadromous fish species. ***RI4*** - Target outreach and conservation projects in priority reaches for fisheries enhancement. ***RI12*** - Conduct surveys for species of concern, such as pond-breeding and stream-breeding amphibians, throughout both watersheds. ***RI13*** - Continue Broodstock Program monitoring and survey efforts of salmonid populations.

Recommendation	Actions
In-Stream Habitat Enhancement	***RI6*** - Install instream structures in reaches of Redwood Creek, reaches of Porter Creek towards the confluence of Mark West Creek, and within Mark West Creek where landowner interest allows. ***RI7*** - Install structures to decrease channel incision and recruit spawning gravel, in order to trap, sort, and expand red distribution in streams across both watersheds. ***RI8*** - Continue to conduct targeted outreach and coordinate with local agencies to assess high priority reaches and areas lacking habitat information, such as Porter Creek, reaches along Mark West Creek, Humbug Creek, Franz Creek, upper Maacama Creek, and portions of Redwood Creek, in order to develop site-specific treatments.
Sediment Inputs and Erosion	
Assess Impacts of Road Erosion	***SSI2*** - Conduct a road development history study utilizing historical aerial imagery in the Upper Mark West watershed. ***SSI3*** - Use findings from historical road development research to identify areas with concentrations of historical roads where to prioritize outreach and future road sediment source assessments. ***SSI4*** - Utilize historical roads data along with current 2014 LiDAR data to map all rural roads within both watersheds. ***SSI5*** - Conduct a multi-phased series of road sediment source assessments on high priority road networks in order to develop a prioritized sediment reduction plan for these watersheds. ***SSI6*** – Continue to assess and inventory farm and ranch roads on agricultural properties in high priority areas through the LandSmart planning program. ***SSI7*** - Prioritize and implement road sediment reduction plans resulting from existing sediment source assessments.

Recommendation	Actions
Assess Other Erosion Processes	***SSI1*** - Conducts in-depth hydrologic and geomorphic assessments of both watersheds to better understand the geomorphic conditions. ***SSI8*** - Conduct a landslide/mass wasting historical study using aerial photographs. Utilize the study to assess if the identified erosion features are naturally occurring or are due to management practices. ***SSI9*** - Conduct field visits, in tandem with the historical study, to 20 percent of the mapped erosion features to assess study accuracy. ***SSI10*** - Encourage landowners with current management-induced mass-wasting occurring to adapt land management practices to reduce or stabilize landslides and bank erosion, through bioengineering techniques wherever possible.
Agricultural and Rural Conservation	
Regulatory Compliance	***AR1*** – Provide educational, technical, and financial services to assist growers and ranchers in understanding and complying with applicable regulations.
Soil Conservation	***AR2*** – Develop LandSmart® farm water quality plans to document existing stewardship and plan for future beneficial management practice implementation. ***AR3*** – Prevent and control soil erosion from working lands, through implementation of best management practices. ***AR5*** - Enhance soil quality through managed grazing, improved tillage and fertilization practices, and avoidance of land disturbance during wet-weather periods.
Land Conservation	***AR9*** - Connect agricultural landowners with programs such as conservation easements and Farm Bill programs that provide additional capital to support agricultural land values and conservation of rural properties. ***AR10*** - Work with local preservation agencies such as SCAPOSD and SLT to promote conservation easements and habitat enhancement projects on agricultural and rural properties.

Recommendation	Actions
Forest Land Preservation	
Forest Habitat Protection	***FP1*** – Evaluate the presence and quantity of critical forest habitat elements, such as snags and downed wood, during project planning. Protect these features and increase their abundance, where necessary, to provide better wildlife forest habitat. ***FP2*** – Perform surveys for species of concern to assess current population status, protect existing populations, and to target restoration actions to recover populations.
Forest Habitat Protection	***FP3*** – Where species of concern are identified, any occupied sites should be protected by implementing noise and disturbance restrictions within minimum distances of nest sites or occupied areas. ***FP6*** – Work with local preservation agencies such as SCAPOSD and SLT to promote conservation easements on high priority forest lands in both watersheds.
Wildlife Habitat Conservation	***AR11*** **–** Encourage landowners to minimize, wherever possible, fencing and other incompatible management practices that disrupt migration through wildlife corridors and riparian areas located on their properties.
Pest/Disease Control	***FP4*** – Complete an entomology and pathology study of large forested properties in these watersheds to assess, diagnose, and plan treatment practices for suspected pest and/or disease problems.
Fire Reduction	***FP5*** - Encourage landowners to develop Forest Management Plans that act to decrease the potential for wildfire by reducing stocking rates, clearing invasive species, establishing shaded fuel breaks, and establishing fire crew access into forested properties.

Recommendation	**Actions**
Climate Resiliency	
Assess Potential Impacts from Climate Variability	***CV1*** – Continue development of climate modeling tools to assist local resource agencies and local businesses and landowners with understanding potential impacts from predicted climate variability. ***CV4*** - Continue to monitor and document climate trends on a local scale to evaluate accuracy of modeled climate scenarios.
Soil Carbon Sequestration	***AR7, CV5*** - Promote farming techniques that increase carbon sequestration, increase water holding capacity, protect soil health, and buffer production from climate extremes.

Note: abbreviations reference the relevant chapter for each recommendation
Key: WR – water resources, WQ – water quality, IR – instream/riparian habitat, SSI – sediment sources and impacts, AR – agricultural and rural sustainability, FP – forest land preservation

CHAPTER 11. SUPPLEMENTAL INFORMATION

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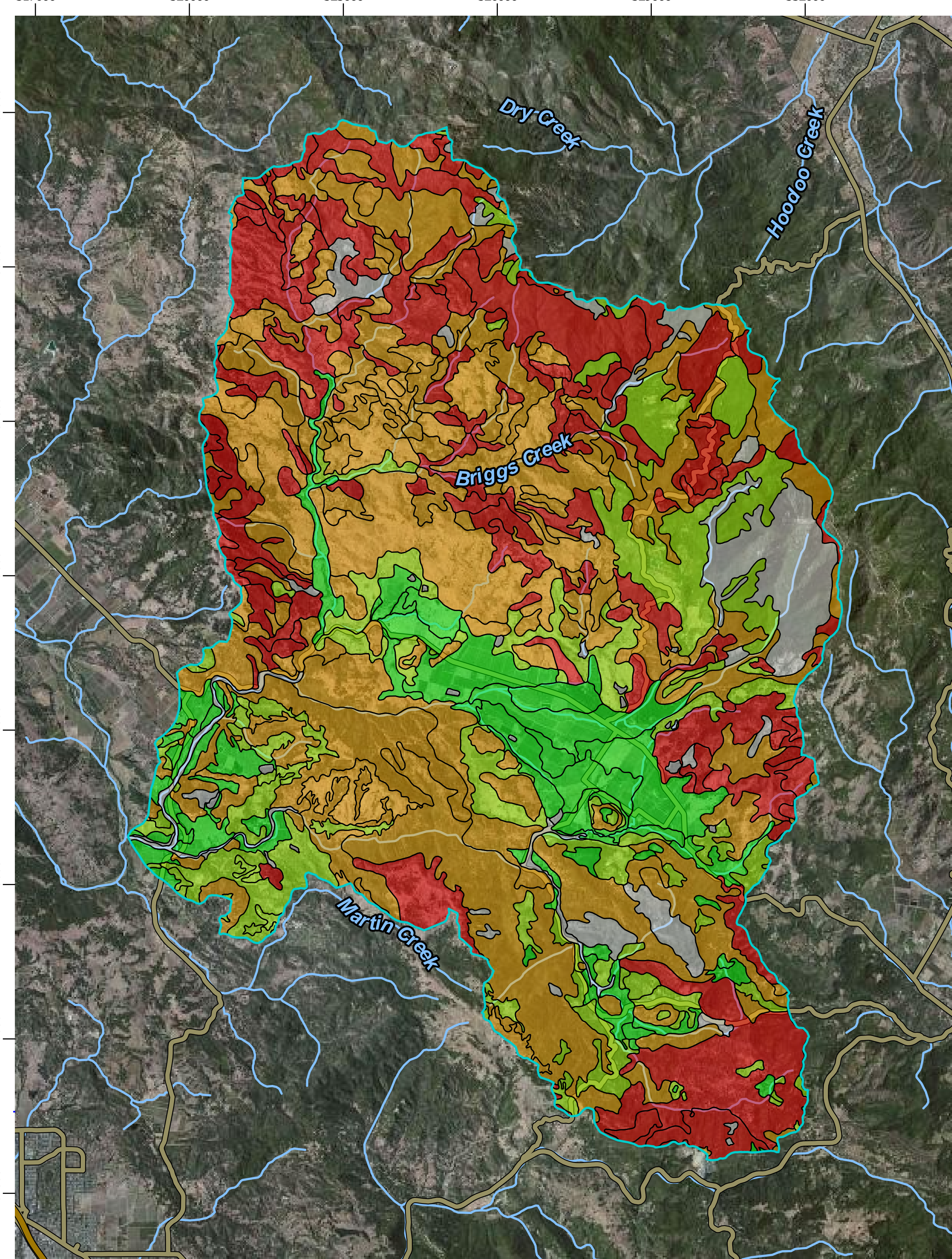
APPENDIX A

WEB SOIL SURVEY SOIL EROSION RATINGS

Erosion Hazard (Off-Road, Off-Trail)—Lake County, California, Napa County, California, and Sonoma County, ...
(Soil Erosion Hazard Rating - Maacama Watershed)



Map Scale: 1:118,000 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 1500, 3000, 6000, 9000

Feet: 0, 5000, 10000, 20000, 30000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- Very severe
- Severe
- Moderate
- Slight
- Not rated or not available

Soil Rating Lines

- Very severe
- Severe
- Moderate
- Slight
- Not rated or not available

Soil Rating Points

- Very severe
- Severe
- Moderate
- Slight
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lake County, California
Survey Area Data: Version 11, Sep 25, 2014

Soil Survey Area: Napa County, California
Survey Area Data: Version 7, Sep 25, 2014

Soil Survey Area: Sonoma County, California
Survey Area Data: Version 8, Sep 25, 2014

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 2, 2010—Feb 17, 2012

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Erosion Hazard (Off-Road, Off-Trail)

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Lake County, California (CA033)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
134	Forward variant-Kidd association, 30 to 50 percent slopes	Severe	Forward variant (50%)	Slope/erodibility (0.75)	4.1	0.0%
			Kidd (20%)	Slope/erodibility (0.75)		
135	Forward variant-Kidd association, 50 to 75 percent slopes	Very severe	Forward, variant (50%)	Slope/erodibility (0.95)	3.0	0.0%
			Kidd (25%)	Slope/erodibility (0.95)		
149	Kidd-Forward complex, 30 to 50 percent slopes	Severe	Kidd (45%)	Slope/erodibility (0.75)	0.6	0.0%
			Forward (35%)	Slope/erodibility (0.75)		
169	Maymen-Etsel-Snook complex, 30 to 75 percent slopes	Very severe	Maymen (35%)	Slope/erodibility (0.95)	0.2	0.0%
			Snook (20%)	Slope/erodibility (0.95)		
			Etsel (20%)	Slope/erodibility (0.95)		
193	Okiota-Henneke-Dubakella association, 15 to 50 percent slopes	Moderate	Okiota (30%)	Slope/erodibility (0.50)	0.1	0.0%
			Henneke (25%)	Slope/erodibility (0.50)		
			Dubakella (25%)	Slope/erodibility (0.50)		
200	Rock outcrop-Etsel-Snook complex, 50 to 80 percent slopes	Not rated	Rock outcrop (60%)		1.5	0.0%
			Maymen (3%)			
			Mayacama (3%)			
			Neuns (2%)			
			Unnamed (2%)			
209	Skyhigh-Millsholm loams, 15 to 50 percent slopes	Moderate	Skyhigh (45%)	Slope/erodibility (0.50)	0.1	0.0%
			Millsholm (25%)	Slope/erodibility (0.50)		
224	Speaker-Marpa-Sanhedrin gravelly loams, 30 to 50 percent slopes	Severe	Speaker (30%)	Slope/erodibility (0.75)	1.2	0.0%
			Marpa (25%)	Slope/erodibility (0.75)		

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Lake County, California (CA033)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Sanhedrin (15%)	Slope/erodibility (0.75)		
229	Speaker-Sanhedrin-Maymen association, 30 to 50 percent slopes	Severe	Speaker (30%)	Slope/erodibility (0.75)	0.2	0.0%
			Sanhedrin (30%)	Slope/erodibility (0.75)		
			Maymen (20%)	Slope/erodibility (0.75)		
254	Yorkville-Yorktree-Squawrock association, 15 to 50 percent slopes	Moderate	Yorkville (45%)	Slope/erodibility (0.50)	0.1	0.0%
			Yorktree (20%)	Slope/erodibility (0.50)		
			Squawrock (15%)	Slope/erodibility (0.50)		
Subtotals for Soil Survey Area					**11.0**	**0.0%**
Totals for Area of Interest					**44,649.2**	**100.0%**

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Napa County, California (CA055)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
102	Aiken loam, 30 to 50 percent slopes	Severe	Aiken (85%)	Slope/erodibility (0.75)	0.0	0.0%
109	Boomer gravelly loam, 30 to 50 percent slopes	Severe	Boomer (85%)	Slope/erodibility (0.75)	2.0	0.0%
140	Forward gravelly loam, 30 to 75 percent slopes	Very severe	Forward (85%)	Slope/erodibility (0.95)	1.7	0.0%
141	Forward-Kidd complex, 50 to 75 percent slopes	Very severe	Forward (60%)	Slope/erodibility (0.95)	2.5	0.0%
			Kidd (30%)	Slope/erodibility (0.95)		
143	Guenoc-Rock outcrop complex, 5 to 30 percent slopes	Moderate	Guenoc (60%)	Slope/erodibility (0.50)	0.0	0.0%
156	Kidd loam, 30 to 75 percent slopes	Very severe	Kidd (85%)	Slope/erodibility (0.95)	0.1	0.0%
177	Rock outcrop-Kidd complex, 50 to 75 percent slopes	Not rated	Rock outcrop (70%)		3.3	0.0%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Napa County, California (CA055)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
CmFsn	Cohasset gravelly loam, 30 to 50 percent slopes	Severe	Cohasset (85%)	Slope/erodibility (0.75)	0.2	0.0%
CmGsn	Cohasset gravelly loam, 50 to 75 percent slopes	Very severe	Cohasset (85%)	Slope/erodibility (0.95)	0.0	0.0%
FrGsn	Forward-Kidd complex, 30 to 75 percent slopes	Very severe	Forward (45%)	Slope/erodibility (0.95)	5.7	0.0%
			Kidd (45%)	Slope/erodibility (0.95)		
GgEsn	Goulding clay loam, 15 to 30 percent slopes	Moderate	Goulding (85%)	Slope/erodibility (0.50)	5.5	0.0%
GgFsn	Goulding clay loam, 30 to 50 percent slopes	Severe	Goulding (85%)	Slope/erodibility (0.75)	0.1	0.0%
GrGsn	Guenoc gravelly silt loam, 30 to 75 percent slopes	Very severe	Guenoc (85%)	Slope/erodibility (0.95)	0.0	0.0%
ToGsn	Toomes rocky loam, 30 to 75 percent slopes	Very severe	Toomes (75%)	Slope/erodibility (0.95)	1.2	0.0%
Subtotals for Soil Survey Area					**22.3**	**0.1%**
Totals for Area of Interest					**44,649.2**	**100.0%**

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
102n	Aiken loam, 30 to 50 percent slopes	Severe	Aiken (85%)	Slope/erodibility (0.75)	12.1	0.0%
134l	Forward variant-Kidd association, 30 to 50 percent slopes	Severe	Forward variant (50%)	Slope/erodibility (0.75)	386.2	0.9%
			Kidd (20%)	Slope/erodibility (0.75)		
135l	Forward variant-Kidd association, 50 to 75 percent slopes	Very severe	Forward, variant (50%)	Slope/erodibility (0.95)	174.8	0.4%
			Kidd (25%)	Slope/erodibility (0.95)		
169l	Maymen-Etsel-Snook complex, 30 to 75 percent slopes	Very severe	Maymen (35%)	Slope/erodibility (0.95)	46.2	0.1%
			Snook (20%)	Slope/erodibility (0.95)		

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
			Etsel (20%)	Slope/erodibility (0.95)		
200I	Rock outcrop-Etsel-Snook complex, 50 to 80 percent slopes	Not rated	Rock outcrop (60%)		161.9	0.4%
			Maymen (3%)			
			Mayacama (3%)			
			Neuns (2%)			
			Unnamed (2%)			
209I	Skyhigh-Millsholm loams, 15 to 50 percent slopes	Moderate	Skyhigh (45%)	Slope/erodibility (0.50)	4.1	0.0%
			Millsholm (25%)	Slope/erodibility (0.50)		
224I	Speaker-Marpa-Sanhedrin gravelly loams, 30 to 50 percent slopes	Severe	Speaker (30%)	Slope/erodibility (0.75)	19.4	0.0%
			Marpa (25%)	Slope/erodibility (0.75)		
			Sanhedrin (15%)	Slope/erodibility (0.75)		
229I	Speaker-Sanhedrin-Maymen association, 30 to 50 percent slopes	Severe	Speaker (30%)	Slope/erodibility (0.75)	8.0	0.0%
			Sanhedrin (30%)	Slope/erodibility (0.75)		
			Maymen (20%)	Slope/erodibility (0.75)		
254I	Yorkville-Yorktree-Squawrock association, 15 to 50 percent slopes	Moderate	Yorkville (45%)	Slope/erodibility (0.50)	42.7	0.1%
			Yorktree (20%)	Slope/erodibility (0.50)		
			Squawrock (15%)	Slope/erodibility (0.50)		
AdA	Alluvial land, sandy	Not rated	Alluvial land (85%)		16.2	0.0%
			Unnamed (15%)			
AgB	Arbuckle gravelly sandy loam, 0 to 5 percent slopes	Slight	Arbuckle (85%)		6.1	0.0%
AkB	Arbuckle gravelly loam, 0 to 5 percent slopes	Slight	Arbuckle (85%)		368.4	0.8%
BoE	Boomer loam, 15 to 30 percent slopes	Moderate	Boomer (85%)	Slope/erodibility (0.50)	3.9	0.0%
BoF	Boomer loam, 30 to 50 percent slopes	Severe	Boomer (85%)	Slope/erodibility (0.75)	225.7	0.5%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
BoG	Boomer loam, 50 to 75 percent slopes	Very severe	Boomer (85%)	Slope/erodibility (0.95)	401.3	0.9%
CbF	Cibo clay, 15 to 50 percent slopes	Moderate	Cibo (85%)	Slope/erodibility (0.50)	10.6	0.0%
CgC	Clough gravelly loam, 2 to 9 percent slopes	Slight	Clough (85%)		373.5	0.8%
CgD	Clough gravelly loam, 9 to 15 percent slopes	Slight	Clough (85%)		2.5	0.0%
CgE	Clough gravelly loam, 15 to 30 percent slopes	Moderate	Clough (85%)	Slope/erodibility (0.50)	10.1	0.0%
CmE	Cohasset gravelly loam, 15 to 30 percent slopes	Moderate	Cohasset (85%)	Slope/erodibility (0.50)	561.6	1.3%
CmF	Cohasset gravelly loam, 30 to 50 percent slopes	Severe	Cohasset (85%)	Slope/erodibility (0.75)	1,127.3	2.5%
CmG	Cohasset gravelly loam, 50 to 75 percent slopes	Very severe	Cohasset (85%)	Slope/erodibility (0.95)	393.5	0.9%
CrA	Cortina very gravelly sandy loam, 0 to 2 percent slopes	Slight	Cortina (85%)		521.4	1.2%
CsA	Cortina very gravelly loam, 0 to 2 percent slopes	Slight	Cortina (85%)		512.7	1.1%
FaD	Felta very gravelly loam, 5 to 15 percent slopes	Slight	Felta (85%)		80.9	0.2%
FaE	Felta very gravelly loam, 15 to 30 percent slopes	Moderate	Felta (85%)	Slope/erodibility (0.50)	825.8	1.8%
FaF	Felta very gravelly loam, 30 to 50 percent slopes	Severe	Felta (85%)	Slope/erodibility (0.75)	398.7	0.9%
FaG	Felta very gravelly loam, 50 to 75 percent slopes	Very severe	Felta (85%)	Slope/erodibility (0.95)	35.7	0.1%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
FoE	Forward gravelly loam, 9 to 30 percent slopes	Moderate	Forward (85%)	Slope/erodibility (0.50)	204.0	0.5%
FoG	Forward gravelly loam, 30 to 75 percent slopes	Very severe	Forward (85%)	Slope/erodibility (0.95)	952.5	2.1%
FrG	Forward-Kidd complex, 30 to 75 percent slopes	Very severe	Kidd (45%)	Slope/erodibility (0.95)	1,658.0	3.7%
			Forward (45%)	Slope/erodibility (0.95)		
GgD	Goulding clay loam, 5 to 15 percent slopes	Slight	Goulding (85%)		168.1	0.4%
GgE	Goulding clay loam, 15 to 30 percent slopes	Moderate	Goulding (85%)	Slope/erodibility (0.50)	240.9	0.5%
GgF	Goulding clay loam, 30 to 50 percent slopes	Severe	Goulding (85%)	Slope/erodibility (0.75)	741.4	1.7%
GlD	Goulding cobbly clay loam, 5 to 15 percent slopes	Slight	Goulding (85%)		9.7	0.0%
GlE	Goulding cobbly clay loam, 15 to 30 percent slopes	Moderate	Goulding (85%)	Slope/erodibility (0.50)	11.6	0.0%
GlF	Goulding cobbly clay loam, 30 to 50 percent slopes	Severe	Goulding (85%)	Slope/erodibility (0.75)	221.5	0.5%
GrE	Guenoc gravelly silt loam, 5 to 30 percent slopes	Moderate	Guenoc (85%)	Slope/erodibility (0.50)	199.2	0.4%
GrG	Guenoc gravelly silt loam, 30 to 75 percent slopes	Very severe	Guenoc (85%)	Slope/erodibility (0.95)	46.2	0.1%
HbC	Haire gravelly loam, 0 to 9 percent slopes	Slight	Haire (85%)		140.4	0.3%
HcC	Haire clay loam, 0 to 9 percent slopes	Slight	Haire (85%)		757.0	1.7%
HcD	Haire clay loam, 9 to 15 percent slopes	Slight	Haire (85%)		83.6	0.2%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
HcE	Haire clay loam, 15 to 30 percent slopes	Moderate	Haire (85%)	Slope/erodibility (0.50)	26.5	0.1%
HgE	Henneke gravelly loam, 5 to 30 percent slopes	Moderate	Henneke (85%)	Slope/erodibility (0.50)	29.4	0.1%
HgG2	Henneke gravelly loam, 30 to 75 percent slopes, eroded	Very severe	Henneke (85%)	Slope/erodibility (0.95)	1,257.3	2.8%
HkF	Hugo very gravelly loam, 30 to 50 percent slopes	Severe	Hugo (85%)	Slope/erodibility (0.75)	1,351.3	3.0%
HkG	Hugo very gravelly loam, 50 to 75 percent slopes	Very severe	Hugo (85%)	Slope/erodibility (0.95)	938.7	2.1%
HnG	Hugo-Josephine complex, 50 to 75 percent slopes	Very severe	Hugo (50%)	Slope/erodibility (0.95)	110.4	0.2%
			Josephine (40%)	Slope/erodibility (0.95)		
HyG	Huse stony clay loam, 30 to 75 percent slopes	Very severe	Huse (85%)	Slope/erodibility (0.95)	1,108.4	2.5%
KdF	Kidd gravelly loam, 9 to 50 percent slopes	Moderate	Kidd (85%)	Slope/erodibility (0.50)	1,543.0	3.5%
KkG	Kidd very rocky loam, 30 to 75 percent slopes	Very severe	Kidd (70%)	Slope/erodibility (0.95)	97.9	0.2%
LaC	Laniger loam, 5 to 9 percent slopes	Slight	Laniger (85%)		169.2	0.4%
LaD	Laniger loam, 9 to 15 percent slopes	Moderate	Laniger (85%)	Slope/erodibility (0.50)	268.1	0.6%
LaE	Laniger loam, 15 to 30 percent slopes	Moderate	Laniger (85%)	Slope/erodibility (0.50)	510.6	1.1%
LaF	Laniger loam, 30 to 50 percent slopes	Severe	Laniger (85%)	Slope/erodibility (0.75)	3,325.8	7.4%
LgE	Laughlin loam, 2 to 30 percent slopes	Moderate	Laughlin (85%)	Slope/erodibility (0.50)	577.3	1.3%
LgF	Laughlin loam, 30 to 50 percent slopes	Severe	Laughlin (85%)	Slope/erodibility (0.75)	2,386.1	5.3%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
LgG	Laughlin loam, 50 to 75 percent slopes	Very severe	Laughlin (85%)	Slope/erodibility (0.95)	886.8	2.0%
LgG2	Laughlin loam, 50 to 75 percent slopes, eroded	Very severe	Laughlin (85%)	Slope/erodibility (0.95)	147.3	0.3%
LkG	Los Gatos loam, 30 to 75 percent slopes, MLRA 15	Very severe	Los Gatos (85%)	Slope/erodibility (0.95)	42.6	0.1%
LoF	Los Osos clay loam, 30 to 50 percent slopes, MLRA 15	Severe	Los Osos (80%)	Slope/erodibility (0.75)	48.7	0.1%
LuA	Los Robles gravelly clay loam, 0 to 2 percent slopes	Slight	Los Robles (85%)		868.5	1.9%
LvB	Los Robles gravelly clay loam, moderately deep, 0 to 5 percent slopes	Slight	Los Robles (85%)		492.4	1.1%
McF	Maymen gravelly sandy loam, 30 to 50 percent slopes	Severe	Maymen (85%)	Slope/erodibility (0.75)	687.9	1.5%
MlG	Maymen-Los Gatos complex, 30 to 75 percent slopes	Very severe	Los Gatos (45%)	Slope/erodibility (0.95)	68.5	0.2%
			Maymen (45%)	Slope/erodibility (0.95)		
MoE	Montara cobbly clay loam, 2 to 30 percent slopes	Moderate	Montara (85%)	Slope/erodibility (0.50)	34.4	0.1%
MoG	Montara cobbly clay loam, 30 to 75 percent slopes	Severe	Montara (85%)	Slope/erodibility (0.75)	240.2	0.5%
RaC	Raynor clay, 2 to 9 percent slopes	Slight	Raynor (85%)		32.7	0.1%
RhD	Red Hill clay loam, 2 to 15 percent slopes	Slight	Red Hill (85%)		169.8	0.4%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
RhE	Red Hill clay loam, 15 to 30 percent slopes	Moderate	Red Hill (85%)	Slope/erodibility (0.50)	106.2	0.2%
RnA	Riverwash	Not rated	Riverwash (85%)		286.1	0.6%
			Unnamed (15%)			
RoG	Rock land	Not rated	Rock land (85%)		2,260.1	5.1%
			Unnamed (15%)			
SfE	Sites loam, 5 to 30 percent slopes	Moderate	Sites (85%)	Slope/erodibility (0.50)	37.4	0.1%
SfF	Sites loam, 30 to 50 percent slopes	Severe	Sites (85%)	Slope/erodibility (0.75)	989.7	2.2%
ShE	Sobrante loam, 15 to 30 percent slopes	Moderate	Sobrante (85%)	Slope/erodibility (0.50)	21.3	0.0%
ShF	Sobrante loam, 30 to 50 percent slopes	Severe	Sobrante (85%)	Slope/erodibility (0.75)	198.4	0.4%
ShG	Sobrante loam, 50 to 75 percent slopes	Very severe	Sobrante (85%)	Slope/erodibility (0.95)	150.0	0.3%
SkC	Spreckels loam, 2 to 9 percent slopes	Slight	Spreckels (85%)		44.5	0.1%
SkD	Spreckels loam, 9 to 15 percent slopes	Moderate	Spreckels (85%)	Slope/erodibility (0.50)	43.9	0.1%
SkE	Spreckels loam, 15 to 30 percent slopes	Moderate	Spreckels (85%)	Slope/erodibility (0.50)	45.7	0.1%
SkF	Spreckels loam, 30 to 50 percent slopes	Severe	Spreckels (85%)	Slope/erodibility (0.75)	1.3	0.0%
SoF	Stonyford gravelly loam, 30 to 50 percent slopes	Severe	Stonyford (85%)	Slope/erodibility (0.75)	519.9	1.2%
SoG	Stonyford gravelly loam, 50 to 75 percent slopes, eroded	Very severe	Stonyford (85%)	Slope/erodibility (0.95)	1,012.8	2.3%
SsG	Supan silt loam, 30 to 75 percent slopes	Very severe	Supan (85%)	Slope/erodibility (0.95)	14.3	0.0%
StE	Suther loam, 15 to 30 percent slopes	Moderate	Suther (85%)	Slope/erodibility (0.50)	432.3	1.0%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
StF	Suther loam, 30 to 50 percent slopes	Severe	Suther (85%)	Slope/erodibility (0.75)	2,788.0	6.2%
SuF	Suther-Laughlin loams, 15 to 50 percent slopes	Severe	Suther (60%)	Slope/erodibility (0.75)	2,684.6	6.0%
SuG	Suther-Laughlin loams, 50 to 75 percent slopes	Very severe	Suther (60%)	Slope/erodibility (0.95)	987.9	2.2%
			Laughlin (35%)	Slope/erodibility (0.95)		
ToG	Toomes rocky loam, 30 to 75 percent slopes	Very severe	Toomes (75%)	Slope/erodibility (0.95)	829.7	1.9%
W	Water	Not rated	Water (100%)		102.2	0.2%
YmB	Yolo sandy loam, overwash, 0 to 5 percent slopes	Slight	Yolo (85%)		8.4	0.0%
YnA	Yolo loam, 0 to 2 percent slopes	Slight	Yolo (85%)		75.8	0.2%
YrB	Yolo gravelly loam, 0 to 5 percent slopes	Slight	Yolo (85%)		28.3	0.1%
YsA	Yolo silt loam, 0 to 2 percent slopes	Slight	Yolo (85%)		10.7	0.0%
YuE	Yorkville clay loam, 5 to 30 percent slopes	Moderate	Yorkville (85%)	Slope/erodibility (0.50)	173.2	0.4%
YuF	Yorkville clay loam, 30 to 50 percent slopes	Severe	Yorkville (85%)	Slope/erodibility (0.75)	577.9	1.3%
YwF	Yorkville-Suther complex, 0 to 50 percent slopes	Moderate	Yorkville (60%)	Slope/erodibility (0.50)	462.5	1.0%
			Suther (25%)	Slope/erodibility (0.50)		
ZaA	Zamora silty clay loam, 0 to 2 percent slopes	Slight	Zamora (85%)		137.8	0.3%
Subtotals for Soil Survey Area					**44,615.8**	**99.9%**
Totals for Area of Interest					**44,649.2**	**100.0%**

Erosion Hazard (Off-Road, Off-Trail)— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Severe	18,948.3	42.4%
Very severe	11,375.4	25.5%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Moderate	6,431.9	14.4%
Slight	5,062.3	11.3%
Null or Not Rated	2,831.3	6.3%
Totals for Area of Interest	**44,649.2**	**100.0%**

Description

The ratings in this interpretation indicate the hazard of soil loss from off-road and off-trail areas after disturbance activities that expose the soil surface. The ratings are based on slope and soil erosion factor K. The soil loss is caused by sheet or rill erosion in off-road or off-trail areas where 50 to 75 percent of the surface has been exposed by logging, grazing, mining, or other kinds of disturbance.

The ratings are both verbal and numerical. The hazard is described as "slight," "moderate," "severe," or "very severe." A rating of "slight" indicates that erosion is unlikely under ordinary climatic conditions; "moderate" indicates that some erosion is likely and that erosion-control measures may be needed; "severe" indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and "very severe" indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

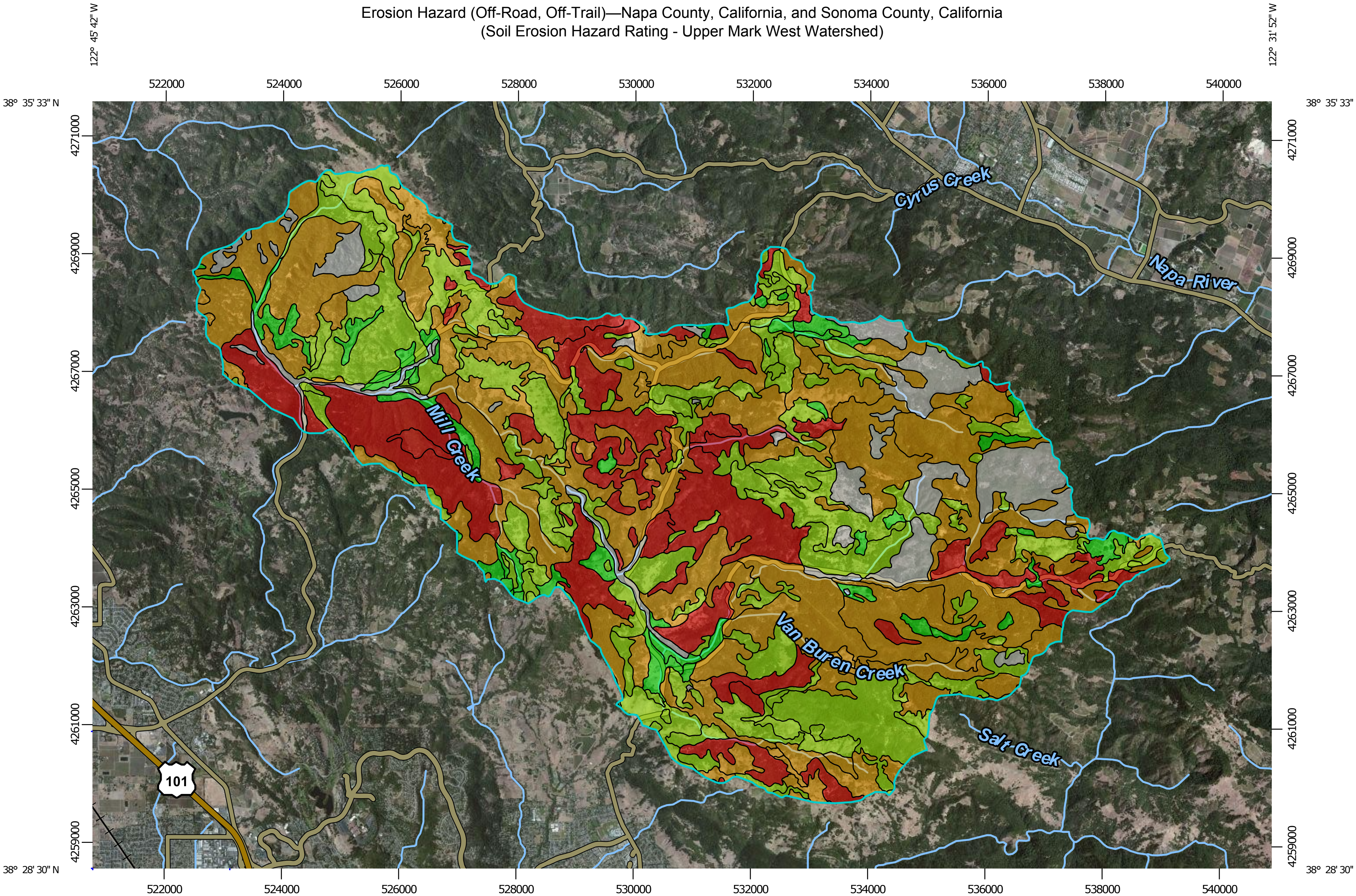
Component Percent Cutoff: *None Specified*

Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

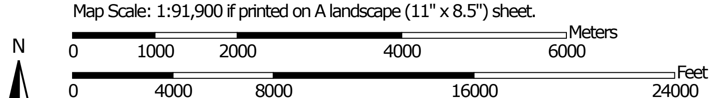
Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

Erosion Hazard (Off-Road, Off-Trail)—Napa County, California, and Sonoma County, California
(Soil Erosion Hazard Rating - Upper Mark West Watershed)



Map Scale: 1:91,900 if printed on A landscape (11" x 8.5") sheet.



Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

Very severe

Severe

Moderate

Slight

Not rated or not available

Soil Rating Lines

Very severe

Severe

Moderate

Slight

Not rated or not available

Soil Rating Points

Very severe

Severe

Moderate

Slight

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Napa County, California
Survey Area Data: Version 7, Sep 25, 2014

Soil Survey Area: Sonoma County, California
Survey Area Data: Version 8, Sep 25, 2014

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 2, 2010—Feb 17, 2012

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Erosion Hazard (Off-Road, Off-Trail)

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Napa County, California (CA055)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
100	Aiken loam, 2 to 15 percent slopes	Slight	Aiken (85%)		0.0	0.0%
101	Aiken loam, 15 to 30 percent slopes	Moderate	Aiken (85%)	Slope/erodibility (0.50)	0.3	0.0%
102	Aiken loam, 30 to 50 percent slopes	Severe	Aiken (85%)	Slope/erodibility (0.75)	0.0	0.0%
110	Boomer-Forward-Felta complex, 30 to 50 percent slopes	Severe	Boomer (40%)	Slope/erodibility (0.75)	0.2	0.0%
			Forward (35%)	Slope/erodibility (0.75)		
			Felta (15%)	Slope/erodibility (0.75)		
111	Boomer-Forward-Felta complex, 5 to 30 percent slopes	Moderate	Boomer (40%)	Slope/erodibility (0.50)	0.7	0.0%
			Forward (35%)	Slope/erodibility (0.50)		
			Felta (20%)	Slope/erodibility (0.50)		
152	Hambright rock-Outcrop complex, 30 to 75 percent slopes	Very severe	Hambright (50%)	Slope/erodibility (0.95)	0.5	0.0%
175	Rock outcrop	Not rated	Rock outcrop (100%)		0.6	0.0%
FaDsn	Felta very gravelly loam, 5 to 15 percent slopes	Slight	Felta (85%)		0.1	0.0%
FaEsn	Felta very gravelly loam, 15 to 30 percent slopes	Moderate	Felta (85%)	Slope/erodibility (0.50)	0.2	0.0%
FrGsn	Forward-Kidd complex, 30 to 75 percent slopes	Very severe	Forward (45%)	Slope/erodibility (0.95)	0.0	0.0%
			Kidd (45%)	Slope/erodibility (0.95)		
GgEsn	Goulding clay loam, 15 to 30 percent slopes	Moderate	Goulding (85%)	Slope/erodibility (0.50)	0.0	0.0%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Napa County, California (CA055)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
GlDsn	Goulding cobbly clay loam, 5 to 15 percent slopes	Slight	Goulding (85%)		1.3	0.0%
GlEsn	Goulding cobbly clay loam, 15 to 30 percent slopes	Moderate	Goulding (85%)	Slope/erodibility (0.50)	0.0	0.0%
GlFsn	Goulding cobbly clay loam, 30 to 50 percent slopes	Severe	Goulding (85%)	Slope/erodibility (0.75)	0.3	0.0%
HgEsn	Henneke gravelly loam, 5 to 30 percent slopes	Moderate	Henneke (85%)	Slope/erodibility (0.50)	0.1	0.0%
Subtotals for Soil Survey Area					**4.3**	**0.0%**
Totals for Area of Interest					**21,509.2**	**100.0%**

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
100n	Aiken loam, 2 to 15 percent slopes	Slight	Aiken (85%)		13.5	0.1%
101n	Aiken loam, 15 to 30 percent slopes	Moderate	Aiken (85%)	Slope/erodibility (0.50)	1.9	0.0%
102n	Aiken loam, 30 to 50 percent slopes	Severe	Aiken (85%)	Slope/erodibility (0.75)	42.1	0.2%
152n	Hambright rock-Outcrop complex, 30 to 75 percent slopes	Very severe	Hambright (50%)	Slope/erodibility (0.95)	17.5	0.1%
AdA	Alluvial land, sandy	Not rated	Alluvial land (85%)		37.5	0.2%
			Unnamed (15%)			
AeA	Alluvial land, clayey	Not rated	Alluvial land (85%)		4.3	0.0%
			Unnamed (15%)			
BoE	Boomer loam, 15 to 30 percent slopes	Moderate	Boomer (85%)	Slope/erodibility (0.50)	25.5	0.1%
BoF	Boomer loam, 30 to 50 percent slopes	Severe	Boomer (85%)	Slope/erodibility (0.75)	877.5	4.1%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
BoG	Boomer loam, 50 to 75 percent slopes	Very severe	Boomer (85%)	Slope/erodibility (0.95)	69.8	0.3%
FaD	Felta very gravelly loam, 5 to 15 percent slopes	Slight	Felta (85%)		313.2	1.5%
FaE	Felta very gravelly loam, 15 to 30 percent slopes	Moderate	Felta (85%)	Slope/erodibility (0.50)	335.1	1.6%
FaF	Felta very gravelly loam, 30 to 50 percent slopes	Severe	Felta (85%)	Slope/erodibility (0.75)	1,050.9	4.9%
FaG	Felta very gravelly loam, 50 to 75 percent slopes	Very severe	Felta (85%)	Slope/erodibility (0.95)	30.4	0.1%
FoE	Forward gravelly loam, 9 to 30 percent slopes	Moderate	Forward (85%)	Slope/erodibility (0.50)	7.0	0.0%
FoG	Forward gravelly loam, 30 to 75 percent slopes	Very severe	Forward (85%)	Slope/erodibility (0.95)	342.5	1.6%
FrG	Forward-Kidd complex, 30 to 75 percent slopes	Very severe	Kidd (45%)	Slope/erodibility (0.95)	195.5	0.9%
			Forward (45%)	Slope/erodibility (0.95)		
GgD	Goulding clay loam, 5 to 15 percent slopes	Slight	Goulding (85%)		195.4	0.9%
GgE	Goulding clay loam, 15 to 30 percent slopes	Moderate	Goulding (85%)	Slope/erodibility (0.50)	308.0	1.4%
GgF	Goulding clay loam, 30 to 50 percent slopes	Severe	Goulding (85%)	Slope/erodibility (0.75)	1,706.4	7.9%
GgG	Goulding clay loam, 50 to 75 percent slopes	Very severe	Goulding (85%)	Slope/erodibility (0.95)	324.1	1.5%
GlD	Goulding cobbly clay loam, 5 to 15 percent slopes	Slight	Goulding (85%)		275.3	1.3%
GlE	Goulding cobbly clay loam, 15 to 30 percent slopes	Moderate	Goulding (85%)	Slope/erodibility (0.50)	900.9	4.2%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
GlF	Goulding cobbly clay loam, 30 to 50 percent slopes	Severe	Goulding (85%)	Slope/erodibility (0.75)	3,171.5	14.7%
GlG	Goulding cobbly clay loam, 50 to 75 percent slopes	Very severe	Goulding (85%)	Slope/erodibility (0.95)	223.9	1.0%
HcC	Haire clay loam, 0 to 9 percent slopes	Slight	Haire (85%)		117.4	0.5%
HgE	Henneke gravelly loam, 5 to 30 percent slopes	Moderate	Henneke (85%)	Slope/erodibility (0.50)	743.1	3.5%
HgG2	Henneke gravelly loam, 30 to 75 percent slopes, eroded	Very severe	Henneke (85%)	Slope/erodibility (0.95)	1,776.0	8.3%
HyG	Huse stony clay loam, 30 to 75 percent slopes	Very severe	Huse (85%)	Slope/erodibility (0.95)	42.9	0.2%
KdF	Kidd gravelly loam, 9 to 50 percent slopes	Moderate	Kidd (85%)	Slope/erodibility (0.50)	229.3	1.1%
LaC	Laniger loam, 5 to 9 percent slopes	Slight	Laniger (85%)		53.9	0.3%
LaD	Laniger loam, 9 to 15 percent slopes	Moderate	Laniger (85%)	Slope/erodibility (0.50)	218.0	1.0%
LaE	Laniger loam, 15 to 30 percent slopes	Moderate	Laniger (85%)	Slope/erodibility (0.50)	937.6	4.4%
LaF	Laniger loam, 30 to 50 percent slopes	Severe	Laniger (85%)	Slope/erodibility (0.75)	1,006.0	4.7%
McF	Maymen gravelly sandy loam, 30 to 50 percent slopes	Severe	Maymen (85%)	Slope/erodibility (0.75)	6.4	0.0%
MoE	Montara cobbly clay loam, 2 to 30 percent slopes	Moderate	Montara (85%)	Slope/erodibility (0.50)	138.4	0.6%
MoG	Montara cobbly clay loam, 30 to 75 percent slopes	Severe	Montara (85%)	Slope/erodibility (0.75)	20.2	0.1%
RaD	Raynor clay, 9 to 15 percent slopes	Slight	Raynor (85%)		4.7	0.0%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
RaE	Raynor clay, 15 to 30 percent slopes	Moderate	Raynor (85%)	Slope/erodibility (0.50)	39.8	0.2%
ReE	Raynor-Montara complex, 0 to 30 percent slopes	Moderate	Raynor (50%)	Slope/erodibility (0.50)	152.4	0.7%
			Montara (35%)	Slope/erodibility (0.50)		
RhE	Red Hill clay loam, 15 to 30 percent slopes	Moderate	Red Hill (85%)	Slope/erodibility (0.50)	11.8	0.1%
RlG	Red Hill cobbly clay loam, 30 to 75 percent slopes	Very severe	Red Hill (85%)	Slope/erodibility (0.95)	988.8	4.6%
RnA	Riverwash	Not rated	Riverwash (85%)		200.1	0.9%
			Unnamed (15%)			
RoG	Rock land	Not rated	Rock land (85%)		1,446.1	6.7%
			Unnamed (15%)			
ShE	Sobrante loam, 15 to 30 percent slopes	Moderate	Sobrante (85%)	Slope/erodibility (0.50)	413.0	1.9%
ShF	Sobrante loam, 30 to 50 percent slopes	Severe	Sobrante (85%)	Slope/erodibility (0.75)	230.3	1.1%
SkC	Spreckels loam, 2 to 9 percent slopes	Slight	Spreckels (85%)		59.7	0.3%
SkD	Spreckels loam, 9 to 15 percent slopes	Moderate	Spreckels (85%)	Slope/erodibility (0.50)	91.1	0.4%
SkE	Spreckels loam, 15 to 30 percent slopes	Moderate	Spreckels (85%)	Slope/erodibility (0.50)	252.4	1.2%
SkE2	Spreckels loam, 15 to 30 percent slopes, eroded	Moderate	Spreckels (85%)	Slope/erodibility (0.50)	9.9	0.0%
SkF	Spreckels loam, 30 to 50 percent slopes	Severe	Spreckels (85%)	Slope/erodibility (0.75)	411.0	1.9%
StE	Suther loam, 15 to 30 percent slopes	Moderate	Suther (85%)	Slope/erodibility (0.50)	11.1	0.1%
ToE	Toomes rocky loam, 2 to 30 percent slopes	Moderate	Toomes (85%)	Slope/erodibility (0.50)	175.0	0.8%

Erosion Hazard (Off-Road, Off-Trail)— Summary by Map Unit — Sonoma County, California (CA097)						
Map unit symbol	**Map unit name**	**Rating**	**Component name (percent)**	**Rating reasons (numeric values)**	**Acres in AOI**	**Percent of AOI**
ToG	Toomes rocky loam, 30 to 75 percent slopes	Very severe	Toomes (75%)	Slope/erodibility (0.95)	166.3	0.8%
W	Water	Not rated	Water (100%)		9.7	0.0%
YoB	Yolo loam, overwash, 0 to 5 percent slopes	Slight	Yolo (85%)		5.3	0.0%
YsA	Yolo silt loam, 0 to 2 percent slopes	Slight	Yolo (85%)		35.3	0.2%
YuE	Yorkville clay loam, 5 to 30 percent slopes	Moderate	Yorkville (85%)	Slope/erodibility (0.50)	814.0	3.8%
YuF	Yorkville clay loam, 30 to 50 percent slopes	Severe	Yorkville (85%)	Slope/erodibility (0.75)	218.0	1.0%
Subtotals for Soil Survey Area					**21,504.9**	**100.0%**
Totals for Area of Interest					**21,509.2**	**100.0%**

Erosion Hazard (Off-Road, Off-Trail)— Summary by Rating Value		
Rating	**Acres in AOI**	**Percent of AOI**
Severe	8,740.7	40.6%
Moderate	5,816.7	27.0%
Very severe	4,178.3	19.4%
Slight	1,075.1	5.0%
Null or Not Rated	1,698.3	7.9%
Totals for Area of Interest	**21,509.2**	**100.0%**

Description

The ratings in this interpretation indicate the hazard of soil loss from off-road and off-trail areas after disturbance activities that expose the soil surface. The ratings are based on slope and soil erosion factor K. The soil loss is caused by sheet or rill erosion in off-road or off-trail areas where 50 to 75 percent of the surface has been exposed by logging, grazing, mining, or other kinds of disturbance.

The ratings are both verbal and numerical. The hazard is described as "slight," "moderate," "severe," or "very severe." A rating of "slight" indicates that erosion is unlikely under ordinary climatic conditions; "moderate" indicates that some erosion is likely and that erosion-control measures may be needed; "severe" indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and "very severe" indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the specified aspect of forestland management (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Aggregation is the process by which a set of component attribute values is reduced to a single value that represents the map unit as a whole.

A map unit is typically composed of one or more "components". A component is either some type of soil or some nonsoil entity, e.g., rock outcrop. For the attribute being aggregated, the first step of the aggregation process is to derive one attribute value for each of a map unit's components. From this set of component attributes, the next step of the aggregation process derives a single value that represents the map unit as a whole. Once a single value for each map unit is derived, a thematic map for soil map units can be rendered. Aggregation must be done because, on any soil map, map units are delineated but components are not.

For each of a map unit's components, a corresponding percent composition is recorded. A percent composition of 60 indicates that the corresponding component typically makes up approximately 60% of the map unit. Percent composition is a critical factor in some, but not all, aggregation methods.

The aggregation method "Dominant Condition" first groups like attribute values for the components in a map unit. For each group, percent composition is set to the sum of the percent composition of all components participating in that group. These groups now represent "conditions" rather than components. The attribute value associated with the group with the highest cumulative percent composition is returned. If more than one group shares the highest cumulative percent composition, the corresponding "tie-break" rule determines which value should be returned. The "tie-break" rule indicates whether the lower or higher group value should be returned in the case of a percent composition tie. The result returned by this aggregation method represents the dominant condition throughout the map unit only when no tie has occurred.

Component Percent Cutoff: *None Specified*

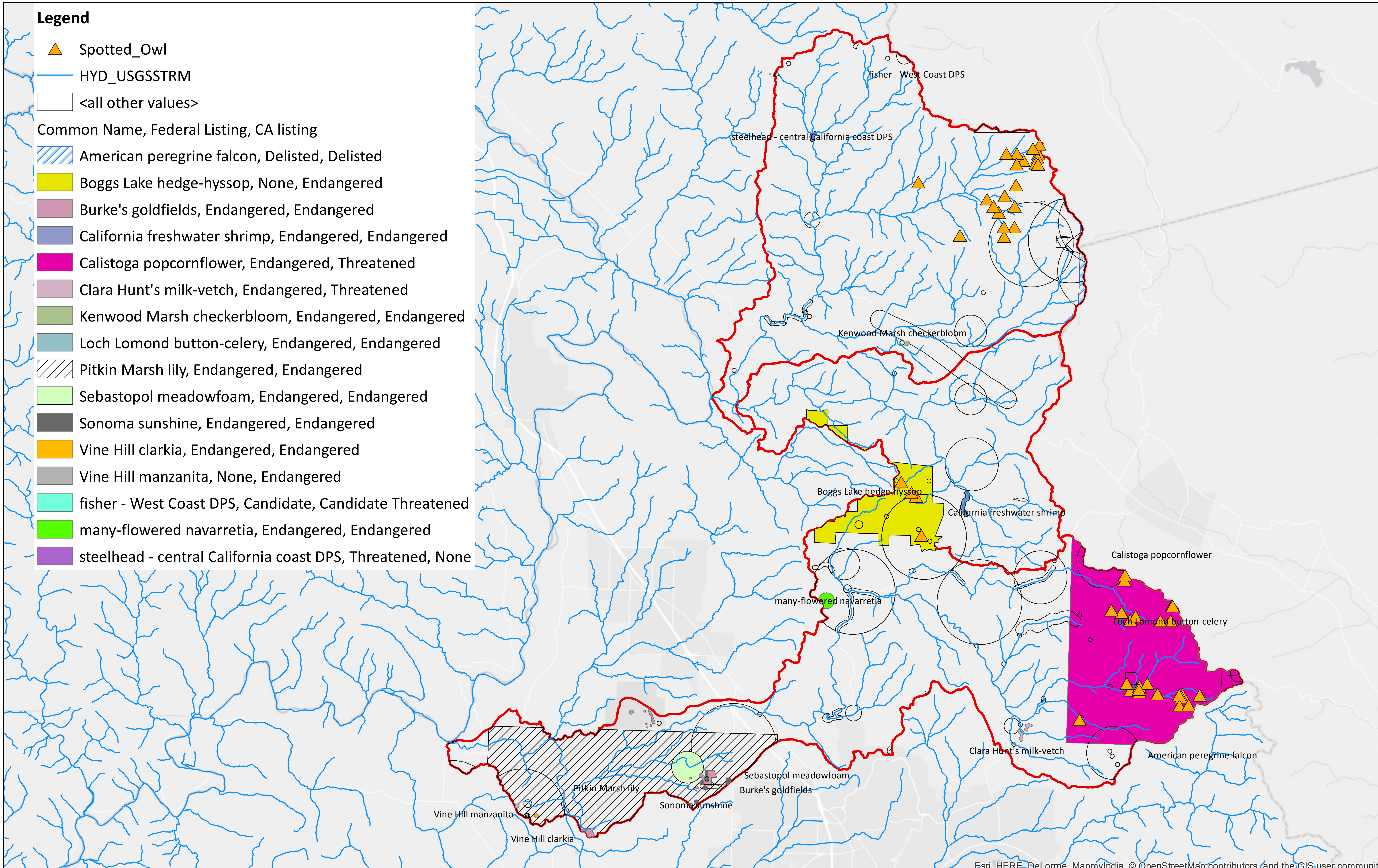
Components whose percent composition is below the cutoff value will not be considered. If no cutoff value is specified, all components in the database will be considered. The data for some contrasting soils of minor extent may not be in the database, and therefore are not considered.

Tie-break Rule: Higher

The tie-break rule indicates which value should be selected from a set of multiple candidate values, or which value should be selected in the event of a percent composition tie.

APPENDIX B

CALIFORNIA NATURAL DIVERSITY DATABASE MAP


Legend
Spotted_Owl
HYD_USGSSTRM
<all other values>
Common Name, Federal Listing, CA listing
American peregrine falcon, Delisted, Delisted
Boggs Lake hedge-hyssop, None, Endangered
Burke's goldfields, Endangered, Endangered
California freshwater shrimp, Endangered, Endangered
Calistoga popcornflower, Endangered, Threatened
Clara Hunt's milk-vetch, Endangered, Threatened
Kenwood Marsh checkerbloom, Endangered, Endangered
Loch Lomond button-celery, Endangered, Endangered
Pitkin Marsh lily, Endangered, Endangered
Sebastopol meadowfoam, Endangered, Endangered
Sonoma sunshine, Endangered, Endangered
Vine Hill clarkia, Endangered, Endangered
Vine Hill manzanita, None, Endangered
fisher - West Coast DPS, Candidate, Candidate Threatened
many-flowered navarretia, Endangered, Endangered
steelhead - central California coast DPS, Threatened, None
fisher - West Coast DPS
steelhead - central California coast DPS
Kenwood Marsh checkerbloom
Boggs Lake hedge-hyssop
California freshwater shrimp
Calistoga popcornflower
many-flowered navarretia
Loch Lomond button-celery
Clara Hunt's milk-vetch
American peregrine falcon
Sebastopol meadowfoam
Burke's goldfields
Pitkin Marsh lily
Sonoma sunshine
Vine Hill manzanita
Vine Hill clarkia
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

APPENDIX C

BASIN PLAN BENEFICIAL USES FOR SURFACE WATER

Beneficial Uses for Surface Water

Beneficial uses designated by the Water Quality Control Plan for the North Coast Region (Basin Plan 2011) for the Geyserville HSA, which encompasses the Maacama Creek watershed, and the Mark West HSA, which encompasses the Upper Mark West Creek watershed, are as follows:

Municipal and Domestic Supply (MUN) Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

Agricultural Supply (AGR) Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

Industrial Service Supply (IND) Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.

Groundwater Recharge (GWR) Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.

Freshwater Replenishment (FRSH) Uses of water for natural or artificial maintenance of surface water quantity or quality (e.g., salinity).

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

Water Contact Recreation (REC-1) Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white-water activities, fishing, or use of natural hot springs.

Non-Contact Water Recreation (REC-2) Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Commercial and Sport Fishing (COMM) Uses of water for commercial, recreational (sport) collection of fish, shellfish, or other aquatic organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

Warm Freshwater Habitat (WARM) Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Cold Freshwater Habitat (COLD) Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Wildlife Habitat (WILD) Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Rare, Threatened, or Endangered Species (RARE) Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.

Migration of Aquatic Organisms (MIGR) Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.

Spawning, Reproduction, and/or Early Development (SPWN) Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

Potential beneficial uses are designated for a number of reasons, including if that beneficial use existed prior to 1975 but does not currently exist, if there are plans to develop such a use, if existing water quality conditions do not support that use but could reasonably be improved to attain that use, or if there is insufficient information to show that the uses exists, but there is potential for the use to exist. The Basin Plan also designates the following potential beneficial uses for the Mark West and Geyserville HSAs:

Industrial Process Supply (PRO) Uses of water for industrial activities that depend primarily on water quality.

Hydropower Generation (POW) Uses of water for hydropower generation.

Aquaculture (AQUA) Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.

Shellfish Harvesting (SHELL) Uses of water that support habitats suitable for the collection of filterfeeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.

APPENDIX D

CDFW STREAM SURVEYS

(provided on CD)

CALIFORNIA DEPARTMENT OF FISH AND GAME
STREAM INVENTORY REPORT
Porter Creek
Report Revised April 14, 2006
Report Completed 2000
Assessment Completed 1996

INTRODUCTION

A stream inventory was conducted during the summer of 1996 on Porter Creek. The inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the amount and condition of available habitat to fish, and other aquatic species with an emphasis on anadromous salmonids in Porter Creek. The objective of the biological inventory was to document the salmonid and other aquatic species present and their distribution.

The objective of this report is to document the current habitat conditions, and recommend options for the potential enhancement of habitat for Chinook salmon, coho salmon and steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Porter Creek is a tributary to Mark West Creek, a tributary of the Russian River, located in Sonoma County, California (see Porter Creek map, page 2). The legal description at the confluence with Mark West Creek is T8N, R8W, S12. Its location is 38°32'52" N. latitude and 122°42'10" W. longitude.

Porter Creek and its tributaries drain a basin of approximately 10 square miles. Porter Creek is a second order stream and has approximately 8 miles of blue line stream, according to the USGS Mark West, and Calistoga 7.5 minute quadrangles. Elevations range from about 40 feet at the mouth of the creek to 1200 feet in the headwaters. Porter Creek flows through redwoods, maple, Oregon ash, tan oak and willows, draining approximately 10 square miles.

The stream flows through a narrow V-shaped canyon except for the last 1 1/4 mile to the mouth which opens up into a wide, flat valley of pasture land and grape fields. The watershed is primarily privately owned.

METHODS

The habitat inventory conducted in Porter Creek follows the methodology presented in the California Salmonid Stream Habitat Restoration Manual (Flosi, et al. 1998). The Sonoma county Water Agency personnel that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG). This inventory was conducted by a two person team with technical oversight by Bob Coey, Russian River Basin Planner (DFG).

Historical Stream Surveys

The 1974 survey reported the average water temperature at 66°F, the maximum being 74°F and the minimum being 61°F. The substrate consisted of 5% boulder, 70% rubble, 10% gravel, 10% sand, 5% detritus. There was an estimated 50% spawning area near the mouth of the stream. The remaining part of the stream had approximately 20% spawning area. Near the headwaters, the ratio of pools to riffles was 25% pools to 75% riffle with the pools averaging 3 feet wide, 4-6 feet long and 1.0-2.5 feet deep. About 3 miles above the mouth the pools became more abundant, averaging 75% pools to 25% riffle with the pools about 4-7 feet wide, 8-10 feet long and 2-3 feet deep. No barriers exist on the main stem of Porter Creek, although two tributaries about 0.5 miles downstream from the headwaters had barriers. One was a 15 ft. high log jam and the other was a 20 ft. high rock wall, located about 50 yards upstream of the tributaries confluence with Porter creek. Four diversions were noted at the time, three along Sharpe Road and one on Mark West Creek.

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the California Salmonid Stream Habitat Restoration Manual. This form was used in Porter Creek to record measurements and observations. There are nine components to the inventory form: flow, channel type, temperatures, habitat type, embeddedness, shelter rating, substrate composition, canopy, and bank composition. See Mark West Creek report for discussion of specific methods used.

BIOLOGICAL INVENTORY

Biological sampling during stream inventory is used to determine fish species and their distribution in the stream. Biological inventory is conducted using one or more of three basic methods:

1) stream bank observation, 2) underwater observation, 3) electrofishing. These sampling techniques are discussed in the California Salmonid Stream Habitat Restoration Manual.

DATA ANALYSIS

Data from the habitat inventory form are entered into Habitat, a dBASE IV data entry program developed by Tim Curtis, Inland Fisheries Division, California Department of Fish and Game. Refer to Mark West Creek report for discussion of methods.

HABITAT INVENTORY RESULTS

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of June 27 - August 1, 1996 was conducted by Sean White and Pam Higgins, Sonoma County Water Agency personnel. The survey began at the confluence with Mark West Creek and extended up Porter Creek to the end of landowner access permission. The total length of the stream surveyed was 24,155 feet, with an additional 586 feet of side channel. Flow was estimated to be 1.36 cfs during the survey period.

This section of Porter Creek has 7 channel types: from the mouth to 3,752 feet an F5; next 766 feet a B3; next 906 feet an F4; next 1,288 feet an F2; next 8,634 feet an F3; next 3,863 feet a B1 and the upper 4,946 feet an F3. F5 channel types are entrenched meandering riffle/pool channels on low gradients (<2%) with a high width/depth ratio and a predominantly sand substrate. F4, F3 and F2 channel types are similar except with gravel, cobble and boulder substrates, respectively.

B3 channel types are moderately entrenched, moderate gradient (2-4%), riffle dominated channels, with infrequently spaced pools, a very stable plan and profile, stable banks and have a predominantly cobble substrate. B1 channels are similar, but with a bedrock substrate.

Water temperatures ranged from 58°F to 74°F and air temperatures ranged from 66°F to 84°F.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 34% flatwater units, 34% pool units, 28% riffle units, and 5% dry streambed units. Based on total length there were 41% flatwater units, 31% pool units, 21% riffle units, and 7% dry streambed units (Graph 1).

Four hundred, eighteen habitat units were measured and 9% were completely sampled. Twenty-one Level IV habitat types were identified. The data is summarized in Table 2. The most frequent habitat types by percent occurrence were glides at 22%, low gradient riffles 21%, root wad scour pools 13% and runs 8% (Graph 2). By percent total length, glides made up 22%, low gradient riffles 15%, step runs 12%, and root wad scour pools 12%.

One hundred forty one pools were identified (Table 3). Scour pools were most often encountered at 70%, and comprised 63% of the total length of pools (Graph 3).

Table 4 is a summary of maximum pool depths by pool habitat types. Pool quality for salmonids increases with depth. Sixty-three of the 141 pools (45%) had a depth of two feet or greater (Graph 4). These deeper pools comprised 17% of the total length of stream habitat.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Shelter measurements are for 1+ salmonids. Pool habitat types in general had a mean shelter rating of 36 (Table 1). The backwater pools rated 49, scour pools rated 39, and main channel pools rated 28 (Table 3).

Table 5 summarizes fish shelter by habitat type. By percent area, the dominant pool shelter types were root masses at 32%, boulders 21%, undercut banks 14%, and terr. vegetation 11%. Graph 5 describes the pool shelter in Porter Creek.

Table 6 summarizes the dominant substrate by habitat type. Gravel was the dominant substrate observed in 5 of the 9 low gradient riffles measured. Small cobble was dominant in 4 of the low gradient riffles (Graph 6).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 128 pool tail-outs measured, 15 had a value of 1 (12%); 37 had a value of 2 (29%); 55 had a value of 3 (43%); and 21 had a value of 4 (16%). On this scale, a value of one is best for fisheries. Graph 7 describes percent embeddedness by reach.

The mean percent canopy density for the stream reach surveyed was 67%. The mean percentages of deciduous and evergreen trees were 64% and 35%, respectively. Graph 8 describes the canopy for the entire survey and graph 9 describes the canopy by reach.

For the entire stream reach surveyed, the mean percent right bank vegetated was 82% and the mean percent left bank vegetated was 84%. For the habitat units measured, the dominant vegetation types for the stream banks were: 65% deciduous trees, 30% evergreen trees, and 5% brush. The dominant substrate for the stream banks were: 58% silt/clay/sand, 25% cobble/gravel, 14% bedrock and 4% boulder(Graph 10).

During the summer of 1997, summer water temperatures were measured using a remote temperature recorder placed in a pool (see Temperature Summary graph at end of report). The recorder was placed in Reach 5 and logged temperatures every two hours from May 15 to September 9, 1997. The highest temperature recorded was 71°F in July and the lowest temperature recorded was 54°F in May.

BIOLOGICAL INVENTORY

JUVENILE SURVEYS:

In the 1974 survey, juvenile steelhead were present from the mouth to the headwaters and California Roach were present from the mouth to the junction of Franz Valley Rd. and Porter Creek Rd. It was noted that steelhead production was limited due to the intermittent nature of the stream during the summer months.

In the 1974 survey, young of the year and 1+ steelhead were estimated at a rate of 20/100ft,in the middle section juvenile steelhead were estimated at a rate of 150/100 ft., roach at 50/100 ft., and adult green sunfish were observed at a rate of 8/100 ft. In the lower section, juvenile steelhead were observed at a rate of 50/100 ft. and roach were observed at a rate of 200/100ft. Other vertebrates observed were tadpoles, unidentified frogs, garter snakes, California newts, and red bellied newts.

Biological surveys were not conducted in Porter Creek in 1996 or 1997 due to inadequate staffing levels.

DISCUSSION

Porter Creek has seven channel types: F5, B3, F4, F2, F3, B1 and F3. There are 3,752 feet of F5 channel type in Reach 1.

According to the DFG Salmonid Stream Habitat Restoration Manual, F5 channel types are good for bank-placed boulders and fair for low-stage weirs, single and opposing wing-deflectors, channel constrictors and log cover.

There are 906 feet of F4 channel type in Reach 3. F4 channel types are good for bank-placed boulders and fair for low-stage weirs, single and opposing wing-deflectors, channel constrictors and log cover.

There are 13,580 feet of F3 channel type in Reaches 5 and 7. F3 channel types are good for bank-placed boulders as well as single and opposing wing-deflectors. They are fair for low-stage weirs, boulder clusters, channel constrictors and log cover.

There are 1,288 feet of F2 channel type in Reach 4. F2 channel types are fair for low-stage weirs, single and opposing wing-deflectors and log cover.

There are 766 feet of B3 channel type in Reach 2. B3 channel types are excellent for low-stage plunge weirs, boulder clusters, bank placed boulders, single and opposing wing-deflectors and log cover. They are also good for medium-stage plunge weirs.

There are 3,863 feet of B1 channel type in Reach 6. B1 channel types are excellent for bank-placed boulders and bank cover and good for log cover.

The water temperatures recorded on the survey days June 27 - August 1, 1996 ranged from 58°F to 74°F. Air temperatures ranged from 66°F to 84°F. These warmer temperatures are above the threshold stress level (65°F) for salmonids.

Pools comprised 31% of the total length of this survey. In first and second order streams a primary pool is defined to have a maximum depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. In Porter Creek, the pools are relatively shallow with 45% having a maximum depth of at least 2 feet. These pools comprised 17% of the total length of stream habitat. However, in coastal coho and steelhead streams, it is generally desirable to have primary pools comprise approximately 50% of total habitat length.

The mean shelter rating for pools was 36. However, a pool shelter rating of approximately 80 is desirable. The relatively small amount of pool shelter that now exists is being provided primarily by root masses (32%), boulders (21%), undercut banks (14%), and terr. vegetation (11%). Log and root wad cover in the pool and flatwater habitats would improve both summer and winter salmonid habitat. Log cover provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

All of the low gradient riffles measured had either gravel or small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

Fifty-nine percent of the pool tail-outs measured had embeddedness ratings of either 3 or 4. Only 12% had a rating of 1. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered best for the needs of salmon and steelhead. In a reach comparison, Reaches 1-5 had very poor embeddedness ratings, while reaches 6 and 7 had fair ratings with more than half of the pool tail-outs having either a 1 or 2.

The higher the percent of fine sediment, the lower the probability that eggs will survive to hatch. This is due to the reduced quantity of oxygenated water able to percolate through the gravel, or because of fine sediment capping the redd and preventing fry emergence. In Reaches 1-5 of Porter Creek, salmonid spawning is likely inhibited by high sediment levels.

The mean percent canopy for the survey was 67%. This is a slightly low percentage of canopy, since 80 percent is generally considered desirable. Cooler water temperatures are desirable in Porter Creek. Elevated water temperatures could be reduced by increasing stream canopy. The large trees required for adequate stream canopy would also eventually provide a long term source of large woody debris needed for instream structure and bank stability.

GENERAL RECOMMENDATIONS

Porter Creek should be managed as an anadromous, natural production stream.

Recent storms brought down many large trees and other woody debris into the stream, which increased the number and quality of pools since the drought years. This woody debris, if left undisturbed, will provide fish shelter and rearing habitat, and offset channel incision. Many signs of recent and historic tree and log removal were evident in the active channel during our survey. Efforts to increase flood protection or improve fish access in the short run, have led to long term problems in the system. Landowners should be encouraged not to remove woody debris from the stream, except under extreme buildup and only under guidance by a fishery professional.

SPECIFIC FISHERY ENHANCEMENT RECOMMENDATIONS

1) Increase the canopy on Porter Creek by planting willow, alder, redwood, and douglas fir along the stream where shade canopy is not at acceptable levels. The reach above the survey section should be assesses for planting and treated as well, since water temperatures throughout are effected from upstream. In many cases, planting will need to be coordinated to follow bank stabilization or upslope erosion control projects.

2) For sources of upslope and in-channel erosion, utilize biotechnical approaches. Near-stream riparian planting along any portion of the stream should be encouraged to provide bank stability and a buffering against agricultural, grazing and urban run-off. Biotechnical approaches should be utilized in reach 5.

3) Where feasible, increase woody cover in the pool and flatwater habitat units along the entire stream. Most of the existing shelter is from vegetation and undercut banks. Adding high quality complexity with larger woody cover is desirable. Combination cover/scour structures constructed with boulders and woody debris would be effective in many flatwater and pool locations. This must be in conjunction with stream bank armor to prevent erosion. In some areas the material is at hand.

4) Where feasible, design and engineer pool enhancement structures to increase the number and quality of pools. This must be done where the banks are stable or in conjunction with stream bank armor to prevent erosion. Many glide habitats could be converted to pools with the addition of large woody debris.

PROBLEM SITES AND LANDMARKS - PORTER CREEK SURVEY COMMENTS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach.

HABITAT UNIT #	STREAM LEN (FT.)	COMMENTS
7.00	330	OBSERVED RED-LEGGED FROG
9.00	402	70% DECIDUOUS BAY

20.00	861	200 YDS DOWNSTREAM OF HOUSE
22.00	1048	DIRT RD. CROSSING
46.00	2470	BRIDGE #1 CEMENT CUL. (SUMMER DAM-EARTH ROCK)
52.00	2831	DRY TRIB R/B
62.00	3414	SM. MOUTH BASS/ROACH/SH/BLUE GILL/SUCKERS
65.00	3816	CHANNEL CHANGE BEGIN
77.00	4635	CHANNEL CHANGED BACK TO DOWNSTREAM SECTION.
84.00	5269	LOTS OF WARMWATER FISH SPECIES: BRN BULLHEAD/GSUN/SM M BASS. INTERMIT. TRIBS R/B
86.00	5426	WOODEN DRIVEWAY BRIDGE (#2) 23' * SEVERAL DEAD JUVENILE SH (UNIT #076-UPSTREAM)
87.00	5452	CHANNEL CHANGE BEGIN (BEDROCK)
88.00	5534	WOODEN DRIVEWAY BRIDGE #2 23' OBSERVED SEVERAL DEAD JUVENILE SH (UNIT #76-UPSTREAM)
96.00	6275	BRIDGE #3 CEMENT 43'L
99.00	6422	BIG CRAWDAD, ALL SPECIES POOL BRIDGE #4 WOODEN/CEMENT 20'L 42'W
103.00	6713	@ HOUSE UPSTREAM OF FV RD BRIDGE
104.00	6735	CHANNEL CHANGE TO LG. BOULDRS
108.00	7216	R/B RD. INTO CREEK
113.00	7369	END OF PROP. ACCESS OK
114.00	7421	BEGIN AGAIN @ULMAN PROPERTY. BRIDGE #5 (DOWNSTREAM)
118.00	7698	EROSION R/B ALDER DOWN IN CREEK
127.00	8247	EROSION/ROCKSLIDE
128.00	8298	SPRING R/B
147.00	9173	END @ PUMPHOUSE
148.00	9240	BEGIN @ BRIDGE #6 SWIGCAMP PROPERTY DOUBLE BOX CEMENT CULVERT 8'H/24'W/124'L
159.00	9811	TRIB L/B WITH CEMENT CULVERT 3' DIA
168.00	10349	CEMENT CHECK DAM
171.00	10654	END AT PROP. LINE 100' DOWNSTREAM OF BRIDGE #7
182.00	11322	THIS UNIT OF QUARRY ENTRANCE

186.00	13122	EROSION R/B JUST ABOVE QUARRY
194.00	13463	3'DIA CULVERT R/B WATER/TRIB
196.00	13576	CORRAGATED METAL RETAINING WALL R/B
199.00	13746	CULVERT R/B 2'DIA
216.00	14643	x 100' downstream of bridge #8 (pet. for. rd.)
218.00	14730	x 2.5'
220.00	14768	METAL & CONCRETE FISH LADDER
221.00	14889	THRU CONCRETE BRIDGE #8 CULVERT (DOUBLE BOX) 11'H / 24' *LOW F10 CHANNEL 120'LONG
224.00	15023	EROSION L/B & R/B
225.00	15057	EROSION L/B & R/B
226.00	15091	LWD JAM 4' HIGH EROSION R/B & L/B
232.00	15277	EROSION L/B
237.00	15404	CHANNEL CHANGE
240.00	15497	EROSION R/B
272.00	17035	DRY TRIB R/B SM. DRY TRIB L/B
308.00	18893	EROSION R/B
310.00	19000	ACROSS FROM PETRIFIED FOREST ENTRANCE
314.00	19100	CEMENT DAM ABANDONED
317.00	19248	CHANNEL CHANGE TO BEDROCK
320.00	19407	EROSION L/B
343.00	20761	EROSION L/B
347.00	21113	DRT RD. XNG
366.00	21892	ACCESS PERM. ENDS HERE
367.00	21944	BEGIN BELOW BRIDGE #9
380.00	22530	HOUSE RT BOTTOM MADRID?
386.00	23149	BRIDGE #10 RD. TO SHARP RD. 7' H/ 29.06/21.5W
394.00	23851	END @ PROP. LINE BELOW HOUSE ON KROHN PROP.
395.00	23911	BEGIN @URGUHART PROP. @ WOODEN FOOT BRIDGE
405.00	24244	EROSION RB
406.00	24272	EROSION RB
409.00	24482	EROSION RB
410.00	24492	END OF SURVEY

CALIFORNIA DEPARTMENT OF FISH AND GAME
STREAM INVENTORY REPORT
Humbug Creek
Report Revised April 14, 2006
Report Completed 2000
Assessment Completed 1996

INTRODUCTION

A stream inventory was conducted during the summer of 1996 on Humbug Creek . The inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the amount and condition of available habitat to fish, and other aquatic species with an emphasis on anadromous salmonids in Humbug Creek. The objective of the biological inventory was to document the salmonid and other aquatic species present and their distribution.

The objective of this report is to document the current habitat conditions, and recommend options for the potential enhancement of habitat for Chinook salmon, coho salmon and steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Humbug Creek is a tributary to Mark West Creek, a tributary of the Russian River, located in Sonoma County, California (see Humbug Creek map, page 2). The legal description at the confluence with Mark West Creek is T8N, R7W, S20. Its location is 38°31'12" N. latitude and 122°39'33" W. longitude.

Humbug Creek and its tributaries drain a basin of approximately 2.75 square miles. Humbug Creek is a second order stream and has approximately 3.25 miles of blue line stream, according to the USGS Mark West 7.5 minute quadrangle. Summer flow was measured as approximately 2.4 cfs. Elevations range from about 640 feet at the mouth of the creek to 1600 feet in the headwaters. Grassland and chaparral dominate the watershed, but there are zones of oak-woodland near the mouth. The watershed is privately owned.

METHODS

The habitat inventory conducted in Mark West Creek follows the methodology presented in the California Salmonid Stream Habitat Restoration Manual (Flosi, et al. 1998). The Sonoma county Water Agency personnel that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG). This inventory was conducted by a two person team with technical oversight by Bob Coey, Russian River Basin Planner (DFG).

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the California Salmonid Stream Habitat Restoration Manual. This form was used in Humbug Creek to record measurements and observations. There are nine components to the inventory form: flow, channel type, temperatures, habitat type, embeddedness, shelter rating, substrate composition, canopy, and bank composition.

1. Flow:

Flow is measured in cubic feet per second (cfs) at the bottom of the stream survey reach using standard flow measuring equipment, if available. In some cases flows are estimated. Flows were also measured or estimated at major tributary confluences.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1985 rev. 1996). This methodology is described in the California Salmonid Stream Habitat Restoration Manual. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are five measured parameters used to determine channel type: 1) water slope gradient, 2)entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity.

3. Temperatures:

Water and air temperatures, and time, are measured by crew members with hand held thermometers and recorded at each tenth unit typed. Temperatures are measured in Fahrenheit at the middle of the habitat unit and within one foot of the water surface. Temperatures are also recorded using remote Temperature recorders which log temperature every two hours, 24 hours/day.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1988). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "DRY". Humbug Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All unit lengths were measured, additionally, the first occurrence of each unit type and a randomly selected 10% subset of all units were completely sampled (length, mean width, mean depth, maximum depth and pool tail crest depth). All measurements were in feet to the nearest tenth.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out reaches is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Humbug Creek, embeddedness was visually estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3), 76 - 100% (value 4). Additionally, a rating of "not suitable" (NS)was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate particle size, having a bedrock tail-out, or other considerations.

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All shelter is then classified according to a list of nine shelter types. In Humbug Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the shelter. The shelter rating is calculated for each habitat unit by multiplying shelter value and percent covered. Thus, shelter ratings can range from 0-300, and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully measured habitat units, dominant and sub-dominant substrate elements were visually estimated using a list of seven size classes.

8. Canopy:

Stream canopy density was estimated using modified handheld spherical densiometers as described in the California Salmonid Stream Habitat Restoration Manual, 1994. Canopy density relates to the amount of stream shaded from the sun. In Humbug Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the center of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated visually into percentages of evergreen or deciduous trees.

9. Bank Composition:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Humbug Creek, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully measured unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation was estimated and recorded.

BIOLOGICAL INVENTORY

Biological sampling during stream inventory is used to determine fish species and their distribution in the stream. Biological inventory is conducted using one or more of three basic methods: 1) stream bank observation, 2) underwater observation, 3) electrofishing. These sampling techniques are discussed in the California Salmonid Stream Habitat Restoration Manual.

DATA ANALYSIS

Data from the habitat inventory form are entered into Habitat, a dBASE IV data entry program developed by Tim Curtis, Inland Fisheries Division, California Department of Fish and Game. This program processes and summarizes the data, and produces the following tables and appendices:

- Riffle, flatwater, and pool habitat types
- Habitat types and measured parameters
- Pool types
- Maximum pool depths by habitat types
- Shelter by habitat types
- Dominant substrates by habitat types

- Vegetative cover and dominant bank composition
- Fish habitat elements by stream reach

Graphics are produced from the tables using Lotus 1,2,3. Graphics developed for Humbug Creek include:

- Level II Habitat Types by % Occurrence and % Total Length
- Level IV Habitat Types by % Occurrence
- Pool Habitat Types by % Occurrence
- Maximum Depth in Pools
- Pool Shelter Types by % Area
- Substrate Composition in Low Gradient Riffles
- Percent Cobble Embeddedness by Reach
- Mean Percent Canopy
- Mean Percent Canopy by Reach
- Percent Bank Composition and Bank Vegetation

HABITAT INVENTORY RESULTS

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of June 4-6, 1996 was conducted by Sean White and Pamela Higgins, Sonoma County Water Agency personnel. The survey began at the confluence with Mark West Creek and extended up Humbug Creek to the end of landowner access permission. The total length of the stream surveyed was 7,052 feet, with an additional 92 feet of side channel. Flow was estimated to be 2.4 cfs during the survey period.

This section of Humbug Creek has four reaches of three different channel types: from the mouth to 2,527 feet an F3; next 1,091 feet an F1; next 1,580 feet an F3 and the upper 1,854 feet an F2. F3 channel types are entrenched meandering riffle/pool channels on low gradients (<2%) with a high width/depth ratio and a predominantly cobble substrate. F1 and F2 channel types are similar, but with bedrock and boulder substrates, respectively.

Water temperatures ranged from 62°F to 66°F, and air temperatures ranged from 68°F to 82°F.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 49% pool units, 35% riffle units, and 16% flatwater units. Based on total length there were 46% pool units, 35% riffle units, and 19% flatwater units (Graph 1).

There were 128 habitat units measured and 19% were completely sampled. Sixteen Level IV habitat types were identified. The data is summarized in Table 2. The most frequent habitat types by percent occurrence were mid-channel pools at 20%, high gradient riffles 16%, low gradient riffles 14% and step pools 7% (Graph 2). By percent total length, mid-channel pools made up 17%, high gradient riffles 17%, low gradient riffles 14%, and step pools 11%.

Sixty-three pools were identified (Table 3). Main Channel pools were most often encountered at 59%, and comprised 70% of the total length of pools (Graph 3).

Table 4 is a summary of maximum pool depths by pool habitat types. Pool quality for salmonids increases with depth. Forty-one of the 63 pools (65%) had a depth of two feet or greater (Graph 4). These deeper pools comprised 32% of the total length of stream habitat.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Pool types in general had a mean shelter rating of 28. Of the pool types, the main channel pools had the highest mean shelter rating at 32, scour pools rated 26, and backwater pools rated 5 (Table 3).

Table 5 summarizes fish shelter by habitat type. By percent area, the dominant pool shelter types were undercut banks at 37%, boulders 30%, and bedrock ledges 22%. Graph 5 describes the pool shelter in Humbug Creek.

Table 6 summarizes the dominant substrate by habitat type. Gravel was a dominant substrate in none of the two low gradient riffles measured. Small cobble was dominant in both of the low gradient riffles (Graph 6).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 58 pool tail-outs measured, six had a value of 1 (10%); 38 had a value of 2 (66%); two had a value of 3 (3%); and twelve had a value of 4 (21%). On this scale, a value of one is best for fisheries.

The mean percent canopy density for the stream reach surveyed was 79%. The mean percentages of deciduous and evergreen trees were 94% and 6%, respectively. Graph 8 describes the canopy for the entire survey.

For the entire stream reach surveyed, the mean percent right bank vegetated was 96% and the mean percent left bank vegetated was 96%. For the habitat units measured, the dominant vegetation types for the stream banks were: 91% deciduous trees, and 9% evergreen trees. The dominant substrate for the stream banks were: 66% bedrock, 17% silt/clay/sand, 13% cobble/gravel and 4% boulder (Graph 10).

Biological surveys were not conducted in Humbug Creek in 1996 or 1997 due to inadequate staffing levels.

During the summer of 1997, summer water temperatures were measured using a remote temperature recorder placed in a pool (see Temperature Summary graph at end of report). A temperature recorder was placed in Reach 1 and logged temperatures every two hours from May 15 to September 9, 1997. The highest temperature recorded was 72°F in August and the lowest temperature was 54°F in May.

DISCUSSION

Humbug Creek has three channel types: F3, F1, and F3. There are 4,107 feet of F3 channel type in Reaches 1 and 3. According to the California Salmonid Stream Habitat Restoration Manual, F3 channel types are good for bank-placed boulders as well as single and opposing wing-deflectors. They are fair for low-stage weirs, boulder clusters, channel constrictors and log cover. There are 1,091 feet of F1 channel type in Reach 2. F1 channel types are good for bank-placed boulders and fair for single wing-deflectors and log cover. There are 1,854 feet of F2 channel type in Reach 4. F2 channel types are fair for low-stage weirs, single and opposing wing-deflectors and log cover.

The water temperatures recorded on the survey days June 4-6, 1996 ranged from 62°F to 66°F, and air temperatures ranged from 68°F to 82°F. These higher temperatures are at the threshold stress level (65°F) for salmonids. To make any further conclusions, temperatures need to be monitored for a longer period of time through the critical summer months, and more extensive biological sampling conducted.

Pools comprised 46% of the total length of this survey. In first and second order streams a primary pool is defined to have a maximum depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. In Humbug Creek, the pools are relatively deep with 65% having a maximum depth of at least 2 feet. These pools comprised 32% of the total length of stream habitat. In coastal coho and steelhead streams, it is generally desirable to have primary pools comprise approximately 50% of total habitat length.

The mean shelter rating for pools was 28. However, a pool shelter rating of approximately 80 is desirable. The relatively small amount of pool shelter that now exists is being provided primarily by undercut banks, boulders, and bedrock ledges. More log and root wad cover in the pool and flatwater habitats would improve both summer and winter salmonid habitat. Log cover provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.
Both of the low gradient riffles measured had small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

Sixty-six percent of the pool tail-outs measured had embeddedness ratings of 2. Only 10% had a rating of 1. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered best for the needs of salmon and steelhead. In a reach comparison, Reaches 1 and 3 had the best ratings. In Humbug Creek, the amount of fine sediment in potential spawning habitat seems to be minimal.

The mean percent canopy for the survey was 79%. This is a good percentage of canopy, since 80 percent is generally considered desirable.

GENERAL RECOMMENDATIONS

Humbug Creek should be managed as an anadromous, natural production stream.

Recent storms brought down many large trees and other woody debris into the stream, which increased the number and quality of pools since the drought years. This woody debris, if left undisturbed, will provide fish shelter and rearing habitat, and offset channel incision. Many signs of recent and historic tree and log removal were evident in the active channel during our survey. Efforts to increase flood protection or improve fish access in the short run, have led to long term problems in the system. Landowners should be encouraged <u>not to remove woody debris</u> from the stream, except under extreme buildup and only under guidance by a fishery professional.

SPECIFIC FISHERY ENHANCEMENT RECOMMENDATIONS

1) Access for migrating salmonids is an ongoing potential

problem at existing flashboard dams, therefore, fish passage should be monitored, and improved where possible.

2) Increase the canopy on Humbug Creek by planting willow, alder, redwood, and Douglas fir along the stream where shade canopy is not at acceptable levels. The reach above the survey section should be assessed for planting and treated as well, since water temperatures throughout are effected from upstream. In many cases, planting will need to be coordinated to follow bank stabilization or upslope erosion control projects.

3) Where feasible, increase woody cover in the pool and flatwater habitat units along the entire stream. Most of the existing shelter is from vegetation and undercut banks. Adding high quality complexity with larger woody cover is desirable. Combination cover/scour structures constructed with boulders and woody debris would be effective in many flatwater and pool locations. This must be in conjunction with stream bank armor to prevent erosion. In some areas the material is at hand.

PROBLEM SITES AND LANDMARKS - HUMBUG CREEK SURVEY COMMENTS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach.

HABITAT UNIT #	STREAM LEN (FT.)	COMMENTS
8	379	Cement bridge #1 (16.1w x 5.5h x 25.8L)
46	2465	Bridge #2, cement (21.2w x 7.7h x 51.0L); Pacific giant salamander and yellow-legged frog
48	2527	Channel change
58	3012	Last unit before Grijalva property.
59	3036	Begin after skipping Grilalva property. Bridge #3 (7.5h x 16.7w x 16.5L)
60	3082	right bank cmp gabions
64	3423	Resident (Manley) noted disappearance of crawdads in lst 2 years; coho seen 20 years ago.
67	3576	Bridge #4 (wood rail car, 16.0w x 7.2h x 22.0L)
69	3700	Channel change, back to downstream channel type
70	3827	Redwood bridge w/2 cmp piers in channel.

74	4108	Pacific giant salamander (PGS) present.
75	4149	crawfish present
76	4257	Dry trib. left bank.
77	4331	Flashboard dam
80	4625	Bridge #5 (Henke property) wooden (7.0h x 12.5w x 11.0L)
84	4860	Bridge #6 cement/wood (5.5h x 14.5w.x.13.0L)
89	5073	Redwood flashboard dam
90	5151	End downstream of Bridge #7.
91	5198	3168 Calistoga (Blair) begin again here. Skipped Upp property.
92	5240	Channel change.
95	5378	Bridge #8 wood (14.0L x 11.6h x 17.0w)
100	5561	Lieberman property (upstream end)
106	5777	concrete check dam
107	5833	Bridge #9 wooden
108	5956	Concrete check dam at downstream end of unit
109	6001	Side channel begins and ends.
110	6039	Bridge #9 wood (10.0L x 15.0w x 4.2h)
113	6346	Rootwad, lwd (1st seen in creek)
126	7027	Gradient getting steeper, habitat not good.
127	7052	End survey Holman property; Moir property--large plunge pool (6' deep, 6' drop to pool)

CALIFORNIA DEPARTMENT OF FISH AND GAME
STREAM INVENTORY REPORT
Mark West Creek Tributaries
Report Revised April 14, 2006
Report Completed 2000
Assessment Completed 1997

INTRODUCTION

A stream inventory was conducted during the summer of 1997 on the following Mark West Creek Tributaries: Horse Hill Creek, Mill Creek, Weeks Creek, and Van Buren Creek. The inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the amount and condition of available habitat to fish, and other aquatic species with an emphasis on anadromous salmonids in the Mark West Creek Tributaries. The objective of the biological inventory was to document the salmonid and other aquatic species present and their distribution.

The objective of this report is to document the current habitat conditions, and recommend options for the potential enhancement of habitat for Chinook salmon, coho salmon and steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW FOR HORSE HILL CREEK

Horse Hill Creek is a tributary to Mark West Creek which flows into the Russian River, located in Sonoma County, California (see Mark West Creek Tributaries map, page 2). The legal description at the confluence with Mark West Creek is T08N, R08W, S11. Its location is 38°32'58" N. latitude and 122°43'17" W. longitude. Year round vehicle access exists from Highway 101 near Santa Rosa, via Mark West Springs Road, via Porter Creek Road.

Horse Hill Creek and its tributaries drain a basin of approximately 2.7 square miles. Horse Hill Creek is a first order stream and has approximately 3.4 miles of blue line stream, according to the USGS Mark West 7.5 minute quadrangles. Summer flow was not measured during the survey. Elevations range from about 440 feet at the mouth of the creek to 1400 feet in the headwaters. redwood forest dominates the watershed. The northwestern pond turtle (*Clemmys marmorata marmorata*) is listed with a federal status of species of concern in the CDFG's Natural Diversity Database as occurring within the Horse Hill Creek watershed.

WATERSHED OVERVIEW FOR MILL CREEK

Mill Creek is a tributary to Mark West Creek which flows into the Russian River, located in Sonoma County, California (see Mark West Creek Tributaries map, page 2). The legal description at the confluence with Mark West Creek is T08N, R08W, S13. Its location is 38°32'49" N. latitude and 122°41'51" W. longitude. Year round vehicle access exists from Highway 101 near Santa Rosa, via Mark West Springs Road, via private roads.

Mill Creek and its tributaries drain a basin of approximately 2.8 square miles. Mill Creek is a first order stream and has approximately 2.3 miles of blue line stream, according to the USGS Mark West Springs 7.5 minute quadrangles. Summer flow was not measured during the survey. Elevations range from about 470 feet at the mouth of the creek to 1400 feet in the headwaters. No sensitive plants or animals were listed in the CDFG’s Natural Diversity Database as occurring within the Mill Creek watershed.

WATERSHED OVERVIEW FOR WEEKS CREEK

Weeks Creek is a tributary to Mark West Creek which flows into the Russian River, located in Sonoma County, California (see Mark West Creek Tributaries map, page 2). The legal description at the confluence with Mark West Creek is T08N, R07W, S29. Its location is 38°30'32" N. latitude and 122°38'53" W. longitude. Year round vehicle access exists from Highway 101 near Santa Rosa, via Highway 12, via Calistoga Road.

Weeks Creek and its tributaries drain a basin of approximately 1.8 square miles. Weeks Creek is a second order stream and has approximately 3.4 miles of blue line stream, according to the USGS Mark West Springs 7.5 minute quadrangle. Summer flow was not measured during the survey. Elevations range from about 670 feet at the mouth of the creek to 1800 feet in the headwaters. The Foothill yellow-legged frog (*Rana boylii*) is listed with a federal status of species of concern and the Clara Hunt's milk-vetch (*Astragalus clarianus*) is listed with a federal status of endangered and a California status of threatened in the CDFG's Natural Diversity Database as occurring within the Weeks Creek watershed.

WATERSHED OVERVIEW FOR VAN BUREN CREEK

Van Buren Creek is a tributary to Mark West Creek which flows into the Russian River, located in Sonoma County, California (see Mark West Creek Tributaries map, page 2). The legal description at the confluence with Mark West Creek is T08N, R07W, S28. Its location is 38°30'44" N. latitude and 122°38'17" W. longitude. Year round vehicle access exists from Highway 101 near Santa Rosa, via Highway 12, via Calistoga Road, via St. Helena Road.

Van Buren Creek and its tributaries drain a basin of approximately 1.4 square miles. Van Buren Creek is a first order stream and has approximately 3.0 miles of blue line stream, according to the USGS Mark West Springs 7.5 minute quadrangle. Summer flow was not measured during the survey. Elevations range from about 800 feet at the mouth of the creek to 1600 feet in the headwaters. The Foothill yellow-legged frog (*Rana Boylii*) is listed with a federal status of species of concern and the Northern spotted owl (*Strix occidentalis caurina*) is listed with a federal status of threatened in the CDFG's Natural Diversity Database as occurring within the Van Buren Creek watershed.

METHODS

The habitat inventory conducted in Sample Creek follows the methodology presented in the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 1998). The AmeriCorps Volunteers that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Game (DFG). This inventory was conducted by a two person team and was supervised by Bob Coey, Russian River Basin Planner (DFG).

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the California Salmonid Stream Habitat Restoration Manual. This form was used in the Mark West Tributaries to record measurements and observations. There are nine components to the inventory form: flow, channel type, temperatures, habitat type, embeddedness, shelter rating, substrate composition, canopy, and bank composition.

1. Flow:

Flow is measured in cubic feet per second (cfs) at the bottom of the stream survey reach using standard flow measuring equipment, if available. In some cases flows are estimated. Flows were also measured or estimated at major tributary confluences.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1985 rev. 1996). This methodology is described in the California Salmonid Stream Habitat Restoration Manual. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are five measured parameters used to determine channel type: 1) water slope gradient, 2)entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity.

3. Temperatures:

Water and air temperatures, and time, are measured by crew members with hand held thermometers and recorded at each tenth unit typed. Temperatures are measured in Fahrenheit at the middle of the habitat unit and within one foot of the water surface. Temperatures are also recorded using remote Temperature recorders which log temperature every two hours, 24 hours/day.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1988). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "DRY". The Mark West

Creek tributaries habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All unit lengths were measured, additionally, the first occurrence of each unit type and a randomly selected 10% subset of all units were completely sampled (length, mean width, mean depth, maximum depth and pool tail crest depth). All measurements were in feet to the nearest tenth.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out reaches is measured by the percent of the cobble that is surrounded or buried by fine sediment. In the Mark West Creek tributaries, embeddedness was visually estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3), 76 - 100% (value 4). Additionally, a rating of "not suitable" (NS)was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate particle size, having a bedrock tail-out, or other considerations.

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All shelter is then classified according to a list of nine shelter types. In the Mark West Creek tributaries, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the shelter. The shelter rating is calculated for each habitat unit by multiplying shelter value and percent covered. Thus, shelter ratings can range from 0-300, and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully measured habitat units, dominant and sub-dominant substrate elements were visually estimated using a list of seven size classes.

8. Canopy:

Stream canopy density was estimated using modified handheld spherical densiometers as described in the California Salmonid Stream Habitat Restoration Manual, 1994. Canopy density relates to the amount of stream shaded from the sun. In the Mark West Creek tributaries, an estimate of the percentage of the habitat unit covered by canopy was made from the center of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated visually into percentages of evergreen or deciduous trees.

9. Bank Composition:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In the Mark West Creek tributaries, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully measured unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation was estimated and recorded.

BIOLOGICAL INVENTORY

Biological sampling during stream inventory is used to determine fish species and their distribution in the stream. Biological inventory is conducted using one or more of three basic methods: 1) stream bank observation, 2) underwater observation, 3) electrofishing. These sampling techniques are discussed in the California Salmonid Stream Habitat Restoration Manual.

DATA ANALYSIS

Data from the habitat inventory form are entered into Habitat, a dBASE IV data entry program developed CDFG. This program processes and summarizes the data, and produces the following tables and appendices:

- Riffle, flatwater, and pool habitat types
- Habitat types and measured parameters
- Pool types
- Maximum pool depths by habitat types
- Shelter by habitat types
- Dominant substrates by habitat types
- Vegetative cover and dominant bank composition
- Fish habitat elements by stream reach

Graphics are produced from the tables using Lotus 1,2,3. Graphics developed for the Mark West Creek tributaries include:

- Level II Habitat Types by % Occurrence and % Total Length
- Level IV Habitat Types by % Occurrence
- Pool Habitat Types by % Occurrence
- Maximum Depth in Pools
- Pool Shelter Types by % Area
- Substrate Composition in Low Gradient Riffles
- Percent Cobble Embeddedness by Reach
- Mean Percent Canopy
- Mean Percent Canopy by Reach

- Percent Bank Composition and Bank Vegetation

HISTORICAL STREAM SURVEYS:

No historical stream surveys exist for any of these Mark West Creek tributaries.

HABITAT INVENTORY RESULTS FOR HORSE HILL CREEK

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of July 24, 1997 was conducted by Joyce Ambrosius and Leigh Miles (Sonoma County Water Agency) with supervision and analysis by CDFG. The survey began at the confluence with Mark West Creek and extended up Horse Hill Creek to the end of the wetted channel. The total length of the stream surveyed was 2871 feet, with no additional feet of side channel.

Flows were not measured on Horse Hill Creek.

This section of Horse Hill Creek has one channel type, from the mouth to 2871 feet a B4.

B4 channel types are moderately entrenched, moderate gradient (2-4%), riffle dominated channels, with infrequently spaced pools, a very stable plan and profile, stable banks and have a predominantly gravel substrate.

Water temperature was not taken. Air temperature was 89°F.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of **occurrence** there were 80% dry streambed units and 20% pool units. Based on total **length** there were 99% dry streambed units and 1% pool units (Graph 1).

Five habitat units were measured and 20% were completely sampled. Two Level IV habitat types were identified. The data is summarized in Table 2. The most frequent habitat types by percent **occurrence** were dry streambed at 80% and root wad scour pools 20% (Graph 2). By percent total **length**, dry streambed made up 99% and root wad scour pools 1%.

One pool was identified, which was a scour pool (Table 3) (Graph 3).

Table 4 is a summary of maximum pool depths by pool habitat types. Pool quality for salmonids increases with depth. The one pool identified had a depth less than two feet (Graph 4).

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Pools were the only habitat type with shelter, and had a mean shelter rating of 10 (Table 1). Of the pool types, the scour pool had the highest mean shelter rating at 10 (Table 3).

Table 5 summarizes fish shelter by habitat type. By percent area, the dominant pool shelter type was root mass at 100%; no undercut banks, small woody debris, or large woody debris were observed to provide shelter.

Table 6 summarizes the dominant substrate by habitat type.

No mechanical gravel sampling was conducted in 1998 surveys.

The depth of cobble embeddedness was estimated at pool tail-outs. The one pool tail-out measured had a value of 3. On this scale, a value of one is best for fisheries.

The mean percent canopy density for the stream reach surveyed was 58%. The mean percentages of deciduous and evergreen trees were 45% and 55%, respectively. Graph 8 describes the canopy for the entire survey.

For the entire stream reach surveyed, the mean percent right bank vegetated was 95% and the mean percent left bank vegetated was 80%. For the habitat units measured, the dominant vegetation types for the stream banks were: 50% brush and 50% deciduous trees. The dominant substrate for the stream banks were: 100% silt/clay/sand (Graph 10).

HABITAT INVENTORY RESULTS FOR MILL CREEK

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of July 29 - 30, 1997 was conducted by Joyce Ambrosius and Miles (Sonoma County Water Agency) with supervision and analysis by CDFG. The survey began at the confluence with Mark West Creek and extended up Mill Creek to a dam which marked the end of the wetted channel. The total length of the stream surveyed was 7157 feet, with no additional feet of side channel.

Flows were not measured on Mill Creek.

This section of Mill Creek has four channel types: from the mouth to 4019 feet an F2; next 1524 feet an A4; next 105 feet a B1 and the upper 1509 feet an A4.

F2 channel types are entrenched meandering riffle/pool channels on low gradients (<2%) with a high width/depth ratio and a predominantly boulder substrate.

A4 channel types are steep (4-10%), narrow, cascading, step-pool streams with a high energy/debris transport associated with depositional soils and a predominantly gravel substrate.

B1 channel types are moderately entrenched, moderate gradient (2-4%), riffle dominated channels, with infrequently spaced pools, a very stable plan and profile, stable banks and have a predominantly bedrock substrate.

Water temperatures ranged from 60°F to 64°F. Air temperatures ranged from 66°F to 75°F.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of **occurrence** there were 32% flatwater units, 29% dry streambed units, 28% pool units, and 10% riffle units. Based on total **length** there were 65% dry streambed units, 22% flatwater units, 10% pool units, and 3% riffle units (Graph 1).

Seventy-eight habitat units were measured and 26% were completely sampled. Ten Level IV habitat types were identified. The data is summarized in Table 2. The most frequent habitat types by percent **occurrence** were dry streambed at 29%, runs 26%, root wad scour pools 18% and low gradient riffles 8% (Graph 2). By percent total **length**, dry streambed made up 65%, runs 20%, root wad scour pools 6%, and low gradient riffles 3%.

Twenty-two pools were identified (Table 3). Scour pools were most often encountered at 91%, and comprised 84% of the total length of pools (Graph 3).

Table 4 is a summary of maximum pool depths by pool habitat types. Pool quality for salmonids increases with depth. Six of the 22 pools (27%) had a depth of two feet or greater (Graph 4). These deeper pools comprised 3% of the total length of stream habitat.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Pool types had the highest shelter rating at 24. Flatwater had the lowest rating with 2 and riffle rated 10 (Table 1). Of the pool types, the scour pools had the highest mean shelter rating at 26 (Table 3).

Table 5 summarizes fish shelter by habitat type. By percent area, the dominant pool shelter types were root masses at 38%, boulders 34%, undercut banks 12%, and small woody debris 7%. Graph 5 describes the pool shelter in Mill Creek.

Table 6 summarizes the dominant substrate by habitat type.

No mechanical gravel sampling was conducted in 1998 surveys.

The depth of cobble embeddedness was estimated at pool tail-outs. Of the nineteen pool tail-outs measured, seven had a value of 2 (37%); eight had a value of 3 (42%); and four had a value of 4 (21%). On this scale, a value of one is best for fisheries.

The mean percent canopy density for the stream reach surveyed was 82%. The mean percentages of deciduous and evergreen trees were 26% and 74%, respectively. Graph 8 describes the canopy for the entire survey.

For the entire stream reach surveyed, the mean percent right bank vegetated was 91% and the mean percent left bank vegetated was 91%. For the habitat units measured, the dominant vegetation types for the stream banks were: 88% evergreen trees, 4% brush, 4% deciduous trees, and 4% bare soil. The dominant substrate for the stream banks were: 44% cobble/gravel, 28% boulder, 20% bedrock and 8% silt/clay/sand (Graph 10).

HABITAT INVENTORY RESULTS FOR WEEKS CREEK

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of July 31, 1997 was conducted by Joyce Ambrosius and Miles (Sonoma County Water Agency) with supervision and analysis by CDFG. The survey began at the confluence with Mark West Creek and extended up Weeks Creek to the end of the wetted channel. The total length of the stream surveyed was 6263 feet, with no additional feet of side channel.

Flows were not measured on Weeks Creek.

This section of Weeks Creek has one channel type, from the mouth to 6263 feet an F4. F4 channel types are entrenched meandering riffle/pool channels on low gradients (<2%) with a high width/depth ratio and a predominantly gravel substrate.

Water temperature was 60°F. Air temperatures ranged from 75°F to 82°F.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of **occurrence** there were 40% dry streambed units, 33% pool units, 13% flatwater units, and 7% riffle units. Based on total **length** there were 54% dry streambed units, 3% pool units, 2% flatwater units, and 1% riffle units (Graph 1).

Fifteen habitat units were measured and 40% were completely sampled. Seven Level IV habitat types were identified. The data is summarized in Table 2. The most frequent habitat types by percent **occurrence** were dry streambed at 40%, root wad scour pools 20%, low gradient riffles 7% and glides 7% (Graph 2). By percent total **length**, dry streambed made up 54%, root wad scour pools 2%, glides 1%, and runs 1%.

Five pools were identified (Table 3). Scour pools were most often encountered at 100%, and comprised 100% of the total length of pools (Graph 3).

Table 4 is a summary of maximum pool depths by pool habitat types. Pool quality for salmonids increases with depth. One of the 5 pools (20%) had a depth of two feet or greater (Graph 4). These deeper pools comprised 1% of the total length of stream habitat.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Pool types had the highest shelter rating at 52. Flatwater and riffle had the lowest rating with 0 (Table 1). Of the pool types, the scour pools had the highest mean shelter rating at 52 (Table 3).

Table 5 summarizes fish shelter by habitat type. By percent area, the dominant pool shelter types were boulders at 43%, root masses 28%, undercut banks 9%, and large woody debris 9%. Graph 5 describes the pool shelter in Weeks Creek.

Table 6 summarizes the dominant substrate by habitat type.

No mechanical gravel sampling was conducted in 1997 surveys.

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 5 pool tail-outs measured, 3 had a value of 3 (60%), and 2 had a value of 4 (40%). On this scale, a value of one is best for fisheries.

The mean percent canopy density for the stream reach surveyed was 73%. The mean percentages of deciduous and evergreen trees were 58% and 43%, respectively. Graph 8 describes the canopy for the entire survey.

For the entire stream reach surveyed, the mean percent right bank vegetated was 88% and the mean percent left bank vegetated was 79%. For the habitat units measured, the dominant vegetation types for the stream banks were: 57% brush, 21% deciduous trees, 14% evergreen trees, and 7% grass. The dominant substrate for the stream banks were: 57% cobble/gravel, 36% silt/clay/sand, and 7% bedrock (Graph 10).

<u>HABITAT INVENTORY RESULTS FOR VAN BUREN CREEK</u>

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of August 5 - 7, 1997 was conducted by Joyce Ambrosius, Parsens and Miles (Sonoma County Water Agency) with supervision and analysis by CDFG. The survey began at the confluence with Mark West Creek and extended up Van Buren Creek to the end of landowner access permission. The total length of the stream surveyed was 13852 feet, with an additional 198 feet of side channel.

Flows were not measured on Van Buren Creek.

This section of Van Buren Creek has three channel types: from the mouth to 2284 feet a B2; next 10433 feet an F2 and the upper 1135 feet an F4.

B2 channel types are moderately entrenched, moderate gradient (2-4%), riffle dominated channels, with infrequently spaced pools, a very stable plan and profile, stable banks and have a predominantly boulder substrate.

F2 channel types are entrenched meandering riffle/pool channels on low gradients (<2%) with a high width/depth ratio and a predominantly boulder substrate. F4 channel types are similar but have a predominately gravel substrate.

Water temperatures ranged from 62°F to 70°F. Air temperatures ranged from 76°F to 88°F.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of **occurrence** there were 35% flatwater units, 34% pool units, 18% dry streambed units, and 12% riffle units. Based on total **length** there were 22% flatwater units, 20% dry streambed units, 8% pool units, and 3% riffle units (Graph 1).

One hundred-thirty one habitat units were measured and 18% were completely sampled. Thirteen Level IV habitat types were identified. The data is summarized in Table 2. The most frequent habitat types by percent **occurrence** were runs at 26%, dry streambed 18%, boulder scour pools 14% and low gradient riffles 11% (Graph 2). By percent total **length**, dry streambed made up 20%, runs 17%, step runs 4%, and low gradient riffles 3%.

Forty-five pools were identified (Table 3). Scour pools were most often encountered at 87%, and comprised 74% of the total length of pools (Graph 3).

Table 4 is a summary of maximum pool depths by pool habitat types. Pool quality for salmonids increases with depth. Five of the 45 pools (11%) had a depth of two feet or greater (Graph 4). These deeper pools comprised 2% of the total length of stream habitat.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Pool types had the highest shelter rating at 27. Riffle had the lowest rating with 0 and flatwater rated 3 (Table 1). Of the pool types, the backwater pools had the highest mean shelter rating at 90, scour pools rated 27, and main channel pools rated 18 (Table 3).

Table 5 summarizes fish shelter by habitat type. By percent area, the dominant pool shelter types were boulders at 60%, bedrock ledges 21%, root masses 14%, and undercut banks 2%. Graph 5 describes the pool shelter in Van Buren Creek.

Table 6 summarizes the dominant substrate by habitat type.

No mechanical gravel sampling was conducted in 1998 surveys.

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 44 pool tail-outs measured, 14 had a value of 3 (32%), and 30 had a value of 4 (68%). On this scale, a value of one is best for fisheries.

The mean percent canopy density for the stream reach surveyed was 90%. The mean percentages of deciduous and evergreen trees were 23% and 77%, respectively. Graph 8 describes the canopy for the entire survey.

For the entire stream reach surveyed, the mean percent right bank vegetated was 92% and the mean percent left bank vegetated was 92%. For the habitat units measured, the dominant vegetation types for the stream banks were: 85% evergreen trees, 8% deciduous trees, and 7% brush. The dominant substrate for the stream banks were: 37% cobble/gravel, 31% bedrock, 24% boulder and 8% silt/clay/sand (Graph 10).

BIOLOGICAL INVENTORY

JUVENILE SURVEYS:

Biological surveys were not conducted in any of these tributaries in 1997 or 1998 due to inadequate staffing levels. However, during the habitat inventory, the crews observed steelhead, sculpin, and California newts in Mill Creek and steelhead and roach in Van Buren Creek. No fish were observed in Weeks Creek or Horse Hill Creek.

A summary of recent data collected appears in the table below.

Table 1. Species Observed in Recent Surveys on Mark West Tributaries

YEARS	SPECIES	SOURCE	Native/Introduced
1997	Steelhead*	SCWA	N
1997	Sculpin*	SCWA	N
1997	Roach*	SCWA	N
1997	California Newt*	SCWA	N

* = Van Buren Creek, Mill Creek

Historical records reflect that no hatchery plants, transfers, or known fish rescue operations have occurred in any of these Mark West Creek tributaries, however planting has occurred in Mark West Creek (see Mark West Creek Report for data).

ADULT SURVEYS:

Spawning/carcass surveys were not conducted in any of these tributaries in 1997 or 1998 due to inadequate staffing levels.

DISCUSSION FOR HORSE HILL CREEK

Horse Hill Creek has one channel type, a B4 (2871 ft.).

There are 2871 feet of B4 channel type in Reach 1. According to the DFG Salmonid Stream Habitat Restoration Manual, B4 channel types are excellent for low-stage plunge weirs, boulder clusters, bank placed boulders, single and opposing wing-deflectors and log cover. They are also good for medium-stage plunge weirs.

These channel types have suitable gradients and the stable stream banks that are necessary for the installation of instream structures designed to increase pool habitat, trap spawning gravels, and provide protective shelter for fish.

No water temperature was taken. Air temperature was 89°F. To make conclusions about temperature conditions on Horse Hill Creek for salmonid survival, temperatures need to be taken and monitored in pools through the critical summer months, and\or biological sampling conducted.

Pools comprised 1% of the total **length** of this survey. In first and second order streams a primary pool is defined to have a maximum depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. In Horse Hill Creek, the pools are relatively shallow, and none have a maximum depth of at least 2 feet. However, in coastal coho and steelhead streams, it is generally desirable to have primary pools comprise approximately 50% of total habitat length.

The mean shelter rating for pools was 10. However, a pool shelter rating of approximately 80 is desirable. The relatively small amount of pool shelter that now exists is being provided primarily by root masses. Additional log and root wad cover in the pool and flatwater habitats would improve both summer and winter salmonid habitat. Log cover provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

No low gradient riffles were observed, which typically provide the gravel and/or small cobble dominant substrates which are ideal for salmonid spawning habitat (Graph 6).

One-hundred percent of the pool tail-outs measured had embeddedness ratings of 3. None had a rating of 1. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered best for the needs of salmon and steelhead.

The higher the percent of fine sediment, the lower the probability that eggs will survive to hatch. This is due to the reduced quantity of oxygenated water able to percolate through the gravel, or because of fine sediment capping the redd and preventing fry emergence. In Horse Hill Creek Reach 1, sediment sources should be mapped and rated according to their potential sediment yields, and control measures taken.

The mean percent canopy for the survey was 58%. This is a low percentage of canopy, since 80 percent is generally considered desirable. Cooler water temperatures are desirable in Horse Hill Creek. Elevated water temperatures could be reduced by increasing stream canopy. The large trees required for adequate stream canopy would also eventually provide a long term source of large woody debris needed for instream shelter and bank stability.

However, the riparian buffer is thin or nearly absent in areas with livestock, agriculture, and urban development. Riparian removal, intensive grazing, and vineyard development within the riparian corridor could all lead to less stream canopy and channel incision causing bank erosion and higher water temperatures.

DISCUSSION FOR MILL CREEK

Mill Creek has four channel types: F2, A4 , B1 and A4.

There are 4019 feet of F2 channel type in Reach 1. According to the DFG Salmonid Stream Habitat Restoration Manual, F2 channel types are fair for low-stage weirs, single and opposing wing-deflectors and log cover.

There are 1524 feet of A4 channel type in Reach 2, and 1509 feet of A4 channel type in Reach 4. A4 channel types are good for bank-placed boulders and fair for low-stage weirs, opposing wing-deflectors and log cover.

There are 105 feet of B1 channel type in Reach 3. B1 channel types are excellent for bank-placed boulders and bank cover and good for log cover.

Many site specific projects can be designed within B and F channel types, especially to increase pool frequency, volume and shelter.

The water temperatures recorded on the survey days July 29 - 30, 1997 ranged from 60°F to 64°F. Air temperatures ranged from 66°F to 75°F. The warmer water temperatures were recorded in Reach 1. This temperature regime is adequate for salmonids.

It is unknown if this thermal regime is typical. To make any further conclusions, temperatures need to be monitored for a longer period of time through the critical summer months, and\or more extensive biological sampling conducted.

Pools comprised 10% of the total **length** of this survey. In first and second order streams a primary pool is defined to have a maximum depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. In Mill Creek, the pools are relatively shallow with 27% having a maximum depth of at least 2 feet. These pools comprised 3% of the total length of stream habitat.

The mean shelter rating for pools was 24. However, a pool shelter rating of approximately 80 is

desirable. The relatively small amount of pool shelter that now exists is being provided primarily by root masses (38%), boulders (34%), undercut banks (12%), and small woody debris (7%).
None of the 2 low gradient riffles measured had either gravel or small cobble as the dominant substrate. This is generally considered poor for spawning salmonids.

Sixty-three percent of the pool tail-outs measured had embeddedness ratings of either 3 or 4. Only Cobble embeddedness measured to be 25% or less, a rating of 1, is considered best for the needs of salmon and steelhead. In a reach comparison, Reach 1 had better embeddedness ratings than Reach 2, which had ratings of 4 for all of the pool tail-outs measured. Reaches 3 and 4 had no cobble embeddedness ratings, since there were no pool habitat types in these reaches.

The mean percent canopy for the survey was 82%. This is good, since 80 percent is generally considered desirable.

DISCUSSION FOR WEEKS CREEK

Weeks Creek has one channel type, a F4 (6263 ft.).

There are 6263 feet of F4 channel type in Reach 1. According to the DFG Habitat Restoration Manual, F4 channel types are good for bank-placed boulders and fair for low-stage weirs, single and opposing wing-deflectors, channel constrictors and log cover.

Any work considered will require careful design, placement, and construction that must include protection for any unstable banks.

The water temperature recorded on the survey day July 31, 1997 was 60°F. Air temperatures ranged from 75°F to 82°F. This temperature regime is favorable to salmonids.

It is unknown if this thermal regime is typical. To make any further conclusions, temperatures need to be monitored for a longer period of time through the critical summer months, and\or more extensive biological sampling conducted.

Pools comprised 3% of the total **length** of this survey. In first and second order streams a primary pool is defined to have a maximum depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. In Weeks Creek, the pools are relatively shallow with 20% having a maximum depth of at least 2 feet. These pools comprised 1% of the total length of stream habitat.

The only low gradient riffle measured had small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

One-hundred percent of the pool tail-outs measured had embeddedness ratings of either 3 or 4. Only Cobble embeddedness measured to be 25% or less, a rating of 1, is considered best for the needs of salmon and steelhead.

The mean percent canopy for the survey was 73%.

DISCUSSION FOR VAN BUREN CREEK

Van Buren Creek has three channel types: B2 , F2 and F4.

There are 2284 feet of B2 channel type in Reach 1. According to the DFG Salmonid Stream Habitat Restoration Manual, B2 channel types are excellent for low and medium-stage plunge weirs, single and opposing wing deflectors and bank cover.

There are 10433 feet of F2 channel type in Reach 2. F2 channel types are fair for low-stage weirs, single and opposing wing-deflectors and log cover.

There are 1135 feet of F4 channel type in Reach 3. F4 channel types are good for bank-placed boulders and fair for low-stage weirs, single and opposing wing-deflectors, channel constrictors and log cover.

Many site specific projects can be designed within B and F channel types, especially to increase pool frequency, volume and shelter.

The water temperatures recorded on the survey days August 5 - 7, 1997 ranged from 62°F to 70°F. Air temperatures ranged from 76°F to 88°F. The warmer water temperatures were recorded in Reach 2. These temperatures, if sustained, are above the threshold stress level (65°F) for salmonids.

It is unknown if this thermal regime is typical. To make any further conclusions, temperatures need to be monitored for a longer period of time through the critical summer months, and\or more extensive biological sampling conducted.

Pools comprised 8% of the total **length** of this survey. In first and second order streams a primary pool is defined to have a maximum depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. In Van Buren Creek, the pools are relatively shallow with 11% having a maximum depth of at least 2 feet.

The mean shelter rating for pools was 27. However, a pool shelter rating of approximately 80 is desirable. The relatively small amount of pool shelter that now exists is being provided primarily by boulders (60%), bedrock ledges (21%), root masses (14%), and undercut banks (2%).

One of the 3 low gradient riffles measured (33%) had either gravel or small cobble as the dominant substrate. This is generally considered poor for spawning salmonids.

One-hundred percent of the pool tail-outs measured had embeddedness ratings of either 3 or 4. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered best for the needs of salmon and steelhead. In a reach comparison, Reach 3 had the poorest ratings, however, all reaches had poor embeddedness values.

The mean percent canopy for the survey was 90%. This is very good, since 80 percent is generally considered desirable.

SUMMARY

The surveys of 1997 documented the presence of salmonids in Mill and Van Buren Creeks, however none were observed in Horse Hill and Weeks Creeks. It is likely that low stream flow dictates the distribution of salmonids in the Mark West Tributaries, and thus biological sampling is necessary to verify the absence of salmonids in Horse Hill and Weeks Creeks.

Both Horse Hill and Weeks Creeks suffer from low flow, lack of deep pools, low canopy, and an elevated degree of embeddedness. Mill and Van Buren Creeks have higher shading due to higher canopy, however temperatures are nonetheless elevated. All four creeks have the following similar ailments, namely: flow is limited, rearing habitat (i.e. number of pools) is limited, spawning gravels are in short supply, and substrates are embedded.

Sediment transported downstream in the winter also impacts fair quality spawning gravel downstream. However, many opportunities and alternatives exist for habitat improvement due to the more stable channel types (i.e. gravel retention structures). Many site specific projects can be designed within Mill and Van Buren Creeks, especially to increase pool frequency, volume and shelter. Any work considered will require careful design, placement, and construction that must include protection for unstable banks and high stream velocities.

GENERAL MANAGEMENT RECOMMENDATIONS

Mill, Horse Hill, Weeks and Van Buren Creeks should be managed as an anadromous, natural production streams.

Landowners should be sensitive about the natural and positive role woody debris plays in the system, and encouraged <u>not to remove woody debris</u> from the stream, except under extreme buildup and only under guidance by a fishery professional.

PRIORITY FISHERY ENHANCEMENT OPPORTUNITIES

1) Access for migrating salmonids is a potential problem in Van Buren Creek, therefore fish passage should be monitored, and improved where possible. Baffles should be installed in culverts to facilitate easier fish access. The road culvert on St. Helena Road is undermining and is a fish barrier. Eventually this culvert will have to be replaced. Future design should include improved passage of gravel as a second priority and fish passage first.

2) Increase the canopy on Horse Hill and Weeks Creeks by planting willow, alder, redwood, and Douglas fir along the stream where shade canopy is not at acceptable levels. The reaches above the survey sections should be assessed for planting and treated as well, since water temperatures throughout are effected from upstream. In many cases, planting will need to be coordinated to follow bank stabilization or upslope erosion control projects.

3) Map sources of upslope and in-channel erosion, and prioritize them according to present and potential sediment yield. Identified sites should then be treated to reduce the amount of fine sediments entering the stream. Near-stream riparian planting along any portion of the stream should be encouraged to provide bank stability and a buffering against agricultural, grazing and urban runoff. In the Mark West Tributaries, active and potential sediment sources related to the road system need to be mapped and treated according to their potential for sediment yield to the streams.

4) Where feasible, increase woody cover in the pool and flatwater habitat units along the entire stream. Most of the existing shelter is from root masses and boulders. Adding high quality complexity with larger woody cover is desirable. Combination cover/scour structures constructed with boulders and additional woody debris would be effective in many flatwater and pool locations in the upper reaches. This must be done where the banks are stable or in conjunction with stream bank armor to prevent erosion. In some areas the material is at hand.

5) Where feasible, design and engineer pool enhancement structures to increase the number of pools in the upper reaches. This must be done where the banks are stable or in conjunction with stream bank armor to prevent erosion.

6) Spawning gravels in these tributaries are limited to relatively few reaches. Structures to decrease channel incision and recruit spawning gravel (using gravel retention structures), should be installed to trap, sort and expand redd distribution in the stream.

PROBLEM SITES AND LANDMARKS - HORSE HILL CREEK SURVEY COMMENTS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach.

Habitat Unit #	Stream Length(ft)	Comments
1.00	416	Dry at mouth.
2.00	450	Isolated pool in dry creek bed.
3.00	2206	800' in-trib on left. 1000'-rd. Culvert on rt.. 1675' conf on rt. (trib)
5.00	2871	Stop at 1st. bridge crossing.

PROBLEM SITES AND LANDMARKS - MILL CREEK SURVEY COMMENTS

Habitat Unit #	Stream Length(ft)	Comments
Reach 1		
1.00	1445	Dry- Confluence with Mark West-start
2.00	1482	Isolated pocket of water.
4.00	1619	Water temp taken at 004@ 11:00, 1st water.
7.00	1820	SHD present
9.00	1917	SHD present.
13.00	2219	4" SHD
17.00	2398	4" SHD
28.00	2852	Trib on right bank.
31.00	3010	Intermittent dry.
32.00	3036	Sculpin, no SHD
38.00	3267	Oily layer on top of pool
42.00	3421	Road crossing
43.00	3468	No SHD
45.00	3576	Sculpin, newt.
48.00	3857	CA newt
Reach 2		
53.00	4602	317'- trib on left. Dry road crossing
54.00	4813	Trib on lf bank.
55.00	4829	SHD present
56.00	4883	Dry rd crossing
63.00	5101	5" SHD.
70.00	5544	End at Poulsen's, no access.
Reach 3		
71.00	5554	Channel change, Start above Poulsen's
75.00	5649	Bedrock chute, channel change
Reach 4		
76.00	5653	Cement dam with water pipe.
77.00	6890	Channel change, dry above dam.
78.00	7157	End of survey-dry above dam to rd. Culvert, Foothill Rd. 1237' to confluence at Foothill Ranch Rd.

PROBLEM SITES AND LANDMARKS - WEEKS CREEK SURVEY COMMENTS

Habitat Unit #	Stream Length(ft)	Comments
1.00	1412	End of Calistoga Rd. bldg. Dry creek bed. Started at confluence of Mark West.
2.00	3904	NO ACCESS
3.00	3952	Start at bridge Calistoga RD u/s Millberg's. Large root wad.

7.00	4165	Trib on LB
13.00	4936	230' trib comin' on left
15.00	6265	400' Dry RD crossing, bulldozed creek bed. 1000' trib.End of survey: Dry creek bed.

PROBLEM SITES AND LANDMARKS - VAN BUREN CREEK SURVEY COMMENTS

Habitat Unit #	Stream Length(ft)	Comments
Reach 1		
1.00	362	Start at confluence of Mark West-dry
2.00	651	4' drop from culvert bridge culvert St. Helena Rd.
6.00	1071	1st water, no fish
12.00	1381	1 roach
14.00	1464	SHD
16.00	1588	SHD and roach 4" SHD
29.00	1986	Flies, caddis larvae
30.00	2005	SHD, hundreds
35.00	2124	SHD-lots
36.00	2285	Huge boulders extended
Reach 2		
39.00	2986	Rd crossing
43.00	3458	no fish
45.00	3658	Roach
51.00	4005	2-3"roach
54.00	4086	4" roach
57.00	4257	frog, roach
58.00	4299	End of survey, no access
58.00	10899	No Access
59.00	10939	Start at 3rd bridge, Becker Property.
69.00	11210	SHD
71.00	11281	SHD
72.00	11465	Springs, at edge of creek.
78.00	11789	SHD 1.5 to 2"
85.00	12097	Log jam with large boulders
94.00	12341	Trib on right bank
104.00	12682	Trib on LB (large)
105.00	12717	Channel change
Reach 3		
107.00	12861	Trib on RB (small)
122.00	13298	Trib on RB
123.00	13543	Sinuous, narrow channel, level gradient.
128.00	13855	***End of survey, no access***

California Department of Fish and Wildlife
Sonoma County
Russian River Watershed
Stream Habitat Assessment Reports

Mill Creek

Surveyed 2012

Report Completed in 2013

STREAM INVENTORY REPORT

Mill Creek

INTRODUCTION

A stream inventory was conducted 9/10/2012 to 9/14/2012 on Mill Creek. The survey began at the confluence with Mark West Creek and extended upstream 2 miles.

The objective of the habitat inventory was to document the habitat available to anadromous salmonids in Mill Creek.

The objective of this report is to document the current habitat conditions and recommend options for the potential enhancement of habitat for Chinook salmon, Coho salmon, and steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Mill Creek is located in Sonoma County, California (Map 1). It is a tributary to Mark West Creek, which flows into Russian River, which flows into Pacific Ocean. Mill Creek's legal description at the confluence with Mark West Creek is T08N R08W Sec.13. Its location is (38:32:49.0N) 38.547 north latitude and (122:41:50.0W) 122.6973 west longitude, LLID number 1226973385470. Mill Creek is a second order stream and has approximately 2.2 miles of blue line stream according to the USGS National Hydrology Dataset (NHD). Mill Creek drains a watershed of approximately 1.9 square miles. Elevations range from about 472 feet at the mouth of the creek to 1,549 feet in the headwater areas (average elevation of headwaters, not highest point). Evergreen forest dominates the watershed. The watershed is entirely privately owned, which accounts for 100% of the land area. One hundred percent of the land is considered natural. Vehicle access exists via Cresta Rd. and further access exists off of Foot Hill Ranch Road in Santa Rosa, CA.

METHODS

The habitat inventory conducted in Mill Creek follows the methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998). The Watershed Stewards Project/AmeriCorps (WSP) Members that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Wildlife (CDFW). This inventory was conducted by a two-person team.

SAMPLING STRATEGY

The inventory uses a method that samples approximately 10% of the habitat units within the survey reach. All habitat units included in the survey are classified according to habitat type and their lengths are measured. All pool units are fully measured. All other habitat unit types encountered for the first time in each reach are measured for all the parameters and characteristics on the field form. Additionally, from the ten habitat units on each field form page, one is randomly selected for complete measurement.

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the *California Salmonid Stream Habitat Restoration Manual*. This form was used in Mill Creek to record measurements and observations. There are eleven components to the inventory form.

1. Flow:

Flow is measured in cubic feet per second (cfs) near the bottom of the stream survey reach using a Marsh-McBirney Model 2000 flow meter.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1994). This methodology is described in the *California Salmonid Stream Habitat Restoration Manual*. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are five measured parameters used to determine channel type: 1) water slope gradient, 2) entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity. Channel characteristics are measured using a clinometer, hand level, hip chain, tape measure, and a stadia rod.

3. Temperatures:

Both water and air temperatures are measured and recorded at every tenth habitat unit. The time of the measurement is also recorded. Both temperatures are taken in degrees Fahrenheit at the middle of the habitat unit and within one foot of the water surface.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1990). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "dry". Mill Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All measurements are in feet to the nearest tenth. Habitat characteristics are measured using a clinometer, hip chain, and stadia rod.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out areas is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Mill Creek, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3) and 76 - 100% (value 4). Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate such as bedrock, log sills, boulders or other considerations.

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide juvenile salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition for prey. The shelter rating is calculated for each fully-described habitat unit by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All cover is then classified according to a list of nine cover types. In Mill Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully-described habitat units, dominant and sub-dominant substrate elements were ocularly estimated using a list of seven size classes and recorded as a one and two, respectively. In addition, the dominant substrate composing the pool tail-outs is recorded for each pool.

8. Canopy:

Stream canopy density was estimated using modified handheld spherical densiometers as described in the *California Salmonid Stream Habitat Restoration Manual*. Canopy density relates to the amount of stream shaded from the sun. In Mill Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the center of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated ocularly into percentages of coniferous or hardwood trees.

9. Bank Composition and Vegetation:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Mill Creek, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully-described unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation (including downed trees, logs, and rootwads) was estimated and recorded.

10. Large Woody Debris Count:

Large woody debris (LWD) is an important component of fish habitat and an element in channel forming processes. In each habitat unit all pieces of LWD partially or entirely below the elevation of bankfull discharge are counted and recorded. The minimum size to be considered is twelve inches in diameter and six feet in length. The LWD count is presented by reach and is expressed as an average per 100 feet.

11. Average Bankfull Width:

Bankfull width can vary greatly in the course of a channel type stream reach. This is especially true in very long reaches. Bankfull width can be a factor in habitat components like canopy density, water temperature, and pool depths. Frequent measurements taken at riffle crests (velocity crossovers) are needed to accurately describe reach widths. At the first appropriate velocity crossover that occurs after the beginning of a new stream survey page (ten habitat units), bankfull width is measured and recorded in the appropriate header block of the page. These widths are presented as an average for the channel type reach.

BIOLOGICAL INVENTORY

Biological sampling during the stream inventory is used to determine fish species and their distribution in the stream. Fish presence was observed from the stream banks in Mill Creek.

DATA ANALYSIS

Data from the habitat inventory form are entered into Stream Habitat 2.0.18, a Visual Basic data entry program developed by Karen Wilson, Pacific States Marine Fisheries Commission in conjunction with the California Department of Fish and Wildlife. This program processes and summarizes the data, and produces the following ten tables:

- Riffle, Flatwater, and Pool Habitat Types
- Habitat Types and Measured Parameters
- Pool Types
- Maximum Residual Pool Depths by Habitat Types
- Mean Percent Cover by Habitat Type
- Dominant Substrates by Habitat Type
- Mean Percent Vegetative Cover for Entire Stream
- Fish Habitat Inventory Data Summary by Stream Reach (Table 8)
- Mean Percent Dominant Substrate / Dominant Vegetation Type for Entire Stream
- Mean Percent Shelter Cover Types for Entire Stream

Graphics are produced from the tables using Microsoft Excel. Graphics developed for Mill Creek include:

- Riffle, Flatwater, Pool Habitat Types by Percent Occurrence

- Riffle, Flatwater, Pool Habitat Types by Total Length
- Total Habitat Types by Percent Occurrence
- Pool Types by Percent Occurrence
- Maximum Residual Depth in Pools
- Percent Embeddedness
- Mean Percent Cover Types in Pools
- Substrate Composition in Pool Tail-outs
- Mean Percent Canopy
- Dominant Bank Composition by Composition Type
- Dominant Bank Vegetation by Vegetation Type

HABITAT INVENTORY RESULTS

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of 9/10/2012 to 9/14/2012, was conducted by D. Dela Vega, C. Neill (WSP). The total length of the stream surveyed was 10,436 feet with an additional 0 feet of side channel.

Stream flow was not measured on Mill Creek.

Mill Creek is a B4 channel type for 4,508 feet of the stream surveyed (Reach 1), a A2 channel type for 1,228 feet of the stream surveyed (Reach 2), a B4 channel type for 813 feet of the stream surveyed (Reach 3), a NA channel type for 1,640 feet of the stream surveyed (Reach 4), a B3 channel type for 2,247 feet of the stream surveyed (Reach 5). B4 channels are moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools, very stable plan and profile, stable banks, and gravel-dominant substrates. A2 channels are steep, narrow, cascading, step-pool, high energy debris transporting channels associated with depositional soils, and boulder-dominant substrates. B3 channels are moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools, very stable plan and profile, stable banks, and cobble-dominant substrates. NA channels had no access.

Water temperatures taken during the survey period ranged from 53 to 58 degrees Fahrenheit. Air temperatures ranged from 58 to 74 degrees Fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 30% pool units, 27% flatwater units, 22% riffle units, 17% dry units, 3% culvert units and 1% not surveyed units, (Graph 1). Based on total length of Level II habitat types, there were 42% dry units, 22% flatwater units, 16% not surveyed units, 11% pool units, 9% riffle units and 1% culvert units (Graph 2).

Thirteen Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were 20% mid-channel pool units, 19% step run units and 17% dry units (Graph 3). Based on percent total length, 42% dry units, 20% step run units and 16% not surveyed units.

A total of 28 pools were identified (Table 3). Main channel pools were the most frequently encountered at 89% (Graph 4), and comprised 92% of the total length of all pools (Table 3).

Table 4 is a summary of maximum residual pool depths by pool habitat types. Pool quality for salmonids increases with depth. Four of the 28 pools (14%) had a residual depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 28 pool tail-outs measured, 14 had a value of 1 (50%) and 14 had a value of 2 (50%) (Graph 6). On this scale, a value of 1 indicates the best spawning conditions and a value of 4 the worst. Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate such as bedrock, log sills, boulders, or other considerations.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Riffle habitat types had a mean shelter rating of 4, flatwater habitat types had a mean shelter rating of 8, and pool habitats had a mean shelter rating of 28 (Table 1). Of the pool types, the main channel pools had a mean shelter rating of 24 and scour pools had a mean shelter rating of 62 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Mill Creek. Graph 7 describes the pool cover in Mill Creek. Boulders are the dominant pool cover type, followed by root masses.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel substrate was observed in 46% of pool tail-outs; and small cobble substrate was observed in 39% of pool tail-outs.

The mean percent canopy density for the surveyed length of Mill Creek was 93%. Of the canopy present, the mean percentages of hardwood and coniferous trees were 50% and 50%, respectively. Seven percent of the canopy was open. Graph 9 describes the mean percent canopy in Mill Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 85%. The mean percent left bank vegetated was 82% (Table 7). The dominant elements composing the structure of the stream banks consisted of 45% boulder, 29% cobble/gravel, 16% bedrock and 10% sand/silt/clay (Graph 10). Deciduous trees were the dominant vegetation type observed in 49% of the units surveyed. Additionally, 48% of the units surveyed had coniferous trees as the dominant vegetation type, and 4% had brush as the dominant vegetation type (Graph 11).

<u>DISCUSSION</u>

Mill Creek is a B4 channel type for 4,508 feet of the stream surveyed, an A2 channel type for 1,228 feet of the stream surveyed, a B4 channel type for 813 feet of the stream surveyed, a NA channel type for 1,640 feet of the stream surveyed, and a B3 channel type for 2,247 feet of the stream surveyed. The suitability of B4, A2, NA, and B3 channel types for fish habitat improvement structures is/are as follows: B4 channel types are excellent for low-stage plunge weirs, boulder clusters, bank placed boulders, single and opposing wing-deflectors, and log cover; A2 channels are generally not suitable for fish habitat improvement projects; NA channel types were not surveyed and suitability cannot be assessed; and B3 channel types are excellent for plunge weirs, boulder clusters and bank-placed boulders, single and opposing wing-deflectors, and log cover.

The water temperatures recorded on the survey days 9/10/2012 to 9/14/2012, ranged from 53 to 58 degrees Fahrenheit. Air temperatures ranged from 58 to 74 degrees Fahrenheit. This is a good water temperature range for salmonids. To make any further conclusions, temperatures would need to be monitored throughout the warm summer months, and more extensive biological sampling would need to be conducted.

Flatwater habitat types comprised 22% of the total length of this survey, riffles 9%, and pools 11% (30% pool units, 27% flatwater units, 22% riffle units, 17% dry units, 3% culvert units and 1% not surveyed units). The pools are relatively shallow/deep, with 4 of the 28 (14%) pools having a maximum residual depth greater than two feet. In general, pool enhancement projects are considered when primary pools comprise less than 40% of the length of total stream habitat. In first and second order streams, a primary pool is defined to have a maximum residual depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. Installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not be threatened by high stream energy, or where their installation will not conflict with the modification of the numerous log debris accumulations (LDA's) in the stream.

Twenty-eight of the 28 pool tail-outs measured had embeddedness ratings of 1 or 2. Zero of the pool tail-outs had embeddedness ratings of 3 or 4. Zero of the pool tail-outs had a rating of 5, which is considered unsuitable for spawning. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. Sediment sources in Mill Creek should be mapped and rated according to their potential sediment yields, and control measures should be taken.

Twenty-four of the 28 pool tail-outs measured had gravel and small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

The mean shelter rating for pools is 28. The shelter rating in the flatwater habitats is 8. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by boulders in Mill Creek. Boulders are the dominant cover type in pools, followed by root masses. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

The mean percent canopy density for the stream was 93%. Reach 1 had a canopy density of 94.3%, Reach 2 had a canopy density of 93%, Reach 3 had a canopy density of 83%, Reach 4 had a canopy density of N/A, and Reach 5 had a canopy density of 85%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was 85% and 82%, respectively. In areas of stream bank erosion or where bank vegetation is sparse, planting endemic species of coniferous and hardwood trees, in conjunction with bank stabilization, is recommended.

GENERAL RECOMMENDATIONS

Mill Creek should be managed as an anadromous, natural production stream.

Winter storms often bring down large trees and other woody debris into the stream, which increases the number and quality of pools. This woody debris, if left undisturbed, will provide fish shelter and rearing habitat, and offset channel incision. Landowners should be sensitive about the natural and positive role woody debris plays in the system, and encouraged not to remove woody debris from the stream, except under extreme buildup and only under guidance by a fishery professional.

RECOMMENDATIONS

1) Increase woody cover in the pools and flatwater habitat units. Most of the existing cover in the pools is from boulders. Adding high quality complexity with woody cover in the pools is desirable.

2) Suitable size spawning substrate on Mill Creek is limited to relatively few reaches. Projects should be designed at suitable sites to trap and sort spawning gravel.

3) Access for migrating salmonids should be assessed at all road crossings and dams. Sites of particular concern include the Cresta Road Bridge and the associated upstream trash rack as well as all the identified ford crossings throughout Reaches 1 and 2. A Dam site is located at the end of the private access road which extends farther southeast off Cresta Road, was also identified as a fish barrier. All fish passage assessments should be done according to Part 9 of the California Salmonid Stream Habitat Restoration Manual (Flosi et al, 1998). Where needed, crossings should be replaced or modified to improve fish passage.

4) Reaches 1, 2, and 3 are being impacted from livestock in the riparian zone. Livestock in streams generally inhibit the growth of new trees, exasperate erosion, and reduce summertime survival of juvenile fish by defecating in the water. Alternatives to limit cattle access, control erosion and increase canopy, should be explored with the landowner, and developed if possible.

5) Increase the canopy on Mill Creek particularly throughout Reaches 3, 4, and 5, by planting appropriate native vegetation like willow, alder, redwood, and Douglas fir along the stream where shade canopy is not at acceptable levels. The reaches above this survey section should be inventoried and treated as well, since the water flowing

here is affected from upstream. In many cases, planting will need to be coordinated to follow bank stabilization or upslope erosion control projects.

6) Mill Creek would benefit from utilizing bio-technical vegetative techniques to re-establish floodplain benches and a defined low flow channel. This would discourage lateral migration of the base flow channel and decrease bank erosion.

7) Where feasible, design and engineer pool enhancement structures to increase the number of pools. This must be done where the banks are stable or in conjunction with stream bank armor to prevent erosion.

COMMENTS AND LANDMARKS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach.

Position	Habitat Unit #	Memo
0	0001.00	Start of Survey at the confluence of Mill Creek and Mark West Creek.
0	0001.00	600' into the unit is a parking pull-out on the left bank.
785	0002.00	Bridge # 1 is Cresta Rd. It is made of wood, concrete, and steel with length = 37', height = 7', width = 11', and the height from the water to sill = N/A. The bridge is retaining gravel, it is downcutting, and it is a possible barrier to salmonids. The width of the upstream wing-wall = 14'. The sill is made of concrete fill and is creating a 3' plunge on the downstream end. The sill is not level and is creating downcutting. There is a gate on the bottom of the bridge, which is a debris catch. WP# 2 N38.54575 W122.69449
822	0003.00	85' into the unit is an old ford crossing on the right bank.
1,059	0006.00	Water temperature was taken. There are dry units and there are 2' plunges between each pool.
1,143	0007.00	One young of the year salmonid, two 1+ salmonids, and one bullfrog were observed.
1,440	0012.00	50' into the habitat unit there is a fence that spans the creek channel.
1,679	0014.00	53' into the habitat unit is a spring on the left bank.
1,819	0016.00	One 1+ salmonid observed.
1,938	0020.00	One pacific treefrog observed.
1,992	0021.00	Cattle have access to the creek channel.

Mill Creek (Mark West tributary)

Position	Habitat Unit #	Memo
1,992	0021.00	One young of the year salmoind observed.
2,527	0031.00	One 1+ salmonid observed.
2,750	0035.00	Three Pacific treefrogs are observed.
2,793	0036.00	At the top of the habitat unit is a right bank tributary that is unnamed on stream reach #1. It is wet with a flow = 0.1-0.5 cfs. It contributes approximately 100% to the downstream flow of the receiving stream. It is accessible to fish. The crew checked up the tributary 200'. The water temperature upstream = N/A, downstream = 57F, and in the tributary = 57F. The slope was approximately 3-6%. There were no fish observed. There is an entrenched channel about 1-2' wide. 75' in is a ford crossing. The substrate of the tributary is silt and small cobble. WP #6 N38.54170 W122.69152
2,989	0042.00	One Pacific treefrog was observed.
3,013	0043.00	One unidentified newt observed.
3,068	0045.00	Three Pacific treefrogs observed.
3,210	0048.00	California newts observed.
3,449	0051.00	An ATV trail follows the creek along the right bank.
3,476	0052.00	50' into the habitat unit is a ford crossing.
3,642	0054.00	There is an ATV trail following along the creek on the left bank.
3,803	0055.00	Cattle still have access to the creek bed.
4,164	0061.00	100' into the habitat unit is a spring on the right bank.
4,164	0061.00	2 salmonid young of the year observed
4,425	0063.00	At bottom of the habitat unit is a ford crossing/ ATV trail on the left bank
4,508	0065.00	100' into the unit is a Left bank tributary #2. It is unnamed and dry, with discharge = 0 cfs. The water temperatures = N/A. The crew checked 50' up and found that it is accessible to fish for the first 50'. 60' into the tributary is a right bank drainage. 70' into the tributary the slope becomes steeper. The slope measured with a clinometer = 25-30%. The dominant substrate is boulders and there are multiple 3' plunges throughout the tributary. WP # 10 N38.53807 W122.68964
4,508	0065.00	Pacific Tree Frog Observed
4,715	0069.00	There is a 2.5' plunge into the pool from the upstream end of the unit. The slope of the channel is beginning to steepen.
4,808	0071.00	Two functioning 2" pvc pipes extend along the right bank and continue upstream into the next habitat units.
4,826	0072.00	45' into the habitat unit is a ford crossing where the ATV trail is crossing to the right bank. The pvc pipe continues along the right

Position	Habitat Unit #	Memo
		bank upslope of the creek channel.
5,135	0073.00	There is a 3' plunge into the pool from the upstream unit. It is a rusty, unused metal pipe spanning the creek at the top of the unit.
5,233	0076.00	The old metal pipe and new pvc pipes continue through the creek.
5,233	0076.00	Left bank tributary # 3 is 160' into the unit. It is unnamed and dry with discharge = 0 cfs. The water temperatures = N/A. The crew checked 100' up and found that it is not accessible to fish. The slope measured with a clinometer = 25%. There is a 5-6' plunge at the mouth of the tributary. The dominant substrate is cobble and boulder. WP 12 N38.53642 W122.68833
5,405	0077.00	There is a 3' plunge into the unit from the upstream unit.
5,442	0078.00	There is a cable spanning the channel, which is suspended approximately 20' in the air. The pvc pipes continue upstream on both the right and left bank.
5,505	0080.00	The pvc pipe spans the channel approximately 15' above the creek.
5,576	0082.00	Three rough skinned newts and a yellow legged frog observed.
5,638	0083.00	The pvc pipe crosses from the left bank to the right bank. There is water running in the pipe.
5,682	0085.00	There is a spring on the left bank near the top of the unit, approximately 43' into the unit.
5,735	0086.00	Dam #1 has length = 1', height = 5', width (o) = 17', width (d) = N/A, and the height from the water to sill = 5'. There are no flashboards and no associated downcutting. There is a bedrock sheet directly below the dam. The flashboard outlet is 3' wide. The dam is retaining gravel to the height of the outlet and it is a possible barrier to adults and juveniles. The left bank side of the dam wall is broken off. The pvc pipe that has been following the creek connects to the dam wall on the left bank side. This is the end of the pvc line. WP 14 N38.53599 W122.68767
5,736	0087.00	There are algae in the water near the top of the unit.
5,804	0088.00	Algae is covering the pool surface, 52' into the unit is a left bank spring. 10-15 pacific giant salamanders observed in the pool.
5,889	0089.00	250' into the unit is a ford crossing.
5,889	0089.00	Right bank tributary #4 is 161' into the unit. It is unnamed and dry, with discharge = 0 cfs. The crew checked 300' up and found that it is not accessible to fish. The water temperatures = N/A. The slope measured with a clinometer = 10-15%. The first 20' is a steep drainage, and then there is a road crossing through the tributary. The natural channel is filled with debris. The dominant

Mill Creek (Mark West tributary)

Position	Habitat Unit #	Memo
		substrate is gravel and cobble. The natural tributary confluence is 60' upstream, but the road is pushing the water to the downstream outlet. WP # 15 N38.53558 W122.68673 Left bank tributary # 5 is 364' into the unit. It is unnamed and dry, with discharge = 0 cfs. The water temperatures = N/A. The crew checked 200' up and found that it is not accessible to fish. The slope measure with a clinometer = 15-20%. The channel is not entrenched. The dominant substrate is gravel and boulder. There is a steady slope with 1-2' plunges. The tributary crosses a ford near the mouth. The mouth of the tributary is eroding away. WP# 16 N38.53509 W122.68623 Left bank tributary #6 is 151' into the unit. It is unnamed and dry with discharge = 0 cfs. The crew checked 200' up and found that it is accessible to fish. The water temperatures = N/A. The estimated slope = 4-6%. The channel is not entrenched. The dominant substrate is gravel and cobble. There is a 3' plunge at the confluence. WP# 17 N38.53449 W122.68539
6,549	0090.00	Start of no access section WP # 18 38.5346 122.6848
8,189	0091.00	Begin access, survey continued. WP #19 38.5343 122.6833
8,204	0092.00	Culvert #1 is under Foothill Ranch Rd. It is made of steel and is an old boiler. The length= 32', height =7.5', width = 7.5', diameter = 7.5'. The plunge height, from the lip to sill = .5'. The maximum depth within 5 ft= N/A. The slope of the culvert <1 %. The culvert is in good condition, and is a little rusty on the bottom. It is not a possible barrier to juvenile or adult salmonids. There is concrete fill in the creek bed within 15' from the outlet. WP# 19 N38.53430 W122.68328
8,236	0093.00	325' into the unit is a small temporary wooden footbridge. 550' into the unit is a small temporary wooden footbridge. 950' into the unit the channel becomes overgrown with grass and brush. The entire unit has very little to no canopy. 1600' into the unit there is more of a canopy.
8,236	0093.00	Left bank tributary #7 is 1767’ into the unit. It is unnamed and dry with discharge = 0 cfs. The crew checked 125' up and found that it is accessible to fish. The water temperatures = N/A. The estimated slope = 6-10%, The channel is extremely overgrown and is not very entrenched. There is lots of debris in the channel. The dominant substrate is bedrock and gravel.
10,436	0093.00	End of survey due to lack of access in the upstream properties. WP# 22 N38.53102 W122.67797

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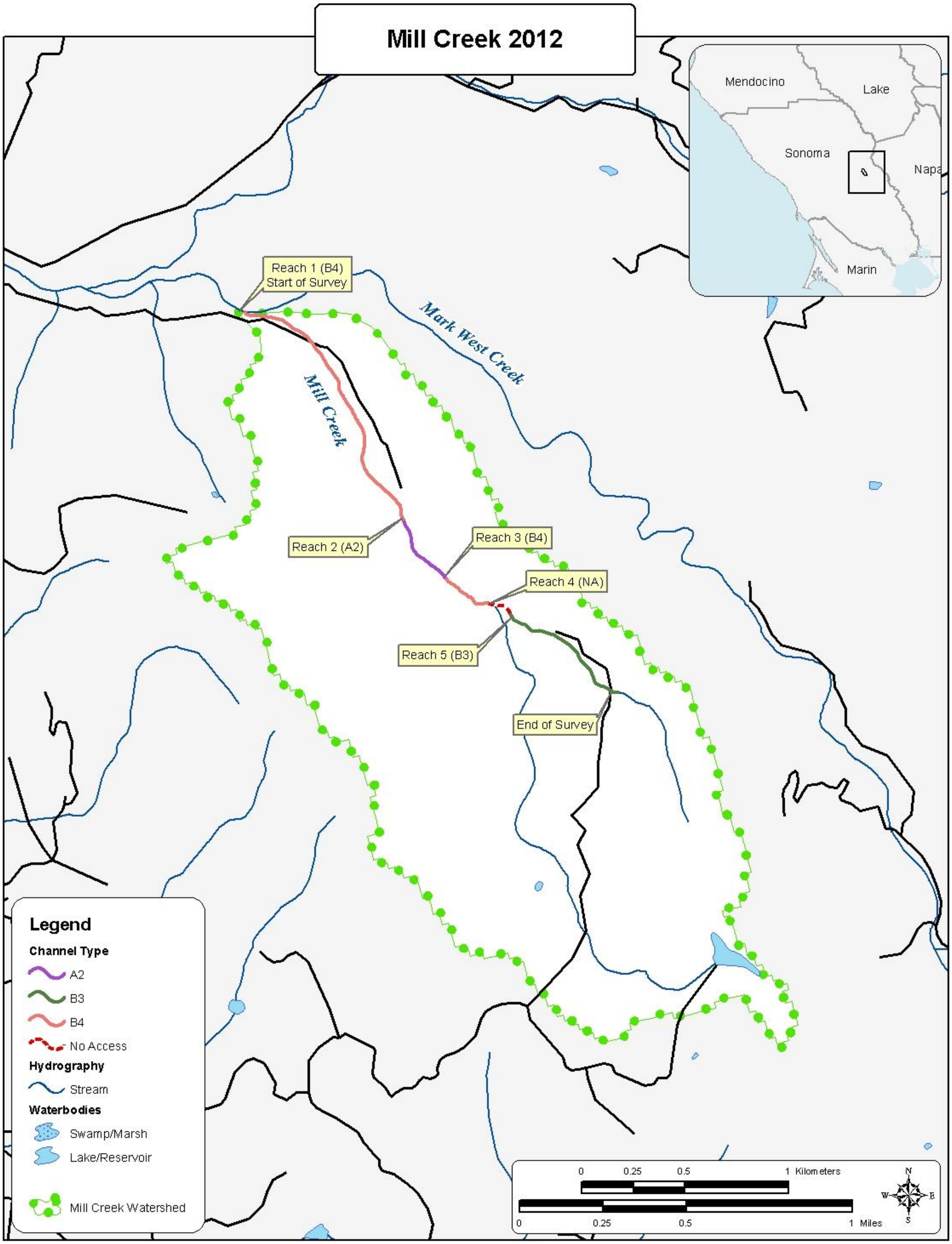
McCain, M., D. Fuller, L. Decker and K. Overton. 1990. Stream habitat classification and inventory procedures for northern California. FHC Currents. No.1. U.S. Department of Agriculture. Forest Service, Pacific Southwest Region.

Rosgen, D.L., 1994. A Classification of Natural Rivers. Catena, Vol 22: 169-199, Elsevier Science, B. V. Amsterdam.

LEVEL III and LEVEL IV HABITAT TYPES

RIFFLE			
Low Gradient Riffle	(LGR)	[1.1]	{ 1 }
High Gradient Riffle	(HGR)	[1.2]	{ 2 }
CASCADE			
Cascade	(CAS)	[2.1]	{ 3 }
Bedrock Sheet	(BRS)	[2.2]	{24}
FLATWATER			
Pocket Water	(POW)	[3.1]	{21}
Glide	(GLD)	[3.2]	{14}
Run	(RUN)	[3.3]	{15}
Step Run	(SRN)	[3.4]	{16}
Edgewater	(EDW)	[3.5]	{18}
MAIN CHANNEL POOLS			
Trench Pool	(TRP)	[4.1]	{ 8 }
Mid-Channel Pool	(MCP)	[4.2]	{17}
Channel Confluence Pool	(CCP)	[4.3]	{19}
Step Pool	(STP)	[4.4]	{23}
SCOUR POOLS			
Corner Pool	(CRP)	[5.1]	{22}
Lateral Scour Pool - Log Enhanced	(LSL)	[5.2]	{10}
Lateral Scour Pool - Root Wad Enhanced	(LSR)	[5.3]	{11}
Lateral Scour Pool - Bedrock Formed	(LSBk)	[5.4]	{12}
Lateral Scour Pool - Boulder Formed	(LSBo)	[5.5]	{20}
Plunge Pool	(PLP)	[5.6]	{ 9 }
BACKWATER POOLS			
Secondary Channel Pool	(SCP)	[6.1]	{ 4 }
Backwater Pool - Boulder Formed	(BPB)	[6.2]	{ 5 }
Backwater Pool - Root Wad Formed	(BPR)	[6.3]	{ 6 }
Backwater Pool - Log Formed	(BPL)	[6.4]	{ 7 }
Dammed Pool	(DPL)	[6.5]	{13}
ADDITIONAL UNIT DESIGNATIONS			
Dry	(DRY)	[7.0]	
Culvert	(CUL)	[8.0]	
Not Surveyed	(NS)	[9.0]	
Not Surveyed due to marsh	(MAR)	[9.1]	



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Prepared by: Scott Webb, December 2012

Table 1 - Summary of Riffle, Flatwater, and Pool Habitat Types

Stream Name: Mill Creek **LLID:** 1226973385470 **Drainage:** Russian River - Middle

Survey 9/10/2012 to 9/14/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR08WS13 **Latitude:** 38:32:49.0N **Longitude:** 122:41:50.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating
20	7	RIFFLE	21.5	44	889	8.5	2.4	0.2	0.4	74	1482	12	241		4
25	5	FLATWATER	26.9	93	2317	22.2	2.4	0.3	0.6	288	7204	99	2465		8
28	28	POOL	30.1	40	1113	10.7	6.6	0.6	1.4	230	6446	160	4467	138	28
16	0	DRY	17.2	275	4407	42.2									
3	0	CULVERT	3.2	23	70	0.7									
1	0	NOSURVEY	1.1	1640	1640	15.7									

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
93	40	10436	15132	7174

Table 2 - Summary of Habitat Types and Measured Parameters

Stream Name: Mill Creek **LLID:** 1226973385470 **Drainage:** Russian River - Middle

Survey 9/10/2012 to 9/14/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR08WS13 **Latitude:** 38:32:49.0N **Longitude:** 122:41:50.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating	Mean Canopy (%)
13	4	LGR	14.0	52	674	6.5	2.0	0.1	0.8	88	1141	11	142		4	94
4	2	HGR	4.3	40	158	1.5	2.0	0.2	0.5	70	281	16	65		5	93
3	1	BRS	3.2	19	57	0.5	2.0	0.3	0.5	27	82	8	25		5	100
7	1	RUN	7.5	30	207	2.0	2.0	0.2	0.2	32	227	6	45		10	90
18	4	SRN	19.4	117	2110	20.2	2.0	0.3	1.0	352	6338	122	2189		8	95
19	19	MCP	20.4	32	615	5.9	7.0	0.6	2.2	229	4353	170	3226	146	27	94
6	6	STP	6.5	68	408	3.9	5.0	0.6	1.6	273	1640	157	939	146	17	89
1	1	LSL	1.1	41	41	0.4	5.0	0.4	1.8	205	205	144	144	82	60	92
1	1	LSR	1.1	25	25	0.2	5.0	0.8	1.3	119	119	107	107	95	120	100
1	1	PLP	1.1	24	24	0.2	6.0	0.3	0.7	130	130	52	52	39	5	93
16	0	DRY	17.2	275	4407	42.2										93
3	0	CUL	3.2	23	70	0.7										
1	0	NS	1.1	1640	1640	15.7										

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume
93	40	10436	14515	6934(cu.ft.)

Table 3 - Summary of Pool Habitat Types

Stream Name: Mill Creek **LLID:** 1226973385470 **Drainage:** Russian River - Middle

Survey 9/10/2012 to 9/14/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR08WS13 **Latitude:** 38:32:49.0N **Longitude:** 122:41:50.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Residual Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Residual Pool Vol (cu.ft.)	Estimated Total Resid. Vol (cu.ft.)	Mean Shelter Rating
25	25	MAIN	89	41	1023	92	6.8	0.6	240	5993	146	3661	24
3	3	SCOUR	11	30	90	8	5.3	0.5	151	453	72	216	62
Total Units	Total Units Fully Measured				Total Length (ft.)					Total Area (sq.ft.)		Total Volume (cu.ft.)	
28	28				1113					6446		3877	

Table 4 - Summary of Maximum Residual Pool Depths By Pool Habitat Types

Stream Name: Mill Creek **LLID:** 1226973385470 **Drainage:** Russian River - Middle

Survey 9/10/2012 to 9/14/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR08WS13 **Latitude:** 38:32:49.0N **Longitude:** 122:41:50.0W

Habitat Units	Habitat Type	Habitat Occurrence (%)	< 1 Foot Maximum Residual Depth	< 1 Foot Percent Occurrence	1 < 2 Feet Maximum Residual Depth	1 < 2 Feet Percent Occurrence	2 < 3 Feet Maximum Residual Depth	2 < 3 Feet Percent Occurence	3 < 4 Feet Maximum Residual Depth	3 < 4 Feet Percent Occurrence	>= 4 Feet Maximum Residual Depth	>= 4 Feet Percent Occurrence
19	MCP	68	1	5	14	74	4	21	0	0	0	0
6	STP	21	2	33	4	67	0	0	0	0	0	0
1	LSL	4	0	0	1	100	0	0	0	0	0	0
1	LSR	4	0	0	1	100	0	0	0	0	0	0
1	PLP	4	1	100	0	0	0	0	0	0	0	0

Total Units	Total < 1 Foot Max Resid. Depth	Total < 1 Foot % Occurrence	Total 1< 2 Feet Max Resid. Depth	Total 1< 2 Feet % Occurrence	Total 2< 3 Feet Max Resid. Depth	Total 2< 3 Feet % Occurrence	Total 3< 4 Feet Max Resid. Depth	Total 3< 4 Feet % Occurrence	Total >= 4 Feet Max Resid. Depth	Total >= 4 Feet % Occurrence
28	4	14	20	71	4	14	0	0	0	0

Mean Maximum Residual Pool Depth (ft.): 1

Table 5 - Summary of Mean Percent Cover By Habitat

Stream Name: Mill Creek **Dry Units:** 16 **LLID:** 1226973385470 **Drainage:** Russian River - Middle

Survey 9/10/2012 to 9/14/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR08WS13 **Latitude:** 38:32:49.0N **Longitude:** 122:41:50.0W

Habitat Units	Units Fully Measured	Habitat Type	Mean % Undercut Banks	Mean % SWD	Mean % LWD	Mean % Root Mass	Mean % Terr. Vegetation	Mean % Aquatic Vegetation	Mean % White Water	Mean % Boulders	Mean % Bedrock Ledges
13	4	LGR	0	0	0	0	0	0	0	75	0
4	2	HGR	0	0	0	0	0	0	0	100	0
3	1	BRS	0	0	0	0	0	0	0	100	0
20	7	TOTAL RIFFLE	0	0	0	0	0	0	0	86	0
7	1	RUN	0	0	0	50	0	0	0	50	0
18	4	SRN	15	0	0	15	0	0	0	45	0
25	5	TOTAL FLAT	12	0	0	22	0	0	0	46	0
19	19	MCP	24	4	1	24	0	0	0	39	3
6	6	STP	14	14	0	23	0	0	0	41	8
1	1	LSL	40	10	10	40	0	0	0	0	0
1	1	LSR	45	10	0	45	0	0	0	0	0
1	1	PLP	0	0	0	0	0	0	0	100	0
28	28	TOTAL POOL	22	7	1	24	0	0	0	39	4
3	0	CUL									
1	0	NS									
93	40	TOTAL	17	5	1	20	0	0	0	48	3

Table 6 - Summary of Dominant Substrates By Habitat Type

Stream Name: Mill Creek **Dry Units:** 16 **LLID:** 1226973385470 **Drainage:** Russian River - Middle

Survey 9/10/2012 to 9/14/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR08WS13 **Latitude:** 38:32:49.0N **Longitude:** 122:41:50.0W

Habitat Units	Units Fully Measured	Habitat Type	% Total Silt/Clay Dominant	% Total Sand Dominant	% Total Gravel Dominant	% Total Small Cobble Dominant	% Total Large Cobble Dominant	% Total Boulder Dominant	% Total Bedrock Dominant
13	4	LGR	0	0	50	50	0	0	0
4	2	HGR	0	0	0	0	0	50	50
3	1	BRS	0	0	0	100	0	0	0
7	1	RUN	0	0	100	0	0	0	0
18	4	SRN	0	0	25	50	25	0	0
19	19	MCP	0	0	58	26	16	0	0
6	6	STP	0	0	0	50	33	17	0
1	1	LSL	0	0	100	0	0	0	0
1	1	LSR	0	0	100	0	0	0	0
1	1	PLP	0	0	0	0	100	0	0
3	0	CUL	0	0	0	0	0	0	0
1	0	NS	0	0	0	0	0	0	0

Table 7 - Summary of Mean Percent Canopy for Entire Stream

Stream Name: Mill Creek **LLID:** 1226973385470 **Drainage:** Russian River - Middle

Survey 9/10/2012 to 9/14/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR08WS13 **Latitude:** 38:32:49.0N **Longitude:** 122:41:50.0W

Mean Percent Canopy	Mean Percent Conifer	Mean Percent Hardwood	Mean Percent Open Units	Mean Right Bank % Cover	Mean Left Bank % Cover
93	50	50	0	85	82

Note: Mean percent conifer and hardwood for the entire reach are means of canopy components from units with canopy values greater than zero.

Open units represent habitat units with zero canopy cover.

Table 8 - Fish Habitat Inventory Data Summary

Stream Mill Creek LLID: 1226973385470 Drainage Russian River - Middle

Survey Dates: 9/10/2012 to 9/14/2012 Survey Length (ft.): 10436 Main Channel (ft.): 10436 Side Channel (ft.): 0

Confluence Location: Quad MARK WEST Legal Description: T08NR08WS13 Latitude: 38:32:49.0N Longitude: 122:41:50.0W

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 1

Channel Type:	B4	Canopy Density (%):	94.3	Pools by Stream Length	17.1
Reach Length (ft.):	4508	Coniferous Component (%):	52.6	Pool Frequency (%):	29.7
Riffle/Flatwater Mean Width (ft.):	2.1	Hardwood Component	47.4	Residual Pool Depth (%):	
BFW:		Dominant Bank	Hardwood Trees	< 2 Feet Deep:	84.2
Range (ft.):	11.00 to 22.00	Vegetative Cover (%):	87.3	2 to 2.9 Feet Deep:	15.8
Mean (ft.):	16.69	Dominant	Boulders	3 to 3.9 Feet Deep:	0.0
Std. Dev.:	3.98	Dominant Bank Substrate	Boulder	>= 4 Feet Deep:	0.0
Base Flow (cfs):	0	Occurrence of LWD (%):	1.3	Mean Max Residual Pool Depth	1.39
Water (F): 56 - 58	Air (F): 67 - 74	LWD per 100 ft.:		Mean Pool Shelter	38
Dry Channel (ft.):	1485	Riffles:	1		
		Pools:	1		
		Flat:	0		

Pool Tail Substrate (%): Silt/Clay: 0.0 Sand: 0.0 Gravel: 52.6 Sm Cobble: 36.8 Lg Cobble: 10.5 Boulder 0.0 Bedrock: 0.0

Embeddedness Values (%): 1. 47.4 2. 52.6 3. 0.0 4. 0.0 5. 0.0

STREAM REACH: 2

Channel Type:	A2	Canopy Density (%):	93.0	Pools by Stream Length	20.9
Reach Length (ft.):	1228	Coniferous Component (%):	50.0	Pool Frequency (%):	36.4
Riffle/Flatwater Mean Width (ft.):	3.0	Hardwood Component	50.0	Residual Pool Depth (%):	
BFW:		Dominant Bank	Hardwood Trees	< 2 Feet Deep:	87.5
Range (ft.):	12.00 to 24.00	Vegetative Cover (%):	73.5	2 to 2.9 Feet Deep:	12.5
Mean (ft.):	16.18	Dominant	Boulders	3 to 3.9 Feet Deep:	0.0
Std. Dev.:	4.86	Dominant Bank Substrate	Boulder	>= 4 Feet Deep:	0.0
Base Flow (cfs):	0	Occurrence of LWD (%):	0.0	Mean Max Residual Pool Depth	1.33
Water (F): 53 - 56	Air (F): 58 - 73	LWD per 100 ft.:		Mean Pool Shelter	8
Dry Channel (ft.):	47	Riffles:	0		
		Pools:	0		
		Flat:	0		

Pool Tail Substrate (%): Silt/Clay: 0.0 Sand: 0.0 Gravel: 25.0 Sm Cobble: 50.0 Lg Cobble: 12.5 Boulder 12.5 Bedrock: 0.0

Embeddedness Values (%): 1. 50.0 2. 50.0 3. 0.0 4. 0.0 5. 0.0

Mill Creek (Mark West tributary)

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 3

Channel Type:	B4	Canopy Density (%):	83.0	Pools by Stream Length	10.5
Reach Length (ft.):	813	Coniferous Component (%):	20.0	Pool Frequency (%):	33.3
Riffle/Flatwater Mean Width (ft.):	2.0	Hardwood Component	80.0	Residual Pool Depth (%):	
BFW:		Dominant Bank	Coniferous Trees	< 2 Feet Deep:	100.0
Range (ft.):	24.00 to 24.00	Vegetative Cover (%):	100.0	2 to 2.9 Feet Deep:	0.0
Mean (ft.):	24.00	Dominant	Undercut Banks	3 to 3.9 Feet Deep:	0.0
Std. Dev.:	0.00	Dominant Bank Substrate	Cobble/Gravel	>= 4 Feet Deep:	0.0
Base Flow (cfs):	0	Occurrence of LWD (%):	0.0	Mean Max Residual Pool Depth	0.9
Water (F):	53 - 53 Air (F): 58 - 58	LWD per 100 ft.:		Mean Pool Shelter	10
Dry Channel (ft.):	660	Riffles:	0		
		Pools:	1		
		Flat:			

Pool Tail Substrate (%): Silt/Clay: 0.0 Sand: 0.0 Gravel: 100. Sm Cobble: 0.0 Lg Cobble: 0.0 Boulder 0.0 Bedrock: 0.0

Embeddedness Values (%): 1. 100.0 2. 0.0 3. 0.0 4. 0.0 5. 0.0

STREAM REACH: 4

Channel Type:	NA	Canopy Density (%):		Pools by Stream Length	0.0
Reach Length (ft.):	1640	Coniferous Component (%):		Pool Frequency (%):	0.0
Riffle/Flatwater Mean Width (ft.):		Hardwood Component		Residual Pool Depth (%):	
BFW:		Dominant Bank		< 2 Feet Deep:	
Range (ft.):	24.00 to 24.00	Vegetative Cover (%):	0.0	2 to 2.9 Feet Deep:	
Mean (ft.):	24.00	Dominant		3 to 3.9 Feet Deep:	
Std. Dev.:	0.00	Dominant Bank Substrate		>= 4 Feet Deep:	
Base Flow (cfs):	0	Occurrence of LWD (%):		Mean Max Residual Pool Depth	
Water (F):	53 - 53 Air (F): 58 - 58	LWD per 100 ft.:		Mean Pool Shelter	
Dry Channel (ft.):	0	Riffles:			
		Pools:			
		Flat:			

Pool Tail Substrate (%): Silt/Clay: Sand: Gravel: Sm Cobble: Lg Cobble: Boulder Bedrock:

Embeddedness Values (%): 1. 2. 3. 4. 5. 0.0

Mill Creek (Mark West tributary)

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 5

Channel Type:	B3	Canopy Density (%):	85.0	Pools by Stream Length	0.0
Reach Length (ft.):	2247	Coniferous Component (%):	0.0	Pool Frequency (%):	0.0
Riffle/Flatwater Mean Width (ft.):		Hardwood Component	100.0	Residual Pool Depth (%):	
BFW:		Dominant Bank		< 2 Feet Deep:	
Range (ft.):	to	Vegetative Cover (%):	0.0	2 to 2.9 Feet Deep:	
Mean (ft.):		Dominant		3 to 3.9 Feet Deep:	
Std. Dev.:		Dominant Bank Substrate		>= 4 Feet Deep:	
Base Flow (cfs):		Occurrence of LWD (%):		Mean Max Residual Pool Depth	
Water (F): 0 - 0	Air (F): 66 - 66	LWD per 100 ft.:		Mean Pool Shelter	
Dry Channel (ft.):	2215	Riffles:			
		Pools:			
		Flat:			

Pool Tail Substrate (%):	Silt/Clay:	Sand:	Gravel:	Sm Cobble:	Lg Cobble:	Boulder	Bedrock:
Embeddedness Values (%):	1.	2.	3.	4.	5. 0.0		

Table 9 -Mean Percentage of Dominant Substrate and Vegetation

Stream Name: Mill Creek **LLID:** 1226973385470 **Drainage:** Russian River - Middle

Survey 9/10/2012 to 9/14/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR08WS13 **Latitude:** 38:32:49.0N **Longitude:** 122:41:50.0W

Mean Percentage of Dominant Stream Bank Substrate

Dominant Class of Substrate	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percentage (%)
Bedrock	5	8	16.3
Boulder	21	15	45.0
Cobble/Gravel	11	12	28.8
Sand/Silt/Clay	3	5	10.0

Mean Percentage of Dominant Stream Bank Vegetation

Dominant Class of Vegetation	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percentage
Grass	0	0	0.0
Brush	0	3	3.8
Hardwood	20	19	48.8
Coniferous	20	18	47.5
No Vegetation	0	0	0.0

Total Stream Cobble Embeddedness Values: 2

Table 10 - Mean Percent of Shelter Cover Types For Entire Stream

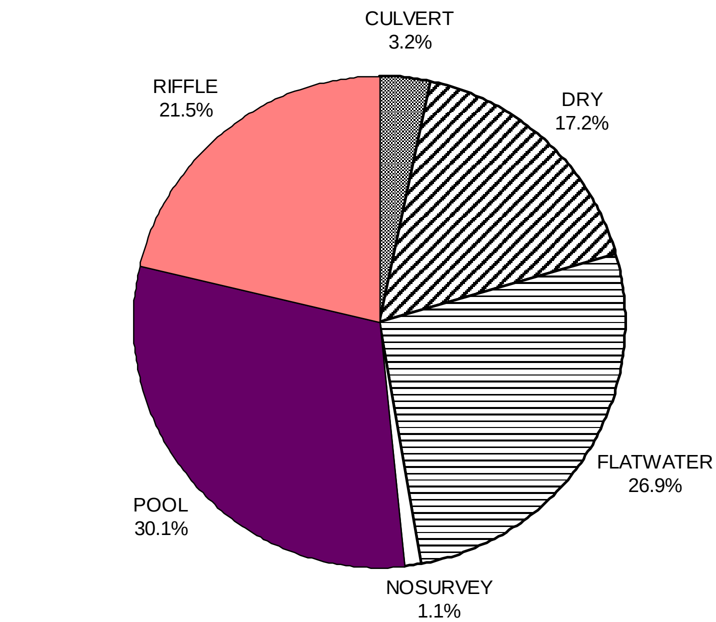
Stream Name: Mill Creek **LLID:** 1226973385470 **Drainage:** Russian River - Middle

Survey 9/10/2012 to 9/14/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR08WS13 **Latitude:** 38:32:49.0N **Longitude:** 122:41:50.0W

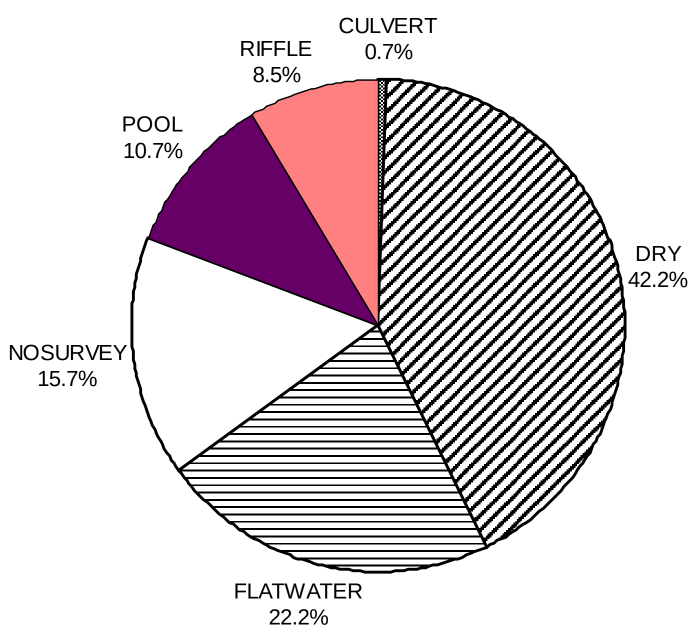
	Riffles	Flatwater	Pools
UNDERCUT BANKS (%)	0	12	22
SMALL WOODY DEBRIS (%)	0	0	7
LARGE WOODY DEBRIS (%)	0	0	1
ROOT MASS (%)	0	22	24
TERRESTRIAL VEGETATION	0	0	0
AQUATIC VEGETATION (%)	0	0	0
WHITEWATER (%)	0	0	0
BOULDERS (%)	86	46	39
BEDROCK LEDGES (%)	0	0	4

MILL CREEK 2012
HABITAT TYPES BY PERCENT OCCURRENCE



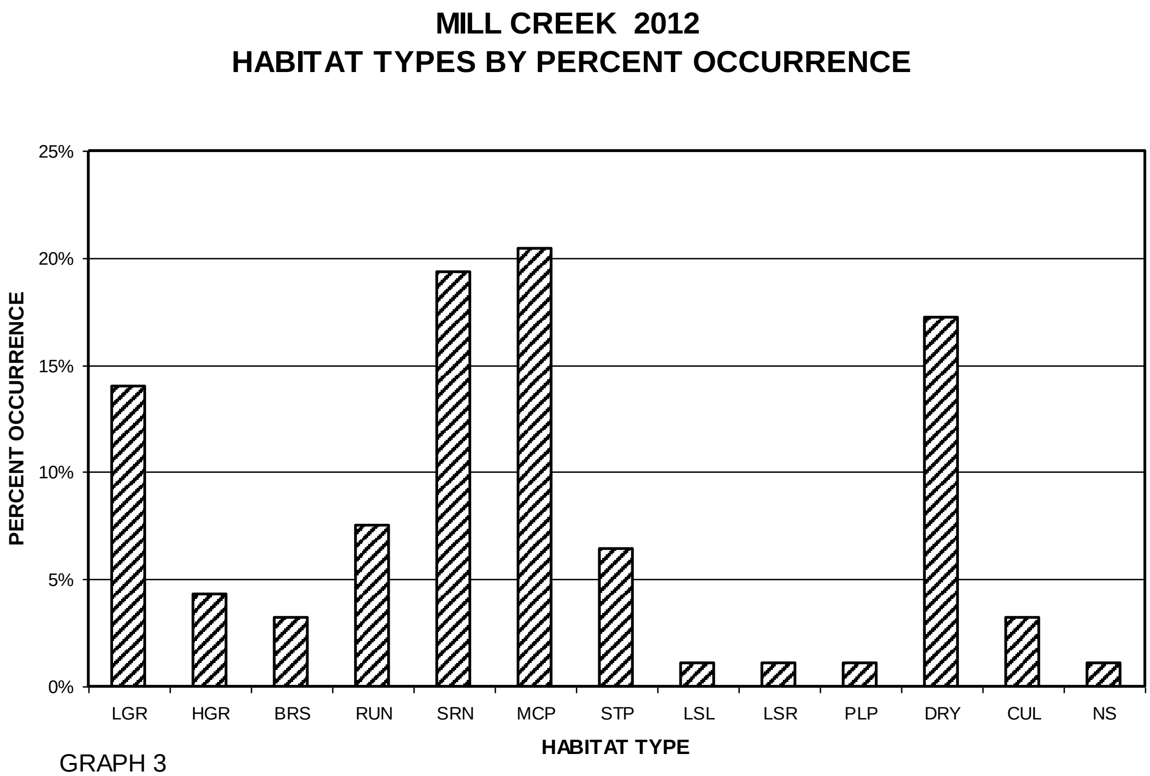
GRAPH 1

MILL CREEK 2012
HABITAT TYPES BY PERCENT TOTAL LENGTH

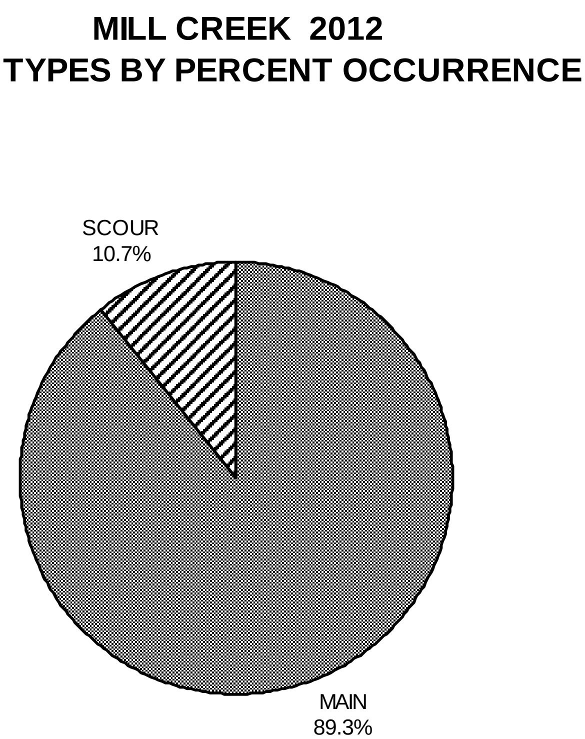


GRAPH 2

Mill Creek (Mark West tributary)

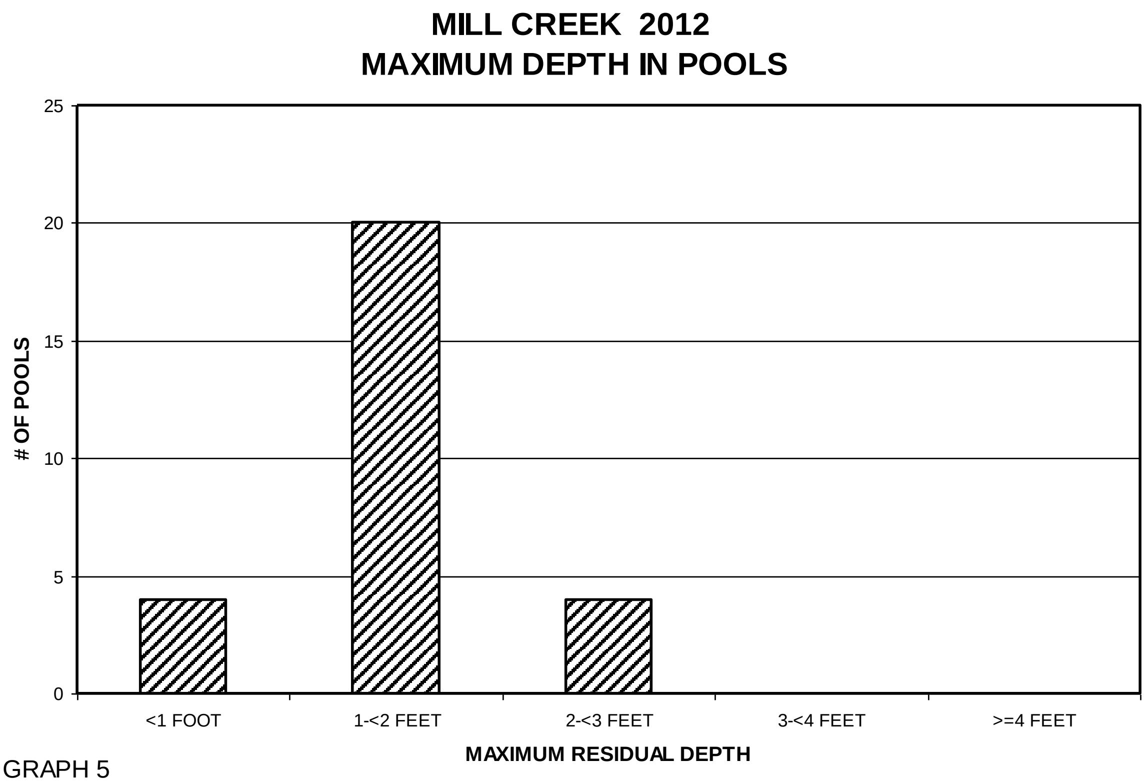


GRAPH 3

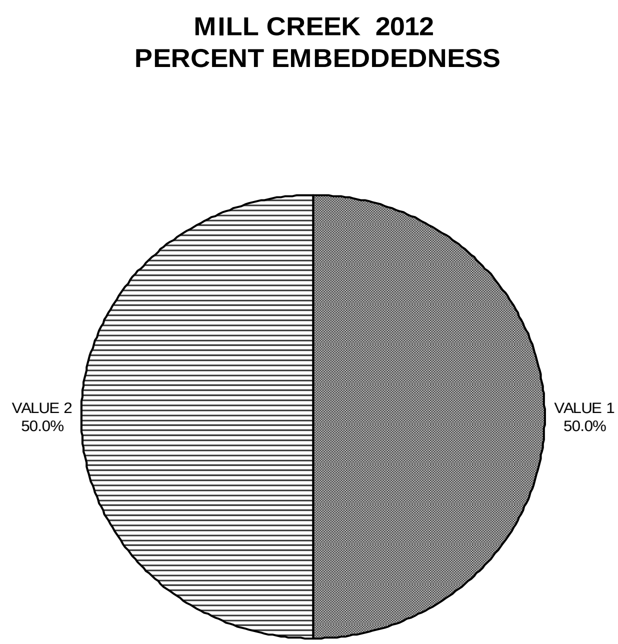


GRAPH 4

Mill Creek (Mark West tributary)

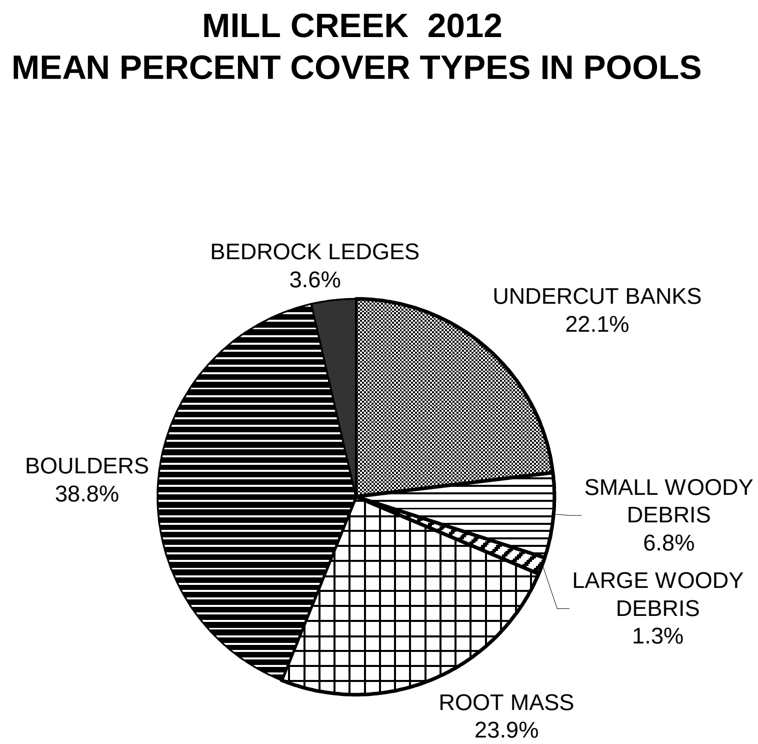


GRAPH 5

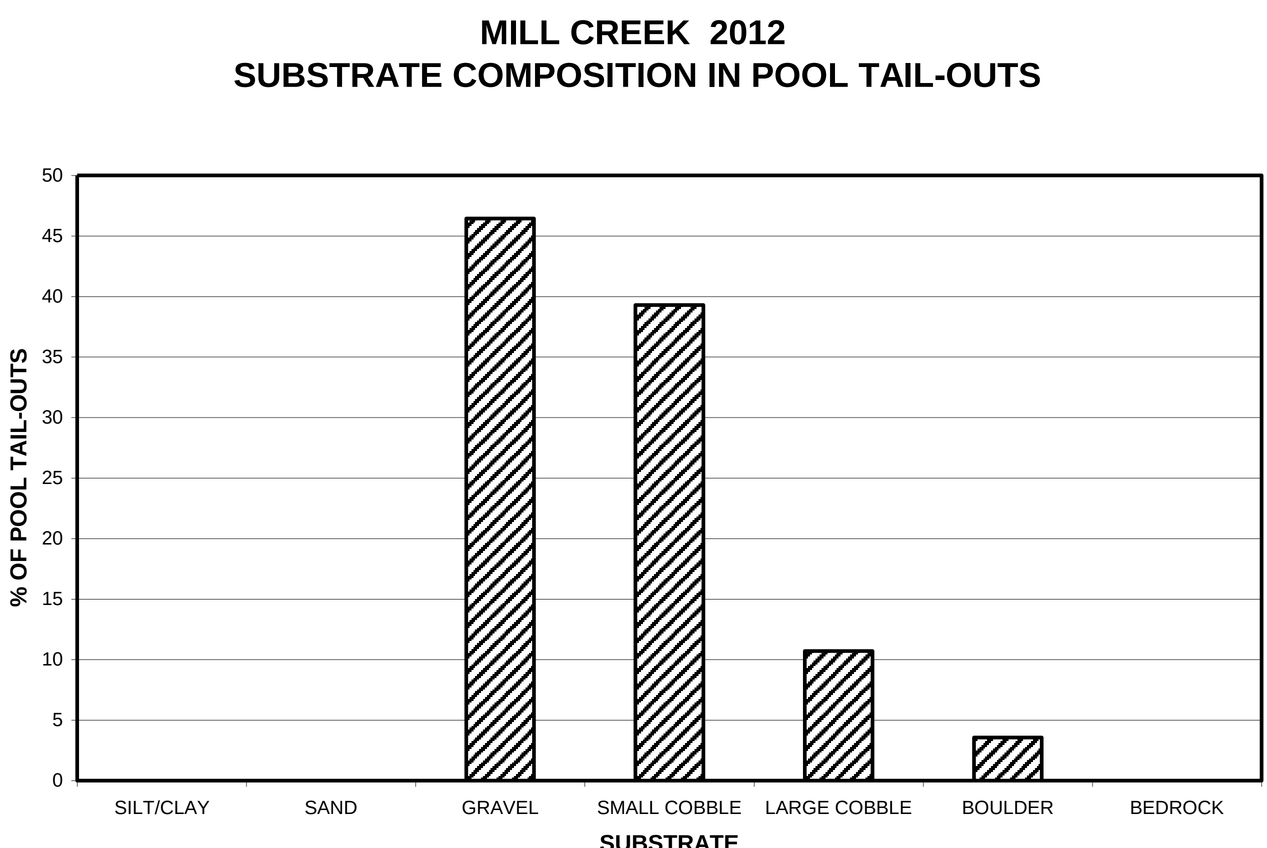


GRAPH 6

Mill Creek (Mark West tributary)

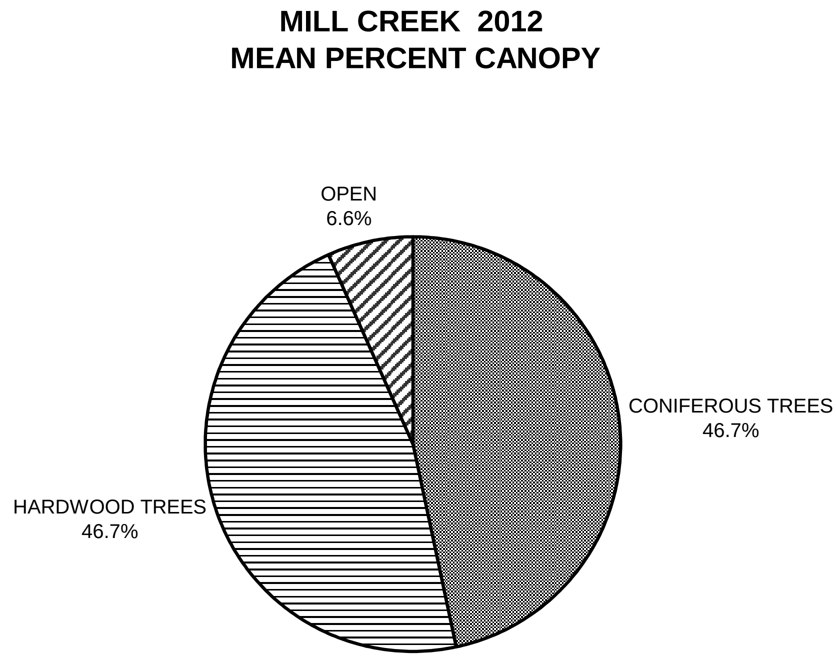


GRAPH 7

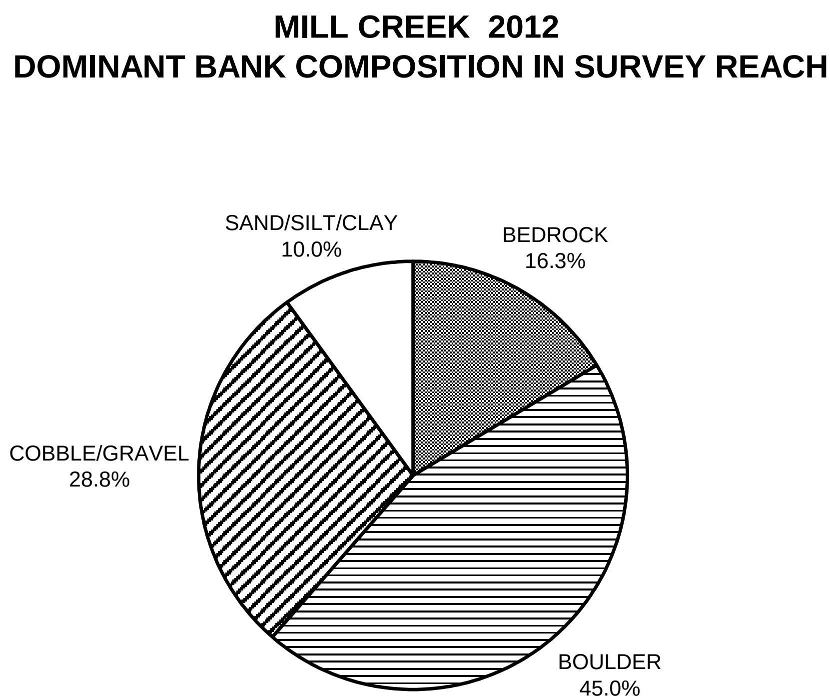


GRAPH 8

Mill Creek (Mark West tributary)

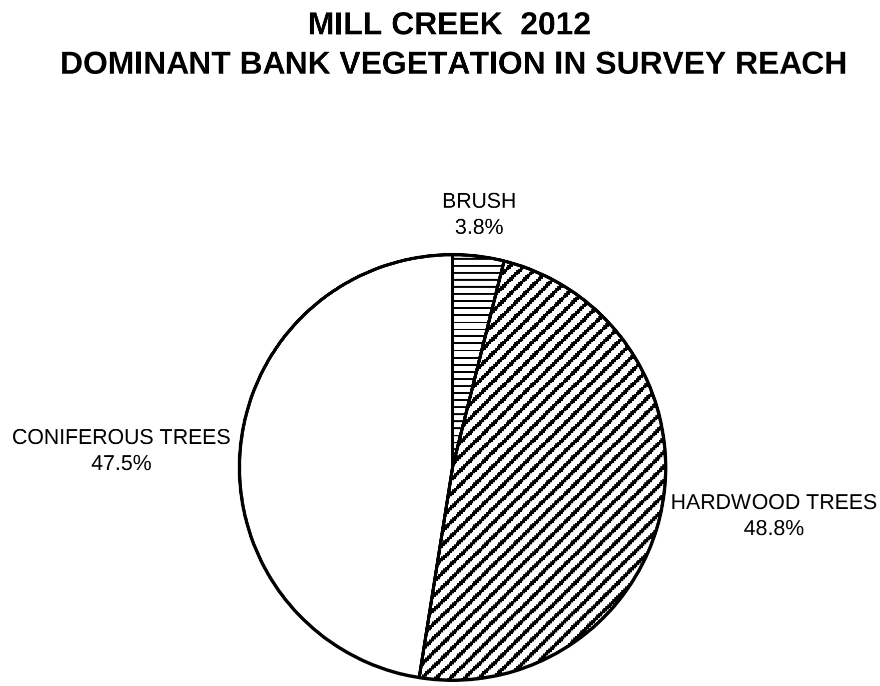


GRAPH 9



GRAPH 10

Mill Creek (Mark West tributary)



GRAPH 11

California Department of Fish and Wildlife
Sonoma County
Russian River Watershed
Stream Habitat Assessment Reports

Weeks Creek

Surveyed 2012

Report Completed in 2013

STREAM INVENTORY REPORT

Weeks Creek

INTRODUCTION

A stream inventory was conducted 8/20/2012 to 8/21/2012 on Weeks Creek. The survey began at the confluence with Mark West Creek and extended upstream 2.2 miles.

The objective of the habitat inventory was to document the habitat available to anadromous salmonids in Weeks Creek.

The objective of this report is to document the current habitat conditions and recommend options for the potential enhancement of habitat for Chinook salmon, coho salmon, and steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's north coast streams.

WATERSHED OVERVIEW

Weeks Creek is located in Sonoma County, California (Map 1). It is a tributary to Mark West Creek, which flows into Russian River, which flows into Pacific Ocean. Weeks Creek's legal description at the confluence with Mark West Creek is T08N R07W Sec.29. Its location is 38.5089 north latitude and 122.6482 west longitude, LLID number 1226482385089. Weeks Creek is a second order stream and has approximately 3.2 miles of blue line stream according to the USGS National Hydrology Dataset (NHD). Weeks Creek drains a watershed of approximately 2.3 square miles. Elevations range from about 673 feet at the mouth of the creek to 2,047 feet in the headwater areas. Grasslands and herbaceous vegetation dominates the watershed. The watershed is entirely privately owned, which accounts for 100% of the land area. One hundred percent of the land is considered natural. Vehicle access exists via Calistoga Rd out of Santa Rosa, CA near the intersection with St. Helena Rd. Further access along the creek can be found off of Cleland Rd.

METHODS

The habitat inventory conducted in Weeks Creek follows the methodology presented in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998). The Watershed Stewards Project/AmeriCorps (WSP) Members that conducted the inventory were trained in standardized habitat inventory methods by the California Department of Fish and Wildlife (CDFW). This inventory was conducted by a two-person team.

SAMPLING STRATEGY

The inventory uses a method that samples approximately 10% of the habitat units within the survey reach. All habitat units included in the survey are classified according to habitat type and their lengths are measured. All pool units are fully measured. All other habitat unit types encountered for the first time in each reach are measured for all the parameters and characteristics on the field form. Additionally, from the ten habitat units on each field form page, one is randomly selected for complete measurement.

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be found in the *California Salmonid Stream Habitat Restoration Manual*. This form was used in Weeks Creek to record measurements and observations. There are eleven components to the inventory form.

1. Flow:

Flow is measured in cubic feet per second (cfs) near the bottom of the stream survey reach using a Marsh-McBirney Model 2000 flow meter.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1994). This methodology is described in the *California Salmonid Stream Habitat Restoration Manual*. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are five measured parameters used to determine channel type: 1) water slope gradient, 2) entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity. Channel characteristics are measured using a clinometer, hand level, hip chain, tape measure, and a stadia rod.

3. Temperatures:

Both water and air temperatures are measured and recorded at every tenth habitat unit. The time of the measurement is also recorded. Both temperatures are taken in degrees Fahrenheit at the middle of the habitat unit and within one foot of the water surface.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1990). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "dry". Weeks Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All measurements are in feet to the nearest tenth. Habitat characteristics are measured using a clinometer, hip chain, and stadia rod.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out areas is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Weeks Creek, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3) and 76 - 100% (value 4). Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate such as bedrock, log sills, boulders or other considerations.

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide juvenile salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition for prey. The shelter rating is calculated for each fully-described habitat unit by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All cover is then classified according to a list of nine cover types. In Weeks Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully-described habitat units, dominant and sub-dominant substrate elements were ocularly estimated using a list of seven size classes and recorded as a one and two, respectively. In addition, the dominant substrate composing the pool tail-outs is recorded for each pool.

8. Canopy:

Stream canopy density was estimated using modified handheld spherical densiometers as described in the *California Salmonid Stream Habitat Restoration Manual*. Canopy density relates to the amount of stream shaded from the sun. In Weeks Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the center of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated ocularly into percentages of coniferous or hardwood trees.

9. Bank Composition and Vegetation:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Weeks Creek, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully-described unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation (including downed trees, logs, and rootwads) was estimated and recorded.

10. Large Woody Debris Count:

Large woody debris (LWD) is an important component of fish habitat and an element in channel forming processes. In each habitat unit all pieces of LWD partially or entirely below the elevation of bankfull discharge are counted and recorded. The minimum size to be considered is twelve inches in diameter and six feet in length. The LWD count is presented by reach and is expressed as an average per 100 feet.

11. Average Bankfull Width:

Bankfull width can vary greatly in the course of a channel type stream reach. This is especially true in very long reaches. Bankfull width can be a factor in habitat components like canopy density, water temperature, and pool depths. Frequent measurements taken at riffle crests (velocity crossovers) are needed to accurately describe reach widths. At the first appropriate velocity crossover that occurs after the beginning of a new stream survey page (ten habitat units), bankfull width is measured and recorded in the appropriate header block of the page. These widths are presented as an average for the channel type reach.

BIOLOGICAL INVENTORY

Biological sampling during the stream inventory is used to determine fish species and their distribution in the stream. Fish presence was observed from the stream banks in Weeks Creek.

DATA ANALYSIS

Data from the habitat inventory form are entered into Stream Habitat 2.0.18, a Visual Basic data entry program developed by Karen Wilson, Pacific States Marine Fisheries Commission in conjunction with the California Department of Fish and Wildlife. This program processes and summarizes the data, and produces the following ten tables:

- Riffle, Flatwater, and Pool Habitat Types
- Habitat Types and Measured Parameters
- Pool Types
- Maximum Residual Pool Depths by Habitat Types
- Mean Percent Cover by Habitat Type
- Dominant Substrates by Habitat Type
- Mean Percent Vegetative Cover for Entire Stream
- Fish Habitat Inventory Data Summary by Stream Reach (Table 8)
- Mean Percent Dominant Substrate / Dominant Vegetation Type for Entire Stream
- Mean Percent Shelter Cover Types for Entire Stream

Graphics are produced from the tables using Microsoft Excel. Graphics developed for Weeks Creek include:

- Riffle, Flatwater, Pool Habitat Types by Percent Occurrence
- Riffle, Flatwater, Pool Habitat Types by Total Length
- Total Habitat Types by Percent Occurrence
- Pool Types by Percent Occurrence

- Maximum Residual Depth in Pools
- Percent Embeddedness
- Mean Percent Cover Types in Pools
- Substrate Composition in Pool Tail-outs
- Mean Percent Canopy
- Dominant Bank Composition by Composition Type
- Dominant Bank Vegetation by Vegetation Type

HABITAT INVENTORY RESULTS

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of 8/20/2012 to 8/21/2012, was conducted by C. Neill, D. Dela Vega (WSP). The total length of the stream surveyed was 11,539 feet with no additional feet of side channel.

Stream flow was not measured on Weeks Creek.

Weeks Creek is a B3 channel type for 10,382 feet of the stream surveyed (Reach 1), an A1 channel type for 1,157 feet of the stream surveyed (Reach 2). B3 channels are moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools, very stable plan and profile, stable banks, and cobble-dominant substrates. A1 channels are steep, narrow, cascading, step-pool, high energy debris transporting channels associated with depositional soils, and stable bedrock-dominant substrates.

Water temperatures taken during the survey period ranged from 56 to 69 degrees Fahrenheit. Air temperatures ranged from 64 to 83 degrees Fahrenheit.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence there were 36% pool units, 33% dry units, 13% flatwater units, 12% riffle units, and 7% culvert units (Graph 1). Based on total length of Level II habitat types, there were 76% dry units, 12% pool units, 6% riffle units, 5% flatwater units, and1% culvert units (Graph 2).

Thirteen Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were 33% dry units, 23% mid-channel pool units, and 8% run units (Graph 3). Based on percent total length, there were 76% dry units, 6% step pool units and 5% mid-channel pool units.

A total of 31 pools were identified (Table 3). Main channel pools were the most frequently encountered at 81% (Graph 4), and comprised 87% of the total length of all pools (Table 3).

Table 4 is a summary of maximum residual pool depths by pool habitat types. Pool quality for salmonids increases with depth. Eleven of the 31 pools (35%) had a residual depth of two feet or greater (Graph 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 31 pool tail-outs measured, 17 had a value of 1 (55%), 12 had a value of 2 (39%), 1 had a value of 3 (3%), 1 had a value of 4 (3%) (Graph 6). On this scale, a value of 1 indicates the best spawning conditions and a value of 4 the worst. Additionally, a value of 5 was assigned to tail-outs deemed unsuited for spawning due to inappropriate substrate such as bedrock, log sills, boulders, or other considerations.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Riffle habitat types had a mean shelter rating of 5, flatwater habitat types had a mean shelter rating of 10, and pool habitats had a mean shelter rating of 16 (Table 1). Of the pool types, the main channel pools had a mean shelter rating of 18, and scour pools had a mean shelter rating of 7 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Boulders are the dominant cover type in Weeks Creek. Graph 7 describes the pool cover in Weeks Creek. Boulders are the dominant pool cover type, followed by undercut banks.

Table 6 summarizes the dominant substrate by habitat type. Graph 8 depicts the dominant substrate observed in pool tail-outs. Gravel substrate was observed in 84% of pool tail-outs; and small cobble substrate was observed in 10% of pool tail-outs.

The mean percent canopy density for the surveyed length of Weeks Creek was 85%. Of the canopy present, the mean percentages of hardwood and coniferous trees were 97% and 3%, respectively. Fifteen percent of the canopy was open. Graph 9 describes the mean percent canopy in Weeks Creek.

For the stream reach surveyed, the mean percent right bank vegetated was 84%. The mean percent left bank vegetated was 80% (Table 7). The dominant elements composing the structure of the stream banks consisted of 65% cobble/gravel, 17% boulder, 13% bedrock, and 5% sand/silt/clay (Graph 10). Deciduous trees were the dominant vegetation type observed in 78% of the units surveyed. Additionally, 19% of the units surveyed had brush as the dominant vegetation type, and 3% had grass as the dominant vegetation type (Graph 11).

DISCUSSION

Weeks Creek is a B3 channel type for 10,382 feet of the stream surveyed, and an A1 channel type for 1,157 feet of the stream surveyed. The suitability of B3 and A1 channel types for fish habitat improvement structures is/are as follows: B3 channel types are excellent for plunge weirs, boulder clusters and bank-placed boulders, single and opposing wing-deflectors, and log cover; and A1 channels are generally not suitable for fish habitat improvement projects.

The water temperatures recorded on the survey days 8/20/2012 to 8/21/2012, ranged from 56 to 69 degrees Fahrenheit. Air temperatures ranged from 64 to 83 degrees Fahrenheit. To make any further conclusions, temperatures would need to be monitored throughout the warm summer months, and more extensive biological sampling would need to be conducted.

Flatwater habitat types comprised 5% of the total length of this survey, riffles 6%, and pools 12%. The pools are relatively shallow, with 11 of the 31 (35%) pools having a maximum residual depth greater than two feet. In general, pool enhancement projects are considered when primary pools comprise less than 40% of the length of total stream habitat. In first and second order streams, a primary pool is defined to have a maximum residual depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. Installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not be threatened by high stream energy, or where their installation will not conflict with the modification of the numerous log debris accumulations (LDA's) in the stream.

Twenty-nine of the 31 pool tail-outs measured had embeddedness ratings of 1 or 2. Two of the pool tail-outs had embeddedness ratings of 3 or 4. Zero of the pool tail-outs had a rating of 5, which is considered unsuitable for spawning. Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. Sediment sources in Weeks Creek should be mapped and rated according to their potential sediment yields, and control measures should be taken.

Twenty-nine of the 31 pool tail-outs measured had gravel and small cobble as the dominant substrate. This is generally considered good for spawning salmonids.

The mean shelter rating for pools is 16. The shelter rating in the flatwater habitats is 10. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by boulders in Weeks Creek. Boulders are the dominant cover type in pools, followed by undercut banks. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition.

The mean percent canopy density for the stream was 85%. Reach 1 had a canopy density of 82.2%, and Reach 2 had a canopy density of 93.7%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was 84% and 80%, respectively. In areas of stream bank erosion or where bank vegetation is sparse, planting endemic species of coniferous and hardwood trees, in conjunction with bank stabilization, is recommended.

GENERAL RECOMMENDATIONS

Weeks Creek should be managed as an anadromous, natural production stream.

Winter storms often bring down large trees and other woody debris into the stream, which increases the number and quality of pools. This woody debris, if left undisturbed, will provide fish shelter and rearing habitat, and offset channel incision. Landowners should be sensitive about the natural and positive role woody debris plays in the system, and encouraged not to remove woody debris from the stream, except under extreme buildup and only under guidance by a fishery professional.

RECOMMENDATIONS

1) The limited water temperature data available suggest that maximum temperatures are above the acceptable range for juvenile salmonids. To establish more complete and meaningful temperature regime information, 24-hour monitoring during the July and August temperature extreme period should be performed for 3 to 5 years.

2) Increase woody cover in the pools and flatwater habitat units. Most of the existing cover in the pools is from Boulders. Adding high quality complexity with woody cover in the pools is desirable.

3) Access for migrating salmonids should be assessed at all road crossings and dams. Sites of particular concern include all the identified ford crossings which exist throughout the surveyed watershed, all in-stream private property boundary fences and associated debris catchment racks. Sites also include the Cleland Ranch Road culvert and the Dam site at habitat unit 058. All fish passage assessments should be done according to Part 9 of the California Salmonid Stream Habitat Restoration Manual (Flosi et al, 1998). Where needed, crossings should be replaced or modified to improve fish passage.

4) The majority of Reaches 1 and 2 of Weeks Creek are being impacted from livestock in the riparian zone. Livestock in streams generally inhibit the growth of new trees, exasperate erosion, and reduce summertime survival of juvenile fish by defecating in the water. Alternatives to limit cattle access, control erosion and increase canopy, should be explored with the landowner, and developed if possible.

5) Increase the canopy on Weeks Creek particularly in Reach 1, by planting appropriate native vegetation like willow, alder, redwood, and Douglas fir along the stream where shade canopy is not at acceptable levels. The reaches above this survey section should be inventoried and treated as well, since the water flowing here is affected from upstream. In many cases, planting will need to be coordinated to follow bank stabilization or upslope erosion control projects.

COMMENTS AND LANDMARKS

The following landmarks and possible problem sites were noted. All distances are approximate and taken from the beginning of the survey reach.

Position	Habitat Unit #	Memo
0	0001.00	Start of survey at the confluence of Weeks Creek with Mark West Creek. Way point (WP)# 15

Weeks Creek

Position	Habitat Unit #	Memo
		N38.5089 W122.6493
0	0001.00	100 ft into the unit is a foot bridge with an attached pipe. 423 ft into the unit is a cobble wall on the left bank. 15 ft tall at the highest point, followed by rip rap for the next 73 ft. The total wall length = 118 ft. 100's of chorus frogs were observed. 929 ft into unit is a ford being built out of cobble and cement across the creek. The plunge is 1 ft on both the upstream and downstream side. The walls are 1 ft wide. Likely a barrier to juvenile and adult salmonids.
1,223	0002.00	Bridge1 is Calistoga Rd, made out of concrete, with length =61', height =8', width =24', and the height from the sill to the water level = 0'. The bridge is not retaining gravel, there is no associated downcutting, and it is not a barrier. There is a concrete support wall in middle in the middle of the creek. The left bank side of the bridge is clear and the right bank side has a 1.5' layer of gravel on the bottom. There is rip rap on the right and left bank on both the upstream and downstream side. WP 016 N38.50567, W 122.65013.
1,284	0003.00	Sheep on the left bank have access to creek throughout the property. 560 feet into the unit is an old ford crossing. It is unknown if the crossing is still in use, the channel does not look impacted from crossing.
1,284	0003.00	Left bank tributary 1 is 138' into the unit. The channel is dry. The water temperatures = N/A. The crew checked 200 ft up and determined the tributary is accessible to fish. The estimated slope = 1-2%. The tributary has no canopy for approximately the first 1000 feet because it runs through a pasture. WP 17 N 38.50522, W122.65017
2,198	0007.00	12 feet into the unit is a debris catch/ property line fence through the creek. It is an electric fence.
2,333	0008.00	The water quality looks poor.
2,357	0009.00	Left bank tributary 2 is 91' into unit. The tributary is unnamed and is dry. The water temperatures = N/A. The crew checked 75' up and determined it is accessible to fish. The estimated slope 1-2% for the first 300' then increases to an estimated 4-10%. The tributary is overgrown with blackberry and grass. WP

Weeks Creek

Position	Habitat Unit #	Memo
		18, N 38.50243 W122.65039
2,762	0015.00	Unidentified fish observed
2,817	0017.00	Pacific Giant Salamander observed. A culvert from Calistoga Road is on the right bank near the top of the unit. The culvert is a corrugated metal pipe (CMP) and is 1 ft in diameter.
3,174	0023.00	2+ salmonid observed
3,226	0025.00	Five 1+ salmonids observed
3,347	0027.00	One 2+ and two 1+ salmonids observed
3,427	0028.00	There is a trail to the creek near the top of the unit. The trail follows along the left bank of the creek. There is a road further up on the left bank.
3,546	0030.00	Left bank tributary # 3 is at the top of unit. It is unnamed and is dry. The water temperature upstream = 60F, downstream = N/A, and in the tributary = N/A. The crew checked 300' up and determined it is accessible to fish. The estimated slope= 2%. The channel is moderately entrenched. The dominant substrate is gravel and cobble. The channel is overgrown after 150'. WP 21 N 38.49924 W122.64947
4,084	0037.00	Bridge # 2 is Calistoga Rd, which is made of concrete, with length =45', height =11', width =31', and the height from the water to sill = 0.5'. The bridge is not retaining gravel and there is no associated downcutting. The channel under the bridge has a natural bottom, The right bank sill was removed and part of the channel is covered in concrete 4.5' wide and 30' long from the downstream side. WP 22 N38.49916 W122.64880
4,298	0041.00	Left bank tributary #4 enters at the top of the unit. It is dry. The water temperatures = N/A. The crew checked 150' up and determined it is accessible to fish for the first 125'. The estimated slope = 2-4%. 125' up the tributary is a culvert with 4' plunge. Gravel is the dominant substrate. WP 24 N38.49883 W122.64831
4,647	0047.00	Four young-of-the-year (YOY) salmonids observed. The stream is drying up and is only 0.3 feet deep.
4,657	0048.00	375 feet into the unit is a CMP, approximately 1 foot in diameter, on the left bank from a road drainage.

Weeks Creek

Position	Habitat Unit #	Memo
4,657	0048.00	Left bank tributary # 5 is 450' into unit. It is dry. The water temperatures = N/A. The crew checked 100 ft up to where a fence crosses the creek. The tributary is not accessible to fish. The estimated slope = 4-6%. The channel is slightly overgrown. The gradient increases after the fence crossing. WP 25 N38.49794 W122.64636
6,182	0050.00	The first 14 feet is a ford crossing. There is a spring feeding the crossing on the right bank.
6,238	0051.00	180 feet into the unit is a property fence spanning the creek.
7,070	0053.00	Left bank tributary # 6 is 205' in unit. It is dry. The water temperatures = N/A. The crew checked 200' up and determined it is accessible to fish. The estimated slope = 2-4%, 75' up is a culvert under a dirt rd. The dominant substrate is gravel and cobble. The tributary flows through a pasture. There is no access to the creek. WP 27 N38.49485 W122.64099
7,450	0058.00	Dam 1 has length =4', height =7', width(o)=32', width (d)=N/A, and the height from water to sill= 2'. There are partial flashboards in place. There is downcutting with height = 2.8'. The dam is retaining gravel and it is a possible barrier to juveniles and adults. There is one 1' tall flashboard installed in the dam. WP28 N38.49490 W122.64053, Pictures 9 and 10 taken
7,454	0059.00	There is a bare slope on the right bank and a house upslope of the right bank.
7,523	0060.00	Bridge 3 is a private footbridge made of wood, with length =10', height =5', and width =35'. The bridge is not retaining gravel, there is no associated down cutting, and there is no sill. The bridge is not a barrier and it has a natural stream bottom. There is rip rap on the right bank and a cement retaining wall on the left bank stabilizing bridge WP 29 N38.49492 W122.64009
7,951	0062.00	Bridge 4 is a private driveway/road made of concrete and steel, with length =15', height =5', width =25', and the height from the water to sill = 0'. The sill is level with the channel. It is not retaining gravel, there is no downcutting, and it is not a possible barrier. WP 30 N38.49466 W122.63861
7,951	0062.00	Left bank tributary 7 is at the top unit. It is wet with

Position	**Habitat Unit #**	**Memo**
		discharge =0cfs. The water temperatures = N/A. The crew checked 150' up and determined it is accessible to fish. The estimated slope = 2-4%. 75' up the tributary are 2 culverts half full of gravel. On the right bank of the tributary 75' up are 2 large water tanks, one is providing water to the tributary through a pvc pipe. The tributary is overgrown. WP # 30 N38.49466 W122.63861
9,318	0066.00	Four unidentified fish observed
9,371	0069.00	Bridge 5 is Cleland Ranch Road. It is made of wood and steel with length =23', height =9.5', width =50', and the height from the water to sill = 2'-3'. The bridge is retaining gravel, there is associated downcutting, and it is a possible barrier to salmonids. There is a partially intact sill on the downstream end of the bridge with a 3-5' plunge. The sill is slanted and the spill way under the bridge sill is broken out. The old wood bridge remnants are left under the functional railroad bridge. WP 32 N38.49426 W122.63420
9,394	0070.00	10' downstream from the top of the unit is a property boundary fence spanning the creek.
9,394	0070.00	Left bank tributary 8 is 46 ft into the unit. It is dry. The water temperatures = N/A. The crew checked 150' up and determined the tributary is accessible to fish. The estimated slope = 4-10%. The dominant substrate is gravel and cobble. Overall the gradient is steep and the channel is entrenched. WP 32 taken 48 ft downstream of the tributary. N38.49426 W122.63420 Right bank tributary # 9 is 338' into unit. It is dry. The water temperatures = N/A. The crew checked 200' up and determined it is accessible to fish. The estimated slope 1-4%. The dominant substrate is gravel and cobble substrate. 25' up the tributary is a trail crossing. The channel is overgrown. WP 33 N38.49413 W122.63314. Left bank tributary 10 is 644' into unit. It is dry. The water temperatures = N/A. The crew checked 200' up and determined it was accessible to fish. The estimated slope = 1-3%. 75' into the tributary is a trail crossing. The trail is extremely overgrown with vegetation. The dominant substrate is cobble and gravel. WP 34 N38.49415

Weeks Creek

Position	Habitat Unit #	Memo
10,274	0071.00	At the top of the unit is a 2" diameter pvc pipe spanning the channel
10,382	0072.00	One unidentified fish and many pacific chorus frogs observed. 66' into the unit is an old ford crossing.
10,471	0073.00	Many salmonid YOY observed throughout the unit. Water begins to flow starting at this unit.
10,941	0077.00	Salmonid YOY observed
11,060	0078.00	One sculpin observed
11,060	0078.00	Right bank tributary 11 is 22' into the unit. It is dry with discharge = 0cfs.The water temperatures = N/A. The crew checked 100' up and determined it is not accessible to fish. The estimated slope >10%. The dominant substrate is boulder and bedrock. The channel is steep from the confluence up. WP 36 N38.49499 W122.62897
11,105	0079.00	One 1+ salmonid and one YOY observed
11,163	0081.00	At the top of the unit on the right bank is an animal trail.
11,213	0082.00	The grade of the unit is approximately 4-10%
11,213	0082.00	At top of unit on the left bank is a landslide, approximately 55' x40' x4'.
11,351	0083.00	The left bank landslide extends into this unit
11,539	0086.00	End of survey due to a large water fall, which is a barrier to anadromous fish. Previous surveys concluded that no fish are present above the natural barrier. WP 38 N38.49509 W122.62760

REFERENCES

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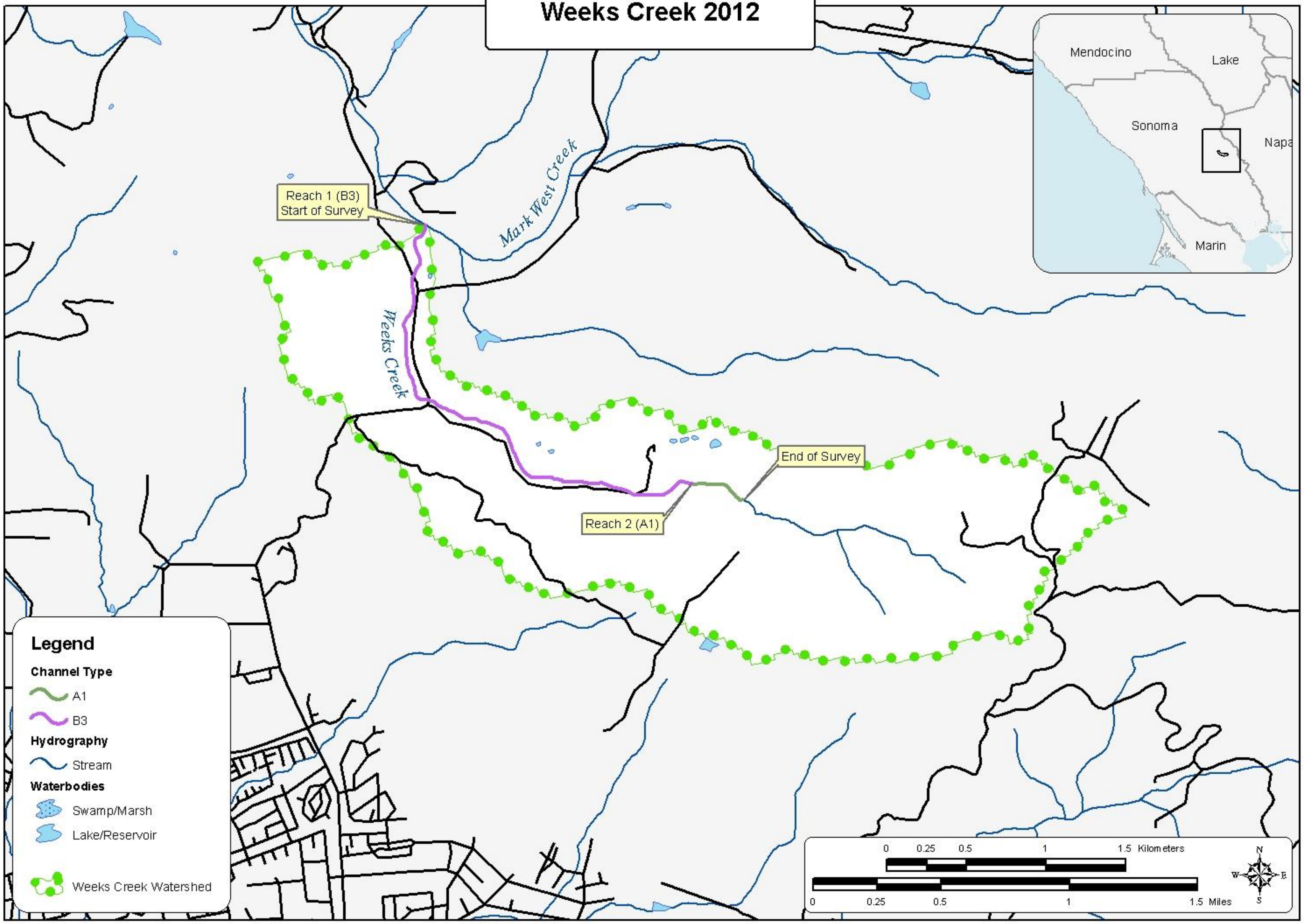
McCain, M., D. Fuller, L. Decker and K. Overton. 1990. Stream habitat classification and inventory procedures for northern California. FHC Currents. No.1. U.S. Department of Agriculture. Forest Service, Pacific Southwest Region.

Rosgen, D.L., 1994. A Classification of Natural Rivers. Catena, Vol 22: 169-199, Elsevier Science, B. V. Amsterdam.

LEVEL III and LEVEL IV HABITAT TYPES

RIFFLE			
Low Gradient Riffle	(LGR)	[1.1]	{ 1 }
High Gradient Riffle	(HGR)	[1.2]	{ 2 }
CASCADE			
Cascade	(CAS)	[2.1]	{ 3 }
Bedrock Sheet	(BRS)	[2.2]	{24}
FLATWATER			
Pocket Water	(POW)	[3.1]	{21}
Glide	(GLD)	[3.2]	{14}
Run	(RUN)	[3.3]	{15}
Step Run	(SRN)	[3.4]	{16}
Edgewater	(EDW)	[3.5]	{18}
MAIN CHANNEL POOLS			
Trench Pool	(TRP)	[4.1]	{ 8 }
Mid-Channel Pool	(MCP)	[4.2]	{17}
Channel Confluence Pool	(CCP)	[4.3]	{19}
Step Pool	(STP)	[4.4]	{23}
SCOUR POOLS			
Corner Pool	(CRP)	[5.1]	{22}
Lateral Scour Pool - Log Enhanced	(LSL)	[5.2]	{10}
Lateral Scour Pool - Root Wad Enhanced	(LSR)	[5.3]	{11}
Lateral Scour Pool - Bedrock Formed	(LSBk)	[5.4]	{12}
Lateral Scour Pool - Boulder Formed	(LSBo)	[5.5]	{20}
Plunge Pool	(PLP)	[5.6]	{ 9 }
BACKWATER POOLS			
Secondary Channel Pool	(SCP)	[6.1]	{ 4 }
Backwater Pool - Boulder Formed	(BPB)	[6.2]	{ 5 }
Backwater Pool - Root Wad Formed	(BPR)	[6.3]	{ 6 }
Backwater Pool - Log Formed	(BPL)	[6.4]	{ 7 }
Dammed Pool	(DPL)	[6.5]	{13}
ADDITIONAL UNIT DESIGNATIONS			
Dry	(DRY)	[7.0]	
Culvert	(CUL)	[8.0]	
Not Surveyed	(NS)	[9.0]	
Not Surveyed due to marsh	(MAR)	[9.1]	

Weeks Creek 2012



DFGWatershed_Overview\Russian_River\2012_MW\WeeksCreek_2012.mxd

Prepared by: Scott Webb, December 2012

Table 1 - Summary of Riffle, Flatwater, and Pool Habitat Types

Stream Name: Weeks Creek **LLID:** 1226482385089 **Drainage:** Russian River - Middle

Survey 8/20/2012 to 8/21/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR07WS29 **Latitude:** 38:30:32.0N **Longitude:** 122:38:54.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating
6	0	CULVERT	7.0	26	158	1.4									
28	0	DRY	32.6	313	8770	76.0									
11	7	FLATWATER	12.8	51	566	4.9	3.6	0.4	0.8	151	1656	66	725		10
31	31	POOL	36.0	45	1386	12.0	7.5	0.9	1.7	255	7919	321	9943	307	16
10	5	RIFFLE	11.6	66	659	5.7	2.0	0.2	0.5	75	746	16	164		5

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
86	43	11539	10321	10832

Table 2 - Summary of Habitat Types and Measured Parameters

Stream Name: Weeks Creek **LLID:** 1226482385089 **Drainage:** Russian River - Middle

Survey 8/20/2012 to 8/21/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR07WS29 **Latitude:** 38:30:32.0N **Longitude:** 122:38:54.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating	Mean Canopy (%)
3	2	LGR	3.5	52	157	1.4	2.0	0.1	0.3	45	135	5	14		0	86
2	1	HGR	2.3	70	139	1.2	2.0	0.2	0.4	53	107	11	21		5	96
2	1	CAS	2.3	117	234	2.0	3.0	0.3	0.8	166	331	50	99		15	90
3	1	BRS	3.5	43	129	1.1	2.0	0.2	0.8	64	191	13	38		5	96
7	4	RUN	8.1	31	220	1.9	3.0	0.4	1.1	86	605	41	286		8	71
4	3	SRN	4.7	86	346	3.0	4.0	0.4	1.0	236	944	99	397		13	79
20	20	MCP	23.3	28	555	4.8	7.0	0.8	2.9	191	3830	193	3854	181	21	85
5	5	STP	5.8	131	656	5.7	7.0	0.8	2.6	474	2370	564	2820	535	7	93
3	3	CRP	3.5	32	96	0.8	7.0	0.9	2.3	276	828	380	1139	380	7	60
1	1	LSL	1.2	34	34	0.3	7.0	1.7	2.4	238	238	405	405	405	5	90
2	2	PLP	2.3	22	45	0.4	16.0	2.3	4.6	327	654	863	1725	830	8	94
28	0	DRY	32.6	313	8770	76.0										87
6	0	CUL	7.0	26	158	1.4										

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume
86	43	11539	10233	10799(cu.ft.)

Table 3 - Summary of Pool Habitat Types

Stream Name: Weeks Creek **LLID:** 1226482385089 **Drainage:** Russian River - Middle

Survey 8/20/2012 to 8/21/2012

Confluence Location: **Quad:** MARK WEST SPRINGS **Legal Description:** T08NR07WS29 **Latitude:** 38:30:32.0N **Longitude:** 122:38:54.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Residual Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Residual Pool Vol (cu.ft.)	Estimated Total Resid. Vol (cu.ft.)	Mean Shelter Rating
25	25	MAIN	81	48	1211	87	7.0	0.8	248	6200	252	6306	18
6	6	SCOUR	19	29	175	13	10.0	1.5	287	1720	534	3204	7
Total Units	Total Units Fully Measured				Total Length (ft.)					Total Area (sq.ft.)		Total Volume (cu.ft.)	
31	31				1386					7919		9510	

Table 4 - Summary of Maximum Residual Pool Depths By Pool Habitat Types

Stream Name: Weeks Creek **LLID:** 1226482385089 **Drainage:** Russian River - Middle

Survey 8/20/2012 to 8/21/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR07WS29 **Latitude:** 38:30:32.0N **Longitude:** 122:38:54.0W

Habitat Units	Habitat Type	Habitat Occurrence (%)	< 1 Foot Maximum Residual Depth	< 1 Foot Percent Occurrence	1 < 2 Feet Maximum Residual Depth	1 < 2 Feet Percent Occurrence	2 < 3 Feet Maximum Residual Depth	2 < 3 Feet Percent Occurence	3 < 4 Feet Maximum Residual Depth	3 < 4 Feet Percent Occurrence	>= 4 Feet Maximum Residual Depth	>= 4 Feet Percent Occurrence
20	MCP	65	5	25	11	55	4	20	0	0	0	0
5	STP	16	0	0	2	40	3	60	0	0	0	0
3	CRP	10	1	33	1	33	1	33	0	0	0	0
1	LSL	3	0	0	0	0	1	100	0	0	0	0
2	PLP	6	0	0	0	0	0	0	1	50	1	50

Total Units			Total < 1 Foot Max Resid. Depth	Total < 1 Foot % Occurrence	Total 1< 2 Feet Max Resid. Depth	Total 1< 2 Feet % Occurrence	Total 2< 3 Feet Max Resid. Depth	Total 2< 3 Feet % Occurrence	Total 3< 4 Feet Max Resid. Depth	Total 3< 4 Feet % Occurrence	Total >= 4 Feet Max Resid. Depth	Total >= 4 Feet % Occurrence
31			6	19	14	45	9	29	1	3	1	3

Mean Maximum Residual Pool Depth (ft.): 2

Table 5 - Summary of Mean Percent Cover By Habitat

Stream Name: Weeks Creek **Dry Units:** 28 **LLID:** 1226482385089 **Drainage:** Russian River - Middle

Survey 8/20/2012 to 8/21/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR07WS29 **Latitude:** 38:30:32.0N **Longitude:** 122:38:54.0W

Habitat Units	Units Fully Measured	Habitat Type	Mean % Undercut Banks	Mean % SWD	Mean % LWD	Mean % Root Mass	Mean % Terr. Vegetation	Mean % Aquatic Vegetation	Mean % White Water	Mean % Boulders	Mean % Bedrock Ledges
3	2	LGR	0	0	0	0	0	0	0	0	0
2	1	HGR	0	0	0	0	0	0	0	100	0
2	1	CAS	0	0	0	0	0	0	0	100	0
3	1	BRS	0	0	0	0	0	0	0	100	0
10	5	TOTAL RIFFLE	0	0	0	0	0	0	0	60	0
7	4	RUN	13	0	0	13	25	25	0	25	0
4	3	SRN	0	0	0	13	0	0	0	87	0
11	7	TOTAL FLAT	7	0	0	13	14	14	0	51	0
20	20	MCP	15	6	4	15	11	0	0	38	3
5	5	STP	6	6	14	6	8	0	0	60	0
3	3	CRP	0	3	0	0	20	0	0	77	0
1	1	LSL	40	60	0	0	0	0	0	0	0
2	2	PLP	0	0	0	0	0	0	0	25	75
31	31	TOTAL POOL	12	7	5	10	10	0	0	43	6
6	0	CUL									
86	43	TOTAL	10	5	3	10	10	2	0	47	5

Table 6 - Summary of Dominant Substrates By Habitat Type

Stream Name: Weeks Creek **Dry Units:** 28 **LLID:** 1226482385089 **Drainage:** Russian River - Middle

Survey 8/20/2012 to 8/21/2012

Confluence Location: **Quad:** MARK WEST SPRINGS **Legal Description:** T08NR07WS29 **Latitude:** 38:30:32.0N **Longitude:** 122:38:54.0W

Habitat Units	Units Fully Measured	Habitat Type	% Total Silt/Clay Dominant	% Total Sand Dominant	% Total Gravel Dominant	% Total Small Cobble Dominant	% Total Large Cobble Dominant	% Total Boulder Dominant	% Total Bedrock Dominant
3	2	LGR	0	0	50	0	50	0	0
2	1	HGR	0	0	0	0	100	0	0
2	1	CAS	0	0	0	0	0	100	0
3	1	BRS	0	0	0	0	0	0	100
7	4	RUN	0	0	25	50	25	0	0
4	3	SRN	0	0	33	33	33	0	0
20	20	MCP	0	15	60	15	0	5	5
5	5	STP	0	0	40	0	40	20	0
3	3	CRP	0	0	67	33	0	0	0
1	1	LSL	0	0	100	0	0	0	0
2	2	PLP	0	0	0	0	50	0	50
6	0	CUL	0	0	0	0	0	0	0

Table 7 - Summary of Mean Percent Canopy for Entire Stream

Stream Name: Weeks Creek **LLID:** 1226482385089 **Drainage:** Russian River - Middle

Survey 8/20/2012 to 8/21/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR07WS29 **Latitude:** 38:30:32.0N **Longitude:** 122:38:54.0W

Mean Percent Canopy	Mean Percent Conifer	Mean Percent Hardwood	Mean Percent Open Units	Mean Right Bank % Cover	Mean Left Bank % Cover
85	3	97	0	84	80

Note: Mean percent conifer and hardwood for the entire reach are means of canopy components from units with canopy values greater than zero.

Open units represent habitat units with zero canopy cover.

Table 8 - Fish Habitat Inventory Data Summary

Stream Weeks Creek LLID: 1226482385089 Drainage Russian River - Middle

Survey Dates: 8/20/2012 to 8/21/2012 Survey Length (ft.): 11539 Main Channel (ft.): 11539 Side Channel (ft.): 0

Confluence Location: Quad MARK WEST Legal Description: T08NR07WS29 Latitude: 38:30:32.0N Longitude: 122:38:54.0W

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 1

Channel Type: B3	Canopy Density (%): 82.2	Pools by Stream Length 7.9
Reach Length (ft.): 10382	Coniferous Component (%): 2.4	Pool Frequency (%): 35.2
Riffle/Flatwater Mean Width (ft.): 3.1	Hardwood Component 97.6	Residual Pool Depth (%):
BFW:	Dominant Bank Hardwood Trees	< 2 Feet Deep: 72.0
Range (ft.): 6.00 to 23.00	Vegetative Cover (%): 88.3	2 to 2.9 Feet Deep: 28.0
Mean (ft.): 16.49	Dominant Boulders	3 to 3.9 Feet Deep: 0.0
Std. Dev.: 4.63	Dominant Bank Substrate Cobble/Gravel	>= 4 Feet Deep: 0.0
Base Flow (cfs):	Occurrence of LWD (%): 4.2	Mean Max Residual Pool Depth 1.46
Water (F): 0 - 69 Air (F): 64 - 83	LWD per 100 ft.:	Mean Pool Shelter 18
Dry Channel (ft.): 8725	Riffles: 0	
	Pools: 1	
	Flat: 0	

Pool Tail Substrate (%): Silt/Clay: 0.0 Sand: 0.0 Gravel: 88.0 Sm Cobble: 8.0 Lg Cobble: 0.0 Boulder 0.0 Bedrock: 4.0

Embeddedness Values (%): 1. 60.0 2. 32.0 3. 4.0 4. 4.0 5. 0.0

STREAM REACH: 2

Channel Type: A1	Canopy Density (%): 93.7	Pools by Stream Length 48.7
Reach Length (ft.): 1157	Coniferous Component (%): 5.0	Pool Frequency (%): 40.0
Riffle/Flatwater Mean Width (ft.): 2.5	Hardwood Component 95.0	Residual Pool Depth (%):
BFW:	Dominant Bank Hardwood Trees	< 2 Feet Deep: 33.3
Range (ft.): 6.00 to 15.00	Vegetative Cover (%): 61.8	2 to 2.9 Feet Deep: 33.3
Mean (ft.): 9.60	Dominant Boulders	3 to 3.9 Feet Deep: 16.7
Std. Dev.: 4.41	Dominant Bank Substrate Bedrock	>= 4 Feet Deep: 16.7
Base Flow (cfs): 0	Occurrence of LWD (%): 1.0	Mean Max Residual Pool Depth 2.51
Water (F): 60 - 69 Air (F): 80 - 83	LWD per 100 ft.:	Mean Pool Shelter 8
Dry Channel (ft.): 45	Riffles: 0	
	Pools: 0	
	Flat: 4	

Pool Tail Substrate (%): Silt/Clay: 0.0 Sand: 0.0 Gravel: 66.7 Sm Cobble: 16.7 Lg Cobble: 16.7 Boulder 0.0 Bedrock: 0.0

Embeddedness Values (%): 1. 33.3 2. 66.7 3. 0.0 4. 0.0 5. 0.0

Table 9 -Mean Percentage of Dominant Substrate and Vegetation

Stream Name: Weeks Creek **LLID:** 1226482385089 **Drainage:** Russian River - Middle

Survey 8/20/2012 to 8/21/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR07WS29 **Latitude:** 38:30:32.0N **Longitude:** 122:38:54.0W

Mean Percentage of Dominant Stream Bank Substrate

Dominant Class of Substrate	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percentage (%)
Bedrock	5	6	12.8
Boulder	7	8	17.4
Cobble/Gravel	28	28	65.1
Sand/Silt/Clay	3	1	4.7

Mean Percentage of Dominant Stream Bank Vegetation

Dominant Class of Vegetation	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percentage
Grass	3	0	3.5
Brush	9	7	18.6
Hardwood	31	36	77.9
Coniferous	0	0	0.0
No Vegetation	0	0	0.0

Total Stream Cobble Embeddedness Values: 2

Table 10 - Mean Percent of Shelter Cover Types For Entire Stream

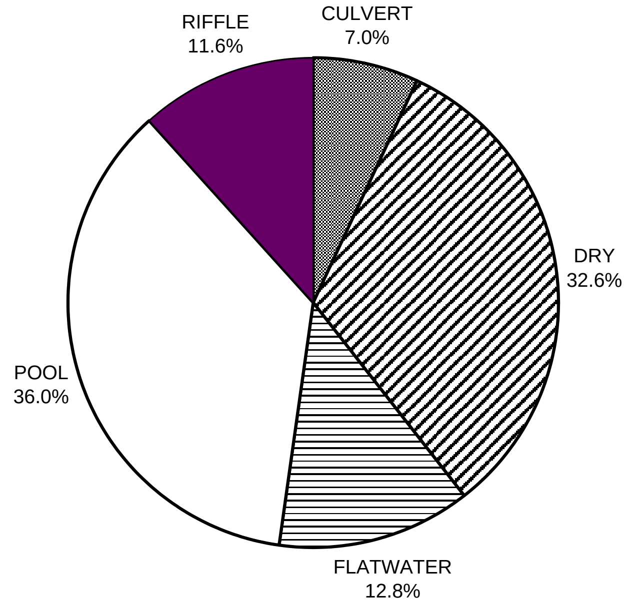
Stream Name: Weeks Creek **LLID:** 1226482385089 **Drainage:** Russian River - Middle

Survey 8/20/2012 to 8/21/2012

Confluence Location: Quad: MARK WEST SPRINGS **Legal Description:** T08NR07WS29 **Latitude:** 38:30:32.0N **Longitude:** 122:38:54.0W

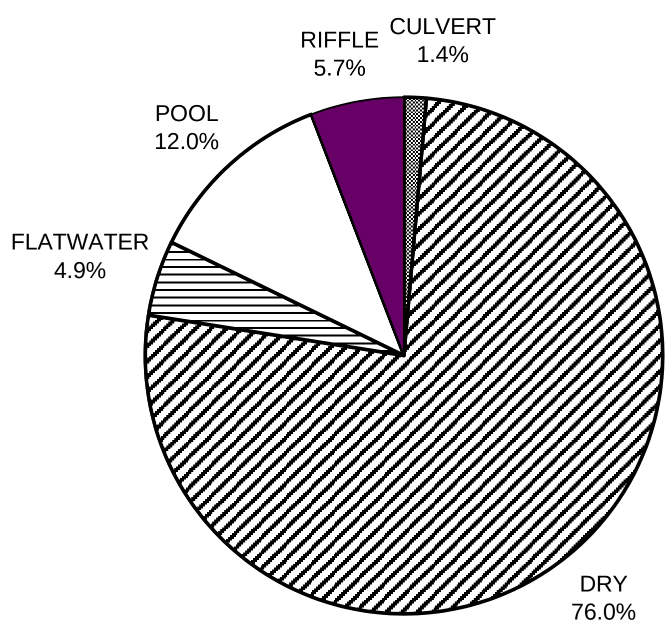
	Riffles	Flatwater	Pools
UNDERCUT BANKS (%)	0	7	12
SMALL WOODY DEBRIS (%)	0	0	7
LARGE WOODY DEBRIS (%)	0	0	5
ROOT MASS (%)	0	13	10
TERRESTRIAL VEGETATION	0	14	10
AQUATIC VEGETATION (%)	0	14	0
WHITEWATER (%)	0	0	0
BOULDERS (%)	60	51	43
BEDROCK LEDGES (%)	0	0	6

WEEKS CREEK 2012
HABITAT TYPES BY PERCENT OCCURRENCE



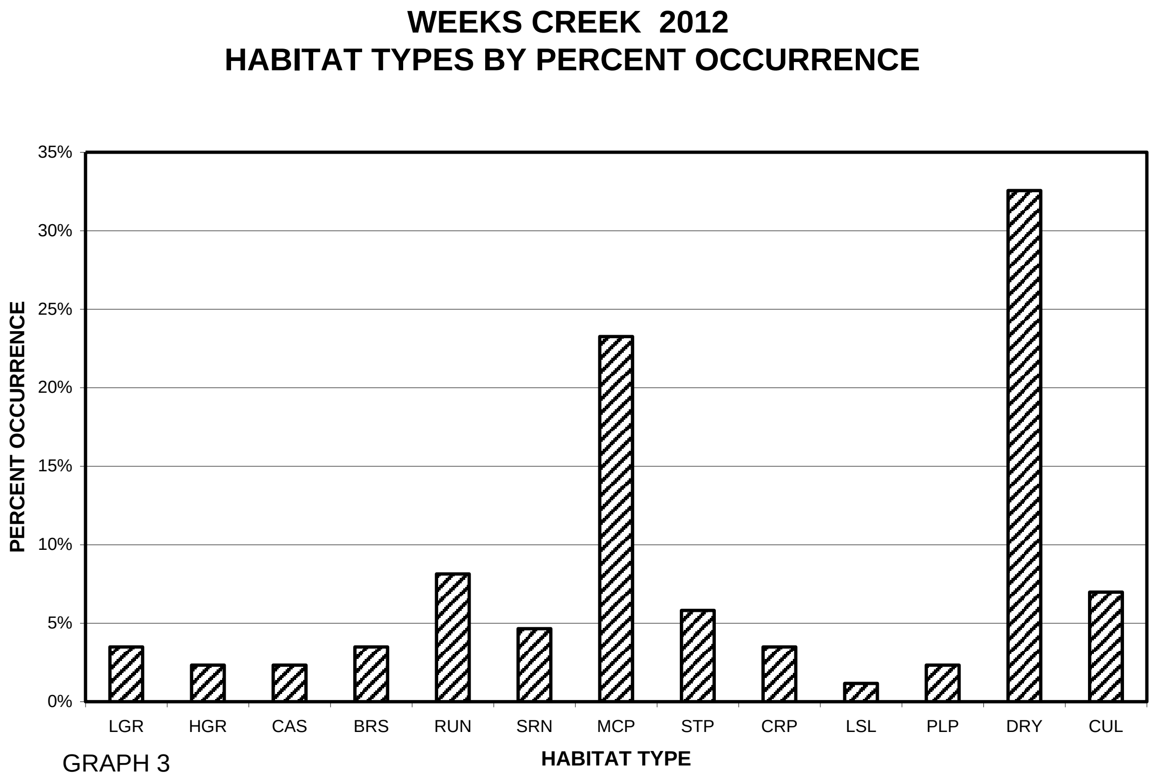
GRAPH 1

WEEKS CREEK 2012
HABITAT TYPES BY PERCENT TOTAL LENGTH

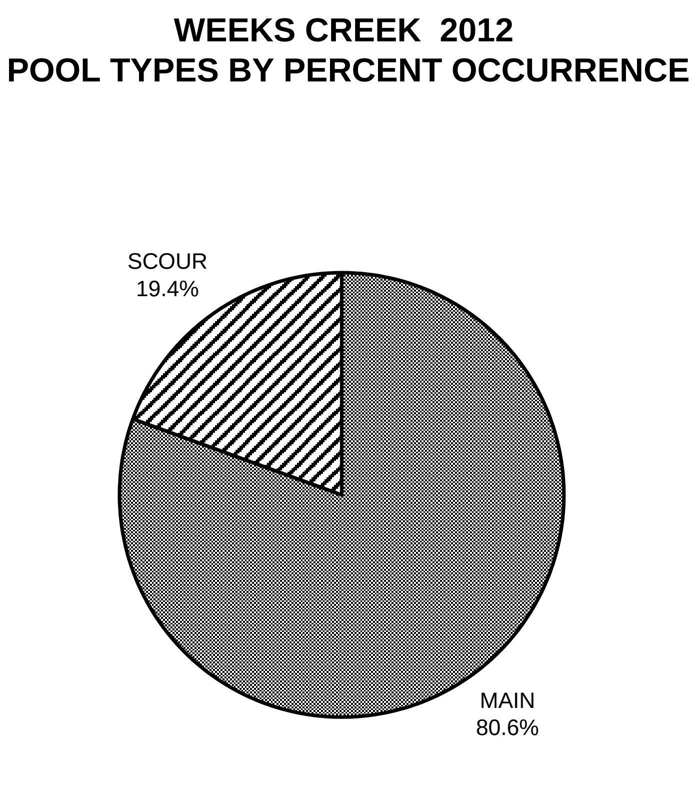


GRAPH 2

Weeks Creek

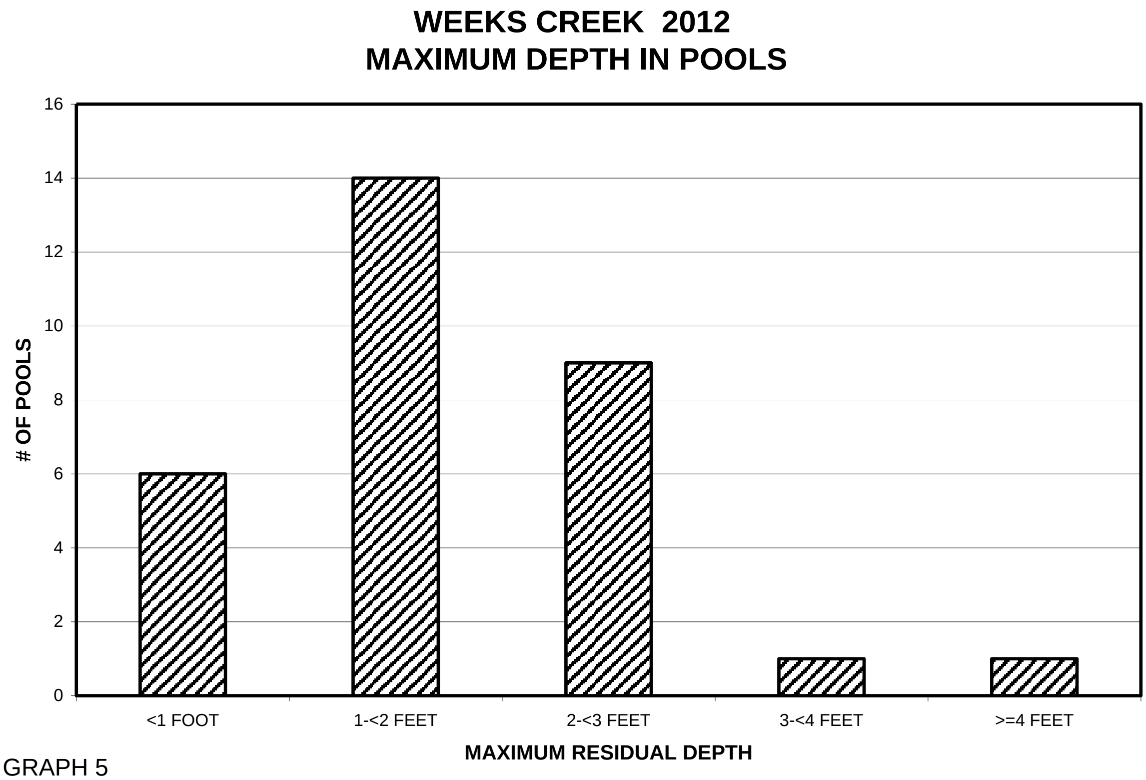


GRAPH 3

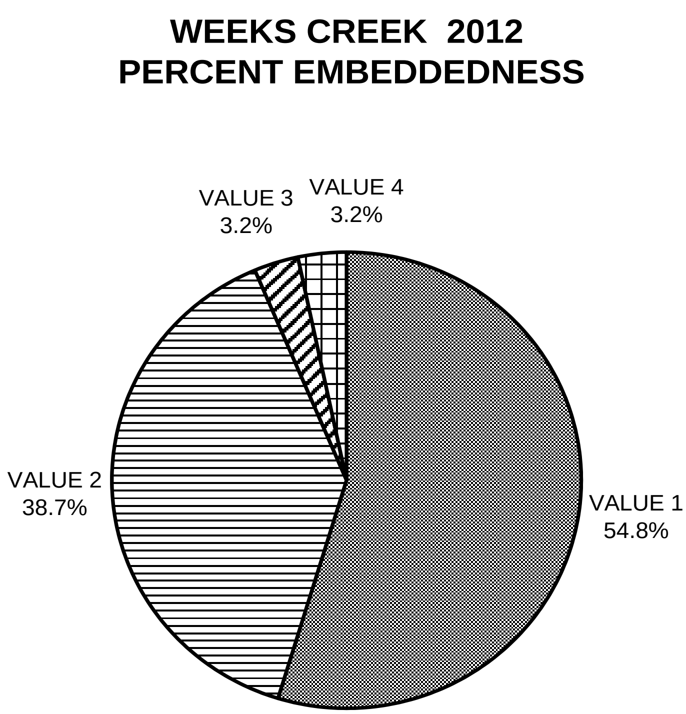


GRAPH 4

Weeks Creek

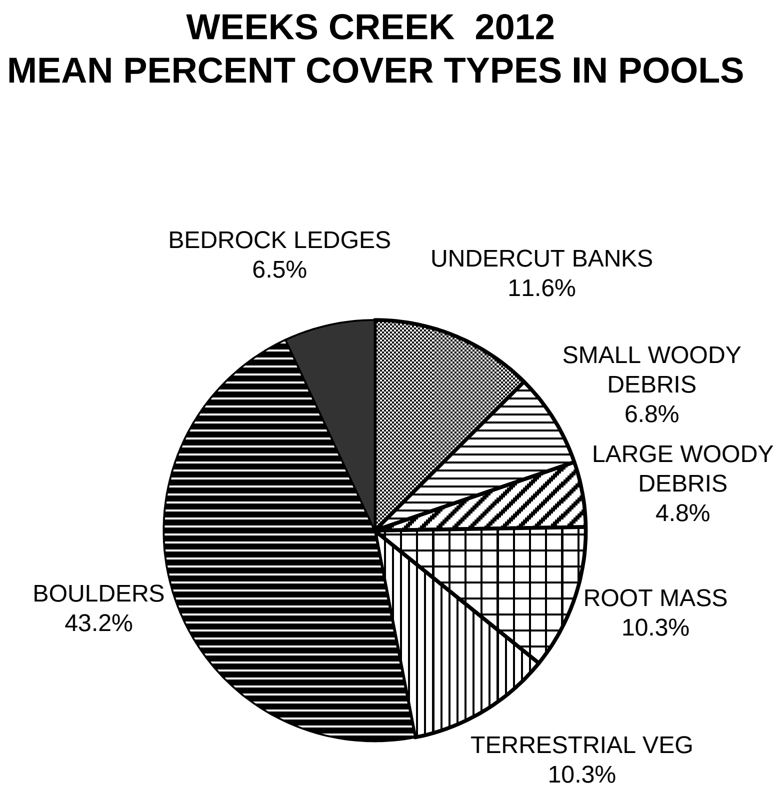


GRAPH 5

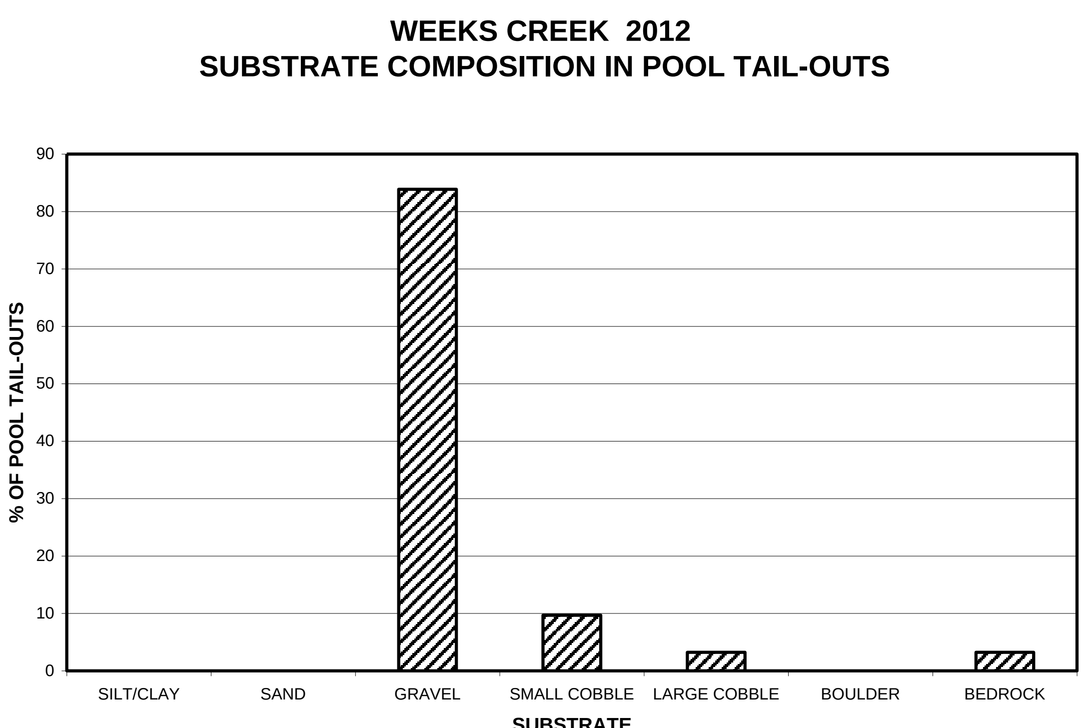


GRAPH 6

Weeks Creek

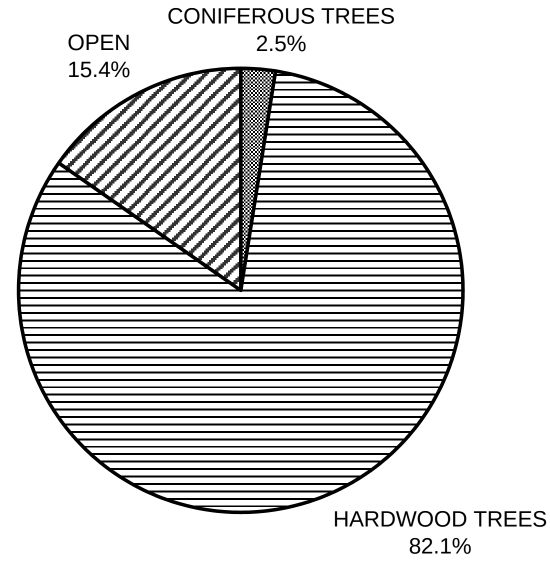


GRAPH 7



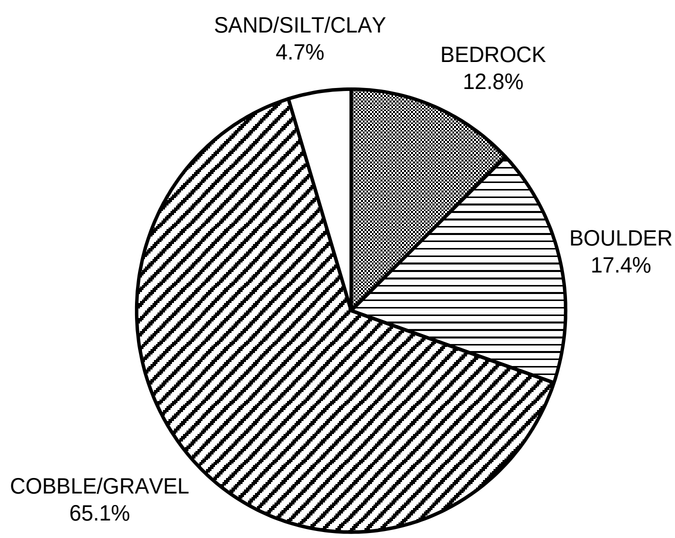
GRAPH 8

WEEKS CREEK 2012
MEAN PERCENT CANOPY

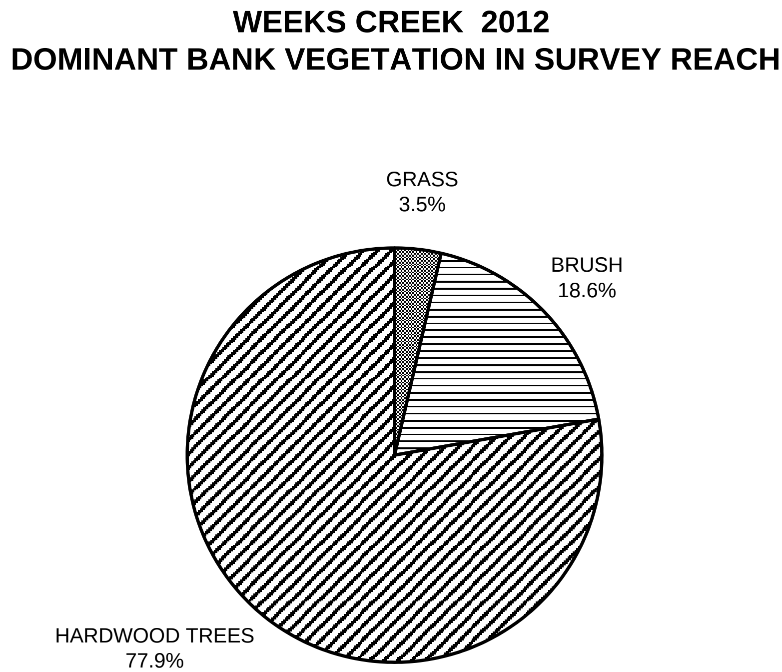


GRAPH 9

WEEKS CREEK 2012
DOMINANT BANK COMPOSITION IN SURVEY REACH



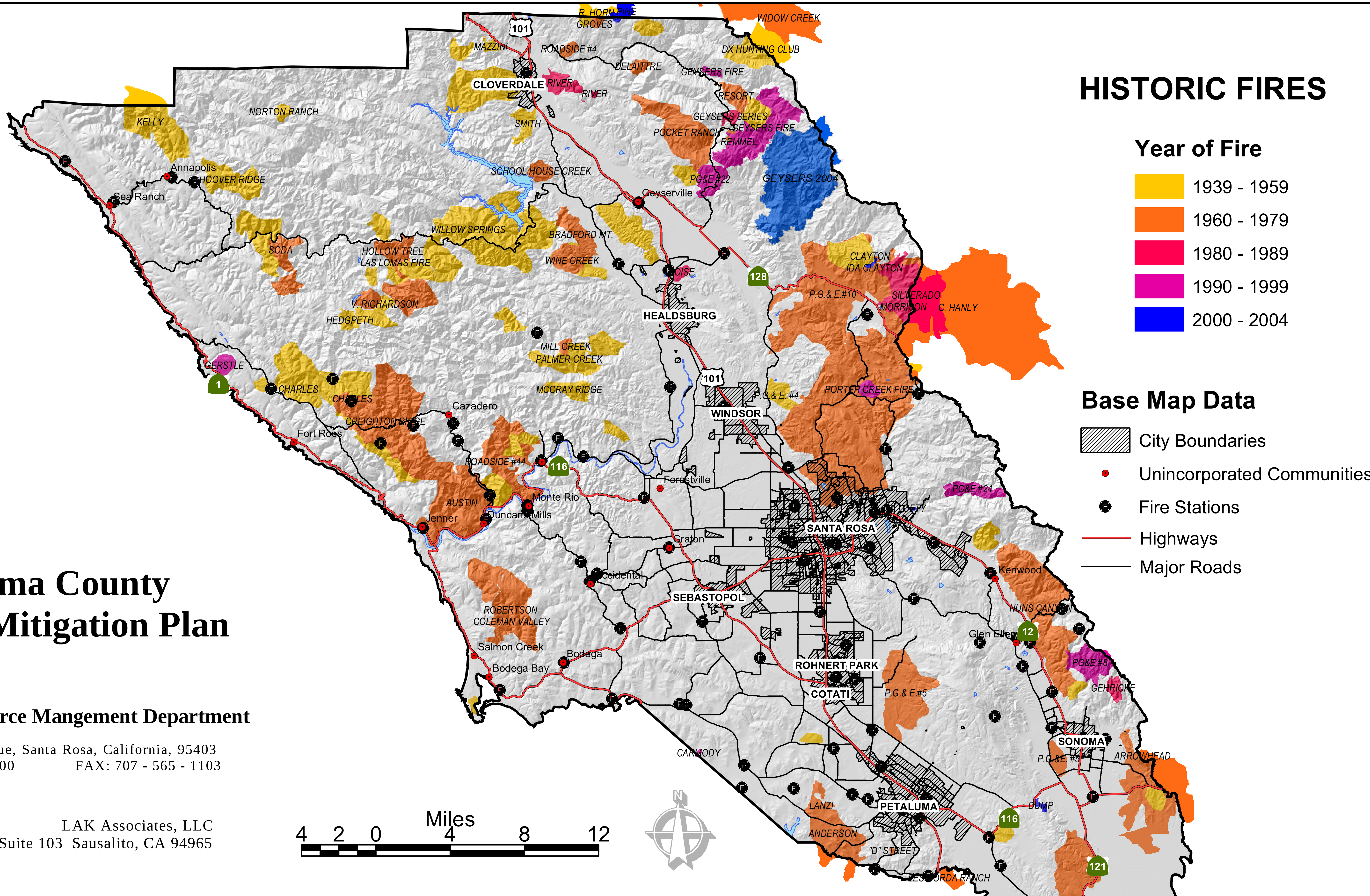
GRAPH 10


WEEKS CREEK 2012
DOMINANT BANK VEGETATION IN SURVEY REACH
GRASS
3.5%
BRUSH
18.6%
HARDWOOD TREES
77.9%

GRAPH 11

APPENDIX E

SONOMA COUNTY HAZARD MITIGATION MAP HISTORICAL FIRES



Sonoma County
Hazard Mitigation Plan

Permit and Resource Mangement Department

2550 Ventura Avenue, Santa Rosa, California, 95403
TEL: 707 - 565 - 1900 FAX: 707 - 565 - 1103

Map Created by: LAK Associates, LLC
3030 Bridgeway, Suite 103 Sausalito, CA 94965

Source: Modified from data obtained with permission from the County of Sonoma, Permit and Resource Management Department (PRMD). Data and/or analysis depicted may be altered from the original PRMD source data therefore not representative of PRMD data Fire History from California Department of Forestry and Fire, FRAP, 2004. Digital Elevation Model data from U.S. Geological Survey. Major roads and hydrology from Thomas Brothers Maps, Inc., 2000, 2001.

Map Scale and Reproduction methods limit precision in physical features displayed. This map is for illustrative purposes only, and is not suitable for parcel-specific decision making. The parcels contained herein are not intended to represent surveyed data. Site-specific studies are required to draw parcel-specific conclusions. Assessor's parcel data are current as of the date indicated. For more current parcel data, consult the County of Sonoma Assessor's Office

FIGURE: 2-9

APPENDIX F

CLIMATE VARIABILITY DATA TABLES

Climate Portfolio Report
The Conservation Lands Network
Maacama Creek Watershed

Model Variables	Climate Model	Time 30-yr block	Tmax °C	Change %	Tmin °C	Change %	PPT mm/yr	Change %	Runoff mm/yr	Change %	CWD mm/yr	Change %
Baseline		1951 - 1980	29.9	--	3.4	--	1137	--	435		743	--
Recent		1981 - 2010	29.7	-1%	4	18%	1113	-2%	426	-2%	765	3%
Drier	**GA2**	2011 - 2039	30.8	3%	4.7	38%	1105	-3%	408	-6%	775	4%
High	**GA2**	2040 - 2069	31.8	6%	5.9	74%	1041	-8%	404	-7%	833	12%
Emis.	**GA2**	2070 - 2099	33.1	11%	7.4	118%	875	-23%	303	-30%	887	19%
Drier	**GB1**	2011 - 2039	30.7	3%	5	47%	1184	4%	514	18%	799	8%
Low	**GB1**	2040 - 2069	31.2	4%	5.7	68%	1123	-1%	428	-2%	789	6%
Emis.	**GB1**	2070 - 2099	31.7	6%	5.8	71%	947	-17%	329	-24%	814	10%
Wetter	**PA2**	2011 - 2039	30.4	2%	3.9	15%	1113	-2%	412	-5%	756	2%
High	**PA2**	2040 - 2069	31	4%	4.7	38%	1153	1%	465	7%	794	7%
Emis.	**PA2**	2070 - 2099	32.1	7%	6	76%	1206	6%	522	20%	828	11%
Wetter	**PB1**	2011 - 2039	30.3	1%	4.4	29%	1352	19%	610	40%	769	3%
Low	**PB1**	2040 - 2069	30.7	3%	4.1	21%	1153	1%	454	4%	767	3%
Emis.	**PB1**	2070 - 2099	31.2	4%	5.3	56%	1251	10%	547	26%	784	6%

Climate Portfolio Report
The Conservation Lands Network
Upper Mark West Creek Watershed

Model Variables	Climate Model	Time 30-yr block	Tmax °C	Change %	Tmin °C	Change %	PPT mm/yr	Change %	Runoff mm/yr	Change %	CWD mm/yr	Change %
Baseline		1951 - 1980	29.1	--	4.2	--	1139	--	448		759	--
Recent		1981 - 2010	28.8	-1%	4.8	14%	1135	-0.4%	457	2%	775	2%
Drier	**GA2**	2011 - 2039	30	3%	5.5	31%	1125	-1%	444	-1%	791	4%
High	**GA2**	2040 - 2069	30.9	6%	6.7	60%	1077	-5%	445	-1%	848	12%
Emis.	**GA2**	2070 - 2099	32.2	11%	8.2	95%	892	-22%	331	-26%	906	19%
Drier	**GB1**	2011 - 2039	29.8	2%	5.8	38%	1213	6%	562	25%	814	7%
Low	**GB1**	2040 - 2069	30.4	4%	6.4	52%	1142	0%	460	3%	806	6%
Emis.	**GB1**	2070 - 2099	30.9	6%	6.6	57%	974	-14%	361	-19%	830	9%
Wetter	**PA2**	2011 - 2039	29.5	1%	4.7	12%	1144	0%	450	0%	768	1%
High	**PA2**	2040 - 2069	30.1	3%	5.6	33%	1184	4%	501	12%	807	6%
Emis.	**PA2**	2070 - 2099	31.2	7%	6.9	64%	1249	10%	573	28%	839	11%
Wetter	**PB1**	2011 - 2039	29.3	1%	5.2	24%	1396	23%	673	50%	781	3%
Low	**PB1**	2040 - 2069	29.8	2%	4.9	17%	1178	3%	481	7%	775	2%
Emis.	**PB1**	2070 - 2099	30.3	4%	6.2	48%	1291	13%	597	33%	794	5%