



Photo Courtesy of Lauren Hammack (PCI)

Salmon Creek Integrated Coastal Watershed Management Plan

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Developed By:



Gold Ridge
Resource Conservation District



PRUNUSKE CHATHAM, INC.

Funding and Oversight Provided By:



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ACRONYMS USED IN THIS PLAN

ARRA	American Recovery and Reinvestment Act
BAEDN	Bay Area Early Detection Network
BLT	Bodega Land Trust
BMI	Benthic Macroinvertebrate
BMP	Best Management Practices
CAFO	Confined Animal Feeding Operation
CAP	NOAA's Conservation Action Planning
CCA	Bodega Marine Life Refuge Critical Coastal Area
CCC	Central California Coast
CCOF	California Certified Organic Farmers
CDFG	California Department of Fish & Game
CNGA	California Native Grass Association
CNPS	California Native Plant Society
DO	Dissolved Oxygen
DPS	Distinct Population Segment
EFH	Essential Fish Habitat
ESU	Evolutionary Significant Unit
GRRCD	Gold Ridge Resource Conservation District
HU	Hydrologic Unit
KRIS	Klamath Resource Information System
LEED	Leadership in Energy and Environmental Design
LID	Low impact development
LWD	large woody debris
MPA	Marine Protected Area
MSWMA	Marin Sonoma Weed Management Area
MWAT	Maximum Weekly Average Temperatures
NCRWQCB	North Coast Regional Water Quality Control Board
NMFS	NOAA's National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Agency's Restoration Center
NRCS	USDA Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units
OAEC	Occidental Arts and Ecology Center
PCI	Prunuske Chatham, Inc.
PRMD	Sonoma County Permit and Resource Management Department
PWA	Pacific Watershed Associates
RWQCB	Regional Water Quality Control Board
SCC	State Coastal Conservancy
SCAPOS	Sonoma County Agricultural Preservation and Open Space District
SCEIP	Sonoma County Energy Incentive Program
SCICWMP	Salmon Creek Integrated Coastal Watershed Management Plan
SCWA	Sonoma County Water Agency
SCWC	Salmon Creek Watershed Council
SCFCWG	Sonoma County Forest Conservation Working Group
SLT	Sonoma Land Trust
SMCGWG	Sonoma Marin Coastal Grasslands Working Group
SOD	Sudden Oak Death
STRAW	Students and Teachers Restoring a Watershed
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TBD	To Be Determined

TSS	Total Suspended Solids
TU	Trout Unlimited
UAW	Unaccounted For Water Losses
UCCE	University of California Cooperative Extension
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish & Wildlife Service
WMI	SWRCB's Watershed Management Initiative

EXECUTIVE SUMMARY

This *Salmon Creek Integrated Coastal Watershed Management Plan* (Plan or SCICWMP) was prepared jointly by staff at the Gold Ridge Resource Conservation District (GRRCD) and ecological consulting firm Prunuske Chatham, Inc. (PCI) with assistance from the Technical Advisory Committee (TAC). GRRCD and PCI, along with the Salmon Creek Watershed Council (SCWC), initiated the Plan through an application and subsequent award of a Proposition 50 bond-funded grant from the State of California to GRRCD. The grant was awarded in late 2005 and has been administered through the State Water Resources Control Board (SWRCB), with local assistance and direction from the North Coast Regional Water Quality Control Board (NCRWQCB).

GRRCD provided administration and facilitation of the planning process, while the team, which included staff PCI and the University of California Cooperative Extension (UCCE) provided the science and technical expertise needed to consider the hydrologic boundaries of the subwatersheds, characterize factors limiting the recovery of salmonids in the watershed, and work with the TAC to develop feasible strategies to address all issues. Through a geomorphic assessment, sediment source and water quality analyses, and water supply and demand study, a thorough base of resource knowledge was examined to better understand the current health of Salmon Creek Watershed. Based on these assessments, the Plan contains goals and actions to enhance and protect the natural resources of the watershed for current and future generations.

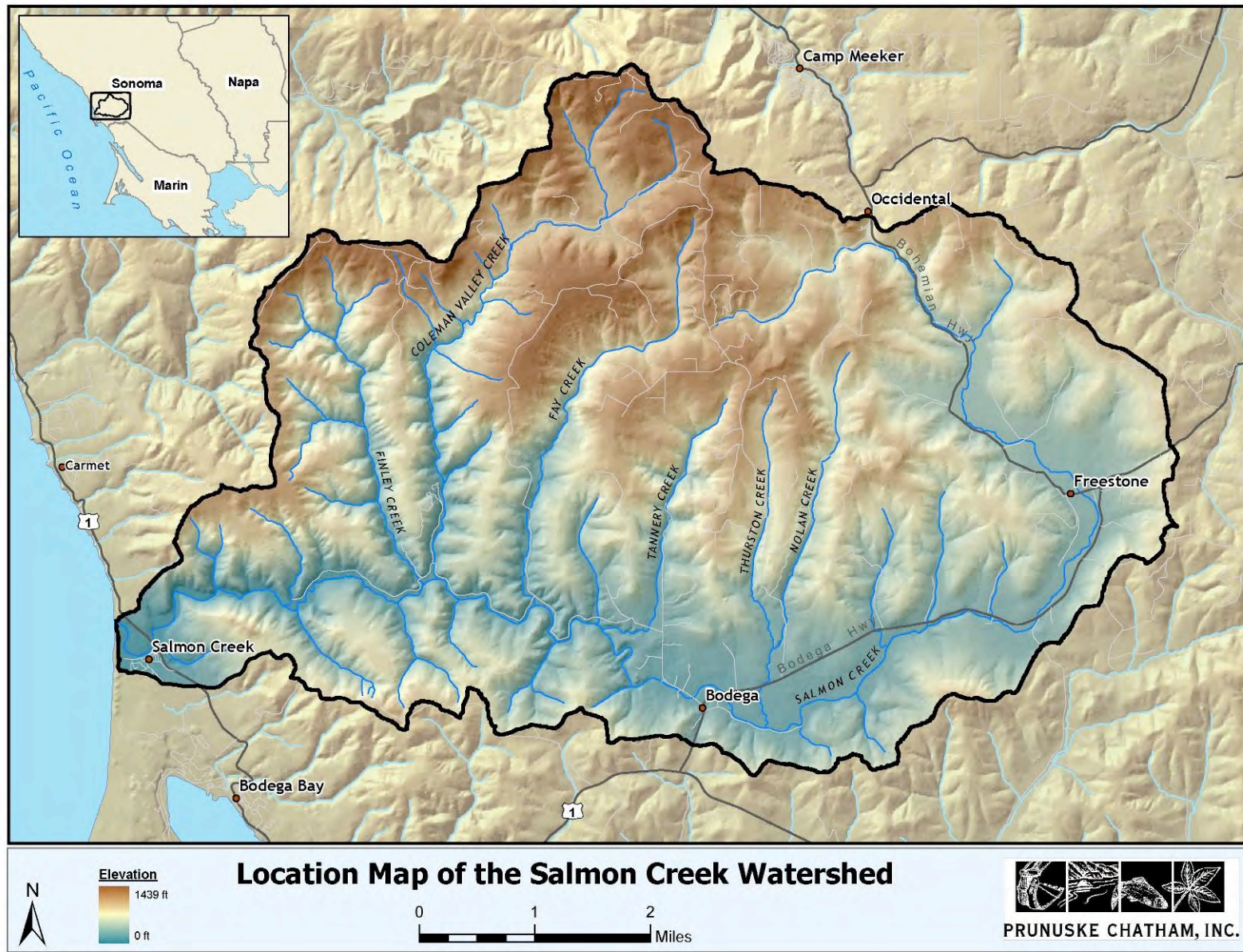
This Plan takes a watershed approach to address issues of water quality and quantity, rather than looking at stream restoration on a site-by-site basis. Because 95% of the land is privately owned, economic viability for the landowners has been a central tenet in the team's planning process, a vital element in sustaining and enhancing the health of the watershed. Also, because the idea of watershed management can mean different things to different people depending on their perspective, the team has worked toward an approach to watershed management in Salmon Creek that will foster an understanding and appreciation of the landowners and their contribution toward land stewardship.



*Salmon Creek Technical Advisory Committee (TAC) meeting.
Photo courtesy of Brock Dolman (OAEC)*

The Plan should be viewed as a “living document.” The goals and actions included in this plan are based on our current level of understanding of the ecological processes and health of the watershed. It is expected that management issues and priorities will change through time, and stakeholders will adapt this plan and subsequent recommendations as conditions change.

Figure 1. Salmon Creek Watershed location map.



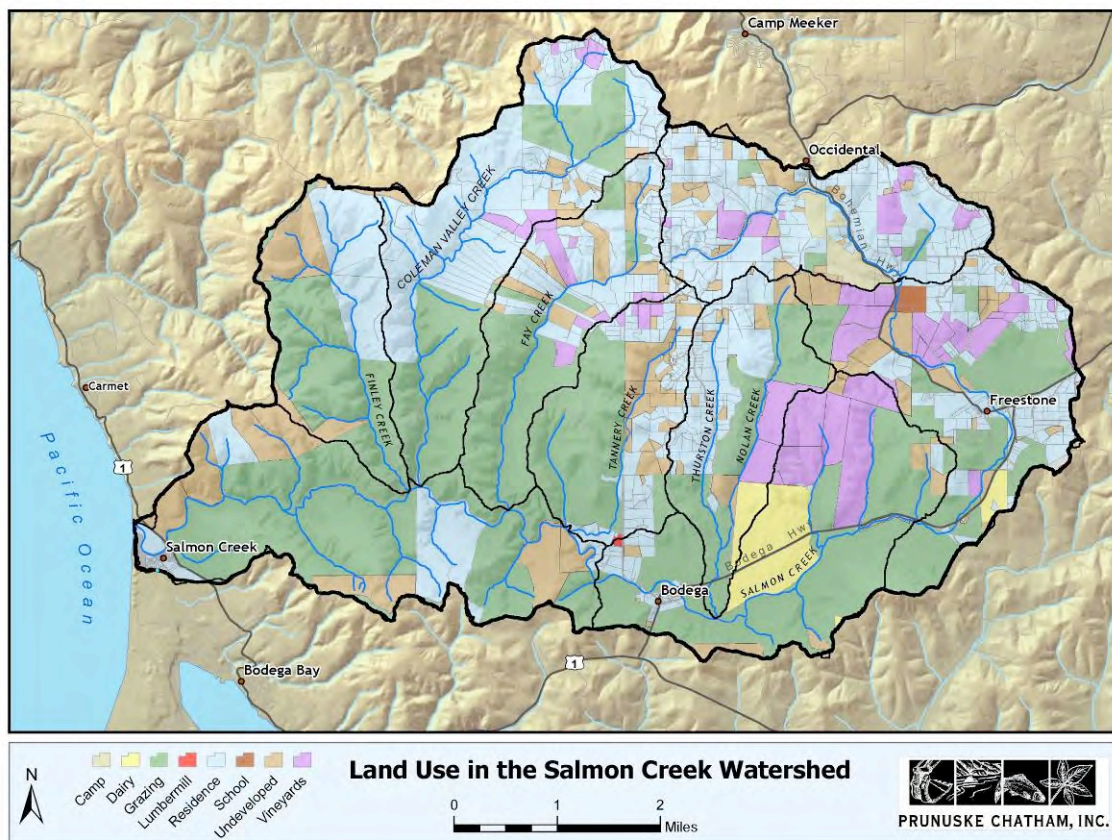
CHAPTER 1: INTRODUCTION

Background

The Salmon Creek Watershed covers approximately 35.3 square miles in coastal Sonoma County and is a salmonid-bearing stream that drains to the Pacific Ocean immediately north of the Bodega Marine Life Refuge Critical Coastal Area (CCA). Salmon Creek has 6 major north-south trending tributaries: Finley, Fay, Tannery, Nolan, Thurston, and Coleman Valley Creeks. The watershed also contains 17 unnamed, smaller tributaries. From its highest point at 797 feet, the mainstem of Salmon Creek runs south through Occidental and makes a westerly curve near Freestone before reaching the ocean 3 miles north of Bodega Bay. The watershed's terrain is characterized by steep topography and soils that are highly erosive and sensitive to disturbance. Vegetation occurring in the watershed is a combination of deciduous and mixed coniferous forests and grasslands.



Figure 2. Land use in the Salmon Creek Watershed.



The Salmon Creek Watershed is almost completely privately owned (95%). Primary land uses include rangeland, viticulture, timber, rural residential, and urban. Current and historic land-use activities have degraded the natural environment, impaired water quality and aquatic habitat, and increased the rate and amount of sedimentation.

The watershed once had a thriving anadromous fish population, vibrant stands of vegetation, and exceptional water quality. (See Figure 1. Salmon Creek Watershed Location Map.) The precipitous decline in salmonid populations in the watershed has all but decimated the local fishery, once a key local industry. Although Salmon Creek is not on the federal Clean Water Act §303(d) list of impaired waterbodies, it is an important coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Onchorhynchus mykiss*) stream. The SWRCB's Watershed Management Initiative (WMI) states that "concerns have been raised by the public regarding increased sedimentation, water temperature, nutrients, and salmonid habitat" in Salmon Creek.

However, the California Department of Fish and Game (CDFG) considers Salmon Creek¹ a fully restorable salmonid stream (CDFG 2004d). In both December 2008 and 2009, CDFG reintroduced approximately 500 adult coho salmon into the creek as part of their broodstock program. In the face of climate change and a sharp regional decline in salmonid populations over the past two years, the stakes for supporting the newly reintroduced coho salmon and the returning steelhead trout are very high.

The Salmon Creek Watershed is becoming regionally renowned for its forward thinking, collaborative, non-regulatory driven restoration program and is often cited as a model for other watershed efforts. In 2005, GRRCD received grant funding from the SWRCB to develop the *Salmon Creek Integrated Watershed Management Plan* (Plan). The Plan strives to integrate environmental management, natural resource protection, agricultural sustainability, and community goals to provide a guide for improving watershed health.

The planning process has been a multi-faceted, multi-partner program, begun in earnest, to address poor habitat conditions in the Salmon Creek Watershed through prioritized implementation and long-term outreach and education. The goal of this plan is to develop a program that, if implemented effectively, will improve the rankings of several key habitat condition indicators (e.g., summer rearing baseflow, primary pools and shelter, large woody debris (LWD), and turbidity), currently ranked as "Poor" for coho salmon using NOAA's "Conservation Action Planning" (CAP) process (NOAA Fisheries, Southwest Region, 2009 draft in press), to "Good." Activities to date include development of a watershed-wide water supply planning, management and outreach program aimed at reducing impacts to streamflow and water quality, installation of estuary habitat structures to increase smolt rearing success, road and gully fine-sediment reduction projects, instream habitat (LWD) improvement projects, and riparian revegetation and fencing.

¹ Salmon Creek is located within the Bodega Hydrologic Unit (HU) in the CCC Evolutionary Significant Unit (ESU). Salmon Creek is part of the Sonoma Coast State Marine Conservation Area, a State Marine Protected Area (MPA) (California Marine Life Protection Initiative 2007).

Vision

The Plan offers the following vision for the Salmon Creek Watershed and its tributaries:

The Plan reflects common ground between landowners, program partners, and resource agency staff. The primary aim of this Plan is to better understand and address the conditions necessary for ensuring a healthy and functioning watershed ecosystem, to develop a program to improve habitat for native species, and to promote conservation oriented land management practices while safeguarding the economic viability of the watershed's agricultural heritage.



*Salmon Creek Watershed Planning Meeting,
December 1, 2009*

Planning Process

The Plan is the culmination of years of commitment by landowners (both agricultural and rural residential), SCWC, Occidental Arts and Ecology Center (OAEC), LandPaths, PCI and GRRCD, as well as agency staff from CDFG, State Coastal Conservancy (SCC), NCRWQCB, the USDA Natural Resources Conservation Service (NRCS), the University of California Cooperative Extension (UCCE), and the National Oceanic and Atmospheric Agency's Restoration Center (NOAA). Each of these groups was represented during the planning process at Technical Advisory Committee (TAC) meetings, which were held quarterly except for a one-year period when the State of California experienced a severe fiscal crisis, and planning efforts had to be put on hold. The TAC included members with expertise in hydrology, geomorphology, biology, fisheries, water quality science, agriculture, watershed education, and conservation planning.

Each TAC member offered a unique set of skills and knowledge, and, although there was some disagreement, everyone was respected and heard. Local rural residential and agricultural landowners provided history and familiarity to ensure an accurate representation of land use in the watershed. Other members offered organizational direction, funding, and technical expertise. All members contributed to the planning vision, goals, recommendations and actions presented in this plan. GRRCD, as the lead agency, was responsible for creating an atmosphere of trust that allowed groups with varying interests to learn from the others' points of view.

A History of Partners in Stewardship

The Salmon Creek Integrated Watershed Management Plan represents a significant step towards a more cooperative results-focused way to protect our natural resources that incorporates local values and knowledge in a way that sustains our local agricultural community, the economy, and the environment.

Residents, local watershed groups, and public agencies have worked to assess the ecological health and functioning of the Salmon Creek Watershed and to document specific sites and/or activities that may be degrading the riparian system and impairing critical fish habitat.

The partners involved in this planning process were originally brought together in 2003 by funding from CDFG to GRRCD to perform a baseline assessment and develop a “plan of action” for stream restoration activities in the watershed. This first planning grant was envisioned by the SCWC and resulted in the *Salmon Creek Watershed Assessment and Restoration Plan* (PCI and GRRCD 2007). The grant helped build the organizational capacity of GRRCD and led to implementation of priority conservation projects throughout the watershed.²

Planning efforts continued through funding from SCC to OAEC, which produced the *Salmon Creek Estuary Study and Enhancement Plan* (PCI 2008) and led to the ongoing Salmon Creek Water Conservation Program. The *Salmon Creek Water Conservation Plan* (PCI et al. 2010) presents strategies and recommendations to increase dry-season flow while supporting the freshwater needs of residents. Assessments of watershed and stream conditions have also been completed (CDFG 2002; PCI 2006; GRRCD 2007). The collaborative spirit of the SCWC helped rally landowners together to participate in an assessment of rural roads (PWA and GRRCD 2008). This continuity of public input has allowed the core project team (consisting of landowners, SCWC, PCI, and GRRCD) to provide a vision for protecting and improving the condition of the watershed.

The team understands that agriculture is an important mainstay of the local economy. Agricultural producers in our coastal watersheds are under dual pressures of increasing regulatory oversight and the competitive demands of the marketplace. We believe that sustainable ranching and livestock productions can maintain a living, while at the same time improve the overall conditions of soil, water, grasslands, and riparian resources. The financial benefits of sustainable ranching include reductions in property loss due to soil erosion, improved forage production, improved livestock health, higher product values, market diversification, and greater market accessibility. Chapter 7 provides a more detailed strategy for improving the health of the watershed and the long-term preservation of its habitats and natural capital through a continued partnership with the agricultural community.

Planning Goals and Objectives

Land-use practices in the Salmon Creek Watershed have resulted in altered stream channels, reduced riparian zones, and reduced access to suitable spawning habitat. Streambank alterations have resulted in a loss of natural habitat complexity (i.e., riffles, pools, and other *refugia*), effectively limiting the capacity for freshwater streams to serve

² Salmon Creek Ranch Enhancement Design and Implementation Grant Agreement Nos. 03-005, 06-027 and 06-115 (State Coastal Conservancy); Bodega Coastal Streams Restoration Project Agreement No. 03-175-110 (State Water Resources Control Board); Save Our Salmon – Salmon Creek Habitat Rehabilitation Program –Phase I NA09NMF463236 (NOAA Restoration Center); Mache Ranch Stream Restoration I and II, Fay Creek Revegetation Project, and the Salmon Creek Roads Assessment Project (CDFG).

as spawning, rearing, and migratory habitat for a viable coho salmon population. The removal of riparian vegetation has caused increases in temperature and fine sediment, as well as reduced instream complexity as a result of fewer sources of LWD.

If coho salmon recovery in the watershed is to be realized, there is no doubt that targeted actions need to be taken.



*Fay Creek "Young of the Year", June 29, 2009.
Photo courtesy of Joe Pecharich (NOAA Restoration Center)*

Some of the existing limiting conditions in the watershed include:

- High turbidity and sediment loads from roads and riparian and gully erosion;
- Low streamflow during the dry summer months;
- Poor instream habitat from lack of channel complexity; and
- High summer water temperatures from lack of adequate canopy cover.

However, the team has reached consensus that the Salmon Creek Watershed ecosystem can be considered healthy and functioning if we achieve the following goals and can measure results. All may not be achievable in the current generation, or our children's generation, but we must strive to achieve the ideals outlined below.

1. Water supply in the Salmon Creek Watershed is adequate for the needs of the landowners and the ecosystem.

The amount of the streamflow in the tributaries and in the mainstem of Salmon Creek support the ecosystem such that:

- Freshwater quantity is sufficient to support the needs of the rural residential and agricultural landowners.
- Freshwater quantity is sufficient to support the needs of the native terrestrial and aquatic ecosystems.

2. Water in the Salmon Creek Watershed is clean and of consistent high quality.

Water in the tributaries and in the mainstem of Salmon Creek meets or exceeds regulatory requirements, and both point and nonpoint pollution sources have been reduced in order to support freshwater, estuary, and upland ecosystems.

- Sediment loading does not exceed the level consistent with the requirements of fish and other aquatic species.

- Nutrient pollution from human and other sources is minimized to the point that it is no longer detectable in fresh water.
- Loadings of any pollutant do not exceed levels that may impair healthy ecosystem functions.

3. The quality of life for residents in the Salmon Creek Watershed is supported by a healthy and functioning ecosystem.

A healthy Salmon Creek Watershed can support the social and economic vitality of its landowners.

- The natural resources of the Salmon Creek Watershed are ample enough to support agriculture, fisheries, forestry, and tourism.
- The Salmon Creek Watershed's economic prosperity is compatible with the protection and restoration of a healthy and diverse ecosystem.

4. Stewardship activities in the Salmon Creek Watershed build and support landowner capacity to protect and sustain the environment.

Landowners and decision makers have the information and resource capacity necessary to monitor ecosystem health.

- Landowners are provided with the education and technical support needed to make proactive local decisions regarding water resources.
- Coordinated strategies are supported and encouraged at all levels of government.
- GRRCD, other local nonprofits, and conservation-minded organizations are supported and funded in order to participate in collaborative processes at the ecosystem level.



Plan Contents

GRRCD's grant agreement with the SWRCB scope defines individual elements that the Plan will address. The Plan will strive to:

- Define the watershed vision;
- Define watershed goals, distinguishing between short- and long-term;
- Identify the watershed stakeholders and enroll them in the Plan development process;
- Define the geographical and jurisdictional boundaries of the watershed;
- Describe current watershed conditions through assessment and data integration;
- Develop proposed actions and implementation strategies necessary to achieve watershed goals;
- Identify the persons, organizations, and public agencies responsible for implementing the proposed actions, and enroll them in the watershed improvement projects;

- Outline a schedule and plan for implementing proposed improvement actions with realistic time frames and target dates and a process for adapting the Plan over time;
- Establish a program for project and watershed improvement measure effectiveness monitoring; and
- Establish a system for evaluating and responding to proposed projects based on impacts on natural resources and beneficial uses.

The Plan describes actions for addressing watershed issues and for providing future opportunities for multiple organizations and the community to become involved in restoration and recreation activities in the streams. Stakeholders in the Salmon Creek Watershed have been actively involved in identifying the issues and developing the Plan's goals, objectives, and actions. The following chapters identify pertinent natural resource goals and context, along with implementable actions and the scientific basis for those actions. The integrated watershed approach combines several management strategies to achieve sediment load reductions, water conservation, and riparian and instream habitat improvements throughout the Salmon Creek Watershed. In addition, watershed-wide, landowner-driven erosion prevention, education, restoration and revegetation, better agricultural practices, and other improvements, such as new zoning regulations and enhanced opportunities for easements, will be needed for long-term success.

Conclusion

A large part of the work that went into developing this plan involved characterizing and assessing the ecological processes of the watershed based on both a compilation of existing studies, as well as the creation of new information derived from field analysis of geomorphic and water quality conditions and land uses. Numerous interviews were conducted with watershed residents over the course of this planning study to gain valuable information about historical changes in the watershed and the value of its resources.

The implementation of the Plan is one of many steps that still need to be taken and is designed to be a living and adaptable document that will be updated as necessary over the 10-year implementation schedule. The Plan will not solve all the outstanding issues of the watershed, but it can serve to guide the State of California, County of Sonoma, GRRCD, other conservation-oriented organizations, landowners, and resource agencies in the right direction.

Bodega Dairy Cows, 2009



Bees as part of Gold Ridge RCD Pollinator Program, 2009



CHAPTER 2: STATE OF THE WATERSHED

Introduction

From mature redwood forests to coastal dunes, the Salmon Creek Watershed contains a remarkable diversity of habitats for its size. With no major water impoundments, minimal urban development, and many concerned and active residents, the watershed presents excellent opportunities to address issues common throughout northern coastal California. The watershed's forests, streams, grasslands, and estuarine habitats all face challenges from historical and recent human impacts. They also support many listed plant and animal species, as well as working forests, vineyards, ranches, and dairy operations that depend upon well-functioning ecosystems for long-term viability. This chapter briefly describes current conditions of Salmon Creek habitats, along with key wildlife and plant species.

Uplands

Salmon Creek Watershed marks the southern boundary of the extensive mixed evergreen forests of Sonoma and Mendocino Counties. The five main tributaries and the headwaters of Salmon Creek drain high, steep, forested ridges and canyons. They flow into the open, rolling grasslands that typify the countryside to the south through which the middle portion of Salmon Creek traverses. The low ridges that form the southern boundary of the watershed are mixed grassland and coastal scrub communities. Coastal terrace grassland and dune communities occur near the coast. The diverse, multi-layered canopies and root systems of these native communities soften the erosive impact of rainfall on the land, protecting downstream water quality, and help absorb and store water, recharging aquifers. The diversity of the Salmon Creek uplands also supports a broad range of wildlife, including threatened and special-status species, such as northern spotted owl (*Strix occidentalis caurina*) and Sonoma tree vole (*Arborimus pomo*).



Redwood Forest

The forests of the upper watershed make up approximately 50 percent (11,474 acres) of the land cover (GRRCD & PCI 2007). Of this forested land, almost 50 percent (over 5,000 acres) is comprised of coast redwoods (*Sequoia sempervirens*). In mature stands, these large conifers create a dense canopy, and the understory is often sparse. Common understory species include shade-tolerant plants, such as sword fern (*Polystichum munitum*), coastal wood fern (*Dryopteris arguta*) and slim Solomon's seal (*Smilacina stellata*)³. In younger, more open stands, other woody species can also be abundant.

These include Pacific madrone (*Arbutus meniesii*), hazlenut (*Corylus cornuta*), huckleberry (*Vaccinium ovatum*), poison oak (*Toxicodendron diversilobum*), and wood rose (*Rosa gymnocarpa*).

Logging and clearing for agriculture that began in the early 1800s have reduced and shaped the redwood forests of the watershed today. Redwood from the area was used

³ Botanical names and distribution information based on Best et al. 1996 and Lamont 2004.

for construction in San Francisco during the Gold Rush and for rebuilding efforts after the earthquake of 1906. Timber production declined in the 1920s as old-growth redwoods were depleted. Intensive residential and agricultural development began in the 1940s, and logging intensified again.

By 2000, most of the headwaters of Salmon Creek had been logged. However, the watershed still supports healthy stands of second- and third-growth redwoods in moister areas and in the coastal fog belt. According to a 1994 U.S. Forest Service analysis, trees in the medium-large and small-medium size classes (12-30" diameter at breast height) are most abundant. A few pockets of old-growth redwood forest remain in the watershed, including the Grove of the Old Trees located on a ridgetop above Occidental, which was protected by conservation easement in the 1990s. Sonoma Land Trust and the Sonoma County Agricultural Preservation and Open Space District hold numerous other easements in the watershed, particularly along Coleman Valley Road. Approximately 4 percent (800 acres) of the watershed is in use for timber production today (GRRCD & PCI 2007).

Mixed Evergreen Woodland

A mixture of evergreen trees makes up the remainder of forest (over 6,000 acres) in the watershed. This includes forests where Douglas-fir (*Pseudotsuga menziesii*) dominates, as well as mixed woodlands of coast live oak (*Quercus agrifolia*), Douglas-fir, California bay (*Umbellularia californica*), tanoak (*Lithocarpus densiflora*), madrone (*Arbutus menziesii*), and buckeye (*Aesculus californica*). Like the redwood forest, many of these lands have been logged or cleared, and now support younger forests or have been converted to annual grassland.



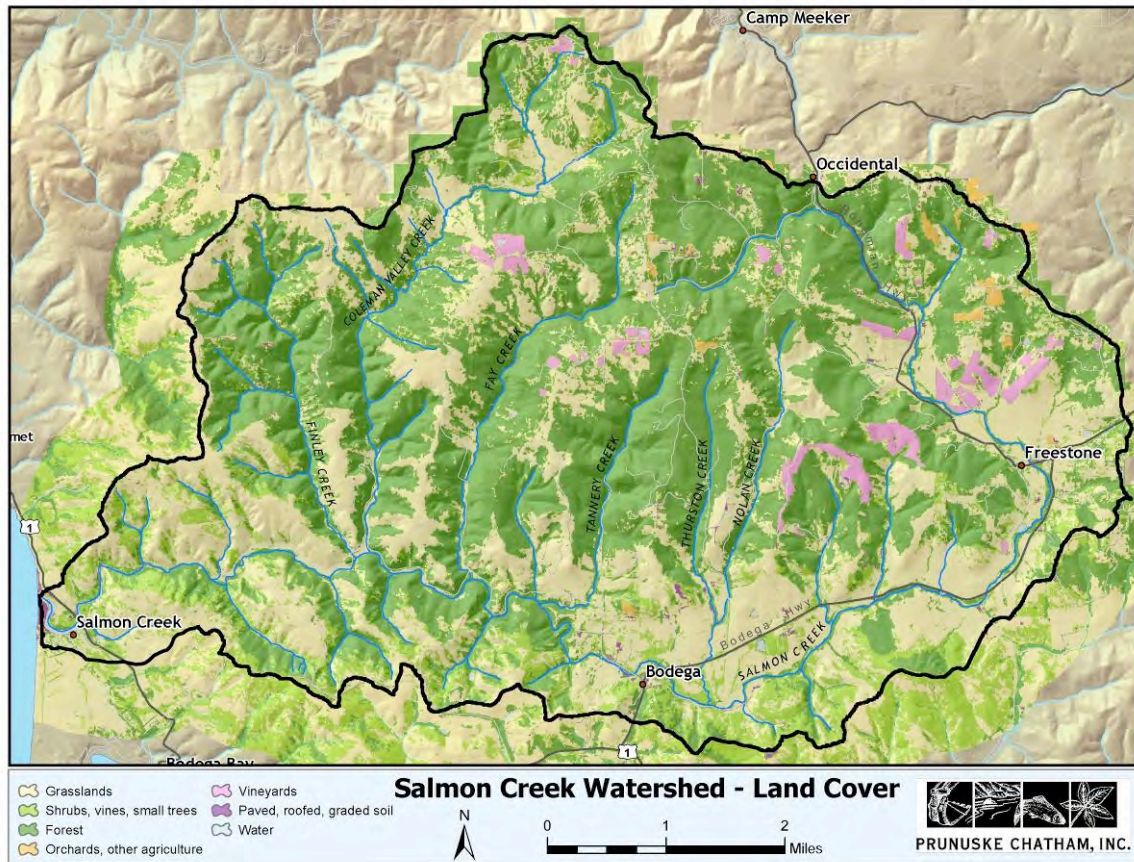
Google Earth via USFS Aerial Detection Survey, Sonoma County 2007 Tree Mortality

Woodlands of the watershed have also been altered by other processes. Sudden Oak Death, a forest disease caused by the pathogen *Phytophthora ramorum*, has infected California bays and killed tanoaks and coast live oaks in the

watershed (UC Berkeley 2010). Aerial surveys of the county show many dead or dying tanoaks in the central portion of the watershed in the hills southwest of Occidental (USFS 2009). In affected areas, the density of dying trees ranges from 1 to 10 per acre. (Laboratory testing has not been done to confirm *P. ramorum* as the cause of all these die-offs, but it is considered to be the most likely cause (USFS 2009; Bell 2010). Where infection occurs, the abundance of dead and dying trees increases the risk of wildfire. Near roads, structures, and populated areas, the risks of damage or injury from falling trees is also increased.

Fire suppression in the watershed and in the region may also be changing forest composition (Hastings et al. 1997). Prior to European-American settlement, Native Americans used fire in many settings to increase habitat for the oak woodland and grassland species most useful to them. Since European settlement, the frequency of low-intensity fires has been reduced. As a result, fire-sensitive Douglas-fir is increasing in abundance, shading out smaller-statured oaks and other hardwoods.

Figure 3. Salmon Creek Watershed land cover map.



Special-status plant species documented in the mixed evergreen woodland of the watershed include western leatherwood (*Dirca occidentalis*) and Napa false indigo (*Amorpha californica* var. *napensis*) [both considered to be fairly endangered in California by the California Native Plant Society (CNPS)]. Western leatherwood is a deciduous shrub with very flexible wood. It is endemic to the San Francisco Bay region and occurs on moist wooded slopes. Napa false indigo is a shrub in the pea family known only from Marin, Monterey, Napa, and Sonoma counties. Both species are threatened by habitat loss from agricultural and residential development.



Photo courtesy of Gerald and Buff Corsi © Calif. Academy of Sciences

Special-status animal species documented in the forests and woodlands of the watershed include the northern spotted owl and Sonoma tree vole. The northern spotted owl (*Strix occidentalis caurina*) is federally listed as threatened and is a California Species of Special Concern. It is a nocturnal species that requires dense, multi-layered canopy cover for roosting sites – predominately occurring in forested habitats; however, occasionally they are observed in riparian woodlands along Salmon Creek (Fawcett 2010). Spotted owls feed upon a variety of small mammals (including dusky-footed woodrats), birds, and large arthropods. Nest sites include tree or snag cavities or broken tops of large trees. A pair of owls may use the same breeding site for 5 to 10 years; however, they may not breed every year. The spotted owl has experienced a population decline due to the loss and degradation of existing mature and old-growth forests.

The Sonoma tree vole (*Arborimus pomo*) is listed as a California Species of Special Concern by CDFG. This rodent occurs only in the coastal fog belt from the Oregon border to Sonoma County in Douglas-fir, redwood, and mixed evergreen forests. It feeds almost exclusively on Douglas-fir needles and prefers to build its nests in tall trees or the broken tops of younger trees. Its home range generally consists of one to several Douglas-fir trees. Nests are typically constructed from 6 to 150 feet above ground and are made primarily of resin ducts from Douglas-fir needles, which they remove before eating. The primary predators of Sonoma red tree vole are spotted owls, saw-whet owls, and possibly raccoons.

Grasslands

Grasslands in the watershed include native-dominated coastal prairie and serpentine grassland, as well as annual grassland dominated by European annual grasses. Together, these types comprise 37 percent of the land cover (over 8,000 acres).

Coastal prairie occurs primarily in areas that have not been heavily disturbed by human uses, on slopes and ridges near the influence of the ocean in the southwestern portion of the watershed. Perennial bunchgrasses, bulbs, and other native herbs characterize these habitats. Typical species in the Salmon Creek Watershed include purple needlegrass (*Nassella pulchra*), California oatgrass (*Danthonia californica*), lupine (*Lupinus* spp.), brodiaea (*Brodiaea* spp.), clarkia (*Clarkia* spp.), and Douglas iris (*Iris douglasiana*).

Native grasses also dominate grassland habitats where serpentine soil is present. Serpentine soils have unusual levels of some minerals important to plant survival and growth; as a result, serpentine plant communities are often unusually rich in native and endemic species. In the Salmon Creek Watershed, serpentine grassland occurs in patches along two bands of serpentine-derived soil in the northern part of the watershed. Typical species include Idaho fescue (*Festuca idahoensis*), woodland brome (*Bromus laevipes*), woolly sunflower (*Eriophyllum lanatum*), and buckwheat (*Eriogonum* spp.).

Annual grassland occurs in more disturbed and intensively used areas, including many ranchlands. Annual grasslands, dominated by nonnative species, are abundant in the southern part of the watershed. European annual grasses were introduced to California in the 1800s. The historic introduction of European grasses to California, coupled with disturbances such as intensive livestock grazing and clearing, have led to conversion of native grassland to annual grassland. Typical species in the Salmon Creek



A fenceline separates grassland grazed by livestock (lower right) from ungrazed grassland (upper left).

Watershed include wild oats (*Avena* spp.), ripgut brome (*Bromus diandrus*), ryegrass (*Lolium multiflorum*), and velvetgrass (*Holcus lanatus*). Common forbs found in these grasslands include nonnative filaree (*Erodium* spp.), cut-leaf geranium (*Geranium dissectum*), bur-clover (*Medicago polymorpha*), vetch (*Vicia* spp.), and clovers (*Trifolium* spp.).

Local researchers are investigating management strategies to maintain and restore native grassland species (Ocean Song 2007). Prescribed burning and managed livestock grazing are two of the main tools thought to be effective in coastal grassland settings. However, relationships between managed disturbance and plant communities are complex, and outcomes vary with plant species, timing of disturbance, climate, and many other factors. Research continues to clarify how local land managers can use grazing and burning effectively.

Sensitive plant species documented in the grasslands of the watershed include showy Indian clover (*Trifolium amoenum*) (federally listed as endangered) and seaside tarplant (*Hemizonia congesta* ssp. *congesta*) (considered by CNPS to be fairly threatened in California). Showy Indian clover, thought to be extinct until a discovery of a single plant in 1993, is now known only from one remnant population in Marin County. Researchers are investigating the possibility of reintroducing the species to former habitat. Both showy Indian clover and seaside tarplant occur in areas of mixed native and nonnative grassland. The primary threat to their survival is habitat loss due to agricultural and residential development (CNPS 2010). A number of other species were documented historically in the watershed but have not been recently observed: purple-stemmed checkerbloom (*Sidalcea malviflora* ssp. *purpurea*), perennial goldfields (*Lasthenia californica* ssp. *macrantha*), and yellow larkspur (*Delphinium luteum*). In addition to habitat loss, competition from nonnative plants, road construction, livestock grazing, and possibly trail construction are other likely factors in the decline of these rare plants.

Focal special-status animal species occurring in the grasslands include the burrowing owl, American badger, and Myrtle's silverspot butterfly:

The **burrowing owl** (*Athene cunicularia*) is a California Species of Special Concern. It is a subterranean nester, dependent upon burrowing mammals for its underground home. In the Salmon Creek Watershed, the burrowing owl has been documented in coastal terrace prairie with a mosaic of native and nonnative grasses and forbs. This species is primarily an uncommon winter resident, as it no longer breeds in Sonoma County. Threats to this species are habitat loss due to agricultural and urban development and habitat degradation due to reductions of burrowing mammal populations.



Photo courtesy of Joyce Gross.



Gerald and Buff
Corsi © Calif.
Academy of Sciences

The **American badger** (*Taxidea taxus*), a California Species of Special Concern, occurs in a variety of habitat types with dry, friable soils. This carnivorous species consumes primarily fossorial rodents but will also eat reptiles, amphibians, insects, eggs, birds, and carrion. Badgers are territorial throughout the year with size of the territory dependent on the availability of food. Typical territory size is approximately 3 or 4 square miles. Territories can be shared. Badgers dig their own burrows which are often quite extensive. They are active year-round, although less active in winter. Mating occurs in summer and early fall with young (average 2 to 3) born in early spring. Badgers can tolerate some level of human activity. Potential threats to badgers in the watershed include ground-disturbing development, pets roaming free, and barbed wire fencing (CDFG 2010). Within the watershed, badgers are noted near the Chanslor Ranch and low coastal hills and in and around Bodega Creek (Fawcett 2010).

Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*), federally listed as threatened, may also occur in the watershed. Historically widespread in coastal areas from the Russian River south to San Mateo County, this species is now known only from four populations in Marin and Sonoma counties. This brown-to-orange butterfly lives in coastal dunes, scrub, and prairie, within 3 miles of the coast. It generally prefers sites at less than 1,000 feet elevation, sheltered from the wind and within the fog zone, which provide a large numbers of adult nectar plants. Adult Myrtle's silverspots nectar on a number of species including, but not limited to, gum plant (*Grindelia rubicaulis*), yellow sand verbena (*Abronia latifolia*), mints (*Monardella* spp.), seaside daisy (*Erigeron glaucus*), and nonnative bull thistle (*Cirsium vulgare*) and false dandelion (*Hypochaeris radicata*). Females lay eggs singly on western dog violet (*Viola adunca*), and the entire reproductive cycle is dependent on this species (USFWS 1998).

Coastal Scrub and Chaparral

Coastal scrub occurs along the slopes of the southern part of the watershed, typically within reach of ocean winds and salt spray. Approximately 2,000 acres of coastal scrub are found in the watershed today (approximately 8 percent of the land cover). Dominant plants include shrubs, such as coyote brush (*Baccharis pilularis*), poison oak (*Toxicodendron diversilobum*), and elderberry (*Sambucus nigra* ssp. *caerulea*), as well as sword fern (*Polystichum munitum*), bracken fern (*Pteridium aquilinum*), and rushes (*Juncus* spp.) and sedges (*Carex* spp.). Coastal scrub often intergrades with annual grassland or coastal prairie. In some locations, the extent of coastal scrub may have decreased since pre-European settlement, as clearing and livestock grazing have caused a transition to

grassland. In other locations, coastal scrub acreage may have increased as modern fire suppression replaced Native American burning practices.

Sensitive plant species documented historically in the coastal scrub of the watershed include Baker's larkspur (*Delphinium bakeri*, federally and state listed as endangered) and coastal bluff morning-glory (*Calystegia purpurata* ssp. *saxicola*; CNPS List 1B.2, fairly endangered in California). Baker's larkspur, once known from Coleman Valley, is now known from only one remnant population in northern Marin County. Threats to the species include agricultural conversion, road maintenance, and grazing. The Coleman Valley area is now designated as a portion of the critical habitat for Baker's larkspur where it may be reintroduced (USFWS 2003). Coastal bluff morning-glory is known from coastal scrub and dunes of Marin, Sonoma, and Mendocino counties. It is threatened by development, foot traffic, and nonnative plants. There are no special-status animals specific to coastal scrub and chaparral.

Invasive Species

Many nonnative, invasive species are abundant in the uplands of Salmon Creek Watershed. Three are particularly damaging to local habitat, directly competing with native species and also altering ecosystem processes. All three of these species are yellow-flowering, evergreen shrubs in the pea family, apparently intentionally

introduced from Europe: gorse (*Ulex europaeus*), French broom (*Genista monspessulana*), and Scotch broom (*Cytisus scoparius*). All of these species can fix atmospheric nitrogen, helping them colonize nitrogen-poor soils and outcompete native plants. They are also unpalatable and/or toxic to livestock, so their infestations reduce rangeland quality as well as native habitat. All three species produce abundant, long-lived seed, so eradication efforts must be long-term undertakings.

Gorse is a prickly shrub that forms dense, nearly impenetrable thickets on some hillsides of the watershed. Gorse tends to spread slowly, with seeds too heavy to be dispersed by wind but potentially carried by ants, quail, and humans. Gorse is highly flammable and can pose a significant fire hazard (California Invasive Plant Council 2010).



French broom and Scotch broom are both abundant along the roadsides of the watershed and in other disturbed habitats. Pods of broom open explosively, dispersing seeds several yards away. Seeds are dispersed further by ants, birds, flowing water, and road maintenance machinery. Broom is flammable and, in wooded areas, can carry fire to the tree canopy layer, increasing fire intensity.

Other invasive species in the watershed that are known to invade native habitat include pampas grass (*Cortaderia* spp.), English ivy (*Hedera helix*), forget-me-not (*Myosotis discolor*), Himalayan blackberry (*Rubus discolor*), giant reed (*Arundo donax*), cape ivy (*Senecio mikanioides*), and periwinkle (*Vinca major*).

Preventing the spread of invasive plants, and quickly eradicating small new infestations, are crucial to managing these and other species. Once established, control is usually costly and difficult. Carefully managed prescribed burning, manual removal, and goat grazing have all been used successfully to control gorse and broom in other areas.

Streams

Salmon Creek and its tributaries flow through steep terrain in their headwaters onto the gentle slopes of the southern watershed and enter the Pacific Ocean north of Bodega Bay. Many of the upper watershed tributaries remain forested with complex communities of redwoods, firs, oaks, and bays shading the streams and stabilizing creek banks. In the lower reaches, riparian corridors continue but are often narrowed and less diverse.

Historic land-use practices in the watershed have contributed to impaired riparian-zone habitat conditions and chronic, widespread disturbances that have altered channel processes (PCI 2006, Appendix A). In the late 1800s and early 1900s, riparian clearing for tilled agriculture and upland logging practices that used the streambed as a haul road, notably in Fay and Tannery Creeks, further simplified, deepened, and widened the channels. More extensive and technologically advanced logging and a couple of large, upland fires in the mid-1900s generated large sediment loads that are still traveling through the system. Additionally, throughout the mid-1950s to 1980s, channel clearing activities by the Sonoma County Water Agency, CDFG, and local landowners removed all large wood, kept riparian vegetation trimmed, and maintained a simplified channel to maximize flood conveyance.

As a result of channel alteration activities, in many locations channel width and structure are out of equilibrium with the size of the watershed and the historic flow regimes. The combination of incised and artificially widened channels, increased sediment loads, and minimal instream structure from large wood or floodplain development decreases the ability of the channel to develop good instream habitat structure. In fact, in some locations, a bowling-alley effect has been created in which sediment moves in large, unsorted masses during high-flow events, filling pools and depositing fines in spawning riffles. The high, historic sediment loads moving through the system have no areas in which to be stored in the upper and middle reaches of the stream system, as the channels are incised and disconnected from their floodplains. Thus, this sediment is being transported to, and deposited in, the estuary at an unusually high rate.

Agricultural and residential development practices have encroached on the channels, narrowing the riparian corridor. In some cases, the channel has been hardened to protect infrastructure adjacent to the stream. Water supply extractions in the uplands, the alluvial valleys, and instream have decreased the water available for summer dry-season flows (PCI and OAEC, in press). Hardening of land throughout the watershed and stormwater practices designed to move excess water quickly increases flood peaks and fine sediment delivery, while decreasing the amount of water infiltrated and available as groundwater in the dry season.

Together, this suite of watershed changes has resulted in incised and artificially widened channels and loss of instream habitat diversity. High-flow refugia—areas of slower-velocity water where fish can shelter during storm events—are limited because of an insufficient quantity of large wood, few undercut banks, and disconnection of the stream channel from its floodplain. Pool frequency and depth are also below desired conditions for salmonid-bearing streams. (See Chapter 4 and Appendix A.)

In 2001 through 2003, CDFG completed stream habitat and biological inventories on mainstem Salmon Creek and the tributaries of Coleman Valley, Finley, Nolan, Tannery, and Thurston Creeks (CDFG 2003a-b; 2004a-e). The inventories were conducted to assess the quantity and condition of aquatic habitat, with an emphasis on salmonid habitat, and document the presence and distribution of aquatic species. The results of the stream inventories found a low number of deep pools, low instream shelter values in pools, and gravels/cobbles embedded with fine sediment within the mainstem and all tributaries surveyed.

Despite changes in the watershed and their subsequent effects on Salmon Creek and its tributaries, the stream channels still support a variety of native fish and wildlife communities. Particularly noteworthy are the presence of anadromous salmonids, including native runs of steelhead and reintroduced coho salmon, and sensitive wildlife species, such as the California red-legged frog (*Rana draytonii*), western pond turtle (*Actinemys marmorata*), and California freshwater shrimp (*Syncaris pacifica*).

Salmonids

Steelhead trout (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*) are anadromous fish; they spawn in freshwater and mature in the ocean. Salmon Creek steelhead are part of the central California coast Distinct Population Segment (DPS), which is federally listed as threatened by NOAA's National Marine Fisheries Service. Coho salmon, central California coast ESU (Evolutionary Significant Unit), are both federally and State-listed as endangered.

Steelhead trout and coho salmon were once abundant in Salmon Creek and its tributaries. Tales of their numbers, sizes, and favorite pools are still a vital part of the local history and lore; see *Historical Timeline of Salmon Creek Watershed* in PCI 2006. Dating back to the early 1920s, local sportsmen called for blasting the bedrock falls on mainstem Salmon Creek, now part of Salmon Creek School, to allow fish passage. Throughout the 1950s, fish appeared relatively abundant in the watershed. A record from 1953 noted 20 anglers caught 13 silver salmon (coho salmon) in a period of 39 hours, all ranging in size from 2.5 to 10 pounds.

In 1961, the first stream survey of Salmon Creek was conducted by CDFG noting the presence of both adult steelhead and coho salmon. Stream surveys were also conducted in 1964 and 1965. In the 1964 survey, the majority of fish observed were silver salmon, 50 to 100 fish per 100 feet with similar findings in 1965—85 silver salmon and 64 steelhead fingerlings were caught. During a survey in 1970, 25 to 40 fish per 100 feet were noted. In 1974, there was a record salmon catch at sea off Salmon Creek. Up to the 1970s, fishermen annually broke through the



Adult coho released into Salmon Creek,
December 2008.

sandbar at the estuary noting coho salmon just “rushed in” and always made it to the plate in time for Thanksgiving.

Now only a small population of steelhead continues to return each year, and the last naturally propagated coho was seen in 1996 (Cox 2005). Many residents, community groups, and agencies have come together to understand reasons for the decline and attempt to restore the fisheries. These efforts include restoring the key habitat features to support each lifestage of these migratory species. Approximately 500 adult coho salmon were reintroduced into the creek in December 2008 and 2009 as part of the California Department of Fish and Game’s annual coho broodstock program. The fish were selected from two strains from neighboring watersheds in an attempt to recreate the likely genetic composition of the historic fishery.

Coho salmon and steelhead trout lifecycles

Adult steelhead trout migrate upstream from the ocean during the rainy season, anytime from November to March. They enter the stream only when sufficient flow has opened the coastal lagoon. Steelhead spawn (mate and lay eggs) typically at the downstream edge of pools where cover habitat exists nearby for predator protection. Eggs are laid in a redd, a depression dug into cobble or gravel substrate. Unlike salmon, steelhead can migrate out to the ocean after spawning and return in subsequent years to spawn again. Eggs hatch in 30-60 days, depending on stream temperatures. The newly hatched fish—called alevins—stay in the gravel for a few additional weeks until their yolk sac is absorbed. When they emerge, they seek slow-water areas, often at the stream margins. As they grow bigger, the juvenile fish move into faster water to feed on drifting insects.

Juvenile steelhead remain in freshwater streams from 1 to 3 years or longer. Rearing juveniles have many habitat requirements. Most important, they need sufficient, cool streamflow to transport drifting insects for feeding and cover habitat, such as undercut banks, woody material, boulders, and deep pools, to hide from predators and areas for refuge during high flows. When juveniles are large enough, they migrate out to the ocean as smolts. During out-migration, steelhead and salmon need adequate streamflow to swim past barriers and cover for predator protection.

Coho salmon have a similar, but more rigid, lifecycle than steelhead. They spend their first year in freshwater streams, migrate out to sea where they mature for two years, and return to their native creeks to spawn and die. Because all non-hatchery females are three years old, coho salmon develop three consecutive “year classes” in each stream; survival of one year class affects subsequent spawning three years later. Coho salmon are vulnerable to extreme environmental conditions, such as droughts, floods, and the timing of winter storms, which affect when the sandbar opens for upstream migration and influence survival of redds and juveniles.

Hines (2010) completed a detailed analysis of coho salmon limiting factors based on the findings of the CDFG inventories, some field observations, and anecdotal information on the watershed. Habitat indicators by lifestages were rated to determine those factors limiting the production of coho salmon within the watershed. Those with the poorest ratings included low base flows, primary pools, and shelter ratings during the summer rearing period; lack of complex, off channel habitat during winter rearing; poor habitat

availability for estuary rearing smolts; and lack of large wood debris and high turbidity levels for multiple life stages.

Other Sensitive Aquatic Species

In addition to supporting native fish populations, Salmon Creek and its tributaries provide critical habitat for other special-status aquatic species. Particularly noteworthy are the presence of California red-legged frog, California freshwater shrimp, and northwestern pond turtle.

California red-legged frog (*Rana draytonii*) is federally listed as threatened and a California Species of Special Concern. In general, they are most common in marshes, streams, lakes, reservoirs, ponds, and other water sources with plant cover. Breeding occurs in deep, slow-moving waters with dense shrubby or emergent vegetation from late November through April. Egg masses are attached to emergent vegetation (e.g., *Typha* sp. or *Scirpus* sp.) near the water's surface. Tadpoles require 3.5 to 7 months to attain metamorphosis.



Photo courtesy of Jennifer Michaud (PCI)

Adults take invertebrates and small vertebrates. Larvae are thought to be algal grazers. Within the watershed, California red-legged frogs are known to occur within stream channel habitats from the estuary and further upstream near the town of Bodega and tributaries. Reservoirs, wetlands, and other large perennial water sources also support this species; however, reported observations in these areas are spotty.

California freshwater shrimp (*Syncaris pacifica*) is federally and State-listed as endangered. It is a small, 10-legged crustacean occurring in low-elevation and gradient (less than 1%) perennial streams in Marin, Sonoma, and Napa counties. They occur in shallow pools away from the main current where they feed primarily on detritus and, to a lesser extent, on decomposing vegetation, dead fish, and invertebrates. Most shrimp appear opaque to nearly transparent with colored flecks across their bodies. Females can appear dark brown to purple under certain conditions. Breeding occurs in the autumn, but young do not hatch until the following May or early June.



Photo courtesy of Bill Cox

After breeding, female shrimp carry the fertilized eggs attached to their abdominal swimming legs throughout the winter. The freshwater shrimp has been extirpated from many streams and continues to be threatened by introduced predators, pollution, and habitat loss. Within the watershed, freshwater shrimp are known to occur from the upper end of the estuary to just north of Freestone along the mainstem (CDFG 2010). Population numbers within the watershed have tended to fluctuate from year to year due to pollution and drought (CDFG 2010).

The **northwestern pond turtle** (*Actinemys marmorata marmorata*) is a California Species of Special Concern and is one of two distinct subspecies of the western pond turtle. They are most commonly found in or near permanent or semi-permanent water sources in a variety of suitable habitats throughout much of western California. This omnivorous species requires basking sites, such as emergent logs, rocks, mud banks, or mats of aquatic vegetation, for thermoregulation. Underwater retreats are also required for predator avoidance. Nesting sites of this species have been found some distance, up to 400 meters or more, from aquatic habitat. They have also been found using upland sites for aestivation and overwintering. Within the watershed, pond turtles occur along stream channel habitats and also utilize reservoirs and other permanent water sources extensively.



Photo courtesy of Jennifer Michaud (PCI)

Riparian and Wetland Plant Communities

Upper reaches of the watershed's streams are cloaked in forests of redwood, Douglas-fir, oaks, bays, and tanoaks. While logging and clearing have occurred in these areas, the streams remain generally well-shaded by second-growth trees. Lower in the watershed, red alders (*Alnus rubra*), big-leaf maples (*Acer macrophyllum*), and buckeyes (*Aesculus californica*) line the streams. Understory shrubs and vines, including Pacific ninebark (*Physocarpus capitatus*), snowberry (*Symphoricarpos* spp.), gooseberry (*Ribes* spp.), California blackberry (*Rubus ursinus*), and honeysuckle (*Lonicera hispidula*), add to the structural complexity of the riparian forest and provide food and shelter for wildlife. The complex root structures of this varied vegetation holds soil in place, protecting streambanks and water quality. In the gentle terrain of the southern watershed, where agricultural uses are more extensive, the riparian corridor narrows. Willows (*Salix* spp.) dominate many stretches. Occasional larger trees, including coast live oaks, buckeyes, and alders, also occur.



Patches of seasonal wetland occur in low areas near Salmon Creek. Typical plants found in these areas include common rush (*Juncus patens*), meadow barley (*Hordeum brachyantherum*), and spikerush (*Eleocharis macrostachya*). Historically, wetland habitat along the middle reach of Salmon Creek supported a number of rare plant species, including federally endangered Sonoma alopecurus (*Alopecurus aequalis* var. *sonomensis*), as well as saline clover (*Trifolium depauperatum* var. *hydrophilum*), bristly sedge (*Carex comosa*), and swamp harebell (*Campanula californica*). With agricultural and residential

development, marsh habitat has declined, and none of these species has been documented in recent times.

Estuary

In the lower portion of Salmon Creek, the stream's freshwater meets and mixes with saline tidewater, to create a coastal estuary extending approximately 1.3 miles inland. The estuary supports vital habitat for many coastal and marine organisms by providing essential food, cover, migratory corridors, and breeding/nursery areas. The brackish water of the estuary also provides habitat for returning adult salmonids and outmigrating smolts as they undergo the physiological changes necessary for transition from freshwater to saltwater and back again. The lower estuary is



Aerial photograph of the Salmon Creek Estuary
Photo taken on January 28, 2008 by Lauren Hammack (Prunuske Chatham, Inc.)

part of Sonoma Coast State Beach and is managed by State Parks. As in most small Northern California streams, the mouth of the estuary is closed by a sandbar in spring or summer every year and remains closed until after the first significant storms. Under conditions of adequate streamflow, the closed estuary converts to a largely freshwater lagoon during the summer months.

Coastal Brackish Marsh and Dune Plant Communities

Coastal brackish marsh vegetation occurs near the mouth of the estuary. These low-growing plants thrive in the accumulated sediments of the estuary and are adapted to fluctuating water and salinity levels. Typical species include jaumea (*Jaumea carnosa*), saltgrass (*Distichlis spicata*), rushes (*Juncus* spp.), and bulrushes (*Scirpus* spp.).

A limited area of dune habitat occurs near the mouth. Plants and wildlife that inhabit native dune habitat are adapted to the shifting sandy substrate and constant exposure to wind and salt spray. Vegetation is typically sparse, composed mostly of low-growing herbs such as beach sand-verbena (*Abronia umbellata*), sea rocket (*Cakile maritima*), beach strawberry (*Fragaria chiloensis*), with occasional shrubs such as coyote brush (*Baccharis pilularis*). In Salmon Creek Watershed and along much of California's coast, dune habitat has been altered by the introduction of European beachgrass (*Ammophila arenaria*). This large perennial bunching grass was introduced to stabilize shifting dunes, and it is effective at doing so. However, it also reduces habitat for native species adapted to natural dune dynamics. Many land managers in coastal California are working to remove beachgrass and restore native dune species.

Sensitive plant species documented historically in the coastal dunes of the watershed include Blasdale's bentgrass (*Agrostis blasdalei*; CNPS List 1B.2, fairly threatened in California) and blue coast gilia (*Gilia capitata* ssp. *chamissonis*; CNPS List 1B.1, seriously threatened in California). However, these species have not been observed in recent decades.

Species Usage and Habitat Conditions

Adult salmonids use estuaries for staging in preparation for their upstream migration. Juveniles use them for rearing and for completing the physiological adjustment from fresh to salt water that will allow them to live in the ocean. Juveniles may linger in the estuary for weeks and may move in and out several times before remaining in the ocean. Adequate flow, good water quality, sufficient cover, habitat complexity, and invertebrate food sources within the estuary are all very important factors for the survival of anadromous fish.

Existing biotic conditions of the Salmon Creek estuary were characterized as part of the *Salmon Creek Estuary Study Results and Enhancement Recommendations* (Estuary Study; PCI 2006). Monthly biota was sampled over a one-year period providing a snapshot of salmonid usage and limiting factors with the estuary and occurrence of other coastal species. Water quality, hydrologic, and geomorphic conditions were also assessed to determine how the estuary currently supports and is utilized by salmonids.

Ten species of fish were collected (by trawl and seine) during the Estuary Study (PCI 2006). Steelhead were the only anadromous species captured. The largest number of steelhead captured was 400 individuals of varying age classes on September 8, 2004. Additional sampling by seine yielded 1, 2, 2, 1, and 7 individuals during surveys conducted in July, August, October, November, and March, respectively. Other fish species documented in the estuary included tidewater goby, prickly sculpin, Pacific staghorn sculpin, cabezon, starry flounder, Pacific herring, shiner perch, and topsmelt, as well as a variety of invertebrates, including bay shrimp, black-tailed shrimp, and opossum shrimp.

The study found that many juvenile steelhead (likely in the thousands) migrate from upstream to the Salmon Creek estuary in the late summer/early fall and congregate near the mouth where the water remains mixed and cool. This large complement of the watershed's annual salmonid production becomes trapped in the shallow, open area as flows upstream drop, and water quality becomes inhospitable in other areas of the estuary. Predation by pelagic birds significantly reduces fish populations in this critical habitat, with up to 100% predation occurring during drought years.

The study also found that increased water consumption in the upper watershed from groundwater and direct stream withdrawals has reduced base streamflows during critical periods. Low spring and summer flows increase pool stratification in the estuary to create bottom saline layers too hot and low in oxygen to sustain salmonids. Fish are confined to the upper freshwater layer and to the well-mixed area near the sandbar where they are vulnerable to predation by birds. Low spring and summer flows also reduce lagoon elevations and delay the breaching of the sandbar. If the sandbar opens after or near the end of the coho upstream migration period, as occurred in the 2004/2005 winter, coho have little, if any, chance of returning to Salmon Creek. Low summer flows also reduce viable salmonid rearing habitat in the main channel and tributaries. Many juvenile salmonids are stranded as pools go dry and with no surface or subsurface flow, the remaining pools become anoxic.

Changes in the delivery of coarse sediment have also altered the estuary, compromising habitat for salmonids and other aquatic species. Significant amounts of coarse sediment have dramatically decreased the areal extent and depth of the estuary since the mid 1800s. Ongoing deposition is occurring at a rapid rate. For example, a 2-year period

between 2004 and 2006, over 2 feet of sediment was deposited upstream and downstream of the Highway 1 bridge. Summer lagoon depths now range from 2 to 6 feet as compared to 6 to 12 feet in the 1950s and 1960s. Erosion of fine sediments from the upper watershed creates high turbidity levels that impair salmonid physiological functioning and behavior.

In addition to supporting salmonids, the lower Salmon Creek estuary provides habitat for two other noteworthy special-status species, tidewater goby and western snowy plover:

The **tidewater goby** (*Eucyclogobius newberryi*) is federally listed as endangered and a California Species of Special Concern. It is a small, elongate, grey-brown fish endemic to coastal lagoons, estuaries, and marshes of California. Its annual lifecycle is closely tied to the dynamics of lagoons and estuaries with breeding commencing after their habitat closes to the ocean. Small vertical nesting burrows are dug in the substrate in areas of coarse sand with peak breeding activity occurring in late April through early May. Threats to tidewater goby include development, water diversion and manipulation of habitat, channelization, nonpoint and point source pollution, discharge of agricultural and sewage effluents, and impacts from cattle grazing. The Salmon Creek estuary supports a robust population of gobies.

The **western snowy plover** (*Charadrius alexandrinus nivosus*), federally listed as threatened and a California Species of Special Concern, is a small shorebird,



Photo courtesy of Dee E. Warenycia.

approximately 6-inches in length. They breed primarily on coastal dunes and beaches, including beaches at creek and river mouths, and salt pans at lagoons and estuaries. They forage for small invertebrates amongst beach sand, kelp, and low vegetation. The spread of the densely growing European beachgrass has reduced habitat for the snowy plover. Other threats to plover populations include disturbance by humans and pets. On-going surveys by State Parks have documented plovers occupying the lower estuary during the non-breeding season (Dekelaita and O'Neil

2007). One nesting attempt was successful in 2005; however, this was attributed to the unusual configuration of the mouth of Salmon Creek at the time. For the most part, this species is thought to be an uncommon winter resident.

Climate Change

Average temperature in California has risen 1.5° F over the past 50 years and is projected to rise another 2-4° F by the end of the century (Karl et al. 2009). In California, precipitation is likely to decline slightly overall but with more intense storms during a shorter rainy period and a longer, hotter dry season, resulting in both more droughts and more floods (Karl 2009). Battin et al. (2007) found the three most important climate-induced hydrologic changes for salmonids are peak flow during egg incubation, stream temperature during pre-spawning, and minimum flow during spawning. Scour from high flows during incubation is a significant negative impact for winter-run species (Bisson 2008). Lower flows in the summer will reduce pool depth and riffle connectivity while higher water temperatures will likely promote algal growth and lower dissolved oxygen. These changes, in turn, reduce the quantity of preferred insect food sources even as warmer water raises fish metabolism and food demand.

Climate change will also impact the health and composition of watershed vegetation. Protection and enhancement of riparian habitats can play a vital role in helping aquatic and terrestrial organisms adapt to climate change (Seavey et al. 2009). Because of their high water content, riparian forests absorb heat and can protect both plants and animals from extreme temperatures (Naiman et al. 2000) while providing connectivity to different microclimates.

CHAPTER 3: UPLANDS MANAGEMENT ACTION PLAN

Context

Upland habitats in the Salmon Creek Watershed—steep, forested ridges; open, rolling grasslands; and coastal scrub—provide key ecological functions that protect soil, air, and water quality, as well as water quantity. Native plants associated with these habitats evolved under the specific environmental conditions of the region and often have unique adaptations necessary to provide these functions. Many species of animals are dependent upon the upland habitats and associated native vegetation communities. (See Figure 3 for a map of watershed vegetation.)



*Looking out from Ocean Song Farm and Wilderness Center.
Photo courtesy of Kathleen Kraft.*

Complex interactions between soils, climate, vegetation, and water, with variations of topography in the mix, drive the natural processes that determine the quantity and quality of water in the streams, as well as habitat conditions for aquatic and terrestrial animals. Multi-storied forest canopies and well-managed grasslands intercept rainfall, softening its erosive impact on the soil below, slowing water flowing over the ground surface, and promoting infiltration and groundwater recharge. Plant litter on the ground increases this effect. The root systems of trees, shrubs, and grasses stabilize the land, keep the soils in place, and provide pathways for rainwater to travel deep into the ground. Natural disturbance regimes, such as fire, drought, and disease outbreaks, play an important role in maintaining habitat diversity. Research indicates that biodiverse systems composed of native species are more resilient and can recover more quickly from such disturbances than simplified systems, such as monocultures or those composed primarily of nonnative species (Walker 1992, Tilman et al. 1998).

An example of the interdependency of natural processes and habitat in the Salmon Creek Watershed is found in redwood forests. Regeneration of redwoods and their understory counterparts depends on the microclimate that mature redwoods create. The many fine needles of redwoods intercept and condense fog, which then drops to the ground to substantially increase the water available to the redwoods themselves and the tree seedlings, shrubs, ferns, fungi, and soil around them (Dawson 1998). When large patches of redwood forest are cleared, as occurred throughout the Salmon Creek Watershed beginning in the mid 1800s, this process of moisture capture and fog drip is diminished. In turn, groundwater recharge is reduced, which ultimately affects summer baseflow in nearby streams.

In this watershed and throughout California, the annual grasses and livestock practices brought to the region by early settlers have contributed to the conversion of native perennial grasslands to simplified communities of nonnative annual grasses (Stromberg et al. 2007). The perennial grasses native to the Salmon Creek Watershed typically have large root systems to access limited water in the soil during the dry summers and, therefore, have tremendous potential to hold soil and buffer erosive forces. The short-



*Native California oatgrass (Danthonia californica) along Coleman Valley Road.
Photo courtesy of Kathleen Kraft*

lived annual grasses with their shallow roots are not as effective at trapping and holding moisture, preventing erosion, or storing biomass.

Both forests and grasslands serve a major role in carbon storage and nutrient cycling. Inappropriate clearing of forests and tilling of soils accelerate the release of carbon to the atmosphere and reduce the ongoing carbon sequestration that trees or grasslands would have provided. Nutrients absorbed from the soil are used for plant growth and incorporated into leaves, stems, roots, and seeds. These, in turn, provide essential nutrition for wildlife and livestock. As plants

and animals die and decay, nutrients are released back into the soil. Inappropriate logging, clearing for new construction, and some agricultural practices remove nutrients from the watershed.

Although 50% of the watershed is occupied by forests and woodlands, little active management of these lands presently occurs. While most redwood and Douglas-fir in the watershed have been logged at least once in the past, logging activity in modern times is minimal with less than 100 acres cut in the last 10 years. Active forest management can benefit forest and woodlands by reducing fuel loads, increasing fire safety, and improving forest health. Potential products generated from these lands include lumber, fire wood, carbon sequestration, open space, and scenic beauty. Utilizing sustainable methods, these benefits can be utilized and enjoyed while protecting soil stability, water quality, and wildlife habitat.

Fires, whether started by lightning or people, are thought to have significantly shaped the vegetation of coastal California (Lightfoot and Parrish 2009). Native Americans of the region used managed burning for a number of purposes, including as a tool to increase the density and vigor of edible bulbs, grasses, and other valued plants. High fire frequencies tend to favor grassland over woody plant communities. Native American fire regimes likely resulted in a landscape of increased diversity with a patchwork of burned and unburned areas (Lightfoot and Parrish 2009). Today, prescribed fire is rarely used in the watershed and unintentional fires are typically suppressed. As a result, fuel loads have increased. The spread of Sudden Oak Death (SOD) and flammable invasive species, such as gorse, adds to the risk of catastrophic, widespread wildfires.

Changes to upland conditions from land-use practices can have wide-ranging impacts on the health of the land, streams, and ocean and on their ability to support humans and native wildlife. Upland stewardship choices that protect or restore natural processes are key to sustaining biodiversity and well-functioning habitat throughout the watershed. Since most of the watershed's residents live in the uplands, achieving upland enhancement goals will depend on collective positive action on property of all sizes from backyards to ranches.

Goals

- Uplands include the native plant communities historically known from the watershed and support robust populations of native wildlife.

- Upland habitats are resilient and biologically diverse with intact ecological functions.
- Upland ecosystems and their management help maintain high water quality and sufficient water supplies for humans, terrestrial and aquatic species.

Uplands Recommendation 1: Manage forests and woodlands to maintain diversity and ecosystem function.

Scientific Reasoning

Forests and woodlands help to protect the quality of water in the Salmon Creek Watershed. Healthy forests increase stormwater infiltration, stabilize slopes, and slow erosion. Logging and clearing in the watershed have altered the age structure and composition of remaining forests. Today's forests are younger, with more closely spaced trees and a denser, brushy understory. This can create a high fuel load of flammable branches. The spread of SOD is changing forest composition and increasing the risk of high-intensity wildfires (UCCE et al. 2008). Maintaining diverse, self-sustaining redwood and mixed evergreen forests will entail protecting existing healthy stands and addressing risks from fire and disease.

Forests also play a key role in carbon cycling. Mature forests sequester and store large quantities of carbon in plants and soil. Protecting mature forest enhances the watershed's ability to absorb and store carbon, potentially mitigating the effects of climate change.

Action 1a. Provide education and technical support for landowners to manage healthy forests.

Specific actions may include removal of dead or diseased tanoaks and invasive species, replanting with native trees of local origin, thinning unhealthy young trees or crowded stump sprouts, and building swales to increase on-site water capture.

Implementation Measures

- Conduct a watershed workshop or small forest "fair."
- Provide information on websites. Distribute handouts at local events.
- Encourage landowners to develop Forest Improvement Plans that address forest health and sustainability and assist landowners in applying for grants for funding plan preparation.
- Encourage landowners to utilize NRCS EQIP Forestry CAP (Conservation Activity Plan) to help fund development of Forest Improvement Plans by Registered Professional Foresters working in partnership with Cal Fire.
- Encourage landowners to utilize NRCS EQIP to implement Forest Improvement Plans.
- Promote management of existing redwood forest to encourage development of late seral stands.
- Coordinate with local conservation corps to provide low-cost work crews to assist landowners.

Action 1b: Identify priority areas for forest and woodland conservation, including late-successional redwoods that provide habitat for special-status species.

Knowing where important forest and woodland tracts exist, in combination with records of special-status species, will help identify opportunities for conservation through education, landowner agreements, or conservation purchases.

Implementation Measures

- Target high priority areas.

Action 1c: Implement a fuel-load management program in cooperation with Cal Fire.

Management actions may include downed wood removal, thinning of crowded and unhealthy trees, thoughtful understory management, and controlled burns.

Implementation Measures

- Target high priority areas.
- Organize neighborhood meetings with Cal Fire and local fire departments.
- Coordinate with local conservation corps to provide low-cost work crews to assist landowners.
- Assist neighborhoods in organizing and finding funding for chipping programs.

Action 1d: Determine the extent of Sudden Oak Death in the watershed and educate landowners about minimizing spread and managing infected forests.

Implementation Measures

- Coordinate with UCCE to monitor extent of SOD.
- Create outreach materials to educate landowners about how to prevent SOD spread, treat diseased trees, and handle infected wood. Distribute at local events, other watershed workshops, and through websites.
- [Develop, publish, and publicize Best Management Practice \(BMP\) recommendations for private forest and woodland owners.](#)

Uplands Recommendation 2: Protect existing coastal prairie and other grasslands rich in native species and manage for healthy grasslands throughout the watershed.

Scientific Reasoning

Grasslands in the Salmon Creek Watershed—like grasslands across California—have undergone dramatic changes in the past 200 years. Expanses of native bunchgrass and coastal prairie, rich in native bulbs and annual wildflowers, have been largely replaced by nonnative European grasses. Several native grassland plant species have been extirpated from the watershed, and others are known to be imperiled. Patches of native grassland remain in areas of coastal influence, on serpentine-derived soils, and in other areas of low-nutrient soils within nonnative grassland. However, fire suppression, some livestock grazing practices, and the spread of invasive species are all continuing threats to native grasslands.

Livestock grazing is a common land use in the Salmon Creek Watershed. Appropriate grazing has the potential to maintain or improve the health of the ecosystem, while high-impact grazing practices can cause severe deterioration of grassland health. Grazing can positively impact rangelands by stimulating plant growth, helping to maintain



*Coastal prairie species.
Photo courtesy of Kathleen Kraft*

optimal leaf area, enhancing nutritive value, removing excess litter, accelerating nutrient cycling, and manipulating botanical composition. In carefully managed conditions, grazing can be used as a control mechanism for invasive and undesirable species. Ecologically based grazing management increases the number of different plant species on rangeland, and creates a mosaic of different habitats that enhance biodiversity. A properly designed grazing system can also be used to provide zones of reduced fine fuel to assist in controlling wildfires.

Protecting and enhancing native grasslands, along with managing annual grassland to increase native species composition, will protect biodiversity and help maintain economically valuable livestock forage.

Native perennial bunchgrasses with deep, extensive root systems are very effective at protecting slope stability, an important factor in stream water quality. Healthy grassland also plays an important role in pulling carbon dioxide from the atmosphere and sequestering it in plant tissue and soil.



*Velvet grass flourishes in the absence of grazing.
Photo courtesy of Jim Coleman*

Action 2a: Support watershed ranchers in developing and implementing ranch plans that include sustainable grazing practices.

Implementation Measures

- Coordinate with UCCE and NRCS to support ranchers in developing plans.

Action 2b: Support local research and education efforts to identify and refine management strategies that promote native grassland species.

Implementation Measures

- Establish and support demonstration sites for ongoing education.
- Provide a range of educational materials and tours for ranchers, small grassland owners, and the general public.

Action 2c: Identify priority areas for native grassland conservation.

Action 2d: Develop local seed sources for native grassland plants.

There are very few readily available commercial sources of native grassland seed derived from Salmon Creek Watershed sources. A few commercial sources of California native grassland seed exist, but generally the seed provided is not of local origin. Many native plant populations show local variation. Using local seed ecotypes helps maintain local biodiversity and may also increase the likelihood that planting efforts will be successful. Making local seed available would support landowners and land managers in using appropriate natives in restoration efforts.

Implementation Measures

- Develop database of locations where key grassland species for restoration occur, and where landowners are willing to allow seed collection.
- Offer workshops identifying key grassland species for restoration use, methods of seed collection, and options for seed increase.
- Support development of a community seed bank.

Uplands Recommendation 3: Reduce impact of invasive species populations on habitat quality and function.

Scientific Reasoning

Invasive species are abundant in the watershed. In particular, gorse, French broom, Scotch broom, and Himalaya blackberry have reduced habitat values, increased fire hazards, and reduced rangeland quality. Removing these species and educating residents about their impacts will help restore important ecosystem functions to the uplands of the watershed.

Action 3a: Inform residents about invasive plant species, removal techniques and timing to avoid erosion and wildlife impacts, and native species suitable for residential or rangeland plantings.

Implementation Measures

- Hold a weed-whacking workshop.
- Partner with local nurseries and distributors to provide free native plants, protectors, and other revegetation products to participants.
- Provide information on websites. Distribute handouts at local events.



*Nonnative and invasive velvet grass (Holcus lanatus).
Photo courtesy of Trent Draper*

Action 3b: Promote removal of gorse, French broom, Scotch broom, and Himalaya blackberry infestations and replanting with appropriate native species.

Implementation Measures

- Provide use of weed wrenches for a nominal fee.
- Organize neighborhood work parties.
- Provide free native plant(s) and disposal of invasive plant material.

Action 3c: Monitor new occurrences of invasive species and contribute to regional weed management databases and efforts.

Uplands Recommendation 4: Preserve undisturbed upland habitat and its connectivity.

Scientific Reasoning

Keeping large tracts of land undeveloped is important to the health of the Salmon Creek Watershed in several ways. Many wildlife species depend on being able to move throughout large territories to find the food, water, shelter, and breeding habitat they need to survive. A few local examples include deer, bobcats, mountain lions, spotted owls, and pileated woodpeckers (Crooks 2002, George and Brand 2002). Other species have smaller territories but require adjacent patches of different habitat types for different life stages or functions. Fragmentation of habitat also has negative effects on native plant communities. Compared to intact, continuous habitat, small patches of native forest or grassland have smaller plant population sizes, greater isolation from other populations, and higher proportions of disturbed “edge” areas. As a result, fragmented plant communities are more likely to be invaded by nonnative species and to decline in diversity over time (Minor et al. 2009). Fragmentation can also reduce pollinator populations and their crucial services to native plants and some crops (Keitt 2009). Finally, maintaining large tracts of undeveloped or low-intensity agricultural land

contributes to the beauty and serenity that many residents of the watershed value, and to the ability of local agricultural producers to sustain their livelihood.

Action 4a: Identify and protect areas needed for wildlife corridors and critical habitat.

Action 4b: Encourage use of wildlife-friendly fencing.

Most fences should allow for adequate passage of non-livestock species (i.e., smaller species should be allowed to pass under or climb over freely, and deer should be able to jump over). Fences should be constructed out of materials that will prevent entanglement and should be highly visible to wildlife. They should not restrict movement through critical habitats (e.g., stream corridors, wetlands). Unneeded perimeter fencing that excludes wildlife from large areas of habitat should be avoided. Remnant fences in rural residential neighborhoods left from past agricultural operations should be removed or modified if they unnecessarily impede wildlife movement.

Implementation Measures

- Develop informational materials to post on websites and distribute at workshops, local events, and landowner visits.

Uplands Recommendation 5: Remove invasive species from coastal dunes.

Future funding is needed to develop recommendations for restoration and protection of coastal dunes in the Salmon Creek estuary.

CHAPTER 4: INSTREAM & RIPARIAN HABITAT ENHANCEMENT ACTION PLAN

Context

Stream systems are inherently subject to change. Vegetation distribution and channel form respond dynamically to seasonal, annual, and multi-decadal variations in precipitation and streamflow. They are also shaped by geology, topography, and climatic conditions. Riparian zone and channel processes are inextricably linked. By intercepting and absorbing rainfall and the overland flow of stormwater, vegetation moderates flood flows and filters out nutrients and other pollutants. Varied and extensive root systems hold soil, protecting streambanks from erosion. By slowing down runoff and providing root channels for water



Intact riparian forest along Salmon Creek.

absorption, vegetation increases the water absorbed into the land and stored for later release. Reciprocally, the flow regime (magnitude, frequency, duration, timing of stream flows) influences the distribution and regeneration of riparian plants, as do the dynamics of sediment erosion, transport, and deposition within the riparian zone.

The riparian zone provides important habitat and corridors for wildlife. Where intact riparian vegetation stretches along the length of a creek, it becomes a passageway for native wildlife, linking areas of upland and downstream habitat. These passageways are crucial, especially in landscapes where uplands are developed, farmed, and fragmented. The roots and downed wood of large trees provide shelter for salmonids and other aquatic creatures. Trees shade the water and keep it cool. Allowing the riparian corridor enough space to naturally regenerate its complex of trees, shrubs, and groundcover is crucial to wildlife habitat and water quality.

Many native species have evolved to thrive in the dynamic, complex environment of the riparian zone. In many cases, their survival depends on frequent changes in stream flow, channel morphology, and sediment distribution. For example, willow and alder seeds require fresh sands and gravels left by floodwaters to germinate; salmon and steelhead require deep pools, shelter, and gravel riffles created by downed trees and the scour they generate; and amphibians need the seasonal pond features left behind by shifting channels. All riparian species depend on the floodplains formed through the processes of streambank erosion and channel migration.

Dramatic changes in channels and the riparian zone that severely alter the habitability of a stream for a population of native species are typically caused by natural disturbance regimes, such as floods, fire, or disease. Because the frequency of these large events is low and their distribution is often limited to individual reaches or sub-tributaries within a watershed, the impact of these extreme events is minimal. Native aquatic and riparian species have adapted to local disturbance regimes, which made them resilient. However, their resiliency is limited. Chronic and widespread alterations to the environment that

are outside of the natural range of variation tax individuals and eventually lead to the waning of populations.

The decline and extirpation of coho salmon in Salmon Creek is a case in point. The arrival of Europeans to the area initiated a long period of dramatic changes to the riparian zone and channel processes that, coupled with fishing pressures and altered water quality and quantity conditions, caused the salmon population to crash. The physical and biological effects of the chronic, cumulative impacts are still occurring.

Historic land-use practices have impaired streams and riparian corridors in the Salmon Creek Watershed. Channel incision, over-widening, simplification, and riparian encroachment make certain conservation and restoration activities imperative for riparian and instream habitat in the watershed:

- Instream habitat complexity in the form of large wood structures, vegetated gravel bars, and inset floodplains needs to be created to provide high-flow refugia, pools, and sediment sorting.
- Riparian forests must be protected and enhanced to provide shade, bank stability, and sources of large wood.
- Grasses and small shrubs in the riparian corridor must be protected, and be of sufficient extent, to provide bank stability and pollutant filtration.
- Delivery of fine sediment from upland sources must be reduced.
- Summer base flows must be maintained and increased to supply instream pools and the estuary with cool, oxygenated water.



Healthy riparian forest and large wood structures (installed by Dragonfly Stream Enhancement) provide complex instream channel.

Instream habitat conditions are commonly assessed in relation to the needs of coho salmon and steelhead. Conditions supportive of salmonids generally support other sensitive aquatic species. Salmonids need deep, shaded, cool pools with lots of shelter and sufficient food for successful rearing. High-quality gravel is critical for successful spawning, as well as to support macroinvertebrate production. In neighboring coastal streams, high-flow refugia is cited as being the primary factor limiting coho and steelhead populations (Stillwater Sciences 2008). Agencies tasked with protecting and recovering salmonid populations and restoring instream habitat conditions have developed habitat indicators and associated values to rank habitat quality; see Table 1.

Table 1. Selected instream habitat indicators and a value ranking system for coho salmon.

Habitat Attribute	Indicator	Ranking		
		Poor	Fair	Good
Riparian Vegetation	Species composition based on historical condition	<25%	25-50%	>50%
	Avg. Canopy Cover	<75%	75-85%	85-95%
Pool Habitat and Velocity Refuge	Frequency of primary pools*	<30% pools by length	30-40%	40-50%
	Floodplain Connectivity	<50%	50-80%	>80%
	LWD frequency	<4 key pcs / 100m	4-6 / 100m	6-11 / 100m
	Shelter rating**	Score of <60	60-80	80-100
Gravel Quality and Spawning Substrate	% <0.85 mm % <6.3 mm	>17% >30%	15-17%	12-14% <30%
	% of pool tailouts with ≤50% embeddedness***	<25%	25-50%	>50%

Source: NOAA 2010.

***Primary pools** third and fourth order streams are defined as having a maximum depth of at least 3 feet, occupying at least half of the width of the low flow channel, and being as long as the low flow channel width (CDFG 2004d).

****Pool shelter** includes those elements that provide predator protection, areas of low water velocity that can be used for refuge, and separation of territorial units (CDFG 1988). It is also a useful indicator of pool complexity.

*****Cobble embeddedness** depths (the degree to which materials are buried in fine sediment) at pool tailouts are important to successful spawning of salmonids. Embeddedness ratings of 25% or less are considered desirable for spawning salmon. (CDFG 1988)

As our climate changes, functional riparian zones will likely play an even more important role in native species and habitat resiliency (Seavy et al. 2009). A defining feature of many riparian plants is their ability to withstand hydrologic and geomorphic disturbances. Thus, the impacts of increased flooding and drought, which are predicted to accompany climate change in many regions including coastal California, may be tempered by a healthy, complex riparian corridor and instream structure.

Goals

- The riparian corridor is sufficiently wide to provide shade, nutrient filtration, cover, and a sustainable source of large wood.

- The riparian corridor's vegetation density and diversity provide adequate nesting opportunities, food, and shelter and serve as corridors or islands during migration for a variety of terrestrial wildlife species.
- Instream habitat structure complexity supports fish and other aquatic species at all lifestages for robust, self-sustaining populations.
- Water quality and quantity support instream, riparian, and estuarine communities.

Instream & Riparian Recommendation 1: Protect and increase existing riparian corridors.

Scientific Reasoning

Healthy, mature riparian vegetation helps keep water cool and clean, protects streambanks from erosion, moderates flood flows, and provides roots and wood that are vital to creating the diverse habitat that salmonids and many other aquatic creatures need.

The benefits that riparian habitat or "buffer" zones along streams provide often depend on the width of the protected area. Recommended buffer widths depend on many variables, including local vegetation types, slope steepness, and stream hydrology. Table 2 below summarizes some key functions of riparian buffers and the widths typically needed to provide those functions.



Riparian corridor along Salmon Creek in the Freestone Valley, looking southwest.

Photo courtesy of Lauren Hammack.

Considering these functions, many natural resource management agencies advocate a USDA-recommended three-zone system for riparian buffers (Welsch 1991). Zone 1 is the area nearest the creek, and recommendations are typically to maintain undisturbed native forest in an approximately 15-25' wide swath. Moving out from the creek, Zone 2 is considered to be the next 50-100', with forest and understory shrubs providing wildlife habitat and allowing for some human management and thinning. Zone 3 is the outer 20-25' of the buffer and may consist of additional forest, woodland, or grassland. Even if only grasses are present, this outer zone helps slow the velocity of runoff and filter pollutants.

Table 2. Riparian buffer functions and widths.

Function	Width	Rationale & References
Nutrient reduction	10-100+ feet	<p>Vegetated, and especially forested, riparian areas can reduce nutrient input to waterways. Plants take up nutrients and trap nutrient-rich sediments. Vegetation also supports denitrifying bacterial activity in the soil. (WDFW 1997, Martin et al. 1999)</p> <p>Nutrient removal efficiency of riparian buffers varies with many factors, including the types of soil, nutrients, input pathways, and vegetation involved. A USEPA review estimates that, in general, 50% nitrogen removal efficiency is achieved with a 10' buffer, 75% efficiency with a 92' buffer, and 90% removal with a 367' buffer. (USEPA 2005)</p>
Large woody debris recruitment	100-150 feet	<p>To supply the LWD beneficial to salmonids, buffers must be sufficiently wide to support the growth and recruitment of mature large trees including redwood, Douglas-fir, and bay (WDFW 1997). A 100' buffer typically allows for three to five mature tree widths; redwood crowns average 25-35' wide, Douglas-fir averages 15-25', alder averages 30-40', and bay canopies are typically 25' or wider (Gilman & Watson 1994).</p>
Bank stability and reduction of fine sediment delivery	35+ feet	<p>Roots of riparian vegetation, including rhizomatous sedges and rushes as well as woody species, can hold soil in place and reduce erosion immediately beside the creek (Rashin et al. 2006). Other research indicates additional benefits at widths of 100+ feet (WDFW 1997).</p>
Water temperature reduction	100 feet	<p>Increased shade from riparian trees reduces water temperature, benefiting aquatic species. 100' buffer typically needed to provide 50-100% shading of stream (WDFW 1997).</p>
Regeneration of diverse native riparian vegetation	150+ feet	<p>Riparian vegetation typically contributes to a cooler, moister microclimate that supports its own regeneration. Narrow or denuded riparian areas may become hotter, drier, and less likely to support germination and growth of riparian species (Brosofske et al. 1997).</p> <p>Wide riparian buffers allow space for a diversity of age classes in the woody vegetation. This diversity supports the stand's ability to regenerate naturally and persist in the long term. Limited age structure complexity often indicates that riparian trees are not naturally regenerating or are not reaching maturity.</p> <p>Wider buffers also correlate to lower invasive species cover, leaving more opportunities for native species to regenerate. (Russell 2004)</p>

Function	Width	Rationale & References
Wildlife habitat and corridor protection	100-2,000 feet	Mammals – In a Sonoma County study, activity level of native mammalian predators was highest in riparian areas with wide (2,200') buffers. In narrow (65') buffers, activity was half as great; in denuded areas, it was one-quarter as great (Hilty & Merenlender 2004). Birds – 200- 650' (WDFW 1997). Reptiles and amphibians - 100-312' (WDFW 1997). Invertebrates – 100' (WDFW 1997, Warner & Hendrix 1984).

The riparian zone functions described above are impaired in the Salmon Creek Watershed. Although many reaches are shaded by vegetation, the riparian corridors are often narrow and lacking in complexity or large trees (KRIS 1994). Early logging and clearing for agricultural fields removed mature riparian trees, narrowed the riparian corridor, and simplified the channel. Residential development, livestock grazing, vineyard development, and some bank stabilization measures continue to confine the riparian corridor to an unstable width. In many stream reaches, there is only a single row of mature riparian trees at the top of bank. If streambank retreat—which is natural and desirable in incised systems such as Salmon Creek—removes the single riparian tree, the bank becomes vulnerable to rapid and unchecked erosion. In addition to destabilizing effects on the streambank, a thin canopy affects water temperature and inhibits tree re-establishment. Geomorphic assessments of Salmon Creek and its tributaries indicate that severe bank erosion occurs primarily where riparian forest is limited or absent (PCI, unpublished data).

CDFG habitat assessments rate canopy cover in the watershed as fair (averaging 65%). Canopy cover of 80% or more is considered desirable. This rating is a measure of shading of the streambed, not an indicator of corridor width, continuity, or functionality. Below-average canopy cover was noted on the mainstem and Coleman Valley, Finley, Nolan, and Thurston Creeks. With the measures described below, valuable riparian habitat can be protected and enhanced in the watershed.

Action 1a: Increase and protect riparian corridor widths to improve function and habitat quality.

Implementation Measures

- Educate landowners and residents about the benefits of riparian corridors and functional widths.
 - Develop fact sheets for distribution.
 - Develop workshops that include site visits to demonstration sites with a range of riparian conditions and land-use situations.
- Install riparian fencing along stream reaches accessed by livestock.
 - Set fences back from top of bank a minimum of two tree canopy widths, more where possible to maximize riparian functions.
 - Provide off-channel water sources.
 - Develop riparian pasture management and grazing plans.
- Develop a program to assist rural residential landowners in managing their land for wider riparian corridors.

- Develop guidance on minimizing land-use activities within the biotic resource zones.

Action 1b: Enhance riparian corridor structure complexity and species richness.

Implementation Measures

- Educate landowners along riparian corridors on the components of a healthy riparian corridor.
 - Host workshops on native species planting and invasive removal and control.
 - Produce handouts guiding landowners on riparian plant composition and landscaping for diversity.
- Plant riparian trees and herbaceous shrubs in riparian areas with insufficient density and complexity.
 - Maintain plantings until well established.

Instream & Riparian Recommendation 2: Increase instream channel complexity.

Scientific Reasoning

Large wood accumulations, mature trees along the active channel, and gently sloping vegetated streambanks are all needed to create and maintain instream channel complexity for high-quality aquatic habitat. Large woody debris (LWD) is an important driver for both geomorphic process (channel form as well as sediment sorting and deposition) and ecologic conditions (habitat elements, cover, and organic material input) (Opperman 2005, citing Beechie and Sibley 1997; Bisson et al. 1987; National Research Council 1996). It has been documented that coho salmon juvenile abundance is positively correlated to the presence of large wood within a stream reach (Bryant and Woodsmith 2009). In Mediterranean climate systems, such as Salmon Creek, with their low summer streamflows, the successful rearing of

juvenile salmonids is likely particularly linked to the habitat value of pools associated with woody debris structure (Opperman 2005).

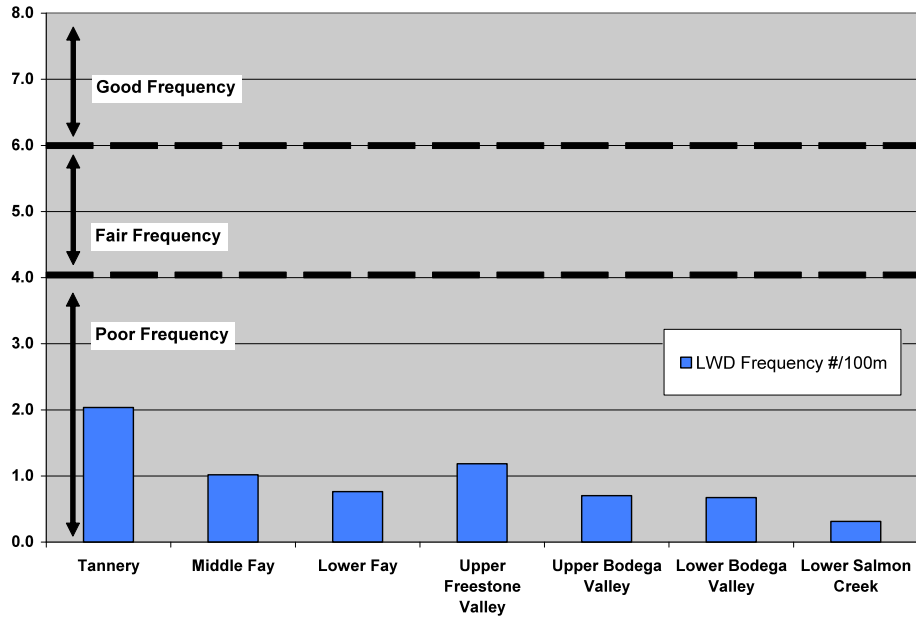
Several measures of large wood frequency and its relation to instream habitat quality have been developed and used in assessing northern California stream conditions (NCRWQCB 2006a; NMFS 1996). NOAA's NMFS (2010) has set ratings for LWD frequency for streams with bankfull widths less than 10 m. Salmon Creek and its tributaries fall under the "Poor" rating with LWD frequencies ranging from 0.3 to 2.0 pieces per 100 m (Figure 4). Frequency of key large wood pieces is used as a metric of habitat quality for coho salmon and steelhead. Note that the frequency in all



Naturally recruited (upper photo) and installed (lower photo) large wood structures.

reaches of Salmon Creek and its tributaries is rated as poor according to NMFS indicator targets (NOAA 2010).

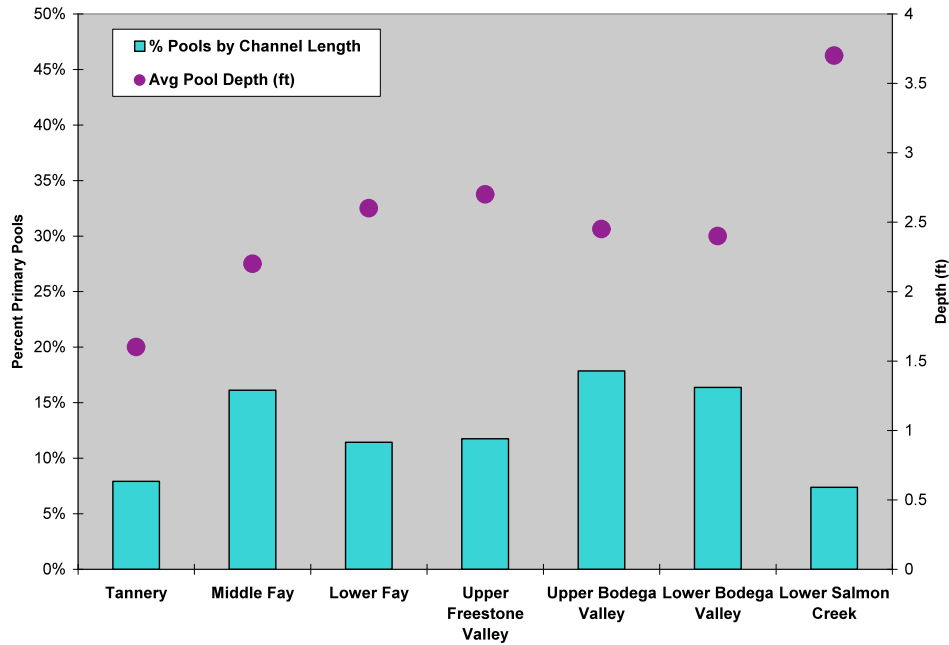
Figure 4. Frequency of key large wood pieces per 100 m.



Source: PCI 2010.

A related metric—the percent of primary pools by length—also rates “Poor.” Good habitat requires 40-50% of the channel length to be pools, and, in the Salmon Creek Watershed, primary pools only account for 7-18% of the channel length (Figure 5) (PCI 2010, Appendix A).

Figure 5. Pool frequencies and depths in reaches of Salmon Creek and tributaries.



Source: PCI 2010.

In coastal, hardwood-dominated watersheds, such as Salmon Creek, live trees adjacent to the channel are key elements in the formation of pools and instream structure that support salmonids and other aquatic species (Opperman and Merelander 2007; Opperman 2005). Live mature trees, when they are located immediately adjacent to the channel, provide shade over the creek, insects and leaves to feed fish and aquatic invertebrates, and material for large wood accumulations. The complex root masses provide bank stability and, when undercut, premium habitat for salmonids and the endangered freshwater shrimp.



Riparian corridor along Fay Creek with good riparian benches but poor instream complexity for fish habitat, July 2008

Many reaches of Salmon Creek and its major tributaries are incised, disconnected from their historic floodplains, and have few inset flood benches (PCI 2010, Appendix A). Vertical, unvegetated banks maintain high velocities and are prone to erosion and bank retreat. Over time, incised channels will typically widen and establish inset floodplains, going through a series of forms commonly referred to as channel evolution (FISRWG 1998; Schumm et al. 1984; Simon 1989). This could take decades or centuries, and channel management practices such as bank stabilization attempt to arrest this process. Bank retreat in incised channels allows vertical banks to become gently sloping and inset benches to develop where riparian vegetation can establish. Vegetated slopes and inset benches stabilize banks, reduce the impacts of flood flows, and provide critical high-flow velocity refugia for salmonids.

Action 2a: Increase wood in stream channels.

Implementation Measures

- Educate landowners and residents on the importance of large wood in stream channels and the legal constraints on its unauthorized removal.
 - Develop and distribute fact sheets that address concerns of bank erosion and flooding.
 - Host workshops.
- Leave naturally downed large wood in channel unless it is threatening infrastructure.
- Install large wood structures.
- See Recommendation 1 for actions to increase available wood and promote natural recruitment through riparian corridor enhancement.

Action 2b: Allow bank widening and inset flood bench development in reaches not constrained by buildings or infrastructure.

Implementation Measures

- Use non-rock, biotechnical engineering practices to stabilize banks.
 - Slope banks back at a minimum of 2:1 slope; 3:1 or 4:1 is optimal for riparian habitat and bank stability.
 - Install floodplain benches at elevations that will be inundated at typical annual high flows.
- Allow natural bank retreat and slumping.
 - Plant slumped areas to stabilize.

Action 2c: Promote tree establishment along the active channel and on streambanks for bank stabilization, live wood complexity, and undercut bank development.

Implementation Measures

- Remove chronic disturbances, such as grazing; see Instream & Riparian Recommendation 1.
- Stabilize and slope eroding banks with bioengineering approaches and plant early successional riparian species such as willow along with hardwood and conifer species.
- Leave or install large wood on active channel margins and banks to slow flood velocities, deposit fine sediment, and protect seedlings.
- Allow undercut banks to develop.

Instream & Riparian Recommendation 3: Reduce fine sediment delivery and maintain gravel quality.

Scientific Reasoning

The presence of excessive fine sediment can degrade instream habitat and cause aquatic species population declines by inhibiting successful reproduction. For salmonids and other fish, excessive sediment can interfere with successful reproduction due to fine materials suffocating and covering eggs and larvae. Insufficient gravels can limit spawning habitat quantity and quality. High sediment loads can fill pools and lead to widespread channel aggradation.

Turbidity levels—a measure of suspended fine sediment—are chronically high during and after winter storm events in Salmon Creek and its tributaries; see Chapter 5 for details. However, assessments of streambed composition and gravel quality indicate

that there is not excessive fine sediment deposition. Gravel embeddedness (CDFG 2004; GRRCD and PCI 2007) and percent of sediment less than 0.85 and /or 6.3 mm (PCI 2010, Appendix A) rate as “Good” for coho salmon habitat in Fay Creek and other tributaries, according to NMFS indicator targets (NOAA 2010). Reaches along mainstem Salmon Creek in Freestone and Bodega Valleys do not meet the sediment composition criteria for good spawning and incubation habitat; however, these reaches are geomorphically predisposed to fine sediment deposition and are not out of equilibrium (PCI 2010, Appendix A).

Historic land-use practices, such as clear-cut logging, crop production, and high-density livestock operations, led to accelerated erosion (PCI 2006; GRRCD and PCI 2007). While these intensive land use practices have largely ceased, the impacts of the increased sediment loads are still seen in the stream system with low pool depths and accelerated aggradation in lower Salmon Creek and the estuary (PCI 2006). Currently, upland gullies, landslides, residential development, and roads are the main sources of fine sediment in the watershed (GRRCD and PCI 2007; PWA 2006). Compacted road surfaces produce fine sediment. Old ranch and logging roads often have failing ditches and culverts that cause wash outs and gullies. Road ditches concentrate runoff and transport sediment directly to streams. Properly designed and maintained roads can significantly reduce sediment delivery to streams (Weaver and Hagans 1994).

Action 3a: Reduce fine sediment delivery from upland gully erosion, residential development, livestock operations, vineyards, and roads.

Implementation Measures

- Educate landowners, construction operators, and public works departments on BMPs for reducing erosion and managing sediment delivery to streams.
 - Hold public workshops on stormwater management and road maintenance practices.
 - See Chapter 3 for additional suggestions.
- Improve grasslands and cross-fence pastures to reduce sheet and rill erosion on livestock ranches and dairies.
- Install riparian fencing to reduce streambank erosion.
- Decommission non- or under-used roads.
- Upgrade poorly designed roads.
- Document and repair upland gullies delivering sediment directly to the stream system.

Action 3b: Improve in-channel complexity for the capture and sorting of suitable spawning gravels.

See Instream & Riparian Recommendation 2.

CHAPTER 5: WATER QUALITY MANAGEMENT ACTION PLAN

Context

Water quality is of utmost importance to human and ecosystem health. All terrestrial and aquatic life relies on pollutant-free fresh water to thrive. The quality of surface waters—streams, wetlands, ponds, and shallow groundwater—is dependent upon physical factors and processes in the uplands and along the riparian corridors. See Chapters 3 and 4 for more information on these related ecosystem processes.

Beneficial uses within a watershed are determined by the Regional Water Quality Control Boards (Regional Board) based on climate, topography, geology, hydrology, and native aquatic species. The waters of Salmon Creek are listed as providing the following beneficial uses:

- Water supply for agriculture (AGR), industrial services (IND), and municipal domestic use (MUN),
- Contact (REC1) and non-contact recreational use (REC2),
- Commercial and sport fishing (COMM),
- Navigation (NAV),
- Groundwater recharge (GWR),
- Cold freshwater habitat (COLD),
- Migration of aquatic organisms (MIGR),
- Spawning, reproduction and/or early development of fish (SPAWN),
- Estuarine habitat (EST),
- Wildlife habitat (WILD),
- Habitat for rare, threatened, and endangered species (RARE),
- Water supply for industrial processes (PRO-potential),
- Aquaculture (AQUA—potential), and
- Shellfish Harvesting (SHELL—potential).

If water quality conditions are documented to be outside the standards for a given beneficial use, the RWQCB may recommend to the U.S. Environmental Protection Agency (USEPA) that a watershed should be listed⁴ as impaired for that parameter. For example, many streams in the North Coast region⁵ are listed as impaired due to high sediment and nutrient loads because their levels within the watershed are negatively impacting aquatic habitat and threatened or endangered fish population success. The Salmon Creek Watershed is not listed as impaired for any beneficial use or water quality parameter (NCRWQCB 2009).

The Salmon Creek Watershed Council (SCWC), PCI, and GRRCD started a citizen water quality monitoring program in Salmon Creek with CDFG funding in 2004 to document and track baseline water quality conditions at 13 sites (GRRCD and PCI 2007). (See

⁴ Section 303(d) of the federal Clean Water Act and 40 CFR §130.7 require states to identify waterbodies that do not meet water quality standards and are not supporting their beneficial uses. These waters are placed on the Section 303(d) List of Water Quality Limited Segments (also known as the list of Impaired Waterbodies). The list identifies the pollutant or stressor causing impairment and establishes a schedule for developing a control plan to address the impairment. (http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/303d/)

⁵ In 1980, the State Water Board, the Department of Water Resources, and the U.S. Geological Survey entered into an agreement that redefined the hydrologic basin planning areas within the State of California. The North Coast Region is Hydrologic Unit Number 1 (NCRWQCB, 2007).

Figure 12: Water Quality Monitoring Sites Map.) This volunteer program is still running and has been supported through diverse funding sources to purchase and maintain equipment (Sonoma County Fish and Wildlife Commission, The Hart Foundation, public donations collected at local businesses, and through ongoing, voluntary donations of both staff time and money from GRRCD). The volunteers conduct monthly monitoring of dissolved oxygen (DO), turbidity, temperature, nitrates, phosphates, salinity, pH, and free and total chlorine.

In 2007, GRRCD implemented a more rigorous and focused monitoring protocol with Surface Water Ambient Monitoring Program (SWAMP) guidelines at 8 additional sites for those parameters listed above, as well as total suspended solids (TSS) and conductivity. PCI, through a State Coastal Conservancy grant to OAEC, monitored DO, salinity, temperature, and turbidity in the estuary from June 2004 to June 2005 and storm-related turbidity at 14 upstream sites during the 2004/2005 rainy season.



Gold Ridge RCD staff monitoring water quality in Tannery Creek.

As part of a study of 5 northern California estuaries, UCCE analyzed sediment and water samples at 5 locations in the estuary for fecal coliform and *E.coli* from August 2004 through June 2005 (UCCE 2007). Data was also collected on discharge, temperature, DO, salinity, turbidity, and TSS. During the study period, fecal coliform levels in the Salmon Creek estuary exceeded Regional Board criteria for shellfish harvesting and non-contact recreation.

UCCE analyzed the results of the watershed monitoring efforts and concluded that, given the existing data, “overall, water quality was fair to good in the Salmon Creek Watershed, with tributary streams exhibiting better conditions than the mainstem.” (Appendix A). However, monitoring programs indicated that the following water quality parameters sometimes tested outside optimal levels for salmonids and other aquatic organisms:

- High **turbidity** levels during and after winter storms,
- High **temperatures** during summer in the creeks and estuary,
- Low **DO** levels during summer in pools and in the estuary, and
- High **bacterial levels** in the estuary.

Table 3 indicates targets or objectives for these parameters.

Table 3. Targets or objectives for selected water quality parameters in Salmon Creek.

Parameter	Target/Objective	Source
Dissolved oxygen (DO)	At least 7 mg/L at all times to support the beneficial uses defined for Salmon Creek Watershed and at least 9 mg/L during critical spawning and egg incubation times from November to May	NCRWQCB 2006a
Turbidity	Not to exceed 55 NTU over several days, or 400 NTU for a few hours	Newcombe 2003
Temperature	15° C Maximum Weekly Average Temperature (MWAT)	NOAA 2010
Fecal coliform	Median 30-day levels (based on a minimum of 5 samples/30 days) should not exceed 50/100 ml and that no more than 10% of those samples should exceed 400/100 ml	NCRWQCB 2006a

Although standard water quality parameters are tested through the Salmon Creek monitoring programs, many water quality contaminants linked to human and environmental health have not been tested due to the costs and complexities of sampling and analysis. Inadequate septic systems and agricultural runoff can release *E. coli*, other pathogens, pharmaceuticals, and hormones. Pesticides, herbicides, heavy metals, and petroleum-based pollutants are washed off the ground and road surfaces during rainfall events and transported to the creeks by stormwater runoff. Bacteria and the chemical constituents of toxic substances can concentrate in the water and fine sediments over time. Depending on their levels in the system, they can directly affect human and wildlife health, or they can slowly build up in organisms and concentrate within the food chain. Salmonids have been found to be particularly sensitive to pesticides, herbicides, and other compounds common in most freshwater systems (Laetz et al. 2009; NOAA Fisheries 2008).

Improving water quality where needed in the Salmon Creek Watershed and maintaining existing good quality entails addressing known pollutant sources, using effective management practices to prevent pollution, and enhancing the natural processes that sustain clean, cool water. Stormwater runoff is the primary non-point source pollutant delivery system in rural watersheds such as Salmon Creek. Rainwater carries loosened soil and animal wastes from ranches and residential yards.

Exposed soil from construction or certain agricultural practices is vulnerable to erosion. Water flowing over impervious surfaces, such as roads, buildings, and driveways, collects and concentrates pollutants. Compacted, unpaved soil—common on rural driveways and the network of logging and ranch roads throughout the watershed—behaves as an impervious surface and produces fine sediment that washes into

waterways during each runoff event. Poorly maintained or inadequate septic systems in the riparian corridor and unrestricted livestock access to waterways are other direct pollutant sources.

Maintaining high water quality for human and ecosystem health is possible through careful stormwater management and reducing the use of toxic materials. Upland vegetation management and restoration are key factors in protecting water quality; see Chapter 3. A robust, naturally functioning riparian corridor is also critical for filtering contaminants and maintaining cool, well-oxygenated water; see Chapter 4.

Table 4. Summary of potential pollutants and sources in the Salmon Creek Watershed.

Pollutant	Potential Sources		Impacts on Waterbody
	Point Source	Non-Point Source	
<i>Pathogens</i>	Dairy or Confined Animal Feeding Operation (CAFO)	<ul style="list-style-type: none"> • Animals (domestic, livestock, wildlife) • Pasture and rangeland • Malfunctioning septic systems • Land application of manure 	<ul style="list-style-type: none"> • Primarily human health risks
<i>Metals</i>	<ul style="list-style-type: none"> • CAFO • Urban Runoff 	<ul style="list-style-type: none"> • Hazardous waste sites (unknown) 	<ul style="list-style-type: none"> • Aquatic life impairments • Risk to livestock • Fish contamination
<i>Nutrients</i>	<ul style="list-style-type: none"> • CAFO 	<ul style="list-style-type: none"> • Lawns • Animals (domestic, livestock, wildlife) • Pasture and rangeland • Malfunctioning septic systems • Land application of manure 	<ul style="list-style-type: none"> • Aquatic life impairments • Recreational impacts • Human health impacts • Habitat impacts
<i>Sediment</i>		<ul style="list-style-type: none"> • Rangeland erosion • Streambank erosion • Landslides & gullies • Urban runoff • Roads • Construction 	<ul style="list-style-type: none"> • Aquatic habitat impairments • Recreational impacts • Navigational impacts • Hydrologic impacts • Habitat impacts
<i>Temperature</i>		<ul style="list-style-type: none"> • Sediment (turbidity increases stream temperatures) • Lack of riparian shading • Shallow or wide stream channels (due to hydrologic modification) 	<ul style="list-style-type: none"> • Aquatic life impairments • Recreational impacts

Goals

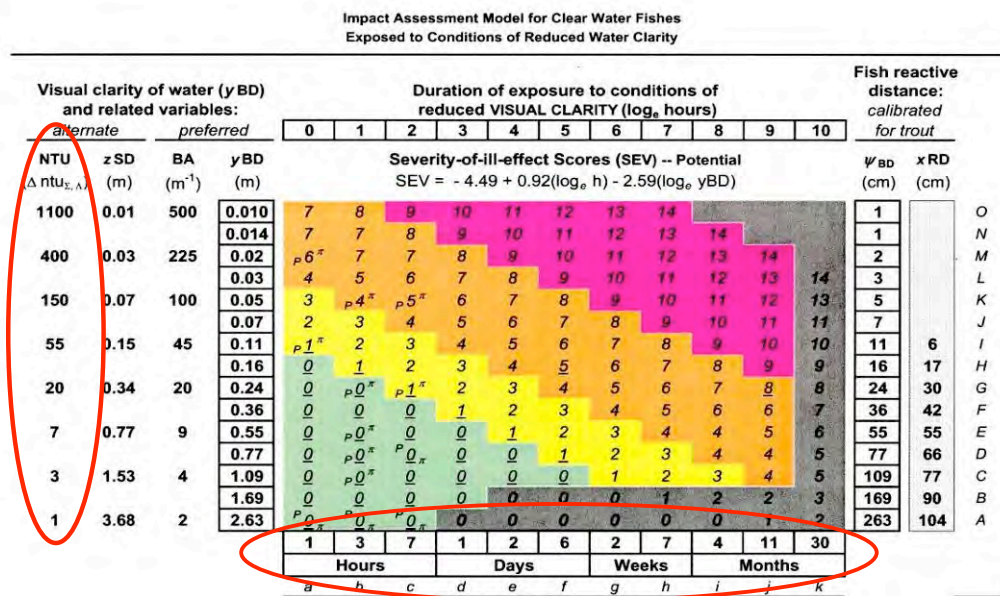
- Water quality conditions in Salmon Creek, its tributaries, and the estuary meet or exceed all regulatory targets.
- Water quality conditions support salmonid fish and other aquatic organisms at all lifestages.
- Sediment and contaminants in the water are at levels that do not harm the health of plants, wildlife, and humans.

Water Quality Recommendation 1: Minimize turbidity and the delivery of fine sediment from upland sources.

Scientific Reasoning

Turbidity, measured in nephelometric turbidity units (NTU), is a measure of the amount of light reflected through a sample of water—it can also be thought of as lack of water clarity. Total suspended solids (TSS), which measures the weight per volume of the sediment load suspended in the water column, is another measurement technique to evaluate suspended solid levels. Turbidity has been scientifically correlated to TSS and is used as a proxy for the amount of suspended solids in water. Increases in turbidity are caused by sediment from soil erosion and roads; particulate matter from sewage, rural and urban runoff, and livestock; and algal blooms caused by excess nutrients (USEPA 1997). Elevated stream turbidity can be used as a measure of the effect of human land use on stream systems (MacDonald et al. 1991). During summer low-flow conditions in nonimpacted streams, normal background turbidity is generally less than 5 NTU (CCWI 2008). In winter, during rainfall runoff events, it is typically higher.

Figure 6. Matrix of impairment levels by turbidity level and duration.



Yellow indicates slight impairment with changes in feeding and other behaviors, orange indicates significant impairment with altered fish growth and habitat quality, and red indicates severe impairment with physiological condition changes and habitat alienation (Newcombe 2001, 2003).

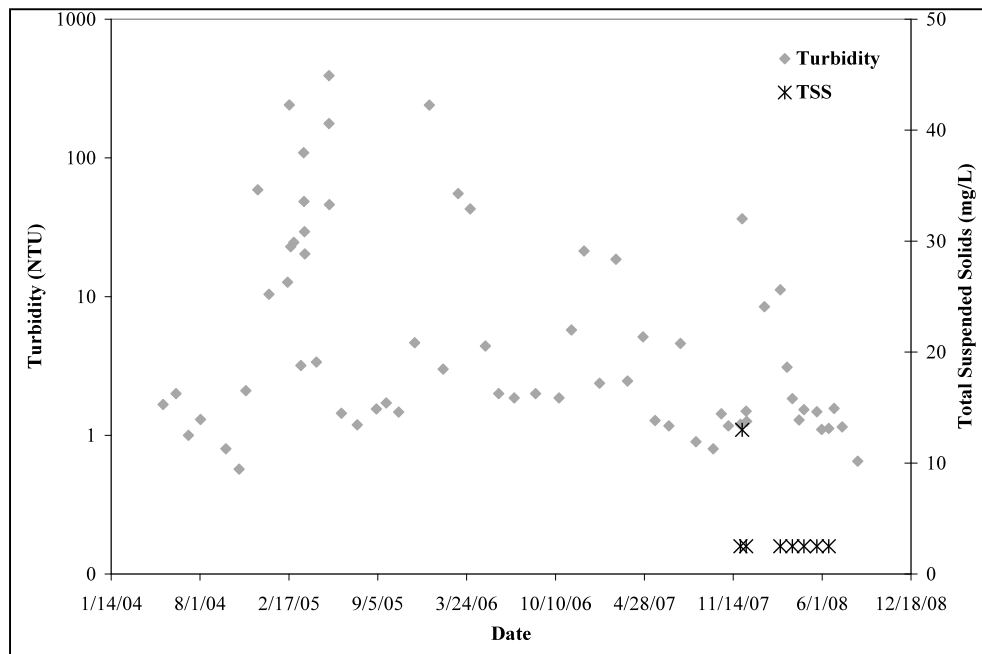
High levels of turbidity may indicate high levels of suspended solids, which can lead to excess fine sediment deposition and smothering effects on benthic organisms, fish eggs, and larvae. Extended periods of high turbidity can alter salmonid behavioral responses and can induce physiological changes in aquatic organisms (Newcombe 2003; Schwartz et al. 2008; UCCE 2009). The detrimental effects of turbidity on fish increase in relationship to the duration of turbid conditions. High levels of suspended solids expressed by turbidity measurements above 55 NTU over several days or weeks, or 400 NTU for a few hours, cause significant impairment to salmonids (Figure 6; Newcombe 2003). High levels of suspended solids can kill fish, and sublethal levels can have long-

term physiological effects. Juvenile and adult salmonids show physiological stress and impaired feeding behavior when exposed to TSS over 300-500 mg/L (McLeay et al. 1987; Servizi and Martens 1987, 1992; MacDonald 1991). Excessive fine sediment that drops out of the water column reduces the quality of salmonid rearing habitat by filling interstitial spaces and, thus, effectively lowering the level of dissolved oxygen that reaches eggs and emerging fry in streambed gravels (UCCE 2009).

High turbidity levels can have an impact on beneficial uses other than fisheries and aquatic organisms. It can impact near- or instream water supplies by decreasing potability and increasing treatment requirements and costs. Heavy metals, such as mercury, pathogens, and toxins, may bind to fine sediment particles in the water column. Concentration of these pollutants in sediment deposits throughout the stream system can impair beneficial uses, such as water supply, contact recreation use, estuarine habitat, and shellfish harvesting.

Water quality monitoring data and instream habitat assessments indicate that excessive fine sediment delivery and deposition and associated high turbidity levels may be the primary water quality issue impacting ecological function and salmonid success in the Salmon Creek Watershed (CDFG 2004; GRRCD and PCI 2007). Appendix A summarizes baseline water quality monitoring data—including turbidity and TSS measurements—collected by volunteers and GRRCD from 2004 through 2008. Data graphs displaying monthly turbidity measurements for multiple locations throughout the watershed show dramatic seasonal variation between the dry, low-flow summer months and wet, high-flow winter period; see Figure 7 for measurements taken at Salmon Creek School.

Figure 7. Turbidity measurements at Salmon Creek School.

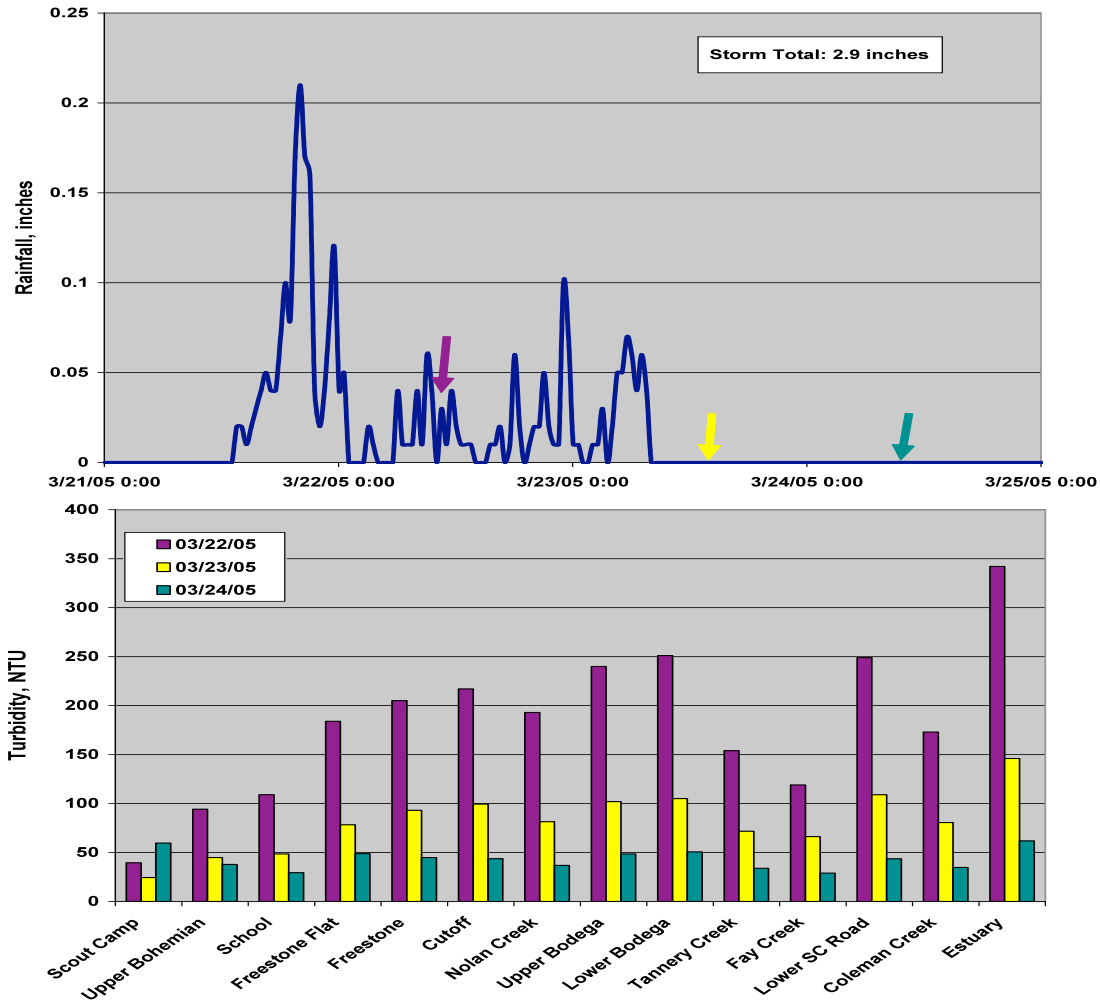


Source: UCCE 2007.

Although turbidity values under low-flow conditions appear to be at or below the 5 NTU suggested background level, high-flow season turbidity levels are frequently well above 10 NTU, with storm-related turbidities in the 100 to 1,000 NTU range. Increased turbidity during rainfall and runoff events is expected to occur naturally in Salmon

Creek given its geology, topography, and precipitation patterns. In addition, it appears that Salmon Creek—based on visual observations of water clarity in the winter by residents—remains turbid longer after storm events compared to neighboring watersheds. As discussed above, extended periods of elevated turbidity can have detrimental effects on salmonids and other aquatic organisms.

Figure 8. Correlation between rainfall and turbidity levels in March 2006 storm.



Storm-related turbidity data were collected by PCI in 2005 (GRRCD and PCI 2007) and GRRCD in 2006 (Appendix A, UCCE 2009) in which measurements were collected on successive days of a storm to document persistence of excessive turbidity levels. The graphs in Figure 8 are an example of data collected during a 2.9-inch rainfall that occurred over a 36-hour period. During the middle of the storm, but after the peak intensity, turbidity values are in the “significant impairment” range (Figure 8; Newcombe 2003). It can be reasonably assumed that these high turbidity levels persisted throughout the rainfall event. Within several hours of rainfall cessation, turbidity fell below 100 NTU but was still above 55 NTU, keeping the water quality in the “significant impairment” range. Three days after the start of the rainfall, turbidity levels were below 55 NTU but still not down to background levels.

Standard approaches to reducing storm-related high turbidity levels focus on preventing delivery of sediment to drainages through controlling upland erosion sites, maintaining rural roads, and managing runoff from livestock-impacted areas and home sites. Once sediment and other particulate matter are in the stormwater drainage system, retention and settling ponds can be used to trap material before it enters the streams.

WQ Action 1a: Document and manage upland sediment sources.

Implementation Measures

- Assess upland erosion sites for delivery of sediment to waterways.
 - Active gullies connected to the stream system.
 - Other sources of large fine-sediment loads, such as landslides.
- Maintain an on-going inventory of high-priority erosion control projects for use in funding and implementation decisions.
- Cooperate with landowners to implement identified high-priority erosion control projects.



WQ Action 1b: Maintain, improve, or decommission rural roads.

Implementation Measures

- Address sediment sources from road networks. Where possible, decommission roads that are no longer in use.
- For roads that are still in use, improve road design and maintenance practices to limit sediment production.
- Provide maintenance workshops and install demonstration projects as outreach to owners of dirt roads and driveways.



WQ Action 1c: Disconnect and filter sediment from waterways.

Implementation Measures

- Increase the width, extent, and vegetative cover of riparian buffer throughout the watershed; see Instream & Riparian Habitat Enhancement Action Plan in Chapter 4.
- Provide off-channel water sources for livestock by developing alternative water supply and providing pasture troughs.
- Construct sediment retention basins and infiltration swales along roadway drainage ditches to capture stormwater runoff and fine sediment.
- Install bioswales to slow stormwater runoff before it enters waterways
- Disconnect impervious surfaces



Examples of fine sediment-producing features on the landscape.

WQ Action 1d: Promote soil retention.*Implementation Measures*

- Provide technical information and training on Best Management Practices for erosion control and farming practices to maintain topsoil.

Water Quality Recommendation 2: Maintain and improve summer water temperatures.*Scientific Reasoning*

Water temperature is important to fish and other aquatic species, as well as the function of the aquatic ecosystem. It influences the rate of metabolism for many organisms, including photosynthesis by algae and other aquatic plants, as well as the amount of oxygen that the water can hold. Salmon Creek is a coldwater system, and native species are adapted to a specific range of water temperatures. California red-legged frogs typically lay their eggs in water about 16 °C. Embryos have a critical thermal maximum of 21° C (Cook 1997). Coho eggs have even more restrictive requirements, with eggs needing 35-50 days of water temperatures from 9-11° C (Shapovalov and Taft 1954).

Both of these species lay eggs at cooler times of year to accommodate temperature requirements. However, adult fish and rearing juveniles must cope with summer maximums. Rearing juvenile steelhead begin to show stress at maximum weekly average temperatures (MWAT) greater than 17° C, and juvenile coho show stress above 14.8° C (Sullivan et al. 2000), although coho studied in Russian River tributaries do not show marked decreased survival until maximum weekly average temperatures reach 22° C (Obedzinski et al. 2008). The NOAA Fisheries Service coho recovery plan defines good habitat as less than 15° C MWAT (NOAA 2010).

Temperature is influenced by:

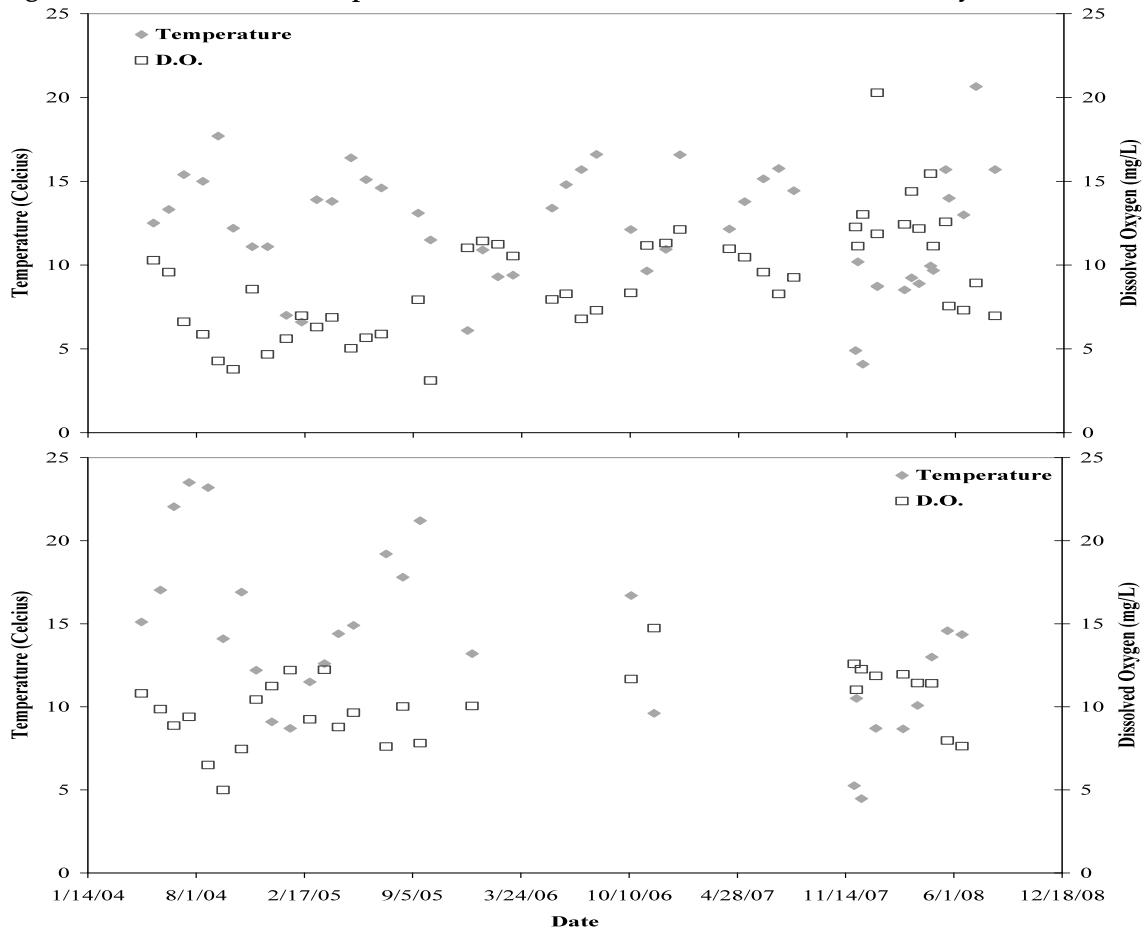
- Ambient air temperature—Direct heat transfer occurs between air and water, with the warmer giving heat to the cooler. However, water temperatures change more slowly than air temperature.
- Volume and depth of water—Greater volumes of water take longer to adjust to changes in air temperature. The water at the bottom of deep pools will adjust more slowly than water at the surface and provide temperature refuges for salmonids and other species.
- Streamflow connectivity—Where groundwater continues to feed surface water during the dry months, the water coming from underground will generally be cool and fairly temperature stable. As long as the water has sufficient flow to maintain connectivity, there is a continuous cool water input to the system.
- Turbidity—Suspended solids directly absorb more heat than a clear water column.
- Shade—The extent and density of riparian canopy contribute directly to cool water temperatures.



Deep shade in Tannery Creek keeps water temperatures low.

- Salinity stratification—As freshwater inputs to the estuary decline and the bar at the mouth prevents mixing with ocean water, a lens of fresh water develops at the top of the estuary surface and focuses solar radiation on the salty layer below, which, in turn, heats the water. In 2004, estuary temperatures reached 31.6° C (89° F) (PCI 2006).

Figure 9. Seasonal water temperature and DO variations in the Freestone Valley.



Source: UCCE 2007.

Based on the data collected, water temperatures in Salmon Creek and its tributaries are generally supportive for salmonids and other aquatic organisms. Water temperatures increase during summer months when ambient air temperature is higher and streamflows are lower, and many monitored locations routinely exhibit temperatures between 15° C and 20° C during this period (Appendix A, UCCE 2009). The two graphs in Figure 9 represent sites within the Freestone Valley and illustrate the seasonal patterns in the watershed. Water temperatures in the mainstem through Freestone and Bodega Valleys tend to be higher in the summer than in the tributaries.

The baseline water quality monitoring occurs primarily at publically accessed locations, such as bridges. Summer water temperatures at critical salmonid rearing locations may locally exceed optimal conditions due to insufficient riparian cover density and pool depths or excessive turbidity levels, while other locations may be cooler due to dense shading and consistent groundwater supplies.

Because of the direct connection to fish and aquatic health, it is imperative to maintain and improve water temperatures throughout the watershed, especially during the hot, dry summer season. Dense riparian canopy cover shades the stream and lowers ambient air temperatures. Groundwater inflows and perennial streamflows supply cool water to pools. Nutrients, fine organic material, and sediment suspended in the water absorb heat and cause algal blooms.



*Stagnant, hot water with excessive algae.
Photo courtesy of Lauren Hammack (PCI)*

WQ Action 2a: Maintain and enhance dry-season flows.

See Chapter 6: Water Supply Sustainability Action Plan.

WQ Action 2b: Maintain and Increase riparian canopy cover.

See Chapter 5: Instream & Riparian Habitat Enhancement Action Plan.

WQ Action 2c: Reduce and minimize turbidity.

See Water Quality Recommendation 1.

Water Quality Recommendation 3: Increase summer DO levels in pools.

Scientific Reasoning

The amount of oxygen dissolved in water influences growth, reproduction, survival of aquatic organisms, and species diversity. Higher water temperatures and nutrient overloading, such as organic wastes, tend to lower DO, while photosynthesis and turbulence in the water increase DO. Levels can vary rapidly, but even short episodes of very low oxygen can cause critical impairment and mortality to aquatic organisms. The *North Coast Regional Water Quality Control Board Basin Plan* requires DO concentrations of at least 7 mg/L at all times to support the beneficial uses defined for Salmon Creek Watershed and at least 9 mg/L during critical spawning and egg incubation times from November to May (NCRWQCB 2006a).



Cool water flowing over riffles maintains high DO levels in pools.

DO levels in Salmon Creek below the NCRWQCB's 7 mg/L target have been measured at 14 of the 17 sites during the 4-year baseline water quality monitoring program (Appendix A, UCCE 2009). These low DO conditions occurred throughout the year, but they are observed more frequently during the dry season. The only sites that did not experience periods of low DO are the headwater sites on the mainstem and Tannery Creek. Instances of DO concentrations below the NCRWQCB's 9 mg/L target during spawning and egg incubation periods occurred at 12 of the 17 sites. Example monitoring

data are shown in Figure 9 from sites in the Freestone Valley (from Appendix A). Note the correlation between low DO concentrations and high water temperatures.

DO concentrations below 3 mg/L, which are noted as lethal to juvenile and adult salmonids by Raleigh et al. (1984) and McMahon (1983), occur in Salmon Creek and its tributaries during late summer. The monitoring program picked up 7 instances of DO below 3 mg/L at the monitoring sites (Appendix A). In addition to the baseline monitoring measurements documented in Appendix A, DO concentrations were measured at pools in Fay Creek, Finley Creek, and mainstem Salmon Creek in the Bodega and Freestone Valleys in summer 2009 as part of the juvenile coho rescue program (Table 5). Pool DO levels in several of the critical rearing habitats were well below 3 mg/L; however, the rescued juvenile coho and steelhead appeared healthy (Michael Fawcett, pers. comm., November 2009).

Table 5. DO and water temperature measurements at critical coho rearing habitat locations during drought conditions, August 2009.

Location	Date	DO (mg/L)	Temp (°C)
Finley Creek	08-28-09	1.6-2.4	14-15
Fay Creek	08-08-09	<5.0	13-15
Fay Creek	Aug -09	1.9-2.5	~14
Salmon Ck – Bodega	08-08-09	2.6-4.6	14
Salmon Ck – Bodega	08-22-09	0.1-1.2	12-14
Salmon Ck – upper Bodega Valley	08-28-09	7.2-7.9	15
Salmon Ck - Freestone	08-26-09	7.2	16

Source: Michael Fawcett, pers. comm., November 2009.

Good pool DO levels are observed to be primarily associated with freshwater surface flows upstream, while pools with very low DO are disconnected and stagnant. Thus, maintaining sufficient streamflows in the summer to keep pools connected and aerate the water as it flows over the riffles and bedrock ledges is a high priority. Cool water temperatures help keep DO levels high, as does minimizing the nutrients inputs.

WQ Action 3a: Increase summer streamflows.

See Chapter 6: Water Supply Sustainability Action Plan.

WQ Action 3b: Reduce summer water temperature.

See Water Quality Recommendation 2.

WQ Action 3c: Reduce nutrient loads.

See Water Quality Recommendation 4.

Water Quality Recommendation 4: Minimize nutrient and pathogen delivery.

Scientific Reasoning

Inorganic nutrients, including phosphorus and nitrogen are abundantly found in nature and necessary for plant and animal growth. However, inorganic nutrients, primarily from animal waste, may be discharged into Salmon Creek and its tributaries during rainfall runoff events. Nutrients can cause environmental problems in a variety of ways. Un-ionized ammonia (a reduced form of nitrogen) is toxic and can be present in such high concentrations that it kills aquatic organisms. In aquatic ecosystems, nutrients can cause blooms of algae. In coastal waters, nitrogen is the nutrient of concern causing overfertilization of aquatic plants. In freshwater systems, phosphorus is the nutrient of concern. Algal blooms and the die-off of aquatic plants cause oxygen depletion in the water column, resulting in poor habitat conditions for aquatic species (Appendix A). The subsequent decay of algae depletes DO and renders water unfit for most or all of the beneficial uses of Salmon Creek. Fertilizers, human and animal wastes, and the use of phosphate detergents all contribute to nutrient levels in the creeks (USEPA 2008).

The *North Coast RWQCB's Basin Plan* states that sufficient information is not yet available to develop numeric nutrient criteria in our region but that levels should be maintained below those that will cause eutrophication or impacts to beneficial uses (NCRWQCB 2006a). Eutrophication is the process by which streams or lakes become enriched with nutrients that stimulate the growth of aquatic plants that, in turn, deplete dissolved oxygen. The EPA guidance on establishing standards gives any rise above baseline conditions as the possible non-numeric criteria (USEPA 2000a). The EPA has set reference guidelines for protection against eutrophication, which state that nitrates should not exceed 0.155 mg-N/L and orthophosphate (reported as total P) not exceed 0.03 mg/L (USEPA 2000).

UCCE analysis of the nutrient data collected concluded that “nutrients were very low on average across subwatersheds” with only one sample from the estuary showing a nitrate level that exceeded the EPA recommendations to prevent eutrophication (Appendix A). The UCCE report also noted possible uncertainties for both nitrate and phosphate results due to the testing methods used in the Salmon Creek Watershed and recommended that methods for these parameters be evaluated to ensure accuracy (Appendix A). Watershed residents have noted pools in middle and lower Salmon Creek with algae, amber color, and unpleasant odor during summer low-flow conditions—potential indicators of high nutrient concentrations and possible pathogens.



*Algae bloom in Bodega Valley, 2008.
Photo courtesy of Lauren Hammack (PCI)*

Pathogens, microbes that cause disease, were not tested in the freshwater portion of the watershed. UCCE sampled fecal coliform and *E. coli* at 5 sites from the mouth to 1.3 km (0.8 mile) inland. Samples were taken from both the water column and the estuarine sediments during wet season storm flows, winter base-flow conditions, and summer base-flow conditions. Mean fecal coliform concentrations were above water quality criteria during all 3 testing seasons for shellfish harvesting and above the criteria for non-contact recreation during wet season storm flow conditions. The report concluded that “contaminated freshwater inflow that enters the estuary, especially during

stormflow conditions, is the primary transport pathway” (UCCE 2007). Freshwater inflow points to upstream land-use activities as the source of bacteria, not a reworking of coliform stored in the estuarine sediments. Of the 5 estuaries studied by UCCE, however, Salmon Creek had the highest concentration of fecal coliform in the estuarine sediments with an unusual pattern of increasing levels towards the mouth (Lewis 2010).

Human and animal wastes are the primary sources of pathogens. In the Salmon Creek Watershed, potential sources of pathogens include poorly maintained or inadequate septic systems, unrestricted livestock access to streams, runoff from confined animal areas, and poor management of livestock and other domestic animal waste. GRRCD, NRCS, and UCCE all have extensive expertise and information to assist ranchers, dairy farmers, and horse owners with selecting and implementing animal waste management practices to prevent transmission of pathogens from livestock into surface water.

The actions below are intended to prevent excessive nutrients and pathogens from entering Salmon Creek and its tributaries.

WQ Action 4a: Restrict direct livestock access to streams and riparian areas.

Implementation Measures

- Provide technical information to horse owners and other rural residents with small numbers of confined animals.
- Support use of riparian fencing, pasture management, water development, and other strategies to protect waterways.

WQ Action 4b: Upgrade inadequate septic systems adjacent to waterways.

Implementation Measures

- Provide information to landowners on the importance of maintaining a well-functioning septic system to a healthy stream.
- Coordinate with Sonoma County PRMD to streamline permitting to upgrade or replace inadequate systems.
- Seek funding to assist landowners with onsite wastewater treatment systems.

WQ Action 4c: Reduce use of nitrate- and phosphate-rich products.

Implementation Measures

- Develop and distribute a comprehensive list of effective alternatives and methods for reducing quantity of use.
- Develop demonstration sites for reduced fertilizer and pesticide gardening and farming.
- Educate landowners about reducing the use of phosphate soaps to lessen associated phosphate pollution through insufficient filtration by onsite wastewater treatment systems.

Water Quality Recommendation 5: Promote minimal use and proper disposal of toxic compounds.

Scientific Reasoning

Toxic compounds occur in some pharmaceuticals, petroleum products, herbicides, pesticides, and common household substances, such as cleaning solutions, paints, solvents, and swimming pool chemicals. When these compounds enter waterways, they can cause acute or chronic effects in aquatic wildlife. Acute effects include death and disruption of critical life events. Chronic effects can weaken organisms and cause subtle

changes in behavior that compromise breeding success and survival. Adult and juvenile salmonids are increasingly showing sublethal and lethal responses to mixtures of toxic pollutants commonly found in most streams (NOAA Fisheries 2008, Laetz et al. 2009). Research currently underway by the NOAA Coastal Storms Program based in Seattle on mysterious mortality of coho using recently restored urban streams has revealed that spawner mortality rates are much higher immediately after storm events. Investigation into the cause of fish mortality shows that the fish are being subjected to high levels of urban pollutants carried by the stormwater (NOAA Coastal Storm Program 2010).

Tests for toxic contaminants, other than chlorine,⁶ have not been conducted in the Salmon Creek Watershed and are not known to be a limiting factor for salmonids or other species. However, because of the potential for even small amounts of pollutants to act synergistically, good stewardship practices should be encouraged to minimize toxin delivery to Salmon Creek and the estuary. Stormwater runoff, swimming pool drainage, improper disposal, and leaking septic systems are likely the primary potential pathways of toxic pollutants into Salmon Creek.

WQ Action 5a: Keep stormwater on site.

Implementation Measures

- Use educational materials, workshops, and demonstration sites to encourage the use of measures such as rainwater catchment, low-impact design, swales, and infiltration ponds to retain stormwater.

WQ Action 5b: Educate community on pollutants of concern and how to reduce water contamination.

Implementation Measures

- Develop and distribute educational materials on websites, at workshops and community events, and on toxic round-up days; see Action 5c.
- Include information on proper use and disposal of household toxics, and safe alternatives.
- Include guidelines for proper drainage of swimming pools and spas.

WQ Action 5c: Promote proper disposal of toxic products.

Implementation Measures

- Hold well-publicized toxics round-up days quarterly to assist landowners with safe disposal of unwanted compounds.

⁶ UCCE's analysis of Salmon Creek water quality monitoring data found that, "total chlorine concentrations were greater than the EPA's acute criterion of 0.019 mg/L at 10 sites on the mainstem, estuary, and tributaries on a total of 114 different occasions" (Appendix A). However, UCCE notes that both total and free chlorine readings "are suspected to be inaccurate due to the interference of oxide manganese, which creates the same chemical reaction as a positive chlorine test" and recommends refinement of the testing method.

CHAPTER 6: WATER SUPPLY SUSTAINABILITY ACTION PLAN

Context

Water supplies within the Salmon Creek Watershed must sustain all consumptive water uses, as well as the needs of the wildlife and plant communities. Consumptive water demands are met by the annually recharged shallow groundwater table, bedrock aquifer storage, direct streamflow withdrawals, and the storage of winter rainfall runoff.

The Mediterranean climate and limited groundwater resources produce dry-season water supplies that often cannot meet the demands of both human habitation and wildlife needs concurrently. Salmon Creek, along with much of the coastal range in Marin, Sonoma, and Mendocino Counties, is often considered a water-scarce area (Kleinfelder 2003; Grantham et al. 2010). Groundwater wells and springs commonly experience diminished or intermittent production with regular use and adjacent extraction pressures (Kleinfelder 2003; PCI 2010). Many small coastal communities and residents struggle to maintain adequate, stable water supplies. Water sources adjacent to streams, whether wells or direct instream diversions, tend to provide more reliable supply and are thus preferentially developed and used.

Perennial streamflows are necessary to sustain aquatic ecosystem health and successfully recover salmonid populations. “Water is the most important of all habitat attributes necessary to maintain a viable fishery and ... one of the most difficult threats to address effectively.” (NMFS 2010). Intermittent flows during the summer rearing period trap salmonids and other aquatic organisms in disconnected pools, subjecting them to increased predation pressures, water quality impairments, and, in some cases, desiccation. When streamflows go subsurface, the cooling and oxygenating effects of water flowing over riffles are lost. High water temperatures and low dissolved oxygen levels in pools can severely stress juvenile salmonids; see Chapter 5. High stress levels lead to reduced feeding behavior, smaller smolts, and, ultimately, poor survivorship.

Low summer baseflows also impact estuary/lagoon habitat conditions. The ratio of freshwater to saline water is critical in determining the viability of the summer lagoon to support estuarine organisms, salmonids, and other special-status species, such as tidewater goby. When freshwater inflows are insufficient to dilute the remnant saline water—delivered prior to the sand bar closing the estuary mouth—stratification of the lagoon water column occurs. Saline water is heavier and thus sinks to the bottom of the lagoon, while the freshwater floats on top. The lower saline



Dry pool in reach of Salmon Creek adjacent to near-channel wells.

Photo courtesy of Lauren Hammack (PCI)

layer, which comprises the majority of the water column, typically becomes heated, anoxic, and inhospitable to fish. This scenario has been documented in the Salmon Creek estuary (PCI 2006), and it limits the viable habitat to a shallow, wind-mixed reach along the sand bar. Restricted habitat due to poor water quality and low streamflows is implicated in the demise of thousands of juvenile steelhead rearing annually in the Salmon Creek lagoon.

National Marine Fisheries Service states in their Public Draft Recovery Plan for Central California Coast coho salmon (2010):

“Summer baseflow is a critical attribute that is degraded in many streams ... [and] a substantial amount of coho salmon habitat has been lost or degraded as a result of water diversions and groundwater extraction (DFG 1997, KRBFTF 1991). The nature of diversions varies from major water developments which can alter the entire hydrologic regime in a river, to small domestic diversions which may only have a localized impact during the summer low-flow period. In some streams the cumulative effect of multiple small legal diversions may be severe. Illegal diversions are also believed to be a problem in some streams within the range of coho salmon (CDFG 2004). The use of wells adjacent to streams is also a significant and growing issue in some parts of the coho salmon range. Extraction of flow from such wells may directly affect the adjacent stream, but is often not subject to the same level of regulatory control as diversion of surface flow.”

All water extractions in the watershed likely have an impact on streamflow, some directly and some through indirect cumulative effects. Groundwater sources in the uplands are connected through aquifers, bedrock fractures, and geologic-formation contacts to springs. Springs feed directly into first and second order tributaries, or they locally maintain the water table that sustains summer streamflows. It has been shown that groundwater wells in the alluvial valleys, thought to be disconnected from the water table by an impervious clay layer, can lower the water table and impact streamflows (PCI 2006) and in drought conditions may contribute to localized channel drying.

Riparian pumping and livestock watering directly reduce streamflows. During the summer dry season, particularly during drought years, direct withdrawals may cause riffle disconnection within a reach and, eventually, shallow or dry pools. As described above, multiple extractions reduce overall streamflow and impact instream habitat conditions.

Coastal rural watersheds such as Salmon Creek receive more than enough rainfall to meet the annual water demands of the residents (PCI 2010). However, with a Mediterranean climate, this rainfall comes mainly between the months of November and March. Thus, the water scarcity is seasonal and related to lack of storage. Land-use practices that harden the landscape and route stormwater to drainages limit infiltration, thus reducing the volume of water available to recharge bedrock aquifers and the shallow groundwater that maintains water table levels throughout the dry season.

Opportunities exist to reduce demand on extractive water sources that, through direct or cumulative effects, reduce streamflow and degrade instream habitat. Water conservation and wise-use practices can significantly reduce water demand. Stored rainwater in off-channel ponds and roofwater harvesting systems can easily be used for non-potable irrigation and livestock watering needs. Roofwater can also be used as a potable water source with proper filtration and treatment. Practices to slow and infiltrate stormwater

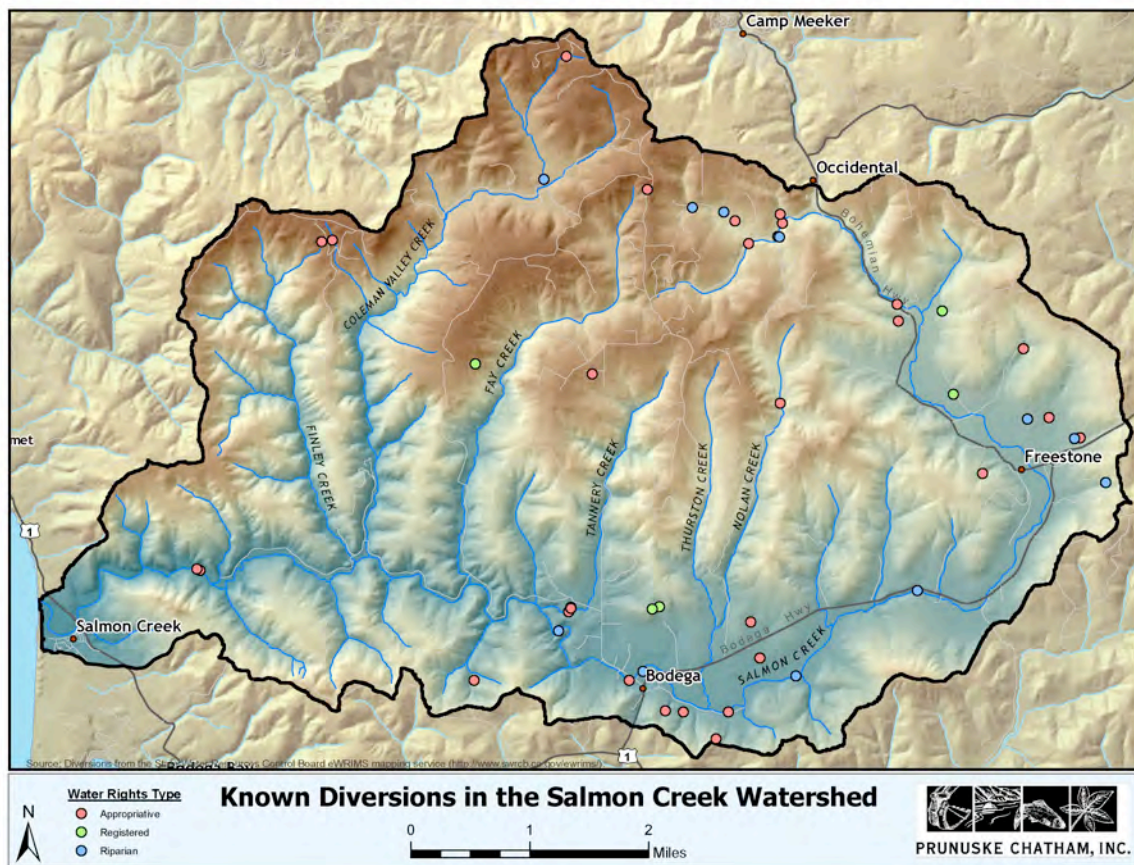
runoff can have long-term impacts on groundwater recharge, spring production, and streamflows.

Concurrent with the development of this Plan, Oaec has spearheaded the Salmon Creek Water Conservation Program with the participation of many partners. The purpose of the program is to support the community in increasing summer instream flows while providing for the freshwater needs of residents. Much of the research and analysis in this chapter is based upon work completed under this program. The program’s Salmon Creek Watershed Conservation Plan (PCI et al. 2010) provides detailed conservation strategies and recommendations for residents and community water system operators, and supports the vision and overall goals of this Plan; see Chapter 1.

Goals

- Water demands do not exceed supply.
- Surface water and groundwater supplies within the watershed are managed to support residents’ quality of life, family agriculture, and ecosystem needs.
- Extractive water sources and practices that impact summer streamflows are minimized and replaced by alternative water sources or improved storage.
- Streamflows support fish and other aquatic organisms at all lifestages.

Figure 10. Known diversions in the Salmon Creek Watershed.

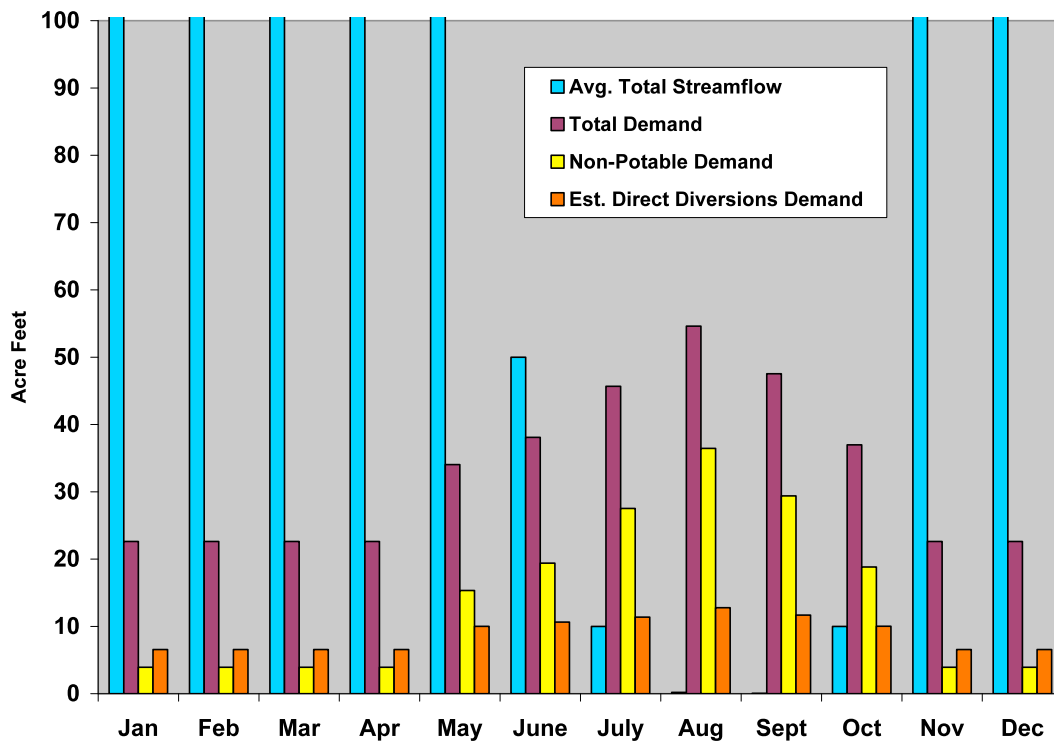


Water Supply Recommendation 1: Develop storage-based water supplies to reduce reliance on, and utilization of, extractive sources.

Scientific Reasoning

Seasonal water scarcity in groundwater and surface water supplies can be offset by storing winter rainfall runoff. Coastal, rural watersheds such as Salmon Creek receive more than enough rainfall to meet the annual water demands of the residents and existing land uses (PCI et al. 2010). Figure 11 illustrates the seasonal cycle of water abundance (winter) and scarcity (summer) as contrasted with the water demand cycles. The seasonal availability disparity can be balanced out—benefiting humans and fish—through the strategic use of storing rainwater in off-channel ponds and roofwater harvesting systems for non-potable irrigation and livestock watering needs. With proper filtration and treatment, roofwater can also be used as a potable water source.

Figure 11. Comparison of water demands in the Salmon Creek Watershed to relative supply, as depicted by streamflow volume.



Source: from PCI et al. 2010.

Estimated late-summer demands on instream sources are 50-200 times greater than streamflow volumes (Figure 11). The direct consumptive uses of instream water in the Salmon Creek Watershed are community water supply wells, livestock watering, summer landscape and garden irrigation, and a small portion of the rural residential use. Capture and storage of winter runoff to replace these direct streamflow withdrawals on a parcel-by-parcel approach could improve instream habitat conditions locally and have significant cumulative effects on summer flows watershed-wide. Replacing all non-potable water demands with stored water would reduce extractive pressures on both the surface water and groundwater supplies and provide greater water security for residents.

Large-scale water storage is not a solution for all water supply concerns and limitations, nor does it mitigate the need for efficient and conservative water use. The impacts of reservoirs on hydrologic flow regimes necessary to maintain ecosystem health have been widely documented (Graff 1999; Richter and Thomas 2007; Grantham et al. 2010). Instream flow regulations for the state of California (AB 2121) are in final draft form and attempt to manage the impacts of water impoundment on streamflow regimes. While it is unlikely that small storage ponds or rainwater catchment systems used to fulfill existing water demands in Salmon Creek would significantly decrease peak runoff during winter storm events, Grantham et al. (2010) suggest that there is an optimal storage capacity for a given watershed that will meet water demands while ensuring critical habitat needs and ecosystem function. Multiple, on-channel storage ponds within a small catchment may reduce early winter base flows and affect salmonid migratory flows.

Water Supply Action 1a: Develop off-channel ponds and distribution systems.

Implementation Measures

- Evaluate agricultural producer's water supply sources to target those using instream or riparian sources.
 - Size systems to cover four (July-Oct.) to six (May-Oct.) months of water demands.
 - Include water distribution systems for livestock use and fence riparian corridors.

Water Supply Action 1b: Install roofwater harvesting systems.

Implementation Measures

- Design and install roofwater catchment systems to replace non-potable water uses from extractive sources and increase water supply security.
 - Size systems to cover four (July-Oct.) to six (May-Oct.) months of water demands.
 - Include water distribution systems for livestock use and fence riparian corridors.
- Consider installing roofwater catchment systems where potable supplies are unreliable, water quality is poor, or water source is a stream diversion.

Water Supply Action 1c: Support landowners in reducing or eliminating use of instream pumps and near-channel wells.

Implementation Measures

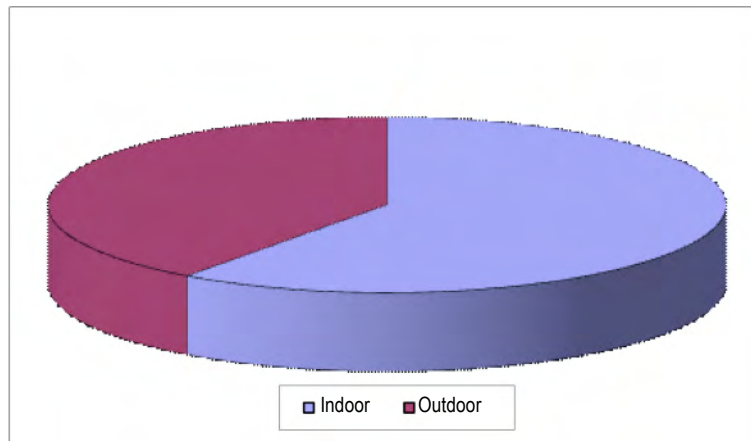
- Conduct an education and outreach program to inform residents of the ecological impacts of using their riparian water rights.
 - Provide alternate solutions to riparian water.
 - Low-flow gardening practices.
- Develop off-channel storage and roofwater harvesting systems to replace riparian water sources; see Water Supply Actions 1a and 1b above.
- Develop program to enroll landowners in abstaining from using their riparian rights for the purpose of salmonid habitat improvements.

Water Supply Recommendation 2: Reduce water demands.

Scientific Reasoning

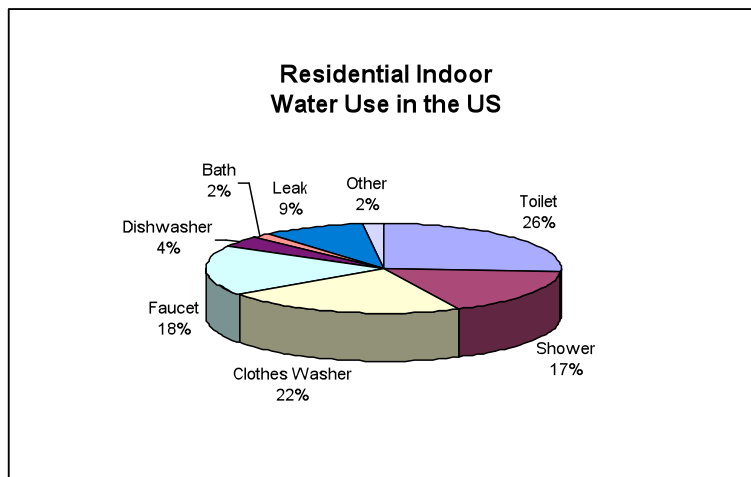
Statewide, the potential exists to reduce residential indoor water use by up to 40% through installing efficient plumbing hardware and adopting practices to maximize water use efficiency and 25-40% in outdoor water use through garden design and maintenance practices (Gleick et al. 2003). Coastal communities and residences fall into the lower portion of these ranges due to climate and water supply constraints. In the Salmon Creek Watershed, it is estimated that a 10-15% reduction in both indoor and outdoor water use could be gained through conservation measures (V. Porter, pers. comm., 4/23/10). Long-term water scarcity issues and increasing water costs have likely pushed residents to implement water conservation measures. Additional water savings may be possible on a site-by-site basis, especially with efficient outdoor irrigation hardware and practices.

It is estimated that 55-65% of all residential water use serves indoor needs in coastal California communities, and outdoor uses make up 35-45% (Pacific Institute 2003). The graph at right illustrates the breakdown of residential water use (PCI et al. 2010).



Actual residential use, or demand, per person (called per capita use) varies according a number of factors, including:

- Age and efficiency of the plumbing fixtures in the home,
- Size of garden, types of plants, climate and efficiency of irrigation,
- Presence of water meters (people use less when water is metered),
- Price of water (people use less when water is costly), and
- Conservation practices used.



A closer look at indoor water use shows that toilets, showers, faucets, and washing machines account for the majority of water use (AWWA 1999); see figure at left (from PCI et al. 2010). The water consumption demand of these devices can be reduced through the installation of low-water use hardware and appliances.

Average nationwide per capita residential indoor water use was measured in a 1999 study (AWWA) to be 73 gallons per person per day. Assuming this represents only 60%

of the residential per capita water use, as discussed above, adding outdoor water use brings the total estimated per capita residential water use to about 120 gallons per person per day. Conservative estimates of Salmon Creek Watershed-specific water demand values align with these nationwide figures (based on an annual demand of 90,000 gallons per residence and 2.06 individual persons per residence; see PCI et al. 2010 for calculation approach and summary). Analyses of meter data from communities within the Salmon Creek Watershed indicate that residences on these systems use 35,000-65,000 gallons per year (47-86 gallons per person per day); however, water costs are relatively high on these systems, and several communities have high numbers of part-time residents (V. Porter in PCI et al. 2010).

Community water systems in the Salmon Creek Watershed have relatively high unaccounted for water (UAW) losses, or the difference between the water produced and water sold (PCI et al. 2010). Water used during routine operational maintenance practices and fire fighting, lost due to leaks, and unaccounted for due to inaccurate meters all comprise UAW. A well-maintained water system should have less than 10% UAW. Freestone and Bodega's UAW are near 30%, which translates to 1,337,800 gallons per year lost. Bodega Bay's UAW averages 14% (PCI et al. 2010). Reducing UAW, especially if it is due to system leaks, and efficiently managing the community water systems will reduce demand on extractive sources (V. Porter in PCI et al. 2010).

Water Supply Action 2a: Implement water conservation program to minimize consumption.

Implementation Measures

- Conduct watershed-wide workshops to educate residents and encourage water conservation practices, such as:
 - Low water use gardening.
 - Water-saving appliances and fixtures.
 - Leak detection and repair.
- Work with County to develop and distribute information on programs that assist landowners in implementing water conservation projects, such as water use audits and Sonoma County Energy Incentive Program (SCEIP).
- Research and develop programs that assist landowners with financial hardships to replace old faucets and appliances with high efficiency devices.

Water Supply Action 2b: Structure water rates to support water conservation and reduce dependence on water supply from sources critical for aquatic habitat.

Implementation Measures

- Address high unaccounted for water losses in community systems.
 - Replace leaking water lines.
 - Replace leaking storage tanks in Bodega.
 - Replace meters regularly.
- Implement conservation rate structure.

Water Supply Recommendation 3: Recharge springs and groundwater.

Scientific Reasoning

In the uplands, along the ridge tops and steep canyons where the rural residential parcels are predominantly clustered, water sources are primarily groundwater wells and springs. However, the dominant geologic formation, Franciscan mélange, is a poor

aquifer with typical yields less than 3 gallons per minute (Kleinfelder 2003). The Franciscan mélangé's metamorphic and sheared rocks are impermeable, only carrying and storing water along fracture zones. Wells that tap into a fracture zone will have greater yields. The Wilson Grove sandstone formation, locally capping the mélangé, is a better, more consistent aquifer, but it is limited in extent and storage capacity. The springs tend to occur along the boundary between the sandstone and mélangé formations (Sonoma County 1974), although they likely also occur where fracture zones in the mélangé daylight on canyon slopes.

Groundwater supplies on the ridges are unpredictable. Well production on neighboring parcels ranges from 25 gal/min to not enough to do laundry (pers. comm., 03/2010). Residents in the Joy Road and Willow Creek Road area report that their groundwater wells experience dramatic seasonal changes in production rates. Many have installed holding tanks to compensate for reduced pressure in the summer, while others are forced to truck in water (PCI et al. 2010). Studies of the Joy Road area document that groundwater wells and springs commonly experience diminished or intermittent production with regular use and adjacent extraction pressures (Kleinfelder 2003; Sonoma County 1974). Kleinfelder (2003) also documented that between the 1970s and 2000 the depths of new wells increased to follow a lowering water table and that this trend correlates to development rates and indicates an overdraft condition in the aquifer.

Managing stormwater runoff in uplands in ways that slow flow overland, temporarily detain it, and allow it to infiltrate into the ground can increase groundwater recharge. The benefits of increasing aquifer recharge rates and storage capacity are greater groundwater supplies and increased stream base flows. Other benefits of keeping stormwater on site, instead of the historic "pave it and pipe it" approach, are decreased topsoil loss, lower flood peaks downstream, and reduced pollutants in the water.

Water Supply Action 3a: Increase infiltration in upland recharge areas and up-gradient from springs.

Implementation Measures

- Install rain gardens to capture excess runoff.
- Install contour infiltration trenches and infiltration swales to temporarily hold and infiltrate runoff.
- Direct excess runoff into catchment basins that store and allow slow infiltration.
- Replace impervious surfaces, such as parking areas and patios, with pervious materials (grass pavers, porous concrete, and other pervious pavers).
- Effectively manage grasslands and forests; see Chapter 3 Uplands Management Action Plan.

Water Supply Action 3b: Reduce stormwater runoff in uplands.

Implementation Measures

See Chapters 3: Uplands Management Action Plan and 5: Water Quality Management Action Plan.

CHAPTER 7: SUSTAINABLE AGRICULTURE ACTION PLAN

Context

Agriculture in the U.S. has changed dramatically over the past fifty years as post-war technologies for fertilizer production, chemical use, plant genetics, petroleum extraction, and mechanization were applied to farming. These practices proved to be essential developments in providing a stable food supply for the ever growing world population suffering from the repercussions of global turmoil. In what was heralded as “the Green Revolution” of the 1950s and 1960s, agricultural productivity skyrocketed, allowing impoverished countries to



greatly improve food security and developed nations to reduce farm labor needs and food costs (Griffin 1979). Agriculture became greatly centralized, with the U.S. farm population shrinking from over 12% in 1950 to less than 2% today (Heller and Keoleian 2000). Prices of staple commodities plummeted, allowing Americans to spend a smaller percentage of their annual incomes on sustenance than any population in the world (USDA 2006). While the benefits of a prolific, dependable food supply are inarguable, these efficiencies in agricultural production have come with a price.

Globally, highly mechanized and chemically dependent farming has led to a multitude of environmental problems, including topsoil erosion and depletion, water quality concerns, pesticide contamination, and loss of biodiversity. Centralized production and processing systems have resulted in most food products travelling an average of 1,500 miles to reach consumers, which has had enormous repercussions for air quality, dependency on foreign oil, and climate change from greenhouse gas emissions (Pirog and Van Pelt 2002). From a human health perspective, while mass quantities of lower-value staples such as corn and soybeans have provided needed surpluses for disadvantaged populations, their overproduction has led producers to develop these goods into value-added products of minimal nutritional value, such as corn chips and soft drinks, a trend that has had unquestionable effects on obesity rates and other health indicators in the U.S. and throughout the world (Wallinga 2010). Loss of production diversity of both plants and farm animals has led to widespread use of fertilizers, pesticides, antibiotics, and other chemicals that have entered the food supply and waterways. Centralized agribusiness production has also had social consequences by removing communities from their food production and threatening family farming traditions and incomes, as well as the widely cherished rural lifestyles and landscapes. Many rural areas, once self-sustaining and productive, have been pushed out of the agricultural markets by the artificially low prices of subsidized mass production and have been left with few economic options (Feenstra, undated).

Such consequences have led to a growing interest in more localized and sustainable alternatives over the past two decades as consumers have begun to recognize the role their buying power can play in addressing the environmental, social, and economic concerns related to food. The concept of sustainable agriculture has continually evolved, growing to include multiple environmental, social, and economic considerations, and

becoming integrated into a variety of certification vernacular such as “organic,” “humane-raised,” or “fish-friendly”[®] (Marcus 2009).

Sustainability in agriculture was more officially defined by the U.S. Congress in the 1990 Farm Bill, which characterized it as “an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- Satisfy human food and fiber needs;
- Enhance environmental quality and the natural resource base upon which the agricultural economy depends;
- Make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
- Sustain the economic viability of farm operations; and
- Enhance the quality of life for farmers and society as a whole.”

The definition describes a broad-scale, integrated approach that provides roles and benefits for the producer, consumer, and community and necessitates involvement from policy makers, researchers, landowners, farm workers, retailers, and others.

Components of Sustainable Agriculture

While the word “sustainable” has in recent years become synonymous with ecological concerns, its true definition must equally consider social and economic aspects. Some considerations related to each of these three primary components of sustainability are described below.

Environmental considerations:

Soil quality. Soil health involves both quality of the soil itself as a living medium and structural stability provided by its supported vegetation. It can be degraded through erosion, compaction, loss of soil biota through pesticide use, and depletion of soil organic matter.

Water use. Water remains a primary concern in California’s Mediterranean climate, which is characterized by cool, wet winters and hot, dry summers. While much of the state’s agriculture relies on a complex system of water storage and transfer from reservoirs, aquifers, and the Sierra snowpack, coastal areas enjoy cooler temperatures and relatively higher annual precipitation than inland regions. However, rainfall patterns on the coast continue to pose complications for farmers and ranchers who face water quality concerns from runoff and erosion during the winter months and limited water supplies in the summer. Production systems need to be appropriate to local availability and to practice water conservation and recycling. Always deeply political, water use issues in northern coastal California have been brought to the forefront with the devastating crash of the Pacific Northwest’s already dwindling salmon populations, which serve as the backbone of the region’s fishing industry, valued at over \$130 million per year, and a way of life for coastal Native American communities.

Water quality. Connected to water use issues is water quality, a concept that considers numerous conditions, including temperature, sedimentation levels, nutrient levels, salinity, pH, dissolved oxygen levels, and levels of contaminants, such as pesticide residues or heavy metals. Water quality is essential for maintaining aquatic life and providing safe drinking water for people, livestock, and wildlife. Sustainable farming systems consider on-farm nutrient and sediment retention and protection of riparian areas.

Air quality. Numerous aspects of agricultural production can have implications for air quality, including carbon and nitrous oxide emissions from fuel and fertilizer use, dust, pesticide drift, and burning of crop residues. The role of agriculture in global climate change is considerable, both in its contributions to carbon emissions and its potential for sequestration through plant CO₂ uptake and preservation of vegetated land.

Energy use. Most modern agriculture is heavily dependent on non-renewable fossil fuels for production, transportation, and processing, totaling over 10% of the energy use in the U.S. An estimated 40% of this is used to create and transport chemical inputs, such as pesticides and inorganic fertilizers (Heller and Keoleian 2000), which has enormous implications for climate change and economic stability. Efforts to reduce fossil fuel use could include minimal-till farming, localized production and processing, reduction in energy-heavy chemical inputs, and fuel alternatives.

Habitat and biodiversity. Conversion of natural areas to modern agricultural production has traditionally removed native habitat and displaced wildlife, while threatening neighboring preserved areas through erosion into waterways, pesticide use, and corridor removal. However, in keeping large tracts of land from development, well-managed agricultural systems can actually provide wildlife habitat and maintain migration corridors.

Agrobiodiversity. Modern agriculture has resulted in loss of diversity in farm production with the economies of scale and specialization favoring monoculture crops and removal of on-farm natural or semi-natural areas, such as hedgerows or wetlands. While initially increasing productivity, this trend has made farms more susceptible to market fluctuations, pest problems, and soil nutrient depletion. These problems have, in turn, created heavy reliance on subsidies, pesticides, and nutrient inputs. Sustainable systems mitigate for these concerns by creating diversity both on-farm and across landscapes.

Social considerations:

Human health and well-being. While modern agriculture has greatly increased overall food availability for much of the world's population, it has had other repercussions on human health and overall well-being. Surpluses of corn, soybeans, and other staples have led the marketing of value-added "junk food" products, while pathogens and contaminants from antibiotics, pesticides, fertilizers, and other chemical inputs have appeared in food and water. Farm worker health and quality of life have also emerged as major concerns, particularly in California, where many immigrant farmhands operate outside of legal protections.

Animal welfare. The vast majority of modern meat and dairy production involves confined animal operations or "factory farms," in which large numbers of animals are often restricted to very small areas where they can be subject to immobilization, stress, disease, and inhumane slaughter practices (Pew Commission 2008). Recent efforts have been taken to incorporate animal welfare standards into certification programs, including the American Humane



Beekeeping is fast becoming an important part of pollinator-based agriculture.

Association “Free Farmed” label and the Humane Farm Animal Care’s ISO-certified label “Certified Humane Raised and Handled.”

Preservation of farmland and farming traditions. While farming was once the mainstay of the American economy and identity, fewer and fewer families have maintained these traditions, with less than 2% of the U.S. population now actively producing food. Rising land values have led many farming families to sell productive land for conversion to housing and suburban development, resulting in the loss of over 30 million acres of farmland since 1970.



Community connection to food production. Most Americans are completely removed from food production systems and have retained little understanding of the issues involved, which has had enormous implications for farmers who remain subject to political measures surrounding land use, subsidies, and regulatory efforts. This lack of involvement also keeps consumers from recognizing the influence of their purchasing power in supporting agriculture.

Economic considerations:

Financial viability of farming operations. As food production has become more and more concentrated into large-scale agribusinesses, family farms have become increasingly untenable financially, and many families have been forced to sell generations-old land to conglomerates or developers. While agricultural sustainability by nature begins with the producer, the burden of its implementation cannot rest solely on the small minority of farmers. A key consideration for communities seeking sustainability in agricultural production is to recognize the process involved and to support local producers as they work to attain it. Many transitional steps are time-consuming and expensive to implement, such as organic certification or the infrastructure development to reduce nutrient runoff, and farmers require financial, technical, and regulatory support throughout the process.

An affordable food supply. Americans currently spend a smaller percentage on food than any civilization in recorded history, with estimates ranging from 9-12% (Gallo 2008). As the hidden costs of this production have begun to emerge, such as fossil fuel and chemical input uses, many have started turning to more sustainable alternatives. The organic food market has grown more quickly than any other agricultural sector, at a rate of nearly 20% annually, despite the higher purchase price of organic food. The challenge for sustainable agriculture will be to ensure food remains affordable while addressing ecological or social concerns.

Rural community development. The loss of small farms has led to a disintegration of local production and marketing structures and a general shift in rural community development away from food production. Rural communities throughout California have been faced with economic losses and greater reliance on urban industries.

Sustainable Agriculture in the Salmon Creek Watershed.

Although Sonoma County remains one of the most productive farm counties in California, ranking 16th in the state and 34th in the nation, farmers throughout the County continue to struggle to keep their operations viable. According to the County's General Plan, "except for vineyards, other agricultural commodities generally do not generate sufficient profit to justify agricultural land prices in the County," forcing local farmers to "rely more on specialty niche markets and creative marketing to be competitive." (PRMD 2008a).

Several producers within the Salmon Creek Watershed have capitalized on niche market opportunities, producing high-value products, such as high-quality wine grapes, goat cheese, free-range or grass-fed meats, and organic milk. Two such producers, Kurt Beitler and Patty Karlin, are profiled below, along with the more conventional production system of rancher Walt Ryan. Efforts such as these have allowed the watershed to retain its rural character and its large, undeveloped parcels, which have, in turn, preserved essential ecological functions, such as wildlife habitat and air quality. A discussion of niche marketing, written by Gold Ridge RCD District Manager and Salmon Creek rancher Joe Pozzi, is also included.

A large component of these niche markets is the certified organic sector. California currently serves as the leading producer of organic commodities, a market growing by 15-20% annually over the last ten years (Sierra et al. 2008). A primary contributor to this movement, Sonoma County had nearly 16,000 acres in organic crop production in 2007 (not including land used for organic meat and dairy) and has been the birthplace of several certification programs focusing on sustainability, such as the "Fish-Friendly Farming" label for wineries or Clover-Stornetta's North Coast Excellence seal for milk production (Sonoma County Agricultural Commissioners Office 2008; Marcus 2009). Working in tandem with niche production, localized food processing has proven to be a growing sector of Sonoma County's economy, with employment increasing by 15% between 1997 and 1999 alone. In response to increased local demand, nearly half of these processors were producing certified organic products by 2002 (Sonoma County Economic Development Board 2002).

Residents of Sonoma County have repeatedly shown strong support for preserving local family farming traditions, voting to fund agricultural land preservation and attending over a dozen popular farmers' markets throughout the County. Multiple objectives laid out in the County's General Plan relate directly to agricultural preservation and sustainability, with the stated goal "to ensure the stability and productivity of the County's agricultural lands and industries" (PRMD 2008a). These include assistance with marketing and promotion of agricultural products, protection of farmland from urban encroachment, and the development of agricultural support services. A second section addresses the goal "to preserve the unique rural and natural character" of the County and "protect and enhance the County's natural habitats and diverse plant and animal communities," riparian corridors, soils, and forestry resources.

Goals

- The Salmon Creek Watershed supports a healthy, competitive, and sustainable agricultural industry.
- Large agricultural parcels are left intact to provide open space, support wildlife habitat, and preserve the watershed's rural character.
- The landowners in the watershed have the financial and technical support necessary so that agriculture continues to conserve or enhance the natural resources.

Sustainable Agriculture Recommendation 1: Facilitate opportunities for producers to locally process and market agricultural products.

Scientific Reasoning

Consumers throughout the Bay Area have shown a growing willingness to pay premium prices for local, sustainably produced products. One example of this trend is the expanding market for grass-fed beef. With prices nearly double that of conventionally produced beef, grass-fed beef has appealed to consumer interest in not only enhanced health benefits, but also in its implications for animal welfare and open space preservation.

Recent market studies from U.C. Davis have shown that the most sensitive consideration in operational costs for grass-fed beef production is shipping, primarily the location of both processing plants and target markets (Harper et al. 1996). This finding has considerable implications for the localized beef industry of Sonoma County, which is facing possible closure of the nearby Rancho Veal processing plant in Petaluma, the last cattle processing plant in the North Bay (Petaluma Argus-Courier 2006). While communities have provided support for local produce production in the area through Community Support Agriculture (CSA) programs and farmers' markets, meat marketing has proved more difficult due to lack of processing options.

Sonoma Direct, a local meat company with processing and distribution capacity, is working in partnership with UCCE to launch a locally focused Meat Buying Club that seeks to connect local ranchers more directly with consumers. The program focuses on grass-fed, family-farmed meats produced without hormones or antibiotics and using practices conducive to humane treatment of livestock and environmental stewardship.

Another distributor linking local producers with the community is Field to Family Natural Foods, begun in 2004 by Wayne and Amy Dufond. Field to Family provides poultry, beef, and pork products to area grocery stores, ensuring products from animals raised in humane, free-range conditions with vegetarian diets and without antibiotics or growth hormones. Their products include Beeler's Naturally Pure Pork, Panorama Grass Fed Beef, and Air Chilled poultry products, and lambs grown in the Salmon Creek Watershed. Efforts such as these can be supported and expanded to allow greater participation among local producers.

Action 1a: Promote and sustain agriculture-related industries in or near the watershed and develop forums for linking them with producers.

Implementation Measures

- Seek funding to support establishment of businesses that provide services, such as processing, storage, bottling, canning, and packaging.
- Address regulatory hurdles to on-farm livestock processing or "mobile slaughterhouses."

Action 1b: Develop a watershed "brand" synonymous with locally produced, sustainable, high-quality farm products.

Implementation Measures

- Work with public outreach organizations to promote public appreciation for local agriculture.
- Develop educational opportunities to teach producers about marketing strategies and business management.

- Assist in the development of effective distribution channels for locally produced goods.
- Assist farmers in developing value-added marketing plans for their products while establishing an overall market presence for the watershed as its own appellation.

Sustainable Agriculture Recommendation 2: Preserve open space and rural landscapes by keeping large agricultural parcels intact and their operations viable.

Scientific Reasoning

Large parcels provide valuable wildlife habitat and open space, while contributing to the watershed's rural character. Agricultural landowners need to be supported to sustain viable operations in order to maintain these large parcels. While updated zoning laws prohibit subdivision in some areas, the affected landowners are struggling to maintain financially viable operations to preserve these working landscapes.

Action 2a: Support producers in diversifying income and seeking financial assistance.

Implementation Measures

- Assist producers to participate in programs that provide additional capital to support agricultural land values, such as conservation easements through the Williamson Act.
- Coordinate with NRCS staff to assist producers in developing Farm Bill program contracts.
- Work with agricultural landowners to explore other farm-related income options, such as farm tours.

Sustainable Agriculture Recommendation 3: Ensure sustainable resource use in agricultural production.

Scientific Reasoning

The Salmon Creek Watershed has sustainably supported agricultural operations since its early settlement. It is actually the loss of agricultural land to residential development that poses the most risk of depleting groundwater supplies and transforming the valued pastoral landscape. However, some aspects of agricultural production itself do merit concerns about resource protection.

Vineyard development poses the greatest concern for agricultural water use within the watershed. Currently, many locally owned Salmon Creek vineyards are dry-farmed. Most are also zoned only above the frostline, eliminating the need for frost protection, which uses water when stream flows are low. However, some vineyards in the area are managed by outside companies, who often don't have a good understanding of local water use issues. Vineyard establishment also requires high water use for several years, making rapid expansion of vineyards a concern. Since this area is predominately dry-farmed, the importance of added economic value vineyards bring to a landowner's viability is important.

Water quality serves as the biggest concern for livestock operations, particularly dairies. Concentrated livestock on dairies produces large nutrient and pathogen loads, threatening aquatic life. Confined animal facilities throughout the Bodega Bay

Hydrological Unit have been identified as sources of nutrient and sediment runoff into the Bodega Bay by the Regional Water Quality Control Board.

Vegetated buffers and intact riparian corridors can serve as effective ways to greatly reduce contamination of water sources from sedimentation, nutrients, and pathogens, while simultaneously maintaining riparian corridors for wildlife and stream shading needed for salmon survival. A U.C. Davis study has shown that 99.9% of pathogens are trapped within one yard of their source, indicating that buffers do not have to remove extensive stretches of land from range to reduce water contamination (Tate et al. 2006). Properly constructed wetlands can also be used to filter pasture runoff through anaerobic denitrification of trapped sediment.

One recent legislative change that may greatly affect the operations of Salmon Creek's two remaining dairies is USDA federal regulations passed in October 2008 governing organic dairying. Meant to target large-scale operators running confined animal-feeding operations with no pasture access, the new regulations state that dairy operators must now keep cows in open pastures during the "growing season." In coastal areas, this may coincide with heavy rains, a requirement that may not be appropriate for rainy coastal areas where fields become overly muddy. Pasturing cows through the winter could have severe repercussions for water quality, forage production, and animal health (Digitale 2008).

Action 3a: Work with vineyard operators to reduce water use.

Implementation Measures

- Provide workshops and technical support for vineyard dry-farming.
- Assist vineyard operators in acquiring support through NRCS and RCD programs to develop water conservation measures.
- Work with vineyard operators to understand and remain a step ahead of groundwater regulation measures as they develop.
- Educate the local community on vineyard practices.

Action 3b: Assist rangeland and dairy operators in implementing water quality protection measures.

Implementation Measures

- Provide workshops and technical support for dairy and rangeland operators to assist in compliance with water-quality regulations.
- Assist rangeland and dairy operators in acquiring assistance through NRCS and RCD programs to protect riparian areas.

Action 3c: Assist livestock operators to develop and implement nutrient management plans.

Implementation Measures

- Implement a proactive, on-farm nutrient management program that will include a "user-friendly" nutrient budgeting model, soil, vegetation, and manure sampling protocols, and a land application tracking system. The program will assist watershed dairy and livestock operators with the ability to write nutrient management plans based on facility inventories and nutrient budgeting information.
- Secure funding to effectively develop nutrient management or conservation plans for all livestock operators.

- Provide technical assistance to dairy and livestock operators to conduct on-farm facilities inventories and nutrient budgeting.
- Conduct soil, vegetation, and manure sampling to identify the proper organic fertilizer application rates for farm fields.
- Complete nutrient management plans and land application tracking systems.
- Use buffer strips to trap sediment from confined animal and other high-use areas.
- Work with interested landowners to develop waste-to-profit systems, such as methane digesters and on-site fertigation equipment that spreads manure onto forage fields.

Landowner Profiles

Joe Pozzi – Creating the Salmon Creek Watershed “Brand”

For many years, agricultural producers in the Salmon Creek Watershed had little involvement with marketing: once the product left the farm gate, it was somebody else’s problem. The commodities produced here were quickly consolidated into larger groups of products from all over the country and world. We had no identity as to who we were or what we produced. The small farmers in the watershed were quickly shut out of these large markets, unable to achieve the economies of scale of large agribusinesses in other areas.



However, a significant change has occurred over the past ten years. Many modern consumers, particularly in the Bay Area, want to know where and how their food and fiber are produced and are seeking organic, humanely raised, or other indications these products have been produced sustainably. With rising concerns about global climate change, there is a heightened scrutiny of the carbon footprint of food production. These evolving consumer concerns have caused farmers and ranchers to become more involved with the public interface, a whole new shift in paradigm for many local producers. Not only do we need to be efficient in producing a wholesome, safe product and be good stewards of the land, we now also need to be the marketing arm of our businesses.

While daunting for some producers, this revelation is actually a silver lining for others, because we are now able to represent our products for what they really are. Now, in a trend reminiscent of the watershed’s agricultural history, there is milk going to local organic creameries, and goats producing cheese marketed throughout the Bay Area. The lambs produced in the watershed are marketed as a specialty product in many restaurants and stores; the wool is used in organic bedding products sold both locally and throughout the United States. The dry-farmed vineyards are family owned and keep a large number of local people employed. The cattle are being marketed as grass-fed beef, and many are identified as to where they were raised and how they were taken care of.

The most important aspect of this process is that the producer has an opportunity to add value to his or her product through this interaction with the consumer. We all have an

interesting story as to what we produce and why. The consumers of today want to hear that story, so you now see ranchers carrying business cards and developing websites. You will see their products at farmers' markets or on a brochure at an upscale restaurant or food store. This trend has helped get our products recognized by the surrounding consumers and has put the producer in a position to be a price giver instead of a price taker, to create markets rather than being shut out of them.

I think we will continue to see an expansion into niche and value-added products being produced within the Salmon Creek Watershed. While it can be successful and profitable, niche marketing is not easy. There is a tremendous amount of work getting the product to the farm gate, and there is just as much work in getting it to the consumer. The value of the product has to reflect the time put into it by the farmer for his or her business to succeed and for the farming traditions and landscapes of the Salmon Creek Watershed to be preserved.

Kurt Beitler (Viticulture)

Kurt manages several vineyard properties along Taylor Lane, the top of the Tannery Creek Subwatershed, including a 10-acre area producing high-value pinot noir grapes for prestigious Napa Valley's Belle Glos label, a winery built by Kurt's grandfather. Other properties provide grapes for Caymus Winery cabernets and Kurt's own Bohème label. Since he began managing the property in 2000, Kurt has introduced many innovative practices to the operation. While most vineyards in the area use conventional vertical shoot position (VSP) trellises, with fruiting vines growing vertically at hip height, Kurt's family has converted their vines to an overhead pergola system. This allows the fruiting vines to grow horizontally overhead, which adapts the plants to the region's more limited sunlight by maximizing sun exposure. The system has the added advantage of producing fruit 5 to 6 feet off the ground, allowing Kurt to use sheep for weed control. The system has proven effective in producing high-quality grapes, allowing for early high-sugar levels from the added sun exposure. Productivity ranges from 0.5 tons/acre in a poor year to 2.5 tons/acre, standard levels for the watershed, which produces low-volume, high-quality grapes. Belle Glos wines are generally marketed for \$60-\$70 per bottle.



Kurt Beitler, 2010

A flock of 25 sheep currently graze the vineyard year-round, eliminating the need for strip-spraying, which is normally required to lessen weed competition between vines out of reach of a mower. Grazing also greatly decreases mowing requirements, saving labor and fuel costs and reducing fossil fuel use and greenhouse gas emissions. The sheep themselves require minimal expenses, including some supplemental feed,

veterinary care, and sheering, along with reinforcements to the irrigation system to protect it from grazing damage. Kurt has given the wool to local spinners and has occasionally harvested lambs for personal consumption.

Neighboring landowners have expressed approval of these management techniques, appreciating the multi-use production system and minimal chemical use. Sensitive to neighbors' concerns about water availability, Kurt has also worked to minimize water use, beginning with the use of a local drought-tolerant rootstock. The vineyard is dry-farmed when possible, and any irrigation water comes from an on-site rainwater catchment pond rather than being pulled from overstressed groundwater sources. Most importantly, Kurt emphasizes the importance of on-site management, which allows him to respond appropriately to local conditions and develop a more sustainable production system. (Beitler, K, pers.comm., 2010)

Patty Karlin (Bodega Goat Ranch)

Known throughout western Sonoma County for her goat cheese, Patty owns and manages a diverse operation at the ranch, which sits on over 7 acres up Tannery Creek Road. While the 60 Alpine goats and on site creamery serve as the basis for the operation, Patty promotes a system of cooperative farming in which she works with other producers to keep ducks, guinea hens, turkeys, chickens, and pigs. She plans to soon add beekeeping to the mix to provide hives to area growers requiring pollination services. The livestock diversity holds several advantages, from fertilizer production, whey disposal as pig feed, and weed control as different species can be used to target different weeds. The creamery is also rented to other cheesemakers.



Patty Karlin and her goats, 2010.

To promote biodiversity and forage, Patty has created permaculture swales planted with tree and shrub species as goat browse. Goats are natural browsers, relying on high-protein leguminous shrubs for milk production. While they can and do eat grasses, they can't digest them as effectively, which results in lost productivity, higher methane production, and land needs beyond the ranch's acreage, which would require Patty to purchase supplemental feed. The ranch also has a medicinal garden that supplements the goat feed, which has greatly reduced veterinary costs. Pastures are seeded with selected native grass species, a practice that works both to increase the forage value of the pastures and to enhance the conservation value of the land.

To address the area's low water availability, a complex system of roof water catchments, ponds, and swales were constructed that allow for 90,000 gallons of water storage and supply all of the ranch's water needs. The ranch has also been equipped with commercial-sized solar panels to serve the residences and the creamery, an investment that recouped its own installation costs within 4 years.

The goat cheese is marketed primarily through local farmers' markets, small localized distributors, and area restaurants. Selling a product that can be vacuum-packed or aged also allows Patty to spread her income out throughout the year, selling cheese even during the goats' gestation period in the winter.

While she currently handles all aspects of the operation, Patty is working with FarmLink to have interns take over the fresh cheese production in order for her to assume a more mentoring role. This has proven to be quite a daunting task, with the ranch producing 150 pounds of cheese a week for 8 months each year. In providing internships, hosting agro-tourism tours, and participating in conferences and workshops throughout the world, Patty's vision is to have the Bodega Goat Ranch serve as a model of agricultural sustainability (Carlin, P., pers.comm., 2010).

Walt Ryan (Cattle Ranching)

Walt Ryan's ranch has been in his family for 120 years, since it was purchased by his great-great-grandfather for timber production, and later converted to a grade-B dairy with a small sheep flock. The property was converted to beef cattle rangeland in the 1960s, as small dairies had become financially unviable due to the collapse of the wool market and predation by coyotes. Walt's ranch currently supports cow-calf pairs, and a handful of sheep used to graze around the house for fire protection. While many ranchers in the area calve in the fall, Walt changed the calving regime to the spring so the cows no longer require supplemental feed. While the property's topography make fence installation for rotational grazing challenging, Walt works to ensure grassland health and good use of forage by moving salt supplements, monitoring water sources, and keeping stocking rates at sustainable levels.

With children looking to take over the ranch, Walt has struggled to maintain the viability of his operation, given increasingly strict regulations and zoning constraints. With nearly two-thirds of his ranch covered in valuable hardwoods, redwoods, and Douglas-fir, Walt sees managed timber harvesting as an option for diversification, but has been discouraged from attempting to pursue the option due to the laborious regulatory procedures required. Zoning specifications stemming from the area's limited water supply has restricted subdivision possibilities, and predation continues to limit sheep ranching in the region. Climate and water availability on this coastal property has also limited the possibility of vineyard development. Vertically integrating his cattle operation has also proved infeasible, due to the restrictions placed on on-farm processing. And while grass-fed beef has proved to be a value-added product for some area producers, the steps required to enter that market structure are too often not deemed economical for many ranchers, particularly those with limited marketing experience.

As with all farming families, the Ryans have struggled with the California tax structure, under which it's become more and more difficult for producers to keep their land in agriculture from one generation to the next due to soaring land values and increasing inheritance taxes. Though determined to maintain his families ranching traditions, Walt has even explored other non-agricultural land uses, and has leased the property to hunting clubs and wedding parties, and even looked into establishing conservation easements. However, these uses give rise to obvious privacy and liability concerns, while providing limited income and, of course, no food production.

While continually struggling with regulatory pressures, Walt sees the root issue to be the disintegration of the community's connection to the land. Sonoma County's growing population often supports regulations and political measures that make farming more

and more difficult, without putting into place the necessary support structures to help farmers remain in compliance. With a smaller and smaller percentage directly involved in the industry, many Sonoma County residents fail to recognize the constraints and realities of food production.

Despite the ever-increasing difficulties faced by ranching families in the watershed, Walt has worked tirelessly to push these realities to the forefront. He currently serves as a director on the boards of the Sotoyome Resource Conservation District and the Sonoma County Farm Bureau. He also sits on the advisory board of the Santa Rosa High School Agricultural Department, which works to introduce a new generation to vocational opportunities within agriculture by involving students in the management of an onsite farming operation.

CHAPTER 8: IMPLEMENTATION

This chapter provides a framework to bring the Plan's recommendations into existence. An intention of this Plan is to recommend land management practices that will directly contribute to water pollutant load reductions and hydrologic condition improvement. The first section of this chapter summarizes our current understanding of known pollutants in the watershed and the relative level of load reduction expected from the recommended management practices.

Chapter 8 then goes on to identify who would implement actions by when and addresses the value of partnerships to engage watershed residents and support Gold Ridge RCD in meeting watershed goals. It presents an overall strategy for keeping watershed residents and other stakeholders current with new information and management practices. Finally, the chapter identifies potential funding sources and provides a brief summary of permits that may be needed for implementation.

Pollutant Load Reduction and Success Criteria

Chapters 3 through 7 outline information related to, and actions designed to improve, the overall health and functioning of the watershed for wildlife and human residents. Chapters 4, 5, and 6 focus on riparian and instream habitat conditions, water quality, and water supply availability, respectively. These three chapters summarize baseline data for habitat conditions and pollutant factors and indicate where and when conditions have deviated from indicator target values.

Water-quality and streamflow monitoring efforts to date have not been designed to directly estimate pollutant loading. Results from the baseline water-quality monitoring program were not sufficiently statistically robust to estimate pollutant loads (UCCE 2009, Appendix B). Load estimating using watershed models is an alternative approach. However, for the model results to be accurate, the input data must be correlated to site-specific information and the output checked for accuracy against real data. This type of modeling approach, with its associated data collection and computational needs, was beyond the scope of this Plan. Loading rates based on published literature, while commonly used, are too general to provide a much higher level of precision than local, knowledgeable professional judgment in designing and ranking load reduction measures in the watershed; see Table 6 below. The misapplication of published literature loading values or inaccurate model results may lead to unintended consequences for landowners and resource agencies. Therefore, we have chosen to characterize pollutant load reduction in a qualitative manner that rates their potential to effect changes in indicators.

As illustrated in the Table 6 below, a single land-use management practice may affect multiple hydrologic and pollutant factors. Successful reduction of any pollutant load or improvement in a hydrologic condition requires implementation of multiple management practices. Project development and prioritization will need to include evaluation of the potential to reduce pollutant loads or improve hydrologic conditions within a reach or watershed wide.

Table 6. Potential for land management practices to reduce pollutant loads in the Salmon Creek Watershed.

High potential (H), medium potential (M), and low potential (L) are relative and subjective. Additional data collection and watershed modeling are necessary to substantiate and quantify pollutant loads and expected reduction amounts.

Evaluation of Pollutant Load Reduction Measures									
Management Practices	Hydrologic Factors			Pollutant Factors					
	Dry-season flows	Infiltration/ Groundwater recharge	Flood peaks/ Flashiness	Turbidity	Temperature	Dissolved oxygen	Nutrients	Pathogens	Toxins/ Heavy metals
Manage forests for fire safety, diversity, and health		H	M	M					
Manage grasslands for species diversity and health		H	M	M			M	M	
Stabilize upland gullies				H					
Improve or decommission rural roads				H					
Install sediment retention basins		M	M	H			L	L	
Construct vegetated infiltration bioswales		H	H	M			L	L	
Disconnect impervious surfaces and drainage ditches from waterways		M	H	H			M	M	H
Promote use of pervious materials		M	M	L					
Upgrade septic systems						M	H	H	M
Reduce use of pesticides and fertilizers							M		
Install riparian fencing to limit livestock access	H			M		H	H	H	
Implement agricultural nutrient management				M		M	H	H	
Increase riparian buffer width	L		L	M	H		H	M	
Plant riparian trees					H	H	L		
Stabilize eroding streambanks with bioengineered solutions				L	M				
Implement rainwater harvesting and storage projects	H	M	L		L	L			
Remove instream pumps and reduce use of near-channel wells	H				M	H			
Implement water conservation practices	M				L	L			
Improve community water system efficiency	M				L	M			
Color Key	Watershed-wide and/or seasonal impairment								
	Reach-specific or localized impairment								
	Suspected impairment								

The success of pollutant load reduction implementation will be tracked through the watershed monitoring program; see Chapter 9. The expanded monitoring program will also be used to refine the understanding of reach-specific impairments, as well as design and prioritize projects. The following table outlines the key indicators and criteria to be used in tracking pollutant load reduction and hydrologic condition success.

Table 7. Success criteria for pollutant load reductions and hydrologic condition improvements.

Criteria to track the success of pollutant load reduction projects		
Hydrologic Factors	Dry-season flows	Increasing trend in dry-season baseflow discharge and /or drought-period streamflow
	Infiltration/ Groundwater recharge	Increasing trend in dry-season water depths in upland wells
	Flood peaks/ Flashiness	Decreasing trend in streamflow flashiness
Pollutant Factors	Turbidity	Decreasing trend in winter baseflow and storm-event turbidity levels
	Temperature	Increasing trend in number of weeks with pool MWAT at or below 15°C during the dry season
	Dissolved oxygen	Increasing trend in number of weeks with average pool DO at or above 7 mg/L
	Nutrients	Maintain nitrate levels at or below 0.155 mg-N/L and orthophosphate (reported as total P) at or below 0.03 mg/L
	Pathogens	Fecal coliform: Maintain median 30-day levels at or below 50/100 ml with 10% of those samples not exceeding 400/100 ml
	Toxins/ Heavy metals	No criteria standards established
Color Key	Watershed-wide and/or seasonal impairment	
	Reach-specific or localized impairment	
	Suspected impairment	

Partnerships

The Salmon Creek Watershed is rich in partners. With no incorporated cities, a small population, and no municipal reservoirs, it has fostered an independent population of multi-generational ranch families, farmers, artists, and rural residents accustomed to taking care of themselves and their neighbors. Participation in watershed activities has been high with many people regularly attending public meetings, cooperating with Gold Ridge RCD on conservation projects, and expressing interest in the Save our Salmon (SOS) rainwater harvesting program. The SCWC and OAEC have been leaders with Gold Ridge RCD in creating a vision for a healthy watershed and bringing in funding for assessments, planning, and implementation. Salmon Creek School has just completed the first platinum LEED (Leadership in Energy and Environmental Design) certified building in Sonoma County; the school also includes a strong watershed-based environmental component in the curriculum. BLT, SLT, and SCAPOSD hold conservation easements in the watershed and promote good stewardship practices.

Bodega Water Company has been working with OAEC and Gold Ridge RCD to reduce its impact on summer flows. UCCE and NRCS have been stalwart partners in providing technical assistance to Gold Ridge RCD and landowners, as well as cost-share help through USDA programs. The NCRWQCB, CDFG, SCC, and NOAA Restoration Center have been major funders of watershed programs, and many other agencies have generously served as technical advisors.

Many of the actions in the Plan rely on partners to take the lead or provide support. Table 8 identifies the partners and their existing roles in the watershed. The following acronyms are used in the implementation summaries (Tables 9-13) that follow:

BAEDN	Bay Area Early Detection Network
BLT	Bodega Land Trust
CDFG	California Department of Fish & Game
CNGA	California Native Grass Association
MSWMA	Marin Sonoma Weed Management Area
NCRWQCB	North Coast Regional Water Quality Control Board
NOAA	National Oceanic and Atmospheric Agency's Restoration Center
NRCS	USDA Natural Resources Conservation Service
OAEC	Occidental Arts and Ecology Center
NCRWQCB	North Coast Regional Water Quality Control Board
SCC	State Coastal Conservancy
SCAPOSD	Sonoma County Agricultural Preservation and Open Space District
SCWC	Salmon Creek Watershed Council
SLT	Sonoma Land Trust
STRAW	Students and Teachers Restoring a Watershed
SWRCB	State Water Resources Control Board
TBD	To be determined
TU	Trout Unlimited
UCCE	University of California Cooperative Extension
\$	\$0 to \$24,999
\$\$	\$25,000 to \$100,000
\$\$\$	Over \$100,000

Table 8. Existing programs and efforts in the Salmon Creek Watershed.

Watershed partners	Existing Program or Activity
Landowners	Ongoing stewardship activities including range and forest management, erosion control, invasive plant control, and riparian enhancement.
GRRCD	Outreach and education, water conservation and rainwater harvesting, instream habitat enhancement, streambank restoration, ranch planning, support of on-farm pollination programs, water quality monitoring, grassland monitoring, rural road improvements and assessments, manure management planning, watershed management planning, forest health, and grant writing
Salmon Creek Watershed Council	Outreach and education; community networking; watershed website; generator of and clearinghouse for ideas for grants and initiatives; support of GRRCD, OAEC, Salmon Creek School, and other's grant-funded watershed programs.
OAEC	Salmon Creek Water Conservation Program, outreach and education, estuary enhancement, forest health, landowner consulting, grassland monitoring, endangered species recovery efforts, including native beaver reintroduction, erosion control and stormwater management, grant writing and program development.
Bodega Water Company	Water conservation, rainwater harvesting
UCCE	Ranch water quality plans, assistance with water quality monitoring, and estuary research
Sonoma County Agricultural Preservation and Open Space District	Conservation easements, stewardship activities on District-owned properties
Bodega Land Trust	Conservation easements, outreach and education, stewardship activities on properties with easements
Salmon Creek School	Community education, green building and LID (low impact development) demonstrations, riparian and wetland enhancement
Bodega Volunteer Fire Dept	Rainwater harvesting, LID
California State Parks	Estuary protection and management
Ocean Song	Native grassland mapping and management, environmental education

Implementation summary

\$ = \$0 to \$24,999 \$\$ = \$25,000 to \$100,000 \$\$\$ = over \$100,000

Table 9. Implementation of upland management recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
Uplands 1: Manage forests and woodlands to maintain diversity and ecosystem function.	1a. Provide education and technical support for landowners to manage healthy forests.	<ul style="list-style-type: none"> ✓ Conduct a watershed workshop or small-forest “fair.” ✓ Provide information on websites. Distribute handouts at local events. ✓ Encourage landowners to work with NRCS to develop Forestry Conservation Action Plans (NRCS CAP). ✓ Promote management of existing redwood forest to encourage development of late seral stands. ✓ Coordinate with local conservation corps to provide low-cost work crews to assist landowners. 	5 yrs	\$ - \$\$	GRRCD or UCCE	Cal Fire Sonoma County Forest Conservation Working Group NRCS
	1b. Identify priority areas for forest and woodland conservation, including late-successional redwoods that provide habitat for special-status species.	<ul style="list-style-type: none"> ✓ Target high priority areas. 	5 yrs	\$\$	SCAPOS, SLT, BLT	Sonoma County Forest Conservation Working Group
	1c. Implement a fuel-load management program in cooperation with Cal Fire.	<ul style="list-style-type: none"> ✓ Target high priority areas. ✓ Organize neighborhood meetings with Cal Fire and local fire departments. ✓ Coordinate with local conservation corps to provide low-cost work crews to assist landowners. ✓ Assist neighborhoods in organizing and finding funding for chipping programs ✓ Assist landowners with NRCS EQIP practices 	5 yrs	\$\$-\$	FireSafe Sonoma	Landowners CalFire NRCS Sonoma County Forest Conservation Workgroup Local VFDs Neighborhood associations

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	1d. Determine the extent of Sudden Oak Death in the watershed and educate landowners about minimizing spread and managing infected forests.	<ul style="list-style-type: none"> ✓ Coordinate with UCCE to monitor extent of SOD. ✓ Create outreach materials to educate landowners about how to prevent SOD spread, treat diseased trees, and handle infected wood. Distribute at local events, other watershed workshops, and through websites. ✓ Develop, publish, and publicize BMP recommendations for private forest and woodland owners. 	1-3 yrs	\$\$-\$	UCCE	TBD
Uplands 2: Protect existing coastal prairie and other grasslands rich in native species and manage for healthy grasslands throughout the watershed.	2a. Support watershed ranchers in developing and implementing ranch plans that include sustainable grazing practices.	<ul style="list-style-type: none"> ✓ Coordinate with UCCE and NRCS to support ranchers in developing plans. 	5 yrs	\$\$	MSWMA	Landowners UCCE NRCS GRRCD
	2b. Support local research and education efforts to identify and refine management strategies that promote native grassland species.	<ul style="list-style-type: none"> ✓ Establish and support demonstration sites for ongoing education. ✓ Provide a range of educational materials and tours for ranchers, small grassland owners, and the 	1-3 yrs	\$\$-\$	MSWMA	Sonoma Marin Coastal Grasslands Working Group GRRCD
	2c. Identify priority areas for native grassland conservation.	<ul style="list-style-type: none"> ✓ 	5 yrs	\$\$	Sonoma Marin Coastal Grasslands Working Group	SCAPOSD SCC Sonoma Coast State Park
	2d. Develop local seed sources for native grassland plants.	<ul style="list-style-type: none"> ✓ Develop database of locations where key grassland species for restoration occur, and where landowners are willing to allow seed collection. ✓ Offer workshops identifying key grassland species for restoration use, methods of seed collection, and options for seed increase. 	5 yrs	\$	MSWMA	Sonoma Marin Coastal Grasslands Working Group CNPS, Milo Baker Chapter

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
		√ Support development of a community seed bank.				CNGA
Uplands 3: Reduce impact of invasive species populations on habitat quality and function.	3a. Inform residents about invasive plant species, removal techniques and timing to avoid erosion and wildlife impacts, and native species suitable for residential or rangeland plantings.	<ul style="list-style-type: none"> √ Hold a weed-whacking workshop. √ Partner with local nurseries and distributors to provide free native plants, protectors, and other revegetation products to participants. √ Provide information on websites. Distribute handouts at local events. 	5 yrs	\$	MSWMA	Landowners SCWC
	3b. Promote removal of gorse, French broom, Scotch broom, and Himalaya blackberry infestations and replanting with appropriate native species.	<ul style="list-style-type: none"> √ Provide use of weed wrenches for a nominal fee. √ Organize neighborhood work parties. √ Provide free native plant(s) and disposal of invasive plant material. 	5 yrs	\$	MSWMA	Landowners SCWC
	3c. Monitor new occurrences of invasive species and contribute to regional weed management databases and efforts.	√	on-going	\$	BAEDN	Landowners MSWMA
Uplands 4: Preserve undisturbed upland habitat and its connectivity.	4a. Identify and protect areas needed for wildlife corridors and critical habitat.	√	on-going	\$\$\$	SCAPOSD	BLT SLT GRRCD
	4b. Encourage use of wildlife-friendly fencing	√ Develop informational materials to post on websites and distribute at workshops, local events, and landowner visits.	5 yrs	\$	GRRCD	Landowners NRCS

Table 10. Implementation of instream and riparian enhancement recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
IR 1: Protect and increase existing riparian corridors.	1a. Increase and protect riparian corridor widths to improve function and habitat quality.	<ul style="list-style-type: none"> ✓ Educate landowners and residents about the benefits of riparian corridors and functional widths. ✓ Install riparian fencing along stream reaches accessed by livestock. ✓ Develop a program to assist rural residential landowners in managing their land for wider riparian corridors. 	1- 3 yrs	\$ - \$\$	GRRCD with assistance from NRCS	Landowners SCWC BLT SLT UCCE
	1b. Enhance riparian corridor structure complexity and species richness.	<ul style="list-style-type: none"> ✓ Educate landowners along riparian corridors on the components of a healthy riparian corridor. ✓ Install riparian fencing in reaches accessed by livestock. ✓ Plant riparian trees and herbaceous shrubs in riparian areas with insufficient density and complexity. 	5 yrs	\$ - \$\$	GRRCD with assistance from NRCS SCWC	Landowners BLT STRAW
IR 2: Increase instream channel complexity.	2a. Increase wood in stream channels.	<ul style="list-style-type: none"> ✓ Educate landowners and residents on the importance of large wood in stream channels, and the legal constraints on its unauthorized removal. ✓ Leave naturally downed large wood in channel, unless threatening infrastructure. ✓ Install large wood structures. ✓ See Recommendation 1 for actions to increase available wood and promote natural recruitment through riparian corridor enhancement. 	5 yrs	\$ - \$\$	GRRCD TU	Landowners BLT SCWC UCCE CDFG SWRCB SCC NOAA
	2b. Allow bank widening and inset flood bench development in reaches not constrained by buildings or infrastructure.	<ul style="list-style-type: none"> ✓ Use non-rock, biotechnical engineering practices to stabilize banks. ✓ Allow natural bank retreat and slumping. 	5 yrs	\$\$	TBD	Landowners CDFG SWRCB SCC NOAA

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	2c. Promote tree establishment along the active channel and on stream banks for bank stabilization, live wood complexity, and undercut bank development.	<ul style="list-style-type: none"> ✓ Remove chronic disturbances, such as grazing (See Recommendation 1). ✓ Stabilize and slope eroding banks with bioengineering approaches and plant early successional riparian plants such as willow along with hardwood and conifer species. ✓ Leave or install large wood on active channel margins and banks to slow flood velocities, deposit fine sediment, and protect seedlings. ✓ Allow undercut banks to develop. 	5 yrs	\$\$ - \$\$\$	GRRCD	Landowners BLT STRAW TU SCWC NOAA UCCE CDFG SWRCB SCC
IR 3: Reduce fine sediment delivery and maintain gravel quality.	3a. Reduce fine sediment delivery from upland gully erosion, residential development, livestock operations, vineyards, and roads.	<ul style="list-style-type: none"> ✓ Educate landowners, construction operators, and public works departments on BMPs for reducing erosion and managing sediment delivery to streams. ✓ Improve grasslands and cross-fence pastures to reduce sheet and rill erosion on livestock ranches and dairy operations. ✓ Install riparian fencing to reduce streambank erosion. ✓ Decommission non- or under-used roads. ✓ Upgrade poorly designed roads. ✓ Document and repair upland gullies delivering sediment directly to the stream system. 	Ongoing	-\$\$\$\$	GRRCD	Landowners SWRCB CDFG SCC NOAA
	3b. Improve in-channel complexity for the capture and sorting of suitable spawning gravels.	<ul style="list-style-type: none"> ✓ See Instream and Riparian Recommendation 2. 	5 yrs	\$\$	GRRCD	Landowners SWRCB CDFG SCC NOAA

Table 11. Implementation of water quality enhancement recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
WQ 1: Minimize turbidity and the delivery of fine sediment from upland sources.	1a: Document and manage upland sediment sources.	<ul style="list-style-type: none"> ✓ Assess upland erosion sites for delivery of sediment to waterways. ✓ Maintain an on-going inventory of high-priority erosion control projects for use in funding and implementation decisions. ✓ Cooperate with landowners to implement identified high-priority erosion control projects. 	Ongoing	\$\$-\$\$\$	GRRCD	Landowners SCWC CDFG SCC NCRWQCB NRCS
	1b. Maintain, improve, or decommission rural roads.	<ul style="list-style-type: none"> ✓ Address sediment sources from road networks. Where possible, decommission roads that are no longer in use. ✓ For roads that are still in use, improve road design and maintenance practices to limit sediment production. ✓ Provide maintenance workshops and install demonstration projects as outreach to owners of dirt roads and driveways. 	5 yrs	\$\$-\$\$\$	GRRCD	Landowners SCWC CDFG SCC NCRWQCB NRCS
	1c. Disconnect and filter sediment from waterways.	<ul style="list-style-type: none"> ✓ Increase the width, extent, and vegetative cover of riparian buffer throughout the watershed; see Instream Habitat Enhancement Action Plan in Chapter 5. ✓ Provide off-channel water sources for livestock by developing alternative water supply and providing pasture troughs. ✓ Construct sediment retention basins and infiltration swales along roadway drainage ditches to capture stormwater runoff and fine sediment. ✓ Install bioswales to slow stormwater runoff before it enters waterways ✓ Disconnect impervious surfaces 	5 yrs	\$\$-\$\$\$	GRRCD with assistance from NRCS OAEC	Landowners SoCo Dept. of Transport'n & Public Wks CDFG SCC NCRWQCB

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	1d. Promote soil retention.	√ Provide technical information and training on Best Management Practices for erosion control and farming practices to maintain topsoil.	1-3 yrs	\$	GRRCD with assistance from NRCS	Landowners UCCE NCRWQCB
WQ 2: Maintain and improve summer water temperatures.	2a. Maintain and enhance dry-season flows.	√ See Chapter 7: Water Supply Sustainability Action Plan.			GRRCD	Landowners UCCE NCRWQCB CDFG NOAA
	2b. Maintain and Increase riparian canopy cover.	√ See Chapter 5: Instream Habitat Enhancement Action Plan.			GRRCD	Landowners UCCE NCRWQCB CDFG NOAA
	2c. Reduce and minimize turbidity.	√ See WQ Recommendation 1.			GRRCD	Landowners UCCE NCRWQCB CDFG NOAA
WQ 3: Increase summer DO levels in pools.	3a. Increase summer streamflows.	√ See Chapter 8: Water Supply Sustainability Action Plan.				
	3b. Reduce summer water temperature.	√ See WQ Recommendation 2.				
	3c. Reduce nutrient loads.	√ See WQ Recommendation 4.				
WQ 4: Minimize nutrient and pathogen delivery.	4a. Restrict direct livestock access to	√ Provide technical information to horse owners and other rural residents with small numbers of	1-3 yrs	\$	GRRCD with assistance from NRCS and	Landowners NCRWQCB

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	streams and riparian areas.	confined animals. ✓ Support use of riparian fencing, pasture management, water development, and other strategies to protect waterways.			UCCE	CDFG NOAA Sonoma County Farm Bureau
	4b. Upgrade inadequate septic systems adjacent to waterways.	✓ Provide information to landowners on the importance of maintaining a well-functioning septic system to a healthy stream. ✓ Coordinate with Sonoma County PRMD to streamline permitting to upgrade or replace inadequate systems. ✓ Seek funding to assist landowners with onsite wastewater treatment systems.	5 yrs	\$\$	TBD	Landowners SoCo PRMD NCRWQCB
	4c. Reduce use of nitrate- and phosphate-rich products.	✓ Develop and distribute a comprehensive list of effective alternatives and methods for reducing quantity of use. ✓ Develop demonstration sites for reduced fertilizer and pesticide gardening and farming. ✓ Educate landowners about reducing the use of phosphate soaps to lessen associated phosphate pollution through insufficient filtration by onsite wastewater treatment systems.	1 -3 yrs	\$	TBD	Landowners MSWMA BAEDN UCCE SoCo Agric. Commissioner's
WQ 5: Promote minimal use and proper disposal of toxic compounds.	5a. Keep stormwater on site.	✓ Use educational materials, workshops, and demonstration sites to encourage the use of measures such as rainwater catchment, low-impact design, swales, and infiltration ponds to retain stormwater.	1- 3 yrs	\$	TBD	OAEC UCCE NCRWQCB County of Sonoma

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
	5b. Educate community on pollutants of concern and how to reduce water contamination.	<ul style="list-style-type: none"> ✓ Develop and distribute educational materials on websites, at workshops and community events, and on toxic round-up days (see Action 5c). ✓ Include information on proper use and disposal of household toxics, and safe alternatives. ✓ Include guidelines for proper drainage of swimming pools and spas. 	1 – 3 yrs	\$	TBD	SoCo Env'tl Health SCWC
	5c. Promote proper disposal of toxic products.	<ul style="list-style-type: none"> ✓ Hold well-publicized toxics round-up days quarterly to assist landowners with safe disposal of unwanted compounds. 	1 – 3 yrs	\$	TBD	

Table 12. Implementation of water supply sustainability recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
WS 1: Develop storage-based water supplies to reduce reliance on, and utilization of, extractive sources.	1a. Develop off-channel ponds and distribution systems.	<ul style="list-style-type: none"> ✓ Evaluate agricultural producer’s water supply sources to target those using instream or riparian sources. 	1 – 3 yrs	\$\$\$	GRRCD	Landowners NRCS CDFG SWRCB NOAA
	1b. Install roofwater harvesting systems.	<ul style="list-style-type: none"> ✓ Design and install roofwater catchment systems to replace non-potable water uses from extractive sources and increase water supply security. ✓ Consider installing roofwater catchment systems where potable supplies are unreliable, water quality is poor, or water source is a stream diversion. 	1 – 3 yrs	\$\$ - \$\$\$	GRRCD BWC OAEC	Landowners NRCS CDFG SWRCB NOAA
	1c. Support landowners in reducing or eliminating dry-season use of instream pumps and near-channel wells.	<ul style="list-style-type: none"> ✓ Conduct an education and outreach program to inform residents of the ecological impacts of using their riparian water rights. ✓ Develop off-channel storage and roofwater harvesting systems to replace riparian water sources – see Water Supply Actions 1a and 1b above. ✓ Develop program to enroll landowners in abstaining from using their riparian rights for the purpose of salmonid habitat improvements. 	1 – 3	\$ - \$\$\$	GRRCD OAEC BWC	Landowners NRCS TU SWRCB NOAA
WS 2: Reduce water demands.	2a. Implement water conservation program to minimize consumption	<ul style="list-style-type: none"> ✓ Conduct watershed-wide workshops to educate residents and encourage water conservation practices, such as: ✓ Work with County to develop and distribute information on programs that assist landowners in implementing water conservation projects, such as water use audits and SCEIP. ✓ Research and develop programs that 	1 – 3 yrs	\$	OAEC	GRRCD PRMD County of Sonoma TU SCWA

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
		assist landowners with financial hardships to replace old faucets and appliances with high efficiency devices.				
	2b. Structure water rates to support water conservation and reduce dependence on water supply from sources critical for aquatic habitat.	<ul style="list-style-type: none"> ✓ Address high unaccounted-for water losses in community systems ✓ Implement conservation rate structure 				
WS 3: Recharge springs and groundwater.	3a. Increase infiltration in upland recharge areas and up-gradient from springs.	<ul style="list-style-type: none"> ✓ Install rain gardens to capture excess runoff. ✓ Install contour infiltration trenches and infiltration swales to temporarily hold and infiltrate runoff. ✓ Direct excess runoff into catchment basins that store and allow slow infiltration. ✓ Replace impervious surfaces such as parking areas and patios with pervious materials (grass pavers, porous concrete, and other pervious pavers). ✓ Effectively manage grasslands and forests; see Chapter 4 Uplands Action Plan. 	5 yrs +	\$\$\$	TBD	
	3b. Reduce stormwater runoff in uplands.	<ul style="list-style-type: none"> ✓ See Chapters 4: Uplands Action Plan and 6: Water Quality Action Plan. 	5 yrs +	\$ - \$\$	TBD	

Table 13. Implementation of agricultural sustainability recommendations.

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
Ag 1: Facilitate opportunities for producers to locally process and market agricultural products.	1a. Promote and sustain agriculture-related industries in or near the watershed and develop forums for linking them with producers.	<ul style="list-style-type: none"> ✓ Seek funding to support establishment of businesses that provide services, such as processing, storage, bottling, canning, and packaging. ✓ Address regulatory hurdles to on-farm livestock processing or “mobile slaughterhouses.” 	5 yrs+	\$ - \$\$	GRRCD	Producers Community Alliance with Family Farmers UCCE Sonoma County Farm Bureau Local distributors
	1b. Develop a watershed “brand” synonymous with locally produced, sustainable, high-quality farm products.	<ul style="list-style-type: none"> ✓ Work with public outreach organizations to promote public appreciation for local agriculture. ✓ Develop educational opportunities to teach producers about marketing strategies and business management. ✓ Assist in the development of effective distribution channels for locally produced goods. ✓ Assist farmers in developing value-added marketing plans for their products while establishing an overall market presence for the watershed as its own appellation. 	5 yrs	\$	GRRCD	Producers Community Alliance with Family Farmers UCCE Local distributors Farm Trails LandPaths Local farmers’ market organizers Farmers/ranchers in the watershed Sonoma County Farm Bureau
Ag. 2: Preserve open space and rural landscapes by keeping large agricultural parcels intact and their operations viable.	2a. Support producers in diversifying income and seeking financial assistance.	<ul style="list-style-type: none"> ✓ Assist producers to participate in programs that provide additional capital to support agricultural land values, such as conservation easements through the Williamson Act. ✓ Coordinate with NRCS staff to assist producers in developing Farm Bill program contracts. ✓ Work with agricultural landowners to explore other farm-related income options, such as farm tours. 	Ongoing	\$\$\$	SCAPOSD	Producers SLT BLT GRRCD NRCS Farm Trails LandPaths Sonoma County Farm Bureau

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
<p>Ag 3: Ensure sustainable resource use in agricultural production.</p>	<p>3a. Work with vineyard operators to reduce water use.</p>	<ul style="list-style-type: none"> ✓ Provide workshops and technical support for vineyard dry-farming. ✓ Assist vineyard operators in acquiring support through NRCS and RCD programs to develop water conservation measures. ✓ Work with vineyard operators to understand and remain a step ahead of groundwater regulation measures as they develop. ✓ Educate the local community on vineyard practices. 	<p>5 yrs</p>	<p>\$</p>	<p>GRRCD with assistance from NRCS</p>	<p>Vineyard Operators and Landowners Sonoma County Grape Growers Association Sonoma County Farm Bureau Community Alliance with Family Farmers Local vineyard operators</p>
	<p>3b. Assist rangeland and dairy operators in implementing water quality protection measures.</p>	<ul style="list-style-type: none"> ✓ Provide workshops and technical support for dairy and rangeland operators to assist in compliance with water-quality regulations. ✓ Assist rangeland and dairy operators in acquiring assistance through NRCS and RCD programs to protect riparian areas. 	<p>5 yrs</p>	<p>\$</p>	<p>GRRCD with assistance from NRCS</p>	<p>Straus Family Creamery Clover-Stornetta Farms NCRWQCB UCCE</p>
	<p>3c. Assist livestock operators to develop and implement nutrient management plans.</p>	<ul style="list-style-type: none"> ✓ Implement a proactive, on-farm nutrient management program that will include a “user-friendly” nutrient budgeting model, soil, vegetation, and manure sampling protocols, and a land application tracking system. The program will assist watershed dairy and livestock operators with the ability to write nutrient management plans based on facility inventories and nutrient budgeting information. ✓ Secure funding to effectively develop nutrient management or conservation plans for all livestock operators. ✓ Provide technical assistance to dairy and livestock operators to conduct on-farm facilities inventories and 	<p>5 yrs</p>	<p>\$</p>	<p>GRRCD, with assistance from NRCS and UCCE</p>	<p>Landowners Western United Dairymen Sonoma County Farm Bureau</p>

Recommendation	Action	Implementation Measures	Time-frame	Cost	Action Lead	Key Partners
		nutrient budgeting. ✓ Conduct, soil, vegetation, and manure sampling to identify the proper organic fertilizer application rates for farm fields. ✓ Complete nutrient management plans and land application tracking systems. ✓ Use buffer strips to trap sediment from confined animal and other high-use areas. ✓ Work with interested landowners to develop waste-to-profit systems, such as methane digesters and on-site fertigation equipment.				

Project selection criteria and process

Gold Ridge RCD is taking the lead for implementing many of the Plan actions. The RCD has been working for nearly 70 years to help coordinate funding resources with landowner needs and will use the Plan to solicit and distribute additional funding for the Salmon Creek Watershed. The following process describes how the RCD will assess and select projects. It recognizes that different funding sources have varying requirements and that additional selection criteria may be needed to fit specific funding programs as well as fulfill resource protection and enhancement goals.

Proposed project selection criteria include:

1. Improvement of water quality,
2. Enhancement of summer streamflow,
3. Protection, restoration, or enhancement of one or more natural processes [e.g., restoration of riparian vegetation that will provide shade, LWD, and bank stability over many years; modification of stream crossings to allow sediment transport and movement of aquatic species; and removal of nonnative invasive plants),
4. Improvement of habitat connectivity,
5. Support of habitat for a diversity of plant/ animal species or protection of vital habitat features for special status watershed wildlife species,
6. Addressing causes as well as or instead of symptoms,
7. Strong landowner commitment,
8. Pilot project that will promote additional projects,
9. Support for sustainable agriculture,
10. Technically sound and effective design solution is feasible, and
11. Cost is reasonable for benefits.

Projects would not necessarily need to meet all criteria to be selected. For example, improving drainage on an unsurfaced road may score high in a program to reduce turbidity even though it would not increase summer streamflows or improve connectivity.

Table 14. Gold Ridge RCD project selection process.

	Step	Who	Estimated Day of Completion (from start)	Outcome
1	Adapt overall criteria as needed to fit specific funding source.	GRRCD with funder	14	Criteria meet funding requirements as well as overall watershed goals.
2	Assemble project selection advisory committee (SAC).	GRRCD	30	Advisory team is in place, if needed, and will make recommendations to GRRCD Board.
3	Inform watershed landowners through website, newsletters, and mailings.	GRRCD	60	Watershed landowners are informed of funding opportunities and the selection process.
4	Select project review team.	GRRCD with input from SAC	45	Field team is in place to visit each site and score it according to criteria.
5	Conduct site visits, score projects, and present findings to SAC.	Review team w/ GRRCD staff support	120	SAC and GRRCD staff have an objective evaluation of potential projects.
6	SAC makes project recommendations to GRRCD Board.	SAC	150	GRRCD staff will present recommendations to the GRRCD Board of Directors. The Board will have a thoroughly considered set of projects to approve.
7	GRRCD Board makes final selection and directs staff to proceed.	GRRCD Board	180	Selection completed.

Outreach and education

Outreach and education are fundamental to the success of the Plan. They maintain the visibility and urgency of the need to care for the Salmon Creek Watershed. They provide an avenue for Gold Ridge RCD and program partners to get feedback from watershed residents on how Plan actions are working and to share ideas on how to improve them. For those recommended actions, that rely on voluntary activities by watershed residents, such as control of invasive plant species or water conservation measures, education is the primary access project partners have for implementation.

Outreach and education activities also offer a vital role for organizations that may not be able or willing to manage construction contracts or negotiate landowner agreements, but may have the time, neighborhood connections, and/or long-term funding support necessary for effective outreach. Salmon Creek Watershed Council, local schools and neighborhood organizations, and some County agencies are key partners for outreach and education.

In addition to specific actions in Chapters 3-7, overall strategies for soliciting and distributing information include:

- Gold Ridge RCD and watershed partner newsletters and websites. Excellent resource for announcements of new funding for landowners, tours, and workshops; background information on the watershed; and downloadable reports and brochures.
- Shared electronic calendar. Used by watershed partners to coordinate activities. Accessible as read-only by residents.
- Tours and public meetings. Specific subjects are addressed in the action chapters. Neighborhood-scale meetings and tours may be especially effective for some topics such as small forest management where collective projects between neighboring landowners are optimal.
- Regular watershed summit. A festive annual or biennial event to bring together scientists, residents, and watershed partners for reports and discussion on the state of the watershed. Should include food and art produced in the watershed.
- Presentations and information booths at community events. Enroll the organizers into choosing the watershed as a theme for an upcoming annual Bodega Fire Department community quilt project.
- Presentations at trade associations such as Farm Bureau, Woolgrowers, Cattlemen's, and others.
- Presentations and participation at conferences to share Salmon Creek progress and to bring new information back to the watershed.
- Collaboration with Harmony Union School District on watershed events and projects.

Funding

Although many projects are already underway in the Salmon Creek Watershed as described above, additional funding is needed to fully implement the Plan. Gold Ridge RCD has already been awarded funding for implementation through the Integrated Regional Water Management Program (IRWMP) and the American Recovery and Reinvestment Act (ARRA) from NOAA, and is actively seeking additional funding. Non-profit project partners are also eligible to receive funding from many state and federal agencies, as well as from foundations. In addition to help from Gold Ridge RCD and other project partners, eligible private landowners have direct access to federal cost

share programs through NRCS and USFWS, state cost-share assistance from CalFire, and low-interest loans through the Sonoma County Energy Independence Program. Table 15 identifies funding sources for Plan implementation.

Table 15. Local, state, federal, and foundation funding sources.

Funding Entity	Program
<i>Local Sources</i>	
Sonoma County	Energy Independence Program. Provides low-interest loans to private and commercial property owners for water and energy conservation measures. Loans are repaid through voluntary property tax assessments.
Sonoma County Agricultural Preservation and Open Space District	Protects land through purchasing development rights and acquiring easements. Project selection is based on consistency with the current Acquisition Plan and available funding.
<i>State Agencies</i>	
State and Regional Water Boards	319(h) Nonpoint Source. Funding is through the USEPA and is intended to result in improved water quality through projects that address TMDL implementation or problems in streams, bays, rivers, and lakes that have been listed as impaired.
State and Regional Water Boards	Small Community Wastewater Grant Program. The program provides assistance for planning, design, and construction of publicly owned wastewater treatment and collection systems.
State and Regional Water Boards	Clean Water Revolving Loan Fund. Provides low-interest loans for stormwater and wastewater treatment, and implementation of projects to reduce nonpoint source pollution.
State and Regional Water Boards	Integrated Regional Water Management Grant Program. The intention is to integrate sustainable and reliable water supply, better water quality, stormwater management, environmental stewardship, and a strong economy.
CDFG	Fisheries Restoration Grant Program. This is a long-standing competitive grant program funded by both state and federal sources. Funding can be used for planning, barrier removal, habitat restoration, monitoring, public involvement, maintenance, and education for projects consistent with current CDFG priorities.
State Coastal Conservancy	Funding is primarily through voter-approved bond funds. Provides funding for projects to purchase, protect, restore, and enhance coastal resources.
Department of Water Resources (DWR)	Groundwater program. Includes a range of grants for groundwater monitoring and management.
Department of Water Resources (DWR)	Integrated Regional Water Management Grant Program. DWR administers IRWM grants through Proposition 84. DWR also manages many other grant and loan programs.

	Fire Prevention Program. Fire-safe landscaping for homeowners and communities.
Cal Fire	California Forest Improvement Program (CFIP). Provides cost-share assistance to private landowners, RCDs, and non-profit groups for planning, planting, fish and wildlife habitat improvement, and land conservation practices.
California Department of Public Health	Safe Drinking Water State Revolving Fund. Provides funding to correct public water system deficiencies. Selection is based upon a prioritized funding approach that addresses public health risks, compliance with requirements of the Safe Drinking Water Act, and need on a per household affordability basis.

Federal Agencies

USEPA	The USEPA website features an extensive catalog, sorted by keyword (e.g., invasive species, monitoring, land acquisition, watershed management), of federal funding sources for watershed protection (http://cfpub.epa.gov/fedfund/keyword_list.cfm).
U.S. Fish and Wildlife Service	Cooperative Conservation Initiative. Provides cost-share assistance to private landowners to restore natural resources and establish or expand wildlife habitat.
	Open Rivers Initiative provides funding and technical expertise for community-driven, small dam and river barrier removals.
NOAA Fisheries	NOAA Restoration Center Regional Partnerships provide funding for multi-year regional habitat restoration partnerships including watershed-scale projects that yield significant ecological and socioeconomic benefits. National Association of Counties and NOAA are partners in the Counties Restoration Initiative (CCRI). CCRI encourages innovative, county led or supported projects that restore important marine and coastal habitats and National Association of Counties and NOAA are partners in the Coastal Counties Restoration Initiative (CCRI). CCRI encourages innovative, county-led or supported projects that restore important marine and coastal habitats and living resources. These projects also develop the capacity of county governments, citizens groups and other organizations to conduct community-based restoration that will enhance local watershed-based resource management and promote stewardship.
Natural Resources Conservation Service (NRCS)	NRCS manages a suite of programs to provide technical and cost-share assistance to implement conservation practices, primarily for owners of land in agricultural production. http://www.ca.nrcs.usda.gov/programs/
	The Environmental Quality Incentives Program (EQIP) was established in the 1996 Farm Bill to provide a single, voluntary conservation program for farmers and ranchers to address significant natural resource concerns. Nationally, it provides technical and financial assistance to address natural resource concerns. Administered by the Natural Resources Conservation Service (NRCS), EQIP was reauthorized in the 2008 Farm Bill and awards cost share assistance to projects which provide significant

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The Healthy Forest Reserve Program is a voluntary program established for the purpose of restoring and enhancing forest ecosystems. It can provide cost-share for conservation practices, a conservation easement in exchange for market value, and Safe Harbor from future regulatory restrictions under the Endangered Species Act.

The Agricultural Water Enhancement Program (AWEP) is a voluntary conservation initiative that provides financial and technical assistance to agricultural producers to implement agricultural water enhancement activities on agricultural land for the purposes of conserving surface and ground water and improving water quality. As part of the Environmental Quality Incentives Program (EQIP), AWEP operates through program contracts with producers to plan and implement conservation practices in project areas established through partnership agreements.

The Conservation Stewardship Program encourages land stewards to improve their conservation performance by installing and adopting additional activities, and improving, maintaining, and managing existing activities on agricultural land and nonindustrial private forest land.

Through the Conservation Stewardship Program, NRCS will provide financial and technical assistance to eligible producers to conserve and enhance soil, water, air, and related natural resources on their land. Eligible lands include cropland, grassland, prairie land, improved pastureland, rangeland, nonindustrial private forest lands, agricultural land under the jurisdiction of an Indian tribe, and other private agricultural land (including cropped woodland, marshes, and agricultural land used for the production of livestock) on which resource concerns related to agricultural production could be addressed.

Other Sources:

	NFWF has a number of programs that could apply including:
National Fish and Wildlife Foundation (NFWF)	Native Plant Conservation Initiative supports projects that protect, enhance, and /or restore native plant communities.

Permits

Many of the actions recommended in the Plan will require permits from local, state, and federal agencies. For example, work in a stream requires permits from the U.S. Army Corps of Engineers, RWQCB, CDFG, and, under certain circumstances, Sonoma County; if listed species are potentially present, a permit is needed from USFWS or NOAA Fisheries; and if the project is in the Coastal Zone, a Coastal Development Permit is needed. Acquiring permits can be a lengthy process. Involving regulators in the initial stages can help to address concerns early in the project design process and reduce delays after the application is submitted. Grouping similar projects, such as multiple large woody debris structures in one tributary, can also save time and cost.

CHAPTER 9: TRACKING WATERSHED MANAGEMENT PLAN OBJECTIVES

The assessment and monitoring programs presented in this chapter were selected to address existing data gaps, assist landowners and natural resource managers in their efforts to protect and enhance the natural resource base of the watershed, and provide guidance in the implementation of this watershed management plan. The recommended assessment and monitoring programs are designed to answer two questions:

- Are Salmon Creek and its tributaries currently achieving the water quality objectives established by the North Coast Regional Water Quality Control Board?
- Are the beneficial uses of Salmon Creek being maintained and protected, and, if not, what are the limiting factors?

Monitoring is a technical term that denotes collecting a series of observations over time in order to detect changes or trends. Monitoring programs can be very expensive and labor intensive. The repetition of measurements over time for the purposes of detecting change distinguishes monitoring from inventory and assessment. Although inventories and assessments can be based on a single measurement or observation, they can also incorporate a series of observations to either gauge conditions before and after some management action or change or to gain a more accurate estimate of a specific parameter. Often, an assessment or inventory will serve as a first step towards developing a longer term monitoring program. Assessments and inventories can provide important information on baseline or current conditions if conducted properly.

Recommended Monitoring and Assessment Programs:

1. Surface Water Ambient Monitoring Plan
2. Bioassessment Monitoring
3. Geomorphic Monitoring
4. Fisheries Monitoring
5. Streamflow Monitoring
6. Riparian Assessment
7. Residual Dry Matter (RDM) Assessment
8. Manure Land Application Tracking and Assessment

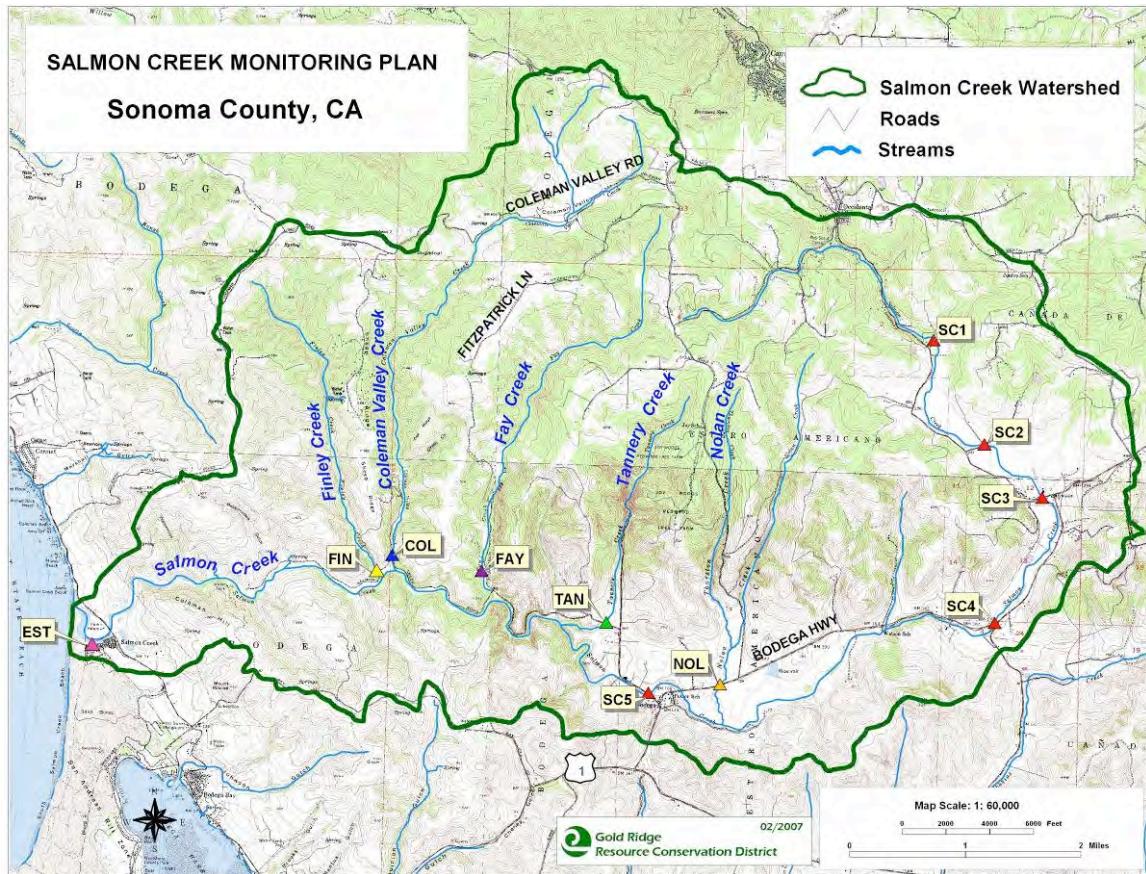
1. Surface Water Ambient Monitoring Plan (MP)

Gold Ridge RCD prepared a water quality monitoring and assessment program plan as a component of the development of the SCICWMP. The purposes of the MP were to assess the overall health of the Salmon Creek Watershed and to establish current baseline conditions. (Refer to Chapter 5 for an analysis of water quality and the associated goals, recommendations, and actions.)

The objectives of monitoring selected locations in the Salmon Creek Watershed were to:

- Document baseline conditions to allow for comparison with future and as yet unplanned monitoring. This comparison will provide for assessment of management measure effectiveness and serve as a guide for the systematic development of restoration projects;
- Assess the efficacy and necessity of future water quality improvement projects; and
- Use the water quality monitoring data as a benchmark for developing watershed-wide BMPs.

Figure 12. Water quality monitoring sites map.



How the Monitoring Data Was Used

Because the SCICWMP is a planning document rather than an implementation project, the overall plan sought to characterize existing conditions in the watershed at a planning level, enabling the development of site-specific restoration or remediation projects. The data gathered provided the information necessary to make implementation decisions necessary at the reach scale.

Pre-project Conditions and Water Quality

Standardized water quality monitoring data were not available for the Salmon Creek Watershed at the onset of this project. Available stream ambient water quality data had been collected by SCWC through a volunteer monitoring program funded by CDFG (2003-2006). A summary of this information is included in Chapter 5, and the full report is found in Appendix B.

Additional Monitoring Objectives

The current Gold Ridge RCD monitoring program should continue in order to document long-term trends and watershed-scale responses to the implementation of recommended BMPs.

Monitoring Activities

Sampling and analysis will include field-measured parameters and laboratory analysis for selected parameters that are key indicators of water quality. Field-measured parameters will include stream discharge, temperature, DO, conductivity and pH.

With the exception of temperature and DO, water quality sampling will be done monthly and in response to the storm events. Grab samples will be taken for turbidity and TSS analyses. These samples will be taken from the established monitoring and other suitable locations where access is granted by landowners. Additional monitoring that is outside of Gold Ridge RCD's SWRCB-approved monitoring plan and quality assurance project plan are noted as recommendations below.

WQ Monitoring Recommendation 1: Conduct and implement a continuous temperature monitoring program throughout the Salmon Creek Watershed during low-flow conditions.

Scientific Reasoning

Watersheds and their associated biological communities are complex. A wide range of watershed conditions and human activities can affect water quality in ways that aren't always obviously related. Temperature, for example, affects both water chemistry and the biological functions of aquatic organisms. Water temperature influences the amount of oxygen that can be dissolved in water, the rate of photosynthesis by algae and other aquatic plants, the metabolic rates of aquatic organisms, the sensitivity of organisms to toxic wastes, parasites and diseases, and timing of reproduction and migration.

The impacts on water quality from watershed conditions and human activities depend on the type of activity and its timing, location, duration, and intensity. Many land uses affect the watershed function and contribute pollutants to the stream system. The mobilization, movement, and concentration of pollutants vary by season, by day, and sometimes from hour to hour. This can make it difficult to accurately measure representative water quality conditions. It is critical to build a data record over time to assess how different conditions affect water quality throughout a watershed.

Instream water temperatures vary both spatially and temporally (diurnally and seasonally) throughout a watershed. High stream temperatures are of most concern during the lower flow, higher air temperature conditions of summer and fall. See Water Quality Recommendation 2 in Chapter 5 for an overview of the importance of and potential impacts on water temperature.

Most water quality monitoring is conducted via grab samples and subsequent chemical analysis. Grab sampling takes a snapshot of the water quality conditions occurring at that particular spot at that particular time. However, water quality sampling can be designed to take a number of instantaneous samples over time to examine trends in water quality (e.g., decline or improvement) and to potentially catch a pollution event or critical threshold condition when it occurs. This sampling method has been occurring on a monthly basis through the volunteer and professional monitoring efforts, but a finer scale, more frequent monitoring design can greatly assist with the use of water quality data to assess the quality of aquatic habitat.

Implementation Measures

- Calibrate and deploy continuous temperature data loggers throughout the Salmon Creek Watershed in order to spatially represent stream temperature

conditions, particularly to evaluate the effects of thermal inputs from significant tributaries.

- Collect continuous temperature data throughout the watershed at 30-minute intervals from May through October.
- Depending on the sampling design, either deploy data loggers in the areas with highest quality aquatic habitat values to evaluate the thermal refugia available to aquatic organisms or, conversely, deploy loggers in areas where stream temperatures are thought to be a limiting factor to the survival and persistence of sensitive aquatic organisms.
- Coordinate with other associated monitoring efforts, such as UCCE coho broodstock monitoring program, to maximize monitoring data and funding resources, and make data applicable to as many assessment and restoration efforts as possible.

WQ Monitoring Recommendation 2: Conduct and implement a continuous DO monitoring program throughout the Salmon Creek Watershed during low-flow conditions.

Scientific Reasoning

DO concentrations vary diurnally and seasonally based on stream temperature, biological and chemical oxygen demands, and aquatic organism respiration. See Water Quality Recommendation 3 in Chapter 5 for more information about how DO levels influence the growth, reproduction, and survival of aquatic organisms.

Microorganisms such as bacteria are responsible for decomposing organic waste. When organic matter such as dead plants, algae, leaves, grass clippings, manure, or sewage is present in a stream, particularly under low-flow conditions, bacteria will begin the process of breaking down the waste. When this happens, DO is consumed by aerobic bacteria, decreasing the DO concentration and lessening the amount available to other aquatic organisms.



Salmon Creek volunteer water quality monitoring.

Additionally, the presence of aquatic plants such as algae can cause diurnal fluctuations in DO concentrations. Photosynthetic processes under daylight conditions can artificially increase the DO content, creating super-saturated (>100% saturation) DO conditions, while oxygen levels drop at night due to consumption during the respiration of aquatic plants and animals. Most monitoring is conducted during the daytime, which biases measurements towards the higher DO concentration conditions while missing the critical low DO conditions, which are lowest just before dawn.

As stated in Water Quality Recommendation 3, DO concentrations can “vary rapidly, but even short episodes of very low oxygen can cause critical impairment and mortality to aquatic organisms.” To measure these seasonal and diurnal variations in DO concentration, continuous DO meters should be deployed under low-flow conditions in

reaches where DO concentration is thought to be a limiting factor for sensitive aquatic organisms.

Implementation Measures

- Calibrate and deploy continuous DO data loggers throughout the Salmon Creek Watershed in order to spatially represent DO concentration conditions, particularly in areas where DO levels are thought to be a limiting factor.
- Collect continuous DO concentration data in as many locations as possible at 30-minute intervals from May through October. However, deployable DO meters are expensive, and it will likely only be feasible in a couple of locations.
- Depending on the sampling design, either deploy loggers in the areas with highest quality aquatic habitat value to evaluate the refugia available to aquatic organisms or, conversely, deploy loggers in areas where DO levels are thought to be a limiting factor to the survival and persistence of sensitive aquatic organisms.
- Coordinate with other monitoring efforts, such as NCRWQCB SWAMP monitoring program, to maximize monitoring data and funding resources, and make data applicable to as many assessment and restoration efforts as possible.

2. Bioassessment Monitoring

Another monitoring strategy is bioassessment—employing stream biota to assess the water quality conditions and overall stream health. By looking at and analyzing the type, number, distribution, age, and size of aquatic macroinvertebrates, algae, fish, etc., one can infer a wide range of information about the quality of water and habitat over time. The mere presence or absence of certain common sensitive species can provide information about both the quality of the water and the ability of that stream to support other sensitive species.

Bio Monitoring Recommendation 1: Conduct and implement a bioassessment monitoring program, including benthic macroinvertebrate (BMI) and algae community sampling, to evaluate aquatic conditions and suitability for sensitive aquatic organisms.

Scientific Reasoning

The use of multiple bioindicators, such as adding algae to BMI sampling, will facilitate the “weight-of-evidence” approach to interpretation of biomonitoring results, which can be used to corroborate assumptions about stressors and limiting factors for stream biota. As primary producers, algae are the most directly responsive of the common bioindicators to nutrients and can be very valuable for assessing nutrient impairment (Fetscher & McLaughlin 2009).

Implementation Measures

- Conduct monitoring using SWAMP bioassessment protocols and producing data that is SWAMP-compatible.
- Depending on the sampling design, either sample BMIs in the areas with highest quality aquatic habitat value during spring to characterize the refugia available to aquatic organisms or, conversely, sample BMIs in the fall in areas where stream conditions are thought to be a limiting factor to the survival and persistence of sensitive aquatic organisms.

- Conduct algae community monitoring in conjunction with BMI monitoring.
- Coordinate with other monitoring efforts, such as NCRWQCB SWAMP and/or UCCE coho broodstock monitoring program, to maximize monitoring data and funding resources, and make data applicable to as many assessment and restoration efforts as possible.

3. Geomorphic Monitoring

Improving instream habitat for salmonids and other aquatic organisms is a stated goal of this Plan, and many of the implementation recommendations were developed to meet this goal. Five geomorphic reference reaches were established in 2006 to quantify channel morphology and sediment-related habitat conditions; see Appendix A. The reference reaches were monumented for repeat measurements and long-term monitoring. In addition to the detailed reference reaches, sections of Salmon Creek Watershed were assessed for LWD frequency, pool characteristics, streambank erosion, and channel type. In 2001 and 2002, CDFG performed habitat assessments along mainstem Salmon Creek and all the major tributaries. Evaluating the ecological effectiveness of many of the proposed implementation projects in this Plan requires long-term, repeated monitoring of the stream's geomorphic conditions.

Geomorphic Monitoring Recommendation 1: Implement a long-term monitoring program in Salmon Creek to track instream physical habitat conditions and document Plan effectiveness.

Scientific Reasoning

Agencies tasked with recovering salmonid populations and protecting beneficial uses of the northern California waterways have been developing standards to measure instream habitat quality (CDFG 2004; RWQCB 2006a and 2006b; NMFS 2010). National Marine Fisheries Service (2010) has compiled many of the habitat condition indicators and set rankings and targets for the indicators; see Table 16 below for geomorphic-related indicators. To improve the viability of streams for salmonid population recovery, it is necessary for existing habitat conditions to be ranked as GOOD, or for conditions to be trending towards GOOD over time.

Table 16. Related coho salmon habitat-quality indicators and their target values.

Compiled and developed by NMFS Southwest Region (NMFS 2010)

Habitat Attribute	Indicator	Ranking		
		Poor	Fair	Good
Pool Habitat and Velocity Refuge	Frequency of Primary Pools	<30% pools by length	30-40%	40-50%
	LWD Frequency	<4 key pcs/100m	4-6/100m	6-11/100m
	Shelter Rating	Score of <60 per km	60-80	80-100
Riparian Vegetation	Canopy Cover	<75% avg. over km	75-85%	85-95%
	Species Composition	<25% of historic diversity	25-50%	>50%

Implementation Measures

- Resurvey and sample geomorphic reference reaches every 5 to 10 years (depending upon upstream projects and hydrologic conditions) to track changes in channel features related to instream habitat conditions. Parameters to be monitored include:
 - Channel longitudinal profile and cross sections (pool depths, riffle/pool spacing, bankfull dimensions, floodplain development).
 - Bed sediment size distribution (riffles).
 - V* or pool fine sediment volume.
 - Canopy cover and riparian buffer width/complexity; see RA Monitoring Recommendation #1.
 - Instream shelter rating.
- Locate, monument, and survey other geomorphic reference reaches as needed.
- Survey LWD and pool frequency throughout salmonid bearing sections of watershed every 10 years to track habitat conditions, as well as effectiveness of implementation and outreach projects. Compare data to baseline conditions in 2006 and salmonid habitat metrics.

4. Fisheries Monitoring

In response to the precipitous decline of coho salmon populations throughout northern and central coastal California, landowners and agencies have engaged in conservation and restoration of critical habitat. These efforts in Salmon Creek Watershed have opened the door for the next step in coho salmon recovery efforts, the reintroduction of the endangered species through release of adult fish into the watershed.

Fisheries Monitoring Recommendation 1: Monitor fish populations to assess success of reintroduction of coho salmon into the Salmon Creek Watershed.

Scientific Reasoning

In an effort to reestablish coho salmon populations in the Salmon Creek Watershed, CDFG released adult fish from the Russian River Coho Broodstock Program into the mainstem of Salmon Creek in December 2008 and 2009. No follow-up monitoring has been conducted by the program, although CDFG supported Gold Ridge RCD in conducting spawning surveys in 2009.

The most efficient way to measure the success of coho salmon reintroduction and recovery efforts is to directly monitor the presence, abundance, and distribution of target fish populations. Surveying Salmon Creek and its significant tributaries for coho salmon will evaluate the effectiveness of the CDFG broodstock releases by documenting if the released fish have successfully spawned and ultimately whether the resulting juveniles are able to reestablish a population of wild coho in the watershed. Specific monitoring objectives include estimating spawning success and abundance and survival of juveniles.

Implementation Measures

- Juvenile monitoring employing snorkel surveys during the summer rearing period to determine presence and distribution of juvenile coho salmon within different reaches of the watershed.

- Spawner surveys conducted bimonthly from November through February to document the presence and distribution of live adult salmonids, redds, and salmonid carcasses. This information will be used to determine if adults are returning to and spawning within the watershed and to identify their distribution and preferred spawning habitat. Pit tag scans will be used to differentiate between hatchery and wild fish.
- Coordinate with other monitoring efforts, such as the Russian River coho broodstock monitoring program, CDFG, and NOAA Fisheries, to maximize monitoring data and funding resources; make data applicable to as many assessment and restoration efforts as possible.

5. Streamflow Monitoring

Impacts on summer rearing habitat from regional and local water withdrawals include reduced pool depths, reduced DO levels, and higher water temperatures. Temperatures frequently exceed optimal levels, and DO has been recorded at 1-2 mg/L in pools within the project reaches. Fish become stranded and are unable to seek better habitat when pools become disconnected. The objective of streamflow augmentation projects should be to increase the amount of water available for instream flow, lengthen the period of riffle connectivity within the project reaches, and subsequently improve water quality in the pools during the summer and early fall dry season.

SF Monitoring Recommendation 1: Conduct and implement a streamflow monitoring program that tracks water depth in pools, connectivity of pools, and trends in streamflow.

Scientific Reasoning

Annual variations in rainfall and hydrologic patterns strongly determine streamflow characteristics and water quality conditions. Limited reach-specific physical baseline data exists with which to quantify the effectiveness of streamflow restoration projects. Thus, streamflow data collected during the initial monitoring period of projects, or over a hydrologic cycle of wet and dry years, is unlikely to show definitive or immediate results. This additional monitoring recommendation is presented to collect baseline data and evaluate long-term trends.

Implementation Measures

- Utilize pressure transducers (stage recorders) to continuously monitor variations in water depths in pools associated with riparian water diversion changes. Longitudinal thalweg surveys will be used to relate stage readings to actual pool depths and riffle connectivity.
- Visually assess and document flow over riffles within project reaches and continuous stage sensors. Any implemented streamflow augmentation project should show a trend of later timing of pool disconnection and decreasing number of days pools remain disconnected.
- Maintain at least one long-term streamflow gage in the watershed, including a mainstem Salmon Creek gage in Bodega. As part of the long-term streamflow monitoring program, surveys and discharge measurements should be taken to check and maintain the stage-to-discharge rating curve.

6. Riparian Assessment

Assessing, protecting, and enhancing riparian habitat are stated goals of this watershed management plan. Riparian areas in the watershed will be periodically assessed to measure the achievement of this goal. Restoring and protecting riparian vegetation along streams will improve water quality and instream and riparian habitat and will significantly reduce sediment loading to Salmon Creek and its tributaries from streambank erosion.

RA Monitoring Recommendation 1: Track the abundance and distribution of riparian vegetation at least once every 5 years.

Scientific Reasoning

Numerous riparian corridor restoration studies have been conducted on streams in arid and semi-arid areas incorporating controlled livestock access to riparian areas (Lewis 2002). In most areas, very little else was needed to affect substantial recovery, although rates of recovery vary. Restoring riparian corridors has important benefits for reduction in peak runoff and flood routing. Increased water retention capabilities of soils and presence of perennial and wet meadow grasses retard runoff from upland areas, spreading runoff events over a longer time period and reducing flood peaks. Changes in hydraulic geometry of stream channels associated with riparian recovery (deepening, narrowing) assist in this process of natural runoff management.

Recovery of riparian areas can be greatly accelerated by a judicious planting program using selected successional and climax species. Strategic plantings of various herbaceous and woody species may eliminate the necessity of actively “treating” the entire riparian corridor by acting as seed stock for downstream areas (Circuit Rider Productions, Inc., 1986).

Implementation Measures

- Riparian area assessments will be conducted using high-resolution aerial photography. Stream segments will be coded based on the abundance of vegetation in the riparian zone, approximately 50’ on each side of the stream. This information will be added to an existing riparian assessment GIS data layer. In addition, the GIS data layer will be updated each time a stream segment is stabilized and revegetated.
- In riparian vegetation enhancement and riparian fencing reaches document existing species density and diversity by establishing vegetation transects. Monitor these transects on a 5 to 10 year basis for changes over time and effectiveness of restoration projects.

7. Residual Dry Matter (RDM) Assessment

Grazing management practices influence sheet and rill erosion on rangeland. Overgrazing can result in low RDM, reducing site fertility and infiltration rates and exposing soil to more rainfall, which increases erosion and runoff (Lewis et al. 2005). Treatment for low RDM includes better site preparation, seeding and fertilization, and increased grazing management.

RDM Assessment Recommendation 1: Conduct RDM assessments on priority conservation parcels and increase RDM values by 15% using conservation management measures and practices.

Implementation Measures

- Work with livestock ranches and dairies to update ranch plans and to conduct RDM assessment in order to develop better grazing practices. Conservation-oriented ranch plans will include an inventory of existing resources and resource conditions, operational goals, water quality management issues and objectives, and a prioritized list of projects designed to reduce soil loss and agricultural runoff (USDA 1997).

8. Tracking Land Manure Application

Gold Ridge RCD, in collaboration with UCCE and NRCS, will design and promote the adoption of a manure land application tracking system as part of a larger nutrient budgeting and nutrient management planning program. Soil, vegetation, and manure sampling will be conducted to evaluate nutrient content and fertilization requirements for individual dairies. A land application tracking system will be implemented to record current waste loads applied on a per field basis. Sampling results will be used to calibrate land application rates and timing the following year.

The end goal of these efforts is to have dairy operators quantify and better manage on-farm nutrient production and consumption. Through this process, operators will be able to assess and calculate potential excess nutrient loads and address any nutrient imbalance through export of nutrients from the watershed, composting strategies, or other effective management strategies.

TLM Assessment Recommendation 1: Assist dairy operators in the watershed to better track land application of manure, and to promote application at agronomic rates based on soil, manure and vegetation sampling.

Implementation Measures

- Work with dairies to adopt nutrient budgeting and management planning.
- Develop a manure land application tracking system.
- Document reductions in nutrient concentration along the mainstem of Salmon Creek.

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Guidance at the mouth of Salmon Creek.

APPENDIX A: SALMON CREEK GEOMORPHIC DATA REPORT

Salmon Creek Geomorphic Data Report

DRAFT FINAL



Produced by:

Lauren Hammack



PRUNUSKE CHATHAM, INC.

For:

Gold Ridge Resource Conservation District

June 11, 2010

Introduction/Purpose

In 2007, a geomorphic assessment of representative portions of Salmon Creek and its tributaries was conducted to document channel features and sediment-related conditions. Ongoing interest in improving instream habitat conditions for steelhead and, more recently, coho salmon was impetus for this project. This geomorphic assessment continues the process of documenting the environmental status of the Salmon Creek Watershed.

The 35-square-mile coastal watershed drains into the Pacific Ocean just north of Bodega Bay (Figure 1). The Salmon Creek Watershed is nearly wholly privately owned, with agricultural land uses accounting for 53% of the watershed area and rural residential accounting for 34%. In addition to salmonids, the streams and estuary are home to several listed species including California freshwater shrimp, tidewater goby, and California red-legged frogs, as well as many other aquatic species.

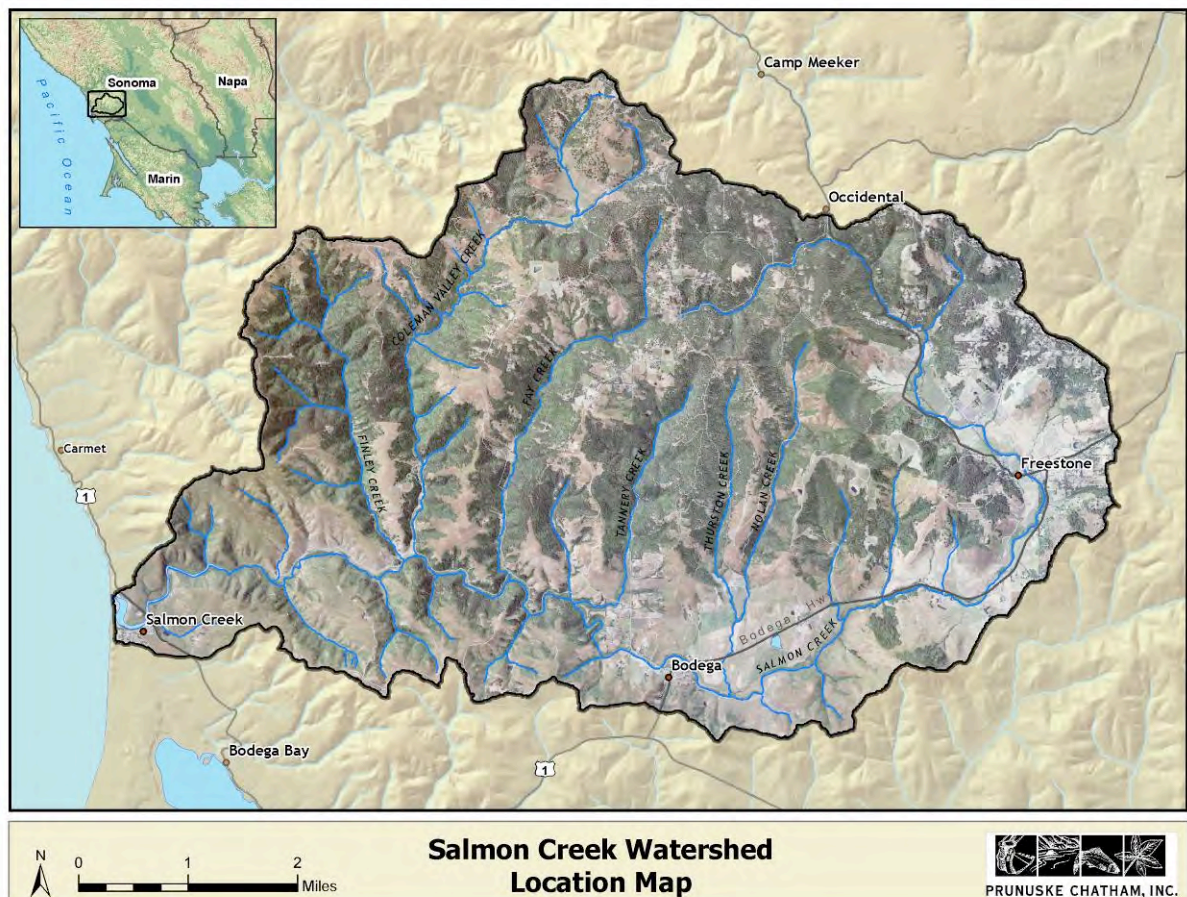


Figure 1: Location of the Salmon Creek Watershed, Sonoma County, California.

The data collected and analyzed for this project provides a snapshot look at both instream channel conditions and overall fluvial geomorphic processes occurring in the watershed. Channel reference reaches were established that illustrate different channel types. Morphologic data collected in these reaches was used to characterize and classify channel conditions, including sediment storage and transport trends. Information provided in this report is geared towards guiding and prioritizing channel enhancement projects that will

work with natural processes to improve fisheries habitat and effectively manage sediment loads.

The original vision for this geomorphic assessment included a detailed evaluation of channel conditions and processes within a geologic, historic, and land use perspective to describe the evolutionary trends of the streams and how those trends relate to fisheries habitat potential. However, funding constraints on the Salmon Creek Integrated Coastal Watershed Management Plan, of which this project was a part, reduced this geomorphic report scope to a simple data report. It is hoped that additional funding can be secured to complete the assessment as originally envisioned.

Geomorphic Assessment Methods

Data Collection and Analysis: Stream Surveys

The initial data collection step for the geomorphic assessment of Salmon Creek and its tributaries was performed by walking sections of the streams (Figure 2) where landowner access was secured. The stream surveys occurred in August 2007. The following data was collected by a two person team and catalogued using a handheld Trimble GPS:

- Pools – location, depth, width, length, bankfull width, type
- Channel dimensions – location, bankfull width and depth, top-of-bank width and depth, substrate composition
- Large woody debris -- location, type, anchoring, size and length descriptions and measurements
- Erosion sites – location, type, activity, dimensions
- Photo points – catalogued channel features

Data collection methods followed the protocol outlined in “Salmonid Freshwater Habitat Targets for Sediment-Related Parameters” (NCRWQCB, 2006).

Through these stream surveys general information on channel morphology and the geomorphic conditions related to sediment transport and deposition was compiled on a reach-by-reach basis. Sediment- and large woody debris (LWD)-related instream habitat conditions were assessed using this data set. This general data, along with GIS-derived maps of geology, soils, channel slopes, stream order, and landuse practices, was used to distinguish a channel reaches with similar geomorphic characteristics. Collection of detailed morphology data and analyses of historic air photos provided additional information.

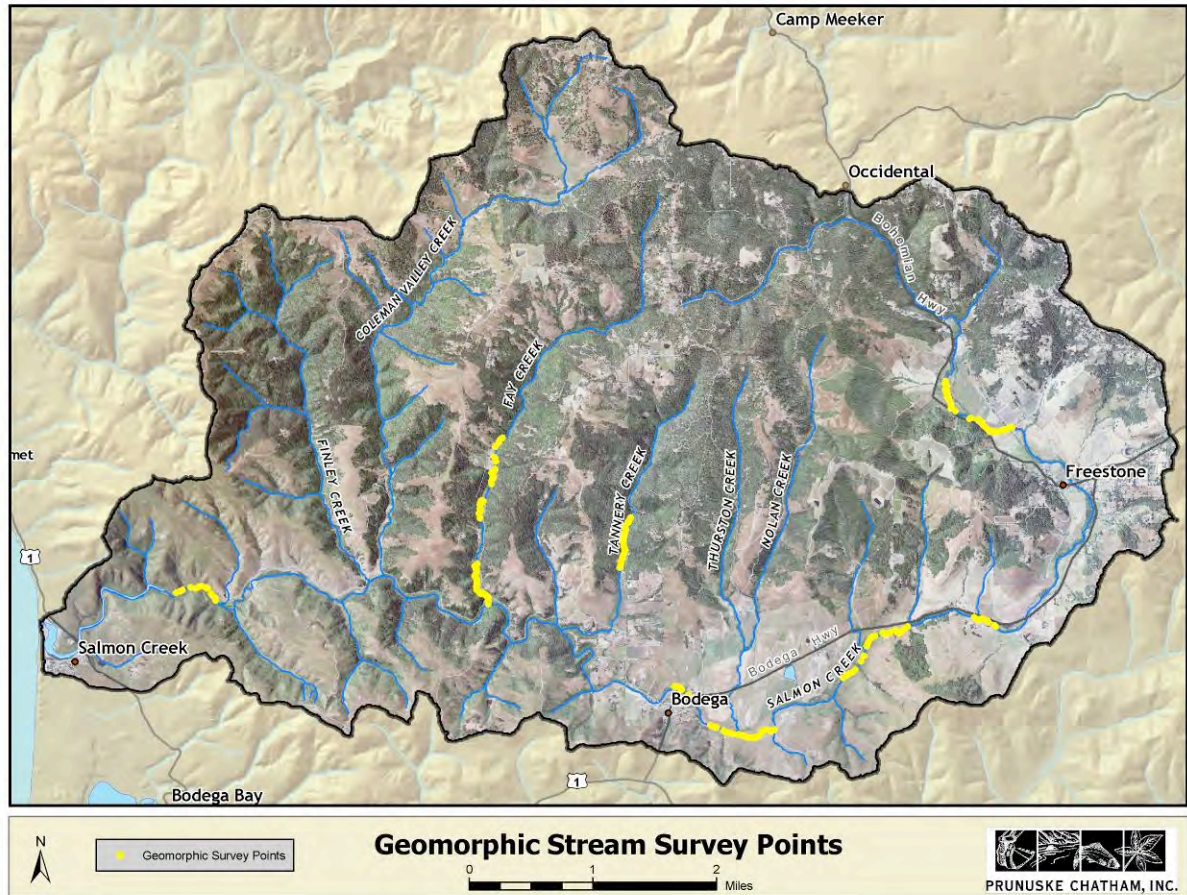


Figure 2: Watershed map showing geomorphic data collection locations.

Data Collection and Analysis: Reference Reaches

Reference study sites were selected within each geomorphic channel reach type within the different subwatershed (Figure 3) for which access was secured. The geomorphic reference reaches were chosen to represent channel types and conditions within the watershed, and are located, where possible, to track the effectiveness of sediment management and habitat enhancement practices. Detailed morphologic description and analysis was performed at each. The reference reaches are at least twenty (20) channel widths in length.

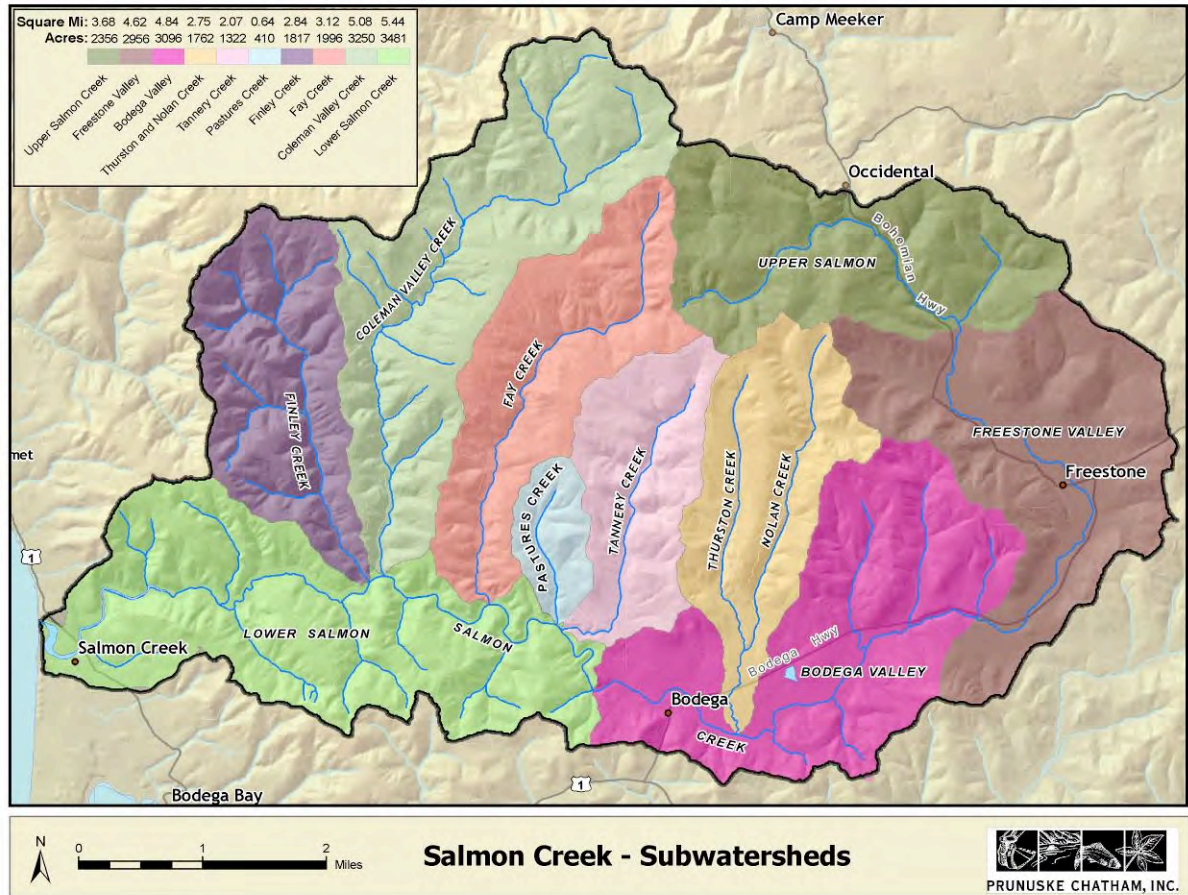


Figure 3: Subwatersheds of the Salmon Creek Watershed.

At each of the five reference reach sites (Figure 4), channel features were surveyed and measured to characterize the average channel morphometry and sediment distribution. Using a total station to collect topographic data, an average of four cross sections per site was surveyed, including riffle, pool, and glide features. From this data, channel and floodplain dimensions were determined (bankfull width and depth, entrenchment ratio, and degree of incision), as well as planform characteristics such as thalweg and meander belt sinuosity. Additionally, a detailed longitudinal profile of the thalweg was surveyed to determine remnant pool depths and channel slope.

Sediment size distribution data was collected on riffle gravel bars. Bulk subsurface samples were collected at riffle features in each reach and sieved to characterize substrate composition. Pool sedimentation was characterized using the V^* analysis.

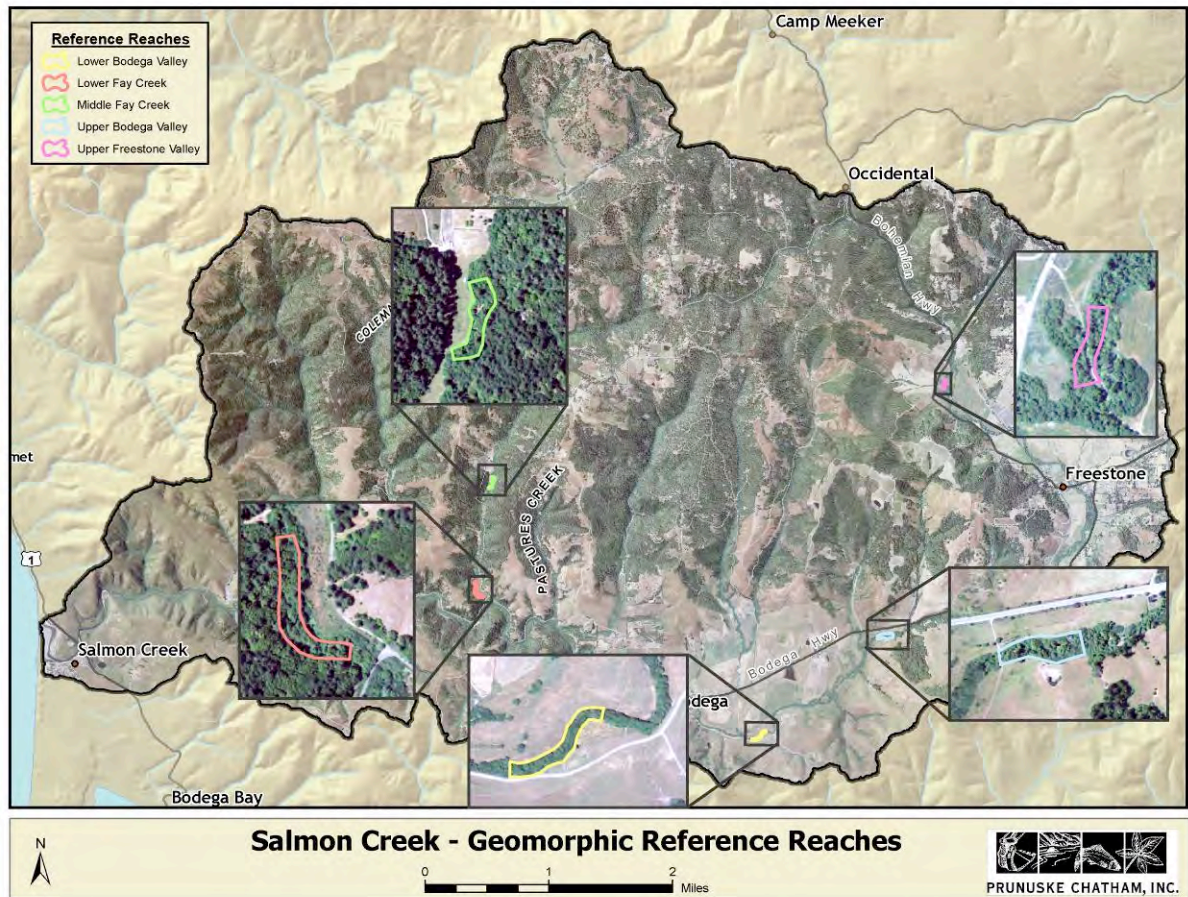


Figure 4: Geomorphic reference reaches established for long-term monitoring of instream habitat conditions and sediment load parameters.

The five reference reaches established for detailed assessment and long-term monitoring are:

- Upper Freestone Valley
- Upper Bodega Valley
- Lower Bodega Valley
- Middle Fay Creek
- Lower Fay Creek

Results

Channel Form

Comparison of morphologic metrics amongst reaches within a watershed can provide insight into channel conditions, the state of channel adjustments to historic landuse practices, and design guidance for instream or riparian enhancement projects. Values of channel morphologic metrics for sections of Salmon Creek and a few of the major tributaries are presented in Table 1.

Table 1: Channel morphologic data for sections of Salmon Creek and its major tributaries.

	Watershed Area Above (sq miles)	Avg. Bankfull Width (ft)	Flood prone Width (ft)*	Entrenchment Ratio**	Degree of Incision***	Avg. Pool Depth (ft)	Max Pool Depth (ft)
Upper Freestone Valley	4.9	20	45	1.8	5.5	2.7	3.9
Upper Bodega Valley	11	25	53	1.6	3.1	2.5	4.3
Lower Bodega Valley	16	25	55	1.8	2.9	2.4	4.3
Lower Salmon Creek	34	42	-	-	-	3.7	4.1
Tannery Creek	1.5	24	-	-	-	1.6	2.6
Fay Creek - Middle	2.7	27	63	2.6	5.2	2.2	3
Fay Creek - Lower	3.1	26	42	1.9	4.5	2.6	3.3

*Floodprone area width is obtained at an elevation twice bankfull depth.

**Entrenchment ratio is the floodprone area width/bankfull width, and was developed by Rosgen (1996). When the entrenchment ratio is less than 1.4 (+/- .2) the river is considered entrenched. An entrenchment ratio greater than 2.2 indicates a well-developed floodplain. The smaller the ratio the less floodplain area is available for vegetation establishment and high-flow refugia for salmonids and other aquatic organisms.

***Degree of incision is obtained by dividing the lowest bank height by bankfull stage height. As this ratio increases above 1.0 the more deeply incised the channel is, indicating that it takes increasingly larger magnitude floods to over-top the banks.

All of the channel reaches surveyed have been subjected to, and altered by, intense and varied landuse pressures over the last 150 years. All of the channels in the surveyed reaches are deeply incised below their valley floor. In most sections, high winter flows stay well below the top of bank except during the 50-100 year floods. Lower Bodega Valley is an exception. The high degree of incision indicates that the channels are cut off from their historic floodplains. It is thought that channel clearing for agriculture in the mid 1800s and perhaps, even earlier, the heavy trapping and extirpation of beaver caused the channels to incise into the valley fill.

Incised channels can be unstable depending upon how the channel has evolved since initial incision. Schumm et al. (1984), Simon (1989), and Thorne (1987) have proposed channel evolution models (CEMs) to explain common, documented trends in alluvial channel response to disturbances such as wetland drainage, channel clearing, and channel construction. The figure at right illustrates the general stages of evolution after such disturbances.

Entrenchment ratios for surveyed reaches of Salmon Creek and its tributaries (Table 1) indicate that, for the most part, the Salmon Creek system is in a widening phase. Characteristics of channels in the widening phase include steep and often eroding banks, a narrow strip of riparian trees found between the active channel bottom and top of bank, and homogenous channel features (i.e. flat, over-wide channels with shallow pools and low elevation bars).

Examination of average bankfull channel widths throughout the watershed (Table 1) reveals that the expected relation between bankfull width and drainage basin area is not present in this system (i.e. while drainage basin areas range from 1.5 to 16 mi² the average bankfull width are all 24-27 ft). Regional curves for the San Francisco area suggest that bankfull widths for these drainage basin areas should range from ~18ft (1.5 mi²) to ~45ft (16mi²) (Dunne and Leopold 1978). Early 20th century logging practices that used the channel beds to transport logs down valley and more recent annual channel clearing practices with heavy equipment for flood control are possible explanations for the system-wide homogenous channel dimensions.

Incised channels reach a new, more stable equilibrium when the banks have widened sufficiently to allow the development of "inset" active floodplains, as shown in the bottom cross section of the illustration above, and the redevelopment of bankfull channel widths and depths that are equilibrated to drainage basin area and sediment loads. Beneficial habitat conditions for salmonids and other aquatic organisms, such as deep and frequent pools with good cover, well sorted gravels, and high-flow refugia elements are more commonly found and naturally maintained in equilibrium channels.

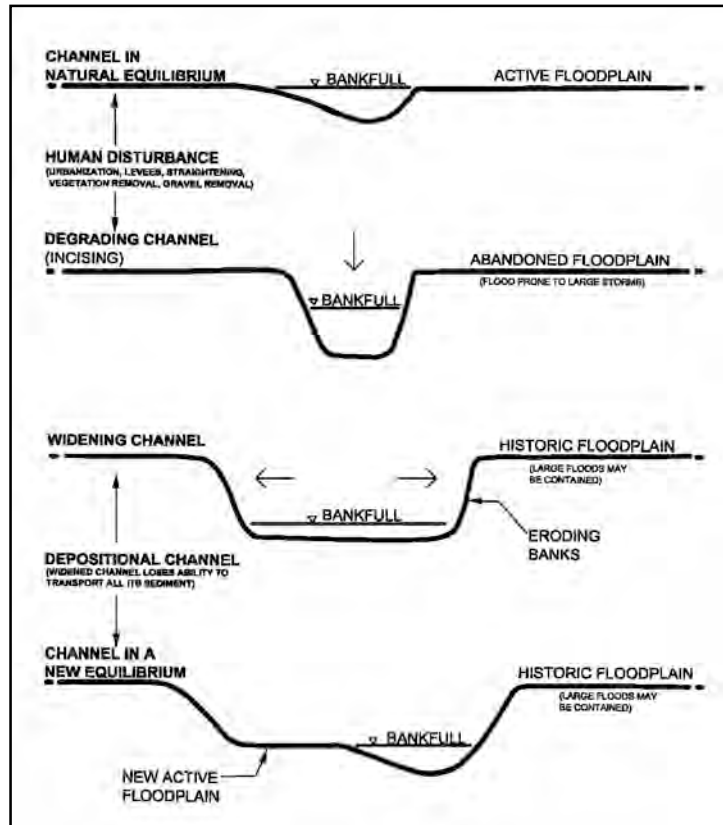


Figure 5. Channel evolution model. Illustration from Groundwork (MRCD 2007)



Example of equilibrium channel with inset floodplains- upper Freestone Valley.



Example of over-widened, flat channel with no inset floodplains – Tannery Creek.

Channel Bed Sediment and Habitat Parameters

The composition of channel bed sediment plays key roles in determining the quality of habitat for salmonids, as well as the macroinvertebrates that support the stream’s food web. Too high a percentage of fine material (clay, silt, and fine sand) will fill the pore spaces between gravels, smothering eggs and larvae. Optimal values for sediment parameters have been determined for salmonid habitat (NCRWQCB 2006; NOAA NMFS 2010). Conditions in the Salmon Creek reference reaches are compared to these optimal conditions in Table 2. Although sediment samples were not collected and analyzed for the upper Freestone Valley reach, based on visual observations of riffle sediment composition, it likely meets or nearly meets the desired conditions for substrate composition.

Table 2: Summary of habitat-related sediment parameters in the geomorphic reference reaches.

Parameter	Desired Condition Value	Channel Reach	Existing Condition	Meets Desired Condition	Applicability/ Comments/ Concerns
Substrate Composition	<14% fines @ <0.85 mm	Upper Freestone Valley	not sampled		
		Upper Bodega Valley	~40%	No	Fine sediment deposition reach
		Lower Bodega Valley	~60%	No	Fine sediment deposition reach
		Fay Ck - Middle	~12%	Yes	
		Fay Ck - Lower	~12%	Yes	
Substrate Composition	<30% fines @ <6.4 mm	Upper Freestone Valley	not sampled		

Parameter	Desired Condition Value	Channel Reach	Existing Condition	Meets Desired Condition	Applicability/ Comments/ Concerns
		Upper Bodega Valley	~90%	No	Fine sediment deposition reach
		Lower Bodega Valley	~80%	No	Fine sediment deposition reach
		Fay Ck - Middle	~25%	Yes	
		Fay Ck - Lower	~20%	Yes	
		Upper Freestone Valley	0.31-0.43 (35%)	No	Fine sediment deposition reach, Not Franciscan Formation
		Upper Bodega Valley	0.23-0.45 (34%)	No	Fine sediment deposition reach, Not Franciscan Formation
		Lower Bodega Valley	0.35-0.47 (43%)	No	Fine sediment deposition reach, Not Franciscan Formation
		Fay Ck - Middle	0.1-0.12 (11%)	Yes	
		Fay Ck - Lower	0.08-0.22 (17%)	Yes	
V* (Pool Sedimentation)	< 0.21 (21%)				

Reaches along mainstem Salmon Creek in Freestone Valley and Bodega Valley do not meet the desired sediment condition criteria for good salmonid habitat. Several factors contribute to this. First, the geology (see Figure 6) of the surrounding hillsides and valleys is primarily the Wilson Grove Formation, a soft sandstone, not the Franciscan Mélange Formation which tends to be harder and produces coarser material when it weathers. The sediment criteria were specifically developed for watersheds underlain by Franciscan Formation, such as Tannery and Fay Creek tributaries, which meet the sediment composition criteria. Second, these valleys are depositional reaches; prior to European settlement they were likely large stretches of wetlands with multi-threaded channels running through extensive willow and alder thickets. The Freestone Valley and Bodega Valley have 10-20 feet of fine-grained alluvium (material transported by streams) filling the broad valleys. Channel gradients through the valley reaches are much lower than the tributaries flowing through the steep canyon-like drainages in the Franciscan Mélange Formation (Figure 7).

The combination of geology, topography, and gradient produces a geomorphic setting in the lower Freestone Valley and the Bodega Valley in which the sediment composition is naturally fine grained. These stream sections should not be expected to meet spawning gravel composition criteria or pool fine sediment conditions found in the steeper, coarser grained streams and tributaries for which the criteria was developed.

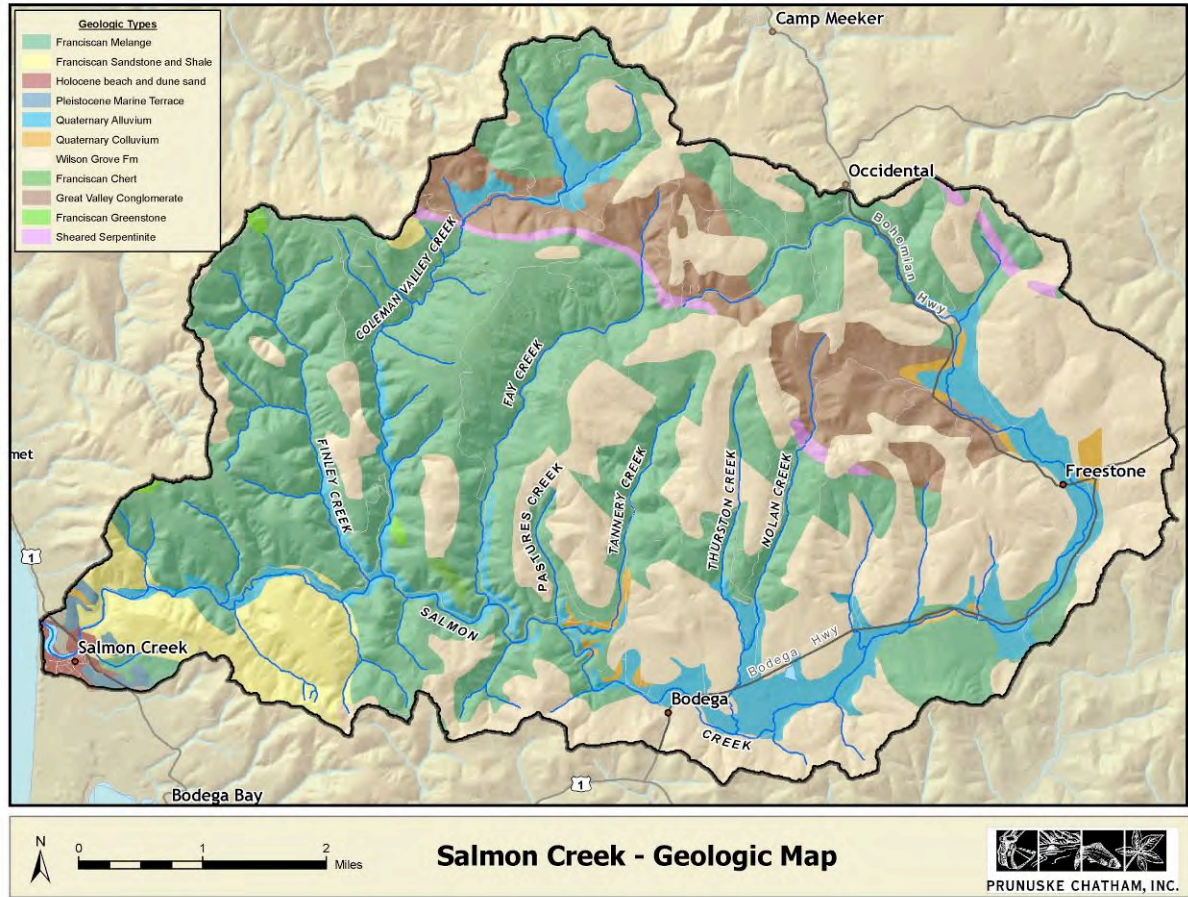


Figure 6: Geology of the Salmon Creek Watershed.

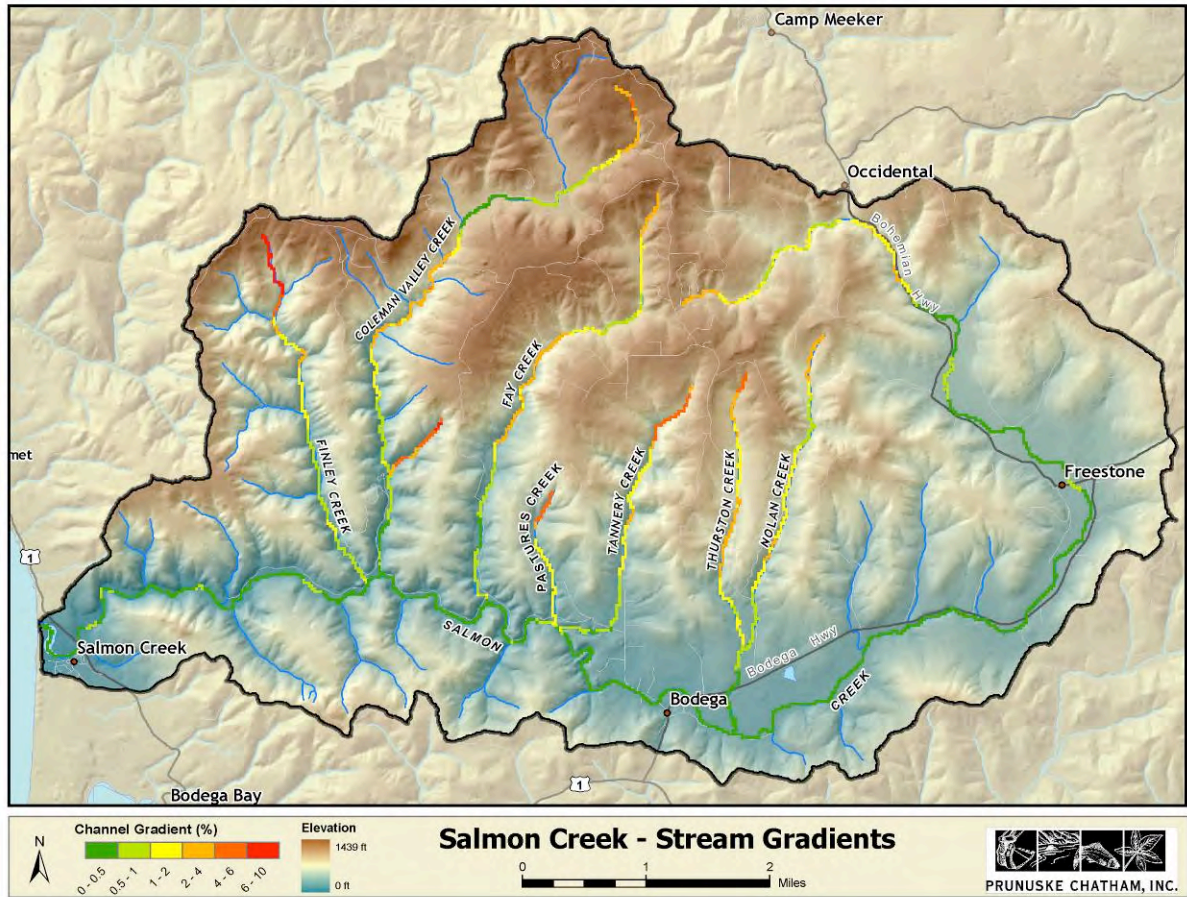


Figure 7: Channel gradients of Salmon Creek and its tributaries.

In coastal California streams such as Salmon Creek the geomorphic processes controlling channel form, sediment transport, and sediment sorting is often driven by large woody debris (LWD). Ecological conditions such as deep pool habitats, structural cover elements, and organic material are directly linked to the presence and abundance of LWD in these systems (Opperman 2005). It has been documented that coho salmon juvenile abundance is positively correlated to the presence of large wood within a stream reach (Bryant and Woodsmith 2009). The successful rearing of juvenile salmonids is likely particularly linked to the habitat value of pools associated with woody debris structure in regions with Mediterranean climate and associated low summer streamflows (Opperman 2005; Opperman and Merenlender 2007).

Several metrics to assess northern California stream habitat conditions have been developed related to LWD and pool frequencies (NCRWQCB 2006; NOAA NMFS 2010). These metrics were measured and are summarized for the Salmon Creek reaches in Table 3. The preferred condition criteria listed in Table 3 were developed for steeper gradient, coarse bed material, redwood and Douglas fir dominated systems; thus they may not accurately represent ideal conditions in low gradient, fine-grained sediment, willow and alder dominated systems such as mainstem Salmon Creek.

Table 3: Summary of habitat-related LWD and pool parameters in the geomorphic reference reaches.

Parameter	Desired Condition Value	Channel Reach	Existing Condition	Meets Desired Condition	Applicability/ Comments/ Concerns
Large Woody Debris Frequency	6-11 key pcs/100 m (based on Redwood/ Douglas Fir Forest type)	Upper Freestone Valley	1.2	No	Alder/Willow Riparian
		Upper Bodega Valley	0.7	No	Alder/Willow Riparian
		Lower Bodega Valley	0.7	No	Alder/Willow Riparian
		Lower Salmon Creek	0.3	No	Alder/Willow Riparian
		Tannery Ck	2.0	No	
		Fay Ck - Middle	1.0	No	
		Fay Ck - Lower	0.8	No	Transition to Alder/Willow
Primary Pool Distribution	>40% length	Upper Freestone Valley	12%	No	
		Upper Bodega Valley	18%	No	
		Lower Bodega Valley	16%	No	
		Lower Salmon Creek	7%	No	
		Tannery Creek	8%	No	
		Fay Ck - Middle	16%	No	
		Fay Ck - Lower	11%	No	
Primary Pool Distribution	# pools per mile based on width (NMFS 1996)	Upper Freestone Valley	33/mile (20ft)	No (56)	
		Upper Bodega Valley	32/mile (25ft)	No (47)	
		Lower Bodega Valley	33/mile (25ft)	No (47)	
		Lower Salmon Creek	7/mile (42ft)	No (30)	
		Tannery Creek	40/mile (24ft)	No (56)	
		Fay Ck - Middle	33/mile (27ft)	No (47)	
		Fay Ck - Lower	37/mile (26ft)	No (47)	

*Based on guidelines in "Desired Salmonid Freshwater Habitat Conditions for Sediment-Related Indices" (NCRWQCB 2006)

All of Salmon Creek and its tributaries have lower than ideal pool frequencies (Table 3), as well as average pool depths below the desired 3+ feet for summer rearing habitat (Table 1). Insufficient downed wood in the channel is one of the primary reasons for insufficient pool features and quality. The frequency of LWD in the Salmon Creek system is approximately a 10th of what is needed for good habitat conditions. The photos at right are a few of the natural and constructed large woody debris structures in Salmon Creek (2 @ left), and Fay Creek (2 @ right).



The low frequency of LWD is due to historic and ongoing removal of logs and LWD for flood control. In the 60s and 70s debris jams formed from slash off the logged hillsides. There is ongoing concern that wood in the streams will cause excessive bank erosion. The only observed bank erosion from log jams were in locations where banks were over-steepened and not stabilized by riparian vegetation. Frequent, regularly spaced large wood will slow flood waters down, reducing bank erosion potential within a reach, especially if the banks well vegetated and are sloped at 2 or 3:1 or have established inset floodplains.

To measurably improve habitat conditions and promote long-term channel stability the streams must be allowed to complete the widening process, inset floodplains must develop, and a well vegetated riparian corridor must be protected and/or established that stabilizes the banks and supports the recruitment of large wood to the system. It is critical that LWD frequencies increase through either natural recruitment or construction.

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**APPENDIX B: UCCE Salmon Creek Watershed Water Quality
Monitoring Results**

Salmon Creek Integrated Coastal Watershed Management Plan Appendix B:

Salmon Creek Watershed Water Quality Monitoring Results



Prepared for:

Gold Ridge Resource Conservation District

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Cover Photos: 1) Gold Ridge RCD staff Chris Choo, Brittany Heck and Devii Rao at the Salmon Creek School water quality monitoring site. 2) YSI instrument. Photos by David Lewis, UCCE.

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INTRODUCTION

Stream and river water quality is highly variable in undisturbed and disturbed watersheds. Geology, groundwater and surface contributions, climate, soils, vegetation type and cover, and distribution of native fauna form a complex web of inter-related factors that contribute to unique physical and chemical water properties for each stream system. Waterbodies often exhibit concentrations of naturally occurring “constituents” to which flora and fauna have adapted. Anthropogenic changes to land use, inputs of natural and synthetic chemicals, and of human and domestic animal wastes further compound the complexity of causal factors and obscure underlying natural conditions. Water quality monitoring may not answer our questions about past impacts but it can provide us with a set of baseline conditions that will allow us to track changes over time and better understand the positive and negative impacts of our actions on the watershed.

Initial assessments of Salmon Creek water quality indicate that sediment delivery from non-point sources is one of the primary issues impairing ecological function of the stream corridor and estuary (CDFG, 2004). Stream ambient water quality data has been, and continues to be, collected by the Salmon Creek Watershed Council (SCWC) through a volunteer monitoring program funded by the California Department of Fish and Game in 2003. Prior to 2007, however, *standardized* water quality monitoring data was not available for the Salmon Creek Watershed. At that time, Gold Ridge RCD supplemented the existing volunteer water quality monitoring program with one that utilized standard, scientifically-acceptable data collection methods. This assessment was intended to provide information for watershed management and pollution prevention, with a focus on salmonid health and habitat restoration.

This chapter discusses past water quality monitoring within the watershed and Gold Ridge RCD’s recent efforts to provide baseline water quality data for Salmon Creek and its tributaries. It also provides a summary of data findings. The Watershed Management Advisor for the Sonoma County University of California Cooperative Extension (UCCE) performed the water quality data evaluation and prepared this section of the report. UCCE was incorporated into the program to provide a scientific approach to spatial and trend analysis for all data collected through Summer 2008.

Past Monitoring

Volunteers

Volunteer water quality monitoring provides critical data and an opportunity for community involvement in watershed management. The effort in the Salmon Creek watershed has received, and continues to receive, a tremendous amount of support from local volunteers. A volunteer water quality monitoring program was originally established through California Department of Fish and Game (DFG) funding in 2003. The program sought to collect baseline data that could be used to determine how water quality issues might contribute to the decline of salmonid populations in the watershed.

Volunteers were recruited by Gold Ridge RCD through public meetings, local media, and the Salmon Creek Watershed Council (SCWC). Volunteers received classroom education about the program and the general concepts of water quality monitoring. Each volunteer selected a specific site or set of sites to monitor once a month at a set time

and received at least two onsite training sessions in the use and troubleshooting of the sampling equipment

Over the past four and a half years, approximately 20 volunteers have monitored 13 sites along mainstem Salmon Creek, the estuary and four of the major tributaries (Figure 1).

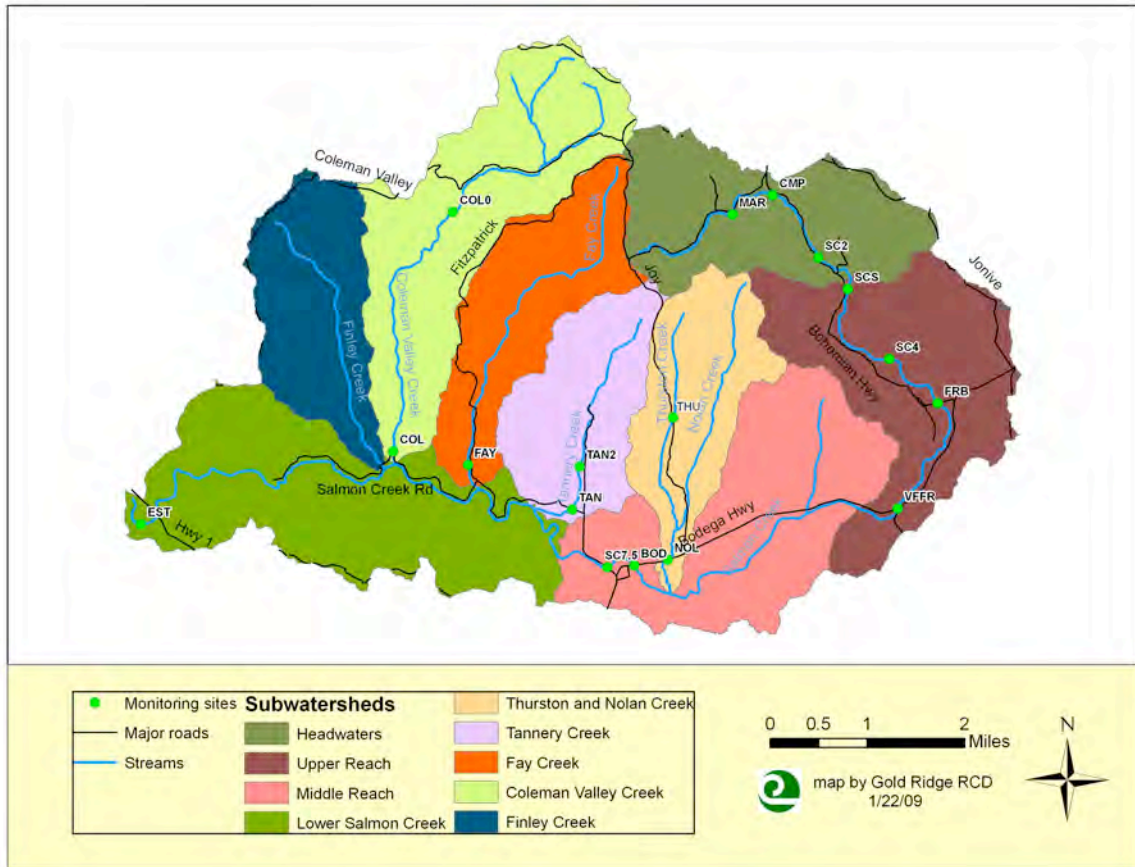


Figure 1: Salmon Creek watershed water quality monitoring sites and subwatersheds.

Water quality sampling efforts continued by a committed group of citizens even after the Gold Ridge RCD began collecting data using its own staff in October 2007. Volunteer sampling at seven of these sites is ongoing today, long after the grant funds have been exhausted. Gold Ridge RCD has taken over monitoring responsibilities at three of the original volunteer sites.

Other Organizations

In order to maintain the integrity of the program by insuring that scientific and uniform standards in data collection and analysis were met, Prunuske Chatham, Inc. (PCI) was contracted to train volunteer monitors, oversee data collection and analyze data in keeping with professional standards. They also calibrated and maintained the sampling equipment according to the State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP) standards until until 2007 and the start of Gold Ridge RCD's water quality monitoring program. In addition, PCI staff collected storm-

related turbidity readings during the 2004-2005 rainy season at 10 sites on the mainstem and 4 tributary locations. That data is included in the results section of this report.

The North Coast Regional Water Quality Control Board (RWQCB) generously loaned the volunteer program essential equipment and provided SWAMP training for calibration, cleaning, and use of the equipment

Gold Ridge RCD's Current Monitoring Effort

Gold Ridge RCD designed a project to supplement the existing volunteer water quality monitoring program by conducting additional monitoring of streams in the Salmon Creek watershed using Gold Ridge RCD field staff. This assessment was intended to provide scientific support for watershed management and pollution prevention. It is anticipated that the information generated from this effort will enable identification of reach- or site-specific restoration and/or remediation actions and development of guidelines for evaluating potential impacts of proposed projects within the watershed. The resulting data will be made available to the public for purposes of watershed education, as well as to resource management agencies.

In February 2007, Gold Ridge RCD drafted the Quality Assurance Project Plan & Monitoring Plan for Collection of Baseline Hydrologic Monitoring in the Salmon Creek Watershed, Sonoma County, CA (QAPP). This document carefully outlines the monitoring plan and requirements for sampling methods, handling and custody procedures, analytical methods, quality control, equipment testing, inspection, maintenance and calibration, data acquisition, data management, review, verification and validation and reconciliation of data quality objectives. The QAPP was reviewed and approved by the California State Water Resources Control Board QAPP staff and accordingly meets SWAMP standards. These measures and objectives are therefore considered adequate for the determination of general water quality conditions, with a potential application of the data to Section 305(b) reporting purposes. It is important to note that the historic and continued volunteer monitoring, though it aimed for SWAMP compliance, was unable to meet all SWAMP requirements due primarily to funding restrictions.

In October 2007, Gold Ridge RCD staff began a year-long ambient water quality monitoring program collecting water quality samples using the methodologies and specific requirements described in the QAPP. They began sampling concurrently with volunteers at four of the historic volunteer sites, took over sampling responsibilities at another three historic sites and established monitoring at three new sites, for a total of ten sites. The RCD sites include five along the mainstem of Salmon Creek, one on Coleman Creek, one on Fay Creek, one on Tannery Creek and one in the estuary.

Watershed Plan Water Quality Monitoring Objectives

The purpose of the water quality monitoring program established by Gold Ridge RCD in 2007 was to assess the freshwater habitat conditions within the Salmon Creek watershed, establish current baseline conditions and provide a foundation for evaluating future conditions. The program was developed with salmonid standards in mind. The specific objectives of sampling at the selected locations are to:

- Use the water quality monitoring data as a benchmark for developing watershed-wide Best Management Practices (BMPs) and enhancement strategy.

- The data collected will provide a guide for the systematic development of restoration projects;
- Establish baseline values that characterize current freshwater habitat conditions at reference locations throughout the watershed; and
 - Assess the efficacy and necessity of future water quality improvement projects by comparing the baseline data collected under this monitoring plan to future, post-project monitoring data.

The following assumptions and practices were an important part of the water quality monitoring plan:

- Sampling conditions in the 2007/2008 season will be considered representative of typical conditions within the watershed.
- Sampling crews will sample all locations within the watershed in a systematic and timely manner to maximize sample comparability.
- Storm sampling crews will collect samples at multiple times during a single storm event, including the peak runoff window, when possible.
- A minimum of three to four storms will be sampled.
- Water quality parameters were selected that facilitate characterization of baseline and storm conditions for the watershed.
- There will be at least 8 sampling sites for both storm and baseflow water quality monitoring.

One intended outcome of this effort was an assessment of the degree of impairment for each parameter sampled based on beneficial uses determined by the North Coast RWQCB. The following beneficial uses have been established in the Salmon Creek Hydrologic Area: municipal and domestic supply, agricultural supply, industrial service supply, groundwater recharge, navigation, water contact recreation, non-contact water recreation, commercial and sport fishing, cold freshwater habitat, estuarine habitat, wildlife, rare, threatened or endangered species, migration of aquatic organisms, and spawning, reproduction and/or early development (NCRWQCB 2007). Generally, the most stringent criteria established by the North Coast RWQCB and the EPA *for the specific water quality constituents sampled* during the Salmon Creek water quality monitoring, including temperature, pH and dissolved oxygen, are relative to the uses of cold freshwater habitat and spawning, reproduction and/or early development. Both of these beneficial uses address the needs of salmonids. Both federally- and state-mandated criteria were considered in evaluating the water quality data results and are included in the discussion.

An additional intended outcome was the establishment of target values for the parameters in question. To this end, UCCE associates reviewed a substantial selection of the available literature, particularly that discussing water quality criteria and thresholds for salmonids (Raleigh et al. 1984, McMahon 1983, USEPA 1986, Newcombe 2003, MacDonald et al. 1991, Reiser and Bjornn 1979, CDFO 2000, NCRWQCB 2008, NCRWQCB 2006, Groot and Margolis 1991, Schwartz et al. 2008, Welsh et al. 2001). Because the water quality monitoring efforts were developed with salmonid standards in mind, results utilized coho and steelhead habitat, breeding and spawning standards to determine suitable water quality. Steelhead trout (*Oncorhynchus mykiss*) are the predominant salmonid species found in Salmon Creek and its tributary streams. Coho salmon (*Oncorhynchus kisutch*) occurred there historically and adult coho were planted in the mainstem in late 2008 by DFG's Russian River Coho Salmon Captive Broodstock Program (RRCSCBB) in an effort to replenish a self sustaining run.

METHODS

Site Selection

Initial site selection within the Salmon Creek Watershed was based primarily on ongoing public access. Public bridges were used for access to a majority of the sampling sites. During the development of the citizen monitoring effort, several volunteers requested to test on their own property and these requests were granted. At that time (2003), Gold Ridge RCD made limited, unsuccessful efforts to locate additional sites along mainstem Salmon Creek in the reach between Freestone and Bodega, and between Bodega and the Estuary.

When Gold Ridge RCD began their renewed effort in 2007, they decided to focus on seven of the 13 original volunteer sites. Gold Ridge RCD's project manager and staff also met with landowners to continue ongoing access to three additional sites on private property. The following criteria were evaluated during the selection of past and new locations to insure that the most appropriate sites were included: access is safe, permission to cross private property is granted, sample may be taken in main river current or where homogeneous mixing of water occurs, sample is representative of the portion of the water body of interest, location complements or supplements baseline data, and location represents an area that has a water quality improvement practice either recently implemented or scheduled for implementation in the next year (QAPP, 2007).

Table 1: Summary of water quality monitoring site location.

Site	Subwatershed	Site Description
MAR	Headwaters	Salmon Creek at Marra Rd
CMP	Headwaters	Salmon Creek at Scout Camp Rd
SC2	Headwaters	Salmon Creek at Bohemian Lane
SCS	Headwaters	Salmon Creek at Salmon Creek School
SC4	Upper	Salmon Creek at Freestone Flat Rd Bridge
FRB	Upper	Salmon Creek at Bohemian Highway in Freestone
VFFR	Upper	Salmon Creek at Bodega Highway & Vallery Ford Freestone Rd
SC7.5	Middle	Salmon Creek at Salmon Creek Rd
BOD	Middle	Salmon Creek at Bodega Highway near Bodega
EST	Estuary	Salmon Creek at Bean Avenue
THU	Nolan Creek	Thurston Creek at Joy Rd Shatkin
NOL	Nolan Creek	Nolan Creek at Bodega Highway
TAN	Tannery Creek	Tannery Creek Bridge at Salmon Creek Rd
TAN2	Tannery Creek	Tannery Creek off Tannery Creek Rd
FAY	Fay Creek	Fay Creek at Salmon Creek Rd
COL0	Coleman Creek	Upper Coleman Creek approx 1/4 mile downstream of Coleman Valley Rd
COL	Coleman Creek	Coleman Valley Creek at Salmon Creek Rd

Sample Collection Protocol

Volunteer Sampling Methods

In April 2004, volunteers began collecting temperature, pH, dissolved oxygen, phosphate, nitrate, free and total chlorine, conductivity, salinity, and turbidity data for Salmon Creek and its tributaries. These parameters were selected to match the effort and experience levels of the volunteers. Where possible, the volunteer monitoring program aimed for compliance with SWAMP protocols. However, this program did not have access to a lab or funding to support sample analysis by an independent laboratory. Therefore, the volunteer program was limited to tests that could be conducted in the field. All equipment was purchased with this in mind, in addition to the goal of keeping

operation and maintenance costs to a minimum. Equipment and reagents for tests were purchased with grant funds and the reagents were replenished with fundraising efforts. Testing procedure, cleaning, and calibration methods were standardized in order to produce as little variance as possible. Volunteers were provided with laminated instructions for each test to limit user error.

The program borrowed a portable YSI 600XL multi-parameter sonde and YSI 650 data collector from the RWQCB. This equipment was configured to collect temperature, pH, conductivity, salinity, and dissolved oxygen. SWAMP training for calibration, cleaning, and use of the equipment were provided to PCI staff by Peter Otis of the RWQCB, and by PCI to all program volunteers.

After several months, when the RWQCB needed their equipment back, a YSI 55 was loaned to the program by PCI. The YSI 55 measured all the same parameters as the YSI 600 except for pH. The YSI 55 required user calibration for altitude adjustments to measure dissolved oxygen, which was performed by volunteers prior to each use.

Hach PocketPal™ testers were used to measure pH and conductivity. The testers were calibrated weekly to ensure that they remained reliable. These meters were purchased prior to borrowing the YSI 55 and the results from the meters and YSI appeared comparable.

Turbidity was measured using a Hach 2100P portable turbidimeter, which measured how cloudy the water appeared using a beam of light projected through the sample in a glass vial. The Model 2100P measures turbidity from 0.01 to 1000 NTU operating on the nephelometric principle of turbidity measurement. The glassware was cleaned by volunteers prior to each reading to limit fouling from fingerprints or dirt. Each vial was marked with an arrow to align the vial with the meter and labeled to ensure repeated use of the same vial. The glassware and the turbidimeter were cleaned and checked weekly by PCI staff. The turbidimeter was calibrated using a Hach's StablCal Formazin standard every 3 months, with a monthly check against Hach's Gelex calibration product. The monthly measurement checked for drift greater than 5%.

Funding restrictions resulted in the purchase of a Hach color wheel to test for nutrients and total chlorine. This technique requires the user to match the color of the treated sample with the color on the gradient color wheel. The tests have a built-in compensation for any background color in the water sample, but leave a notable margin for interpreting the results. Testing with a color wheel, as opposed to a portable colorimeter, increased the subjectivity and margin of error for tests of phosphate, nitrate and chlorine. To decrease subjectivity as much as possible, the protocol required both monitors at each site to analyze their samples separately and confidentially before comparing the results, re-sampling if necessary, and reaching an agreement about the final value recorded.

In Summer 2006, the Salmon Creek Watershed Council received additional funding to purchase a portable colorimeter to replace the color wheels. In July 2006, volunteers began using a Hach colorimeter, instead of the color wheel, to test for free or total chlorine (based on location), nitrate, and phosphate with increased precision.

Air and water temperatures were also measured during data collection. Volunteers were equipped with a pocket thermometer in addition to the internal thermometer on the YSI probe.

Gold Ridge RCD Sampling Methods

Gold Ridge RCD field staff made monthly visits to each of the ten monitoring sites to sample for temperature, pH, dissolved oxygen, phosphorous, nitrate, conductivity, salinity, turbidity and TSS. In addition, they conducted storm event sampling two times during wet weather periods (at least 0.5 inches of rainfall in a 12-hour period). Water quality samples were collected, stored, transported, measured, and analyzed in accordance with SWAMP-approved protocols. Data collection methods followed standard protocols established and endorsed by the Environmental Protection Agency, North Coast RWQCB and U.S. Geologic Survey. Industry-standardized equipment was used to measure water quality parameters. The program's companion QAPP provides the detailed measures that were followed to ensure data collection accuracy, precision and repeatability. This includes instrument calibration, duplicate measurements of field parameters, sample trip blanks and duplicate field sample collection and submission for analyses and audits.

Water quality grab samples were collected and analyzed for turbidity in the field using a Hach 2100P Turbidimeter. This is a handheld turbidity meter, which operates by measuring the amount of light that passes through the sample jar. The Model 2100P measures turbidity from 0.01 to 1000 NTU operating on the nephelometric principle of turbidity measurement. As with the volunteer sampling, the glassware and the turbidimeter were cleaned and checked weekly. The turbidimeter was calibrated using a Hach's StablCal Formazin standard every 3 months, with a monthly check against Hach's Gelex calibration product. The monthly measurement checked for drift greater than 5%.

Dissolved oxygen, pH, conductivity, and temperature were measured with a YSI 600-model meter. The YSI is a handheld display and attached sensor wand used to measure water quality parameters. It was calibrated for dissolved oxygen prior to each use to adjust for altitude and barometric pressure. It was also calibrated for pH weekly and turbidity monthly.

Grab samples for nitrate nitrogen and total phosphorous were collected using a sterile plastic bottle and sent to an independent professional laboratory.

Suspended sediment grab samples were taken with a DH-48 sediment sampler at multiple times throughout the study period. The DH-48 is an isokinetic depth integrated sampler used to collect total suspended solids (TSS) samples. TSS samples were sent to an independent professional laboratory for analysis.

Sample Analyses

Because the volunteer monitoring program did not have funding to support sample analysis by an independent laboratory, analytical tests for all parameters sampled were performed by trained volunteers in the field using accepted equipment and methods.

For the Gold Ridge RCD effort:

- Turbidity, dissolved oxygen, pH, temperature and conductivity measurements were analyzed in the field by trained Gold Ridge RCD field staff using industry-standardized equipment.

- Nutrient samples were collected using a sterile plastic bottle and analyzed for nitrate as nitrogen and total phosphorous by Analytical Sciences, a state-certified professional laboratory in Petaluma (CA Lab Accreditation #2303). Nitrate was analyzed using Environmental Protection Agency (EPA) method 300.0, with a reporting detection limit of 0.15 mg/L. Phosphorous was analyzed using EPA method 200.7, with a reporting detection limit of 0.10 mg/L.
- TSS samples were also analyzed by Analytical Sciences using Standard Method 2540D. Reporting detection limits for TSS were 5.0 mg/L.

Data Management & Analysis

In 2008, all data from both the volunteer and Gold Ridge RCD's monitoring programs were submitted to UCCE. Under the guidance of the Watershed Program Advisor, research associates compiled, organized and analyzed the data. Some data refinement was necessary to insure accuracy during analysis. All temperatures recorded in Fahrenheit were converted to Celsius and conductivity measurements taken in different units using the same equipment were converted to microsiemens for consistency. The data from the current study will be made available to the SWRCB's SWAMP database by Gold Ridge RCD in a format suitable for input into the STORET system.

Statistical analysis of the dataset was conducted to identify significant differences between sample sites. To prepare the dataset for analysis, the non-detectable (ND) readings for phosphorous, nitrate and TSS were assigned a value equal to half the detection limit to allow for statistical analysis (i.e., if the reporting limit was 0.10, a value of 0.05 was assigned). Since the samples were collected at various days and times with varying effects from recent storm events, we summarized rainfall data for each sample collected (storm size, antecedent ppt., and time since rainfall), using Bodega Marine Lab and Occidental automated rain gauges. Ambient temperature was collected at the time of water sampling and this was also used to assist in spatial analysis to detect differences between sites and subwatersheds. Linear Mixed Effects (LME) models were created for each parameter using S-Plus software (version 6.1) using non-parametric methods, because water quality data usually does not have a normal distribution. We cross checked the statistical results from the LME models with Wilcoxon tests (JMP statistical software) in a one-way analysis of variance using the data collected at similar times on the same day across sample sites.

RESULTS & DISCUSSION

Turbidity & Total Suspended Solids

Turbidity is essentially the cloudiness of water, assessed in nephelometric turbidity units (ntu)—a measure of light scattering by suspended clay particles. Turbidity for all sites sampled ranged from zero to 240 ntu (Appendix A). The lowest measurements in the combined Gold RCD and volunteer sampling data set were taken at the EST, SC2, SC4 and TAN sites. This data was from year-round sampling, with only a handful of storm events. The highest reading of 240 ntu was taken at the SCS site during the 12/30/05 storm. This storm totaled less than one inch precipitation, with more than two inches of antecedent precipitation in the three proceeding days.

PCI also measured turbidity during their supplemental storm sampling effort. These values ranged from 13 to 1000 ntu. The lowest values were recorded at the SCMP and COL sites, with the highest value also recorded at the COL site on 5/18/05. Total rainfall for that storm was 2.1 inches, with no antecedent precipitation.

Total suspended solids (TSS) refers to the portion of the sediment load that is suspended in the water column. TSS was measured at nine sites (with a significantly smaller sample size than turbidity) and ranged from 2.5 to 42 mg/L (Appendix A). The lowest values were from the BOD and EST sites and the highest value was from NOL.

In general, streams are typified by naturally low levels of turbidity (less than 5 ntu), outside of rainy periods (CCWI 2008). For this reason, "turbidity is regarded by many as the single most sensitive measure of the effects of land use on streams." (MacDonald et al. 1991). Human activities that disturb land and increase impervious surfaces, such as agricultural and residential development and road building, increase sediment input to streams during rain storms that create turbid conditions.

Excess turbidity reduces light, which decreases aquatic plant life, reducing benthic organisms and ultimately fish populations. High turbidity levels also affect salmonids by causing reduced feeding rates, reduced growth rates, damage to gills, and fatality.

The detrimental effects of turbidity on fishes increase in relationship to the persistence, or duration, of turbid conditions. Newcombe (2003) found that turbidity levels of 55 ntu caused significant impairment to clear water fishes after one day and severe impairment after four months. Turbidity levels above 150 ntu caused significant impairment after three hours and severe impairment after 2 weeks. Turbidity levels above 400 ntu caused significant impairment for any duration and severe impairment after just two days. For this study, significant impairment represents moderately serious sublethal impacts like reduced growth rate and reduced habitat size and severe impairment represents serious impacts, including lethal and para-lethal effects (those resulting in reduced rate of survival from one life stage to the next even if not causing direct mortality). Turbidity levels as low as 40 ntu have also been shown to reduce foraging success of brook trout by 80% (Schwartz et al. 2008).

Direct effects of suspended sediment on salmonids are only known to occur at relatively high levels, with an impaired ability to capture prey at concentrations of 300 to 400 mg/L and mortality at greater than 20,000 mg/L (MacDonald 1991). Indirect detrimental affects on salmonids, benthic invertebrates and other aquatic life can occur at lower levels. High concentrations of TSS affect aquatic life similarly to high turbidity, namely by: 1) acting directly to kill fish or reduce their growth rate and resistance to disease; 2) preventing successful development of fish eggs and larvae by clogging; 3) modifying natural movements and migrations of fish; and 4) reducing the abundance of food available to fish (USEPA 1986).

Maximum turbidity measurements in the Salmon Creek Watershed ranged from 9.58 to 240 ntu for Gold Ridge RCD and volunteer monitoring sites, and from 218 to 1000 ntu for PCI's storm sampling effort (Appendix A). These levels were high enough to cause significant and severe impairment to fish even if they only persisted for one hour (Newcombe 2003). Because these sites were sampled at one point in time, the duration of turbid conditions is not clear and it is not possible to determine whether levels of turbidity above 150 ntu may have persisted long enough to significantly impair fish.

The North Coast RWQCB mandates that turbidity levels not be increased more than 20% above naturally occurring background levels (NCRWQCB 2007). The national criterion for TSS states that: "Settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than ten percent from the seasonally established norm for aquatic life" (USEPA 1986). Natural background levels of turbidity and TSS have not been established for the Salmon Creek Watershed.

Temperature

Water temperature was collected during every site visit and ranged from 4°C to 23.50°C for all sites. The lowest mean and maximum temperatures were recorded at MAR and were 7.72°C and 11.63°C, respectively. The VFFR site had the highest mean temperature of 13.88°C and the highest maximum temperature of 23.50°C (Appendix A).

Stream water temperature is affected by variables such as climate, exposure to solar radiation, stream velocity and depth, inflow of groundwater and tributaries, and turbidity. The primary human activities that affect water temperature include vegetation removal, water withdrawal and discharge, and land use changes that increase sediment input. The optimal temperature range for most salmonid species is around 12-14°C (MacDonald et al. 1991), though this is believed to increase to 18°C for steelhead (Raleigh et al. 1984). Welsh et al. (2001) found that no coho salmon were observed in Mattole River tributaries with maximum weekly maximum temperatures (MWMT) greater than 18°C. Lethal temperatures for adult salmonids depend on variables such as local adaptation, acclimation temperature and duration of increased temperatures but are generally in the range of 20-25°C (MacDonald et al. 1991). McMahan (1983) noted that disease and infection increase markedly for coho salmon at temperatures as low as 12.8°. Spawning adults, eggs and larvae are much more sensitive to high temperatures. Fortunately, these life stages generally occur in the Salmon Creek Watershed between November and May when temperatures are cooler.

There is some speculation that salmonids in California's central coast streams have adapted to warmer water temperatures. UCCE's Russian River Coho Salmon Broodstock Monitoring Program found that, though oversummer survival estimates for coho on Russian River tributaries were negatively correlated with MWMT, survival did not decrease markedly until MWMT reached almost 22°C and there was some survival (>0.10) above 24°C (Obedzinski et al. 2008). Due to the geographic proximity of Salmon Creek to the Russian River, it may be reasonable to expect similar trends in salmonid survival in relation to temperature. Temperature data loggers would need to be utilized to determine MWMT at the Salmon Creek monitoring sites.

Water temperatures exceeded 20°C on a total of nine occasions at the following sites: VFFR (three times), EST (two times), FRB (one time), SCS (one time) and BOD (one time). The warmest temperatures were recorded between June and September.

The North Coast RWQCB mandates that temperatures are not to be increased by more than 5°F above natural receiving water temperature (NCRWQCB 2007). Unfortunately, natural background temperatures are unknown.

Dissolved Oxygen

Dissolved oxygen (DO) refers to the amount of oxygen dissolved in water. DO measurements for the sites sampled ranged from 1.47 to 28.5 mg/L (Appendix A). The lowest DO levels were recorded at TAN, SC2, BOD and FAY.

DO is critical to the survival and growth of aquatic organisms and to the decomposition of organic material. Inputs of organic matter and pollution can decrease DO levels by increasing bacterial consumption of oxygen required to break those substances down. Increases in temperature and salinity also decrease DO. Clogging of gravels with fine sediment inhibits water with higher concentrations of DO from delivering oxygen to fish eggs and alevin.

DO concentrations generally vary between the surface water and that flowing through the alluvial material in the streambed, with intergravel DO concentrations being lower than the well-aerated surface waters. The appropriate DO values for embryo and larval stages of salmonids were obtained by assuming that a difference of 3 mg/L between intergravel and water column DO would adequately maintain DO levels within the gravel (USEPA 1986)

DO levels lower than 3 mg/L are lethal to juvenile and adult salmonids, but the limit to avoid acute mortality in embryo and larval stages is 6 mg/L (Raleigh et al. 1984, McMahon 1983). Moderate production impairment occurs for embryo and larval stages and other life stages at 8 mg/L and 5 mg/L, respectively (EPA 1986). Based on the beneficial use of spawning, reproduction and development, the North Coast RWQCB set criterion in Salmon Creek at 7.0 mg/L, with a minimum limit of 9.0 mg/L during spawning, embryo and larval stages (generally between November and May).

DO concentrations in the Salmon Creek Watershed fell below the lower lethal limit of 3.0 mg/L on seven separate occasions at the following sites: BOD (three times) FAY (one time), TAN (one time), SC2 (one time) and SC4 (one time). All values below 3.0 mg/L were recorded in September and October but only once were they associated with high water temperatures. DO concentrations fell below North Coast RWQCB's criterion of 7.0 mg/L on 123 occasions at 14 of the 17 sites sampled—all sites except for MAR, SCMP, TAN2, which are in the upper mainstem and middle Tannery Creek. These low DO levels occurred during all months and only six times were associated with temperatures above 20°C. SCS and SC4 had the highest number of readings below 7.0 mg/L, with low levels of DO persisting for months on end. Twelve of the 17 sites also had levels below North Coast RWQCB's recommended 9.0 mg/L during the critical spawning and incubation period on a total of 24 occasions.

Nutrients

Nitrate (NO_3) is an inorganic form of nitrogen that is soluble and therefore subject to leaching and biological uptake. Nitrate values at all sites sampled ranged from 0.01 to 5.0 mg/L (Appendix A). The highest measurements were from samples taken at SCS and SC4. Because nitrate as nitrogen cadmium reduction tests conducted with the Hach colorimeter are extremely sensitive to sampling techniques, results from multiple samplers can vary by greater than ten percent (Hach, personal communication 2009).

Phosphate (PO_4) is the primary form of dissolved phosphorous. Phosphate concentrations were measured through the volunteer monitoring program and ranged from zero to 2.55 mg/L (Appendix A). The Gold Ridge RCD tested for total phosphorous (mg/L). One hundred percent of phosphorous concentrations were below

the lab detection limit of 0.10 mg/L for all sites sampled except for the EST site, which had a reading of 0.10 and 0.60 mg/L (Appendix A). Although the samples were labeled as “phosphate”, there is some uncertainty as to whether this refers to total phosphate or free phosphate (not bound to other compounds). It does not appear that the predigester required to acquire total phosphate concentrations was used, which would mean that the phosphate values recorded during this monitoring effort were actually free phosphate concentrations. Method #8167 protocols for tests of both forms of phosphate can be found on the Hach website.

Nitrate-nitrogen, phosphate and phosphorous are not directly toxic to fishes but, where sunlight is available, these chemical nutrients stimulate primary production. Excessive inputs of these nutrients, known as eutrophication, can result in abundant plant growth and decay which depletes dissolved oxygen and can degrade habitat quality. One study indicated that a nitrate concentration of less than 0.3 mg/L would likely prevent eutrophication (Cline 1973). Only one sample at the estuary site had a concentration above 0.3 mg/L.

The national drinking water standard for nitrate-nitrogen is 10 mg/L. This is based links between nitrate concentrations above 10 mg/L and the occurrence of methemoglobinemia, a syndrome which affects human infants (USEPA 1986). The EPA did not establish standards for nitrate in freshwater streams because “concentrations that would exhibit toxic effects on warm or coldwater fish could rarely occur in nature” (USEPA 1986). All sites sampled within the Salmon Creek Watershed had nitrate levels well below drinking water standards.

Although the EPA did not set a freshwater criterion for phosphorous, they set the “desired goal” for the prevention of plant nuisances in streams not discharging directly into lakes at 0.1 mg/L (USEPA 1986). The EST site, which generally was below the detection limit for phosphorous, had one value of 0.60 mg/L on 1/9/2007.

Chlorine

Chlorine is a highly toxic gas that is very reactive and quickly bonds with other compounds in water. It is a common household ingredient in bleach and other cleaners and generally enters the water through runoff and direct discharges from industrial and municipal sources. The volunteer monitoring program sampled for total chlorine at all sites. Total chlorine concentrations ranged from zero to 3.00 mg/L. Fourteen of the 17 sites had zero values on multiple occasions. Concentrations were highest at SCS, FRB, BOD and EST. Chlorine concentrations exceeded 1.0 mg/L one time, on different dates, at each of these four sites.

Volunteers also sampled free chlorine at seven sites. Concentrations ranged from zero to 1.33 mg/L. BOD, FRB, SC2 and SC7.5 had the lowest readings of zero on a total of eight samples on six different dates. The highest reading of 1.33 mg/L was measured at BOD on September 4, 2007. The only other free chlorine concentration above 0.5 mg/L was 0.83 mg/L, measured at SC7.5 on September 5, 2007.

Because the risks associated with chlorine lessen significantly once the chlorine molecules have bonded, free chlorine poses the greatest threat to aquatic life (GRRCD 2007). Thirty-three freshwater species were exposed to total residual chlorine in water and the acute lethal values range from 0.028 to .710 mg/L. Tests of two freshwater

invertebrates and one fish species indicate that chronic lethal values for the species tested ranged from .0037 to over .078 mg/L (USEPA 1986).

The EPA set the chronic criteria for chlorine in freshwater at 11 $\mu\text{g/L}$ (0.011 mg/L). That means the four-day average concentration of total residual chlorine is not to exceed 0.011 mg/L more than once every three years on the average. This is the EPA's best scientific estimate of the average amount of time it will take an unstressed system to recover from a pollution event which inputs greater than that amount of chlorine. The EPA's acute criteria is 19 $\mu\text{g/L}$ (0.019 mg/L), meaning that the one-hour average concentration should not exceed this amount more than once every three years on average (USEPA 1986).

Total chlorine concentrations were greater than the EPA's acute criterion of 0.019 mg/L at ten sites on the mainstem, estuary and tributaries on a total of 114 different occasions. Because chlorine sampling was limited to one point in time monthly, there is no way to establish four-day or even one-hour average concentrations. However, both total and free chlorine data are suspected to be inaccurate due to the interference of oxide manganese, which creates the same chemical reaction as a positive chlorine test. Where there is no known source of chlorine in natural waterways, it is likely that all recorded concentrations of chlorine can be attributed to oxidized manganese (Hach representative, personal communication 2009). For each water quality sample collected, samplers must perform the treatment outlined in Hach (2009) to account for the effect of this interference and obtain accurate concentrations of free and total chlorine.

Water Chemistry

pH

pH refers to the concentration of hydrogen ions in water and determines the acidity or alkalinity of water. pH readings at the monitoring sites ranged from 5.60 to 9.58, with a mean range of 7.34 to 8.21 (Appendix A). The highest reading occurred at the estuary site (EST) and the lowest at SC2.

Natural pH levels are affected by geology vegetation and soil types in the streambed and surrounding the stream, and the availability of carbon dioxide. Algae increases pH, while decomposing organic matter and root respiration decreases pH. A pH range of 5-9 is not directly toxic to fishes, but a decline from 6.5 to 5.0 resulted in a progressive reduction of salmonid egg production and hatching success (USEPA 1986). The emergence of benthic macroinvertebrates also declines below a pH of 6.5. Changes in pH can also have critical effects on water chemistry. For example, the solubility of many metal compounds changes greatly with pH.

The optimal pH range for salmonids is 6.5-8.0 (Raleigh et al. 1984) and the North Coast RWQCB has set a criterion of 6.5-8.5, with levels not to exceed 0.5 above normal ambient pH levels within this range (NCRWQCB 2007). Background pH levels have not been established for the Salmon Creek Watershed but the estuary clearly has a higher pH than the mainstem or tributary sites, with pH exceeding the North Coast RWQCB criterion on nineteen occasions. A handful of other sites had one or two readings outside of the recommended range but only SC2 and THU had three or more occurrences of this.

Conductivity

Conductivity is a measurement of the number of dissolved ions in water. It is an indicator of possible pollution rather than a primary contaminant. Due to high salinity,

specific conductivity was highest in the estuary where it ranged from 133 to 13,150 microsiemens per centimeter. Maximum values at all other sites ranged from 241 to 440 microsiemens (Appendix A).

In a pristine environment, the conductivity of rain water is zero. Soils, geology, rainfall groundwater recharge and evaporation are natural factors affecting conductivity. Sewage discharge, agricultural runoff and inputs of organic compounds like oil and alcohols can cause changes to naturally occurring conductivity. The USEPA did not establish a national criterion due to the relative insensitivity of aquatic biota to conductivity (USEPS 1986). However, the North Coast RWQCB has objectives for conductivity that range in value from 100 to 1,300 microsiemens per centimeter, depending on the water body. There is no numeric objective established for Salmon Creek.

Salinity

Salinity is a measure of salt in water and is related to conductivity because dissolved ions increase salinity as well as conductivity. Salinity data was collected at most sites on the mainstem, tributaries and estuary of Salmon Creek. In this way salinity could be accounted for when considering results for conductivity. Salinity in the estuary ranged from 0.09 to 8.57 ppt. Salinity at all other inland sites ranged from 0.00 to 0.20 ppt (Appendix A).

The average salinity of ocean water is 35 ppt (grams of salt per liter of water). Freshwater salinity is usually less than 0.50 ppt and brackish water, like that in the estuary, generally ranges from 0.5 ppt to 17 ppt (ONR 2009). Rainfall and river runoff can create variations in salinity.

Every organism has a tolerable salinity range. For salmonids, that range varies based on life stage, which determines residence in freshwater or ocean water and timing of smoltification. One study showed that coho salmon fry could survive salinities as high as 29 ppt, provided they had been acclimated to lower salinities for 35 days (Groot and Margolis 1991). Salinity tolerance in coho appears to be a function of size and the threshold for survival in sea water is about seven to eight centimeters (Groot and Margolis 1991). The salinity of Salmon Creek and its tributaries is clearly within the expected range for freshwater, which is suitable for salmonid incubation, rearing and migration.

Subwatershed Analysis

Spatial analysis was conducted to detect differences in water quality between sites and subwatersheds. The limited samples size from each site reduced the statistical power to compare sites so the analysis focused on subwatershed effects. Trends over time were not possible to assess because of changes in data collection methods and annual climatic variation from year to year. However, patterns detected for certain parameters, such as turbidity, will provide adequate baseline data from which to detect future water quality changes in the watershed.

Turbidity and TSS concentration were the result of recent storm events and location in the Salmon Creek watershed. Turbidity concentrations were highly variable depending on the timing of sample collection until storm event factors were statistically accounted for (Figure 2).

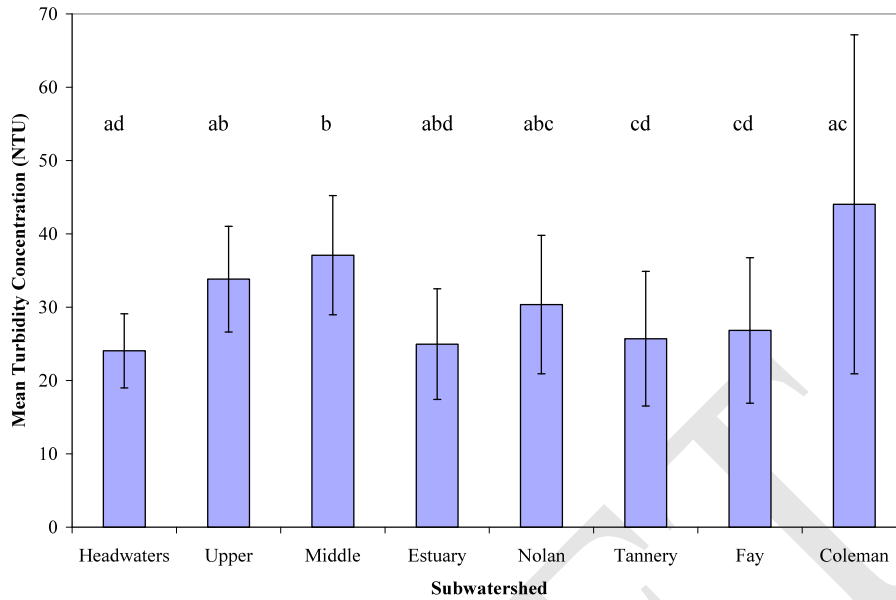


Figure 2: Mean turbidity concentration (Nephelometric Turbidity Units) by subwatershed with Standard Error bars. Different letters combinations represent significant statistical differences ($P < 0.10$) from LME models which controlled for time since storm and amount of precipitation.

Results from our data driven models for the relationship of turbidity and time since precipitation are presented in Figure 3. Though Coleman Creek had the highest single sample value, on average Middle Salmon Creek had greater turbidity for a longer time following storms than Coleman, Tannery, or Fay Creeks (Figure 3). Tannery and Fay Creeks were also lower in turbidity than Upper and Middle Salmon Creek. The biological affect of turbidity on salmon health becomes more of a concern with regard to the duration stream water is turbid and unclear (Newcombe 2003). For the modeled rain event of more than two inches, Middle Salmon Creek turbidity remains over the 20 NTU threshold for three times as long as Tannery and Fay Creeks (Figure 3).

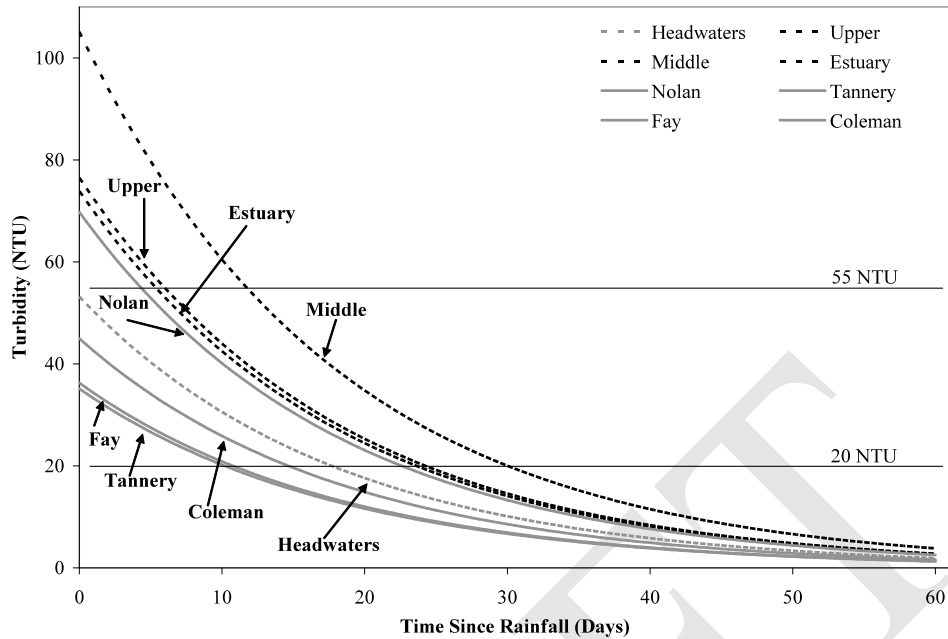


Figure 3: Turbidity concentration as a function of time since rainfall for each subwatershed (dash lines = mainstem Salmon Creek, solid lines = tributary streams) given a storm size over two inches precipitation.

The TSS data was highly variable given the low sample size. As a result, detecting significant differences was difficult and the results should be interpreted cautiously because the time since rainfall was not able to be included in this statistical analysis. The precipitation amount in the previous 24 hours before sample collection provides some confidence in the result that Nolan Creek had higher TSS than the other subwatersheds, except for Middle Salmon Creek (Figure 4). However, more TSS data will be needed to confirm this and strengthen the correlation between TSS and Turbidity ($R^2=0.45$ currently). All the TSS data from Tannery Creek was below the detection limit (0.15 mg/L). With the existing dataset, TSS will not be useful for baseline trend monitoring of sediment reductions in the Salmon Creek water quality. However, the TSS dataset should be strengthened by continuing to collect TSS and turbidity in conjunction with systematic storm event sampling.

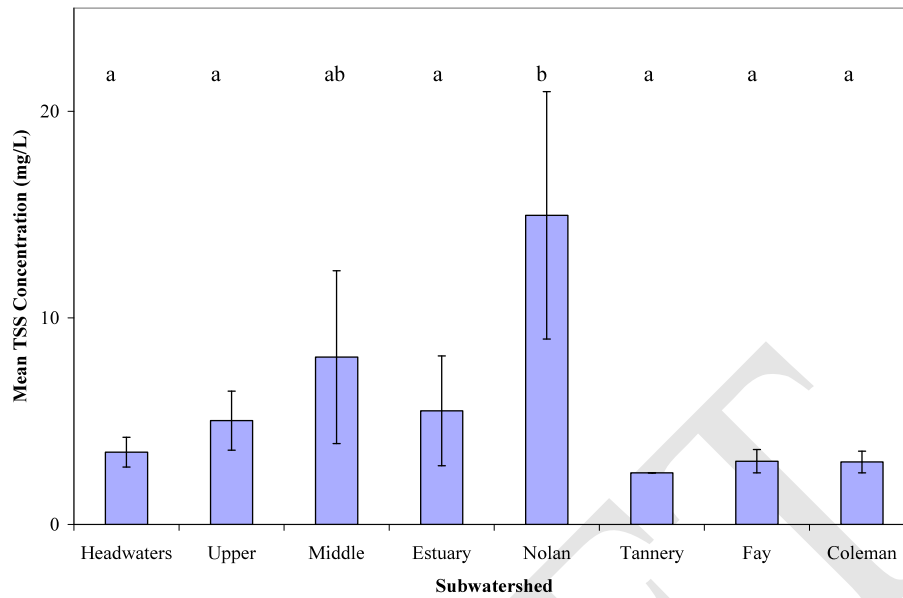


Figure 4: Mean total suspended solid (TSS) concentration by subwatershed with Standard Error bars. Different letters combinations represent significant statistical differences ($P < 0.10$) from LME models which controlled for rainfall amount in previous 24 hours.

Water temperature was also highly variable depending on timing and location of water quality sampling. Ambient air temperature was measured when water samples were analyzed which has a large affect on stream temperature. The LME model for water temperature controlled for ambient temperature to detect significant differences between subwatersheds (Figure 5). The estuary was clearly the warmest subwatershed. Interestingly, Salmon Creek significantly cooled from the upper to the middle subwatershed. Nolan Creek was also colder than Headwaters and Upper Salmon Creek. The other tributaries were no different than the mainstem.

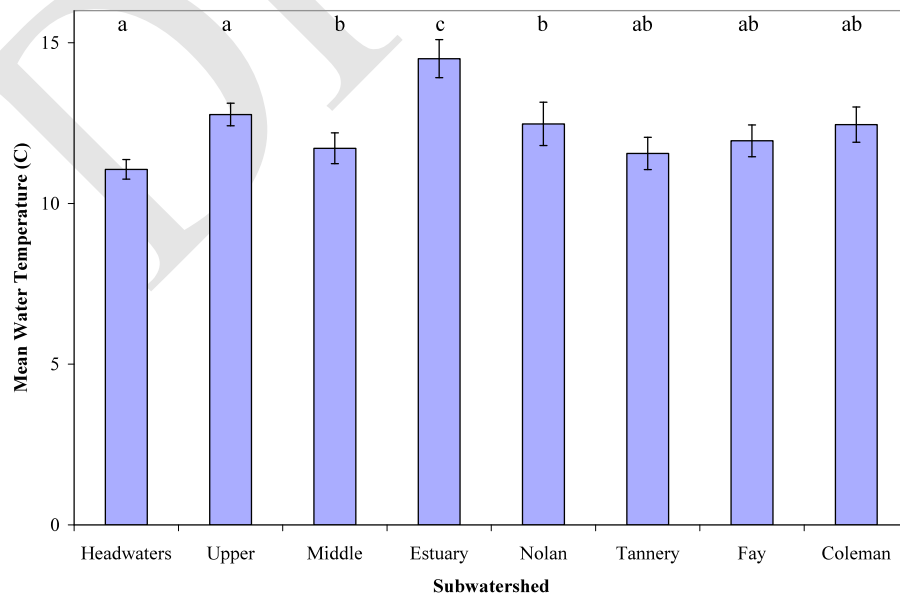


Figure 5: Mean water temperature (Celsius) by subwatershed with Standard Error bars. Different letters combinations represent significant statistical differences ($P<0.10$) from LME models which controlled for ambient temperature.

Dissolved oxygen was also influenced by ambient temperature – dissolved oxygen decreased as air temperature increased. Nolan Creek had the highest dissolved oxygen and all other subwatersheds were not significantly different (Figure 6). This was surprising given the geomorphic variation between subwatersheds. Locations with steeper stream gradients usually have higher dissolved oxygen because of more re-aeration through turbulence.

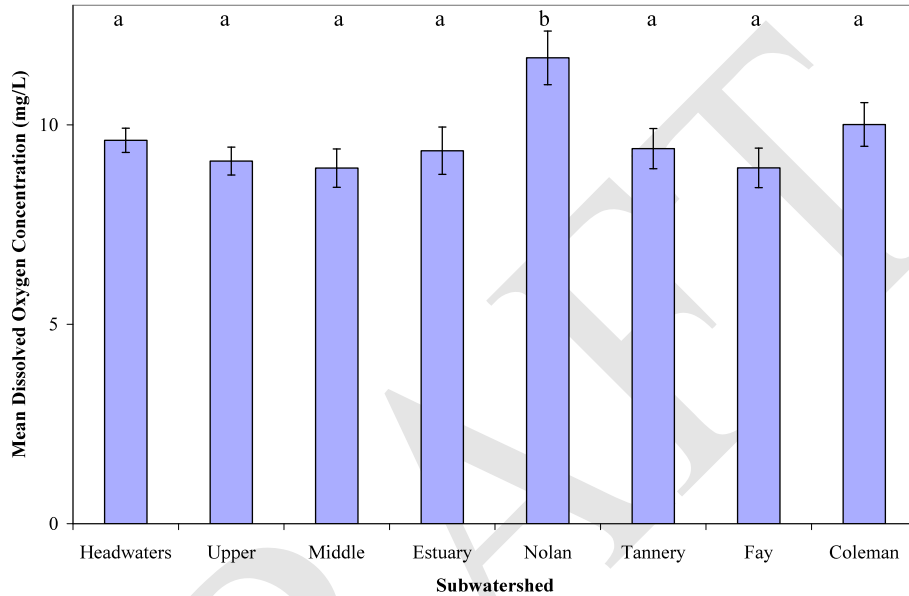


Figure 6: Mean dissolved oxygen (DO) concentration by subwatershed with Standard Error bars. Different letter combinations represent significant statistical differences ($P<0.10$) from LME models which controlled for ambient temperature.

Nutrients were very low on average across subwatersheds. Nitrate was highest in Upper Salmon Creek, but it was only significantly greater than Tannery Creek and not different than the other subwatersheds (Figure 7). Similarly, Tannery Creek was not different than the other subwatersheds and only significantly less than Upper Salmon Creek. Storm event factors and time of year were not useful in statistical analysis of nutrient and chlorine results.

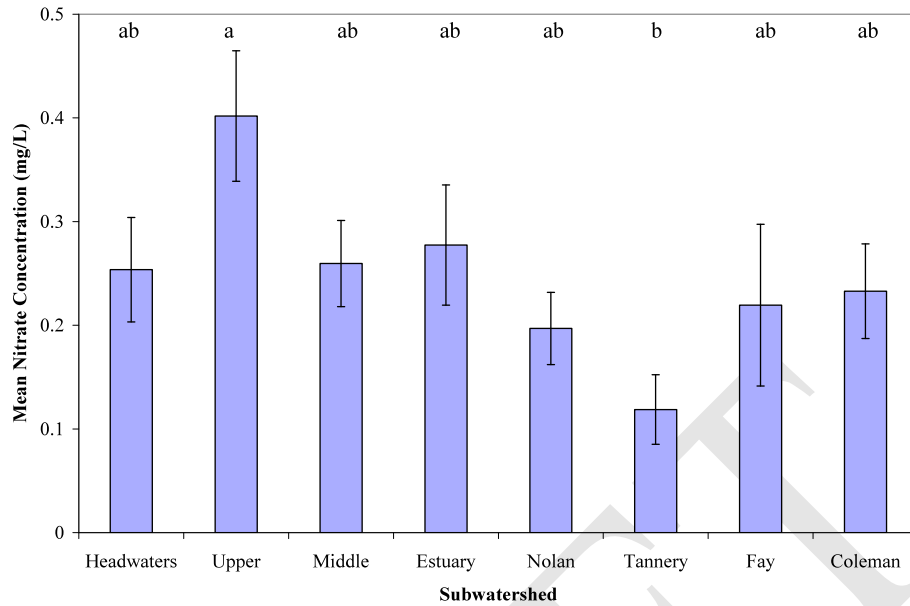


Figure 7: Mean nitrate (NO_3) concentration by subwatershed with Standard Error bars. Different letter combinations represent significant statistical differences ($P < 0.10$) from LME model results.

Phosphate was significantly lower in Tannery and Fay Creeks compared to Upper and Middle Salmon Creek and Nolan Creek (Figure 8).

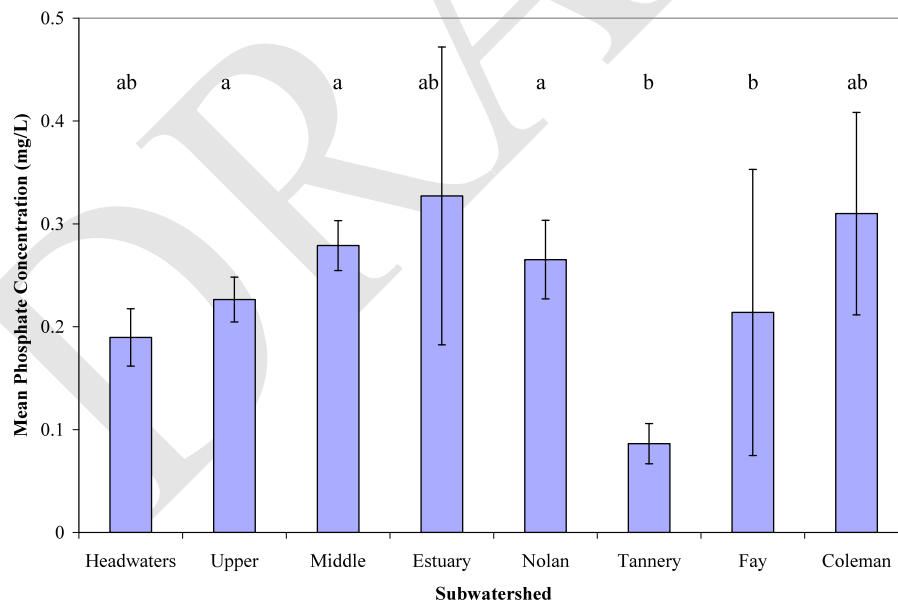


Figure 8: Mean phosphate (PO_4) concentration by subwatershed with Standard Error bars. Different letter combinations represent significant statistical differences ($P < 0.10$) from LME model results.

Total phosphorous was not different across subwatersheds (Figure 9).

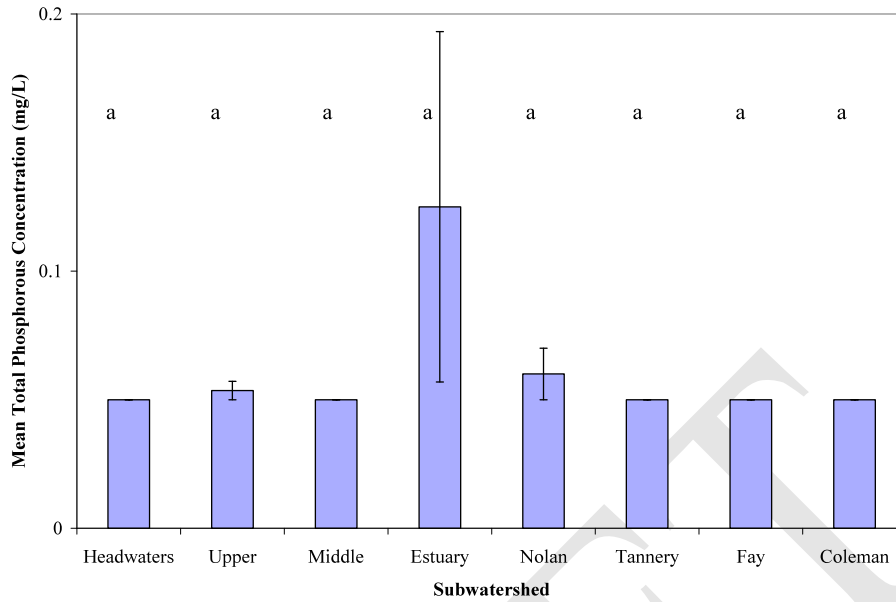


Figure9: Mean total phosphorous concentration by subwatershed with Standard Error bars. Different letter combinations represent significant statistical differences ($P<0.10$) from LME model results.

Free chlorine may be a result of water treatment or minerals leaching from geologic sources. Middle Salmon Creek had significantly greater free chlorine than the estuary.

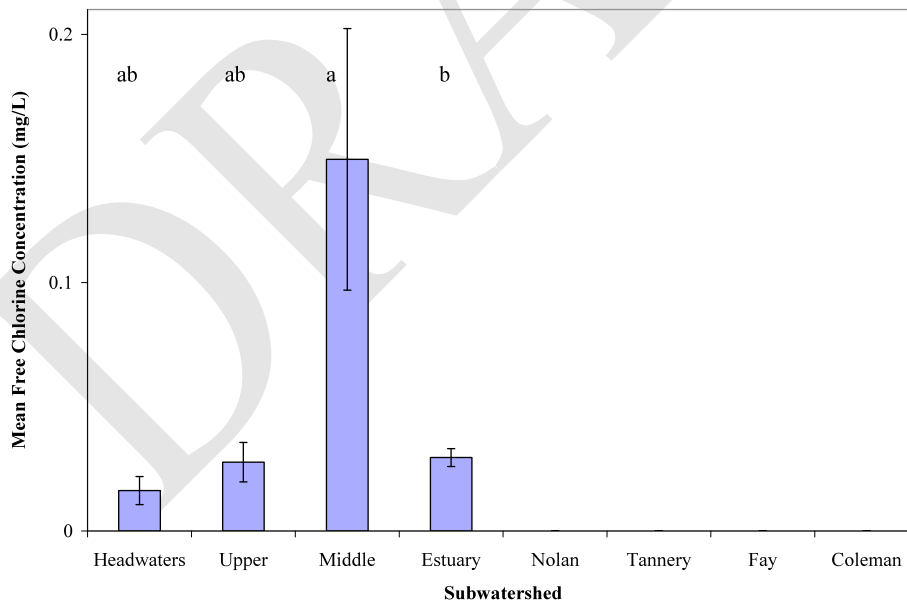


Figure 10: Mean free chlorine concentration by subwatershed with Standard Error bars. Different letter combinations represent significant statistical differences ($P<0.10$) from LME model results.

Total chlorine was not different across subwatersheds (Figure 11).

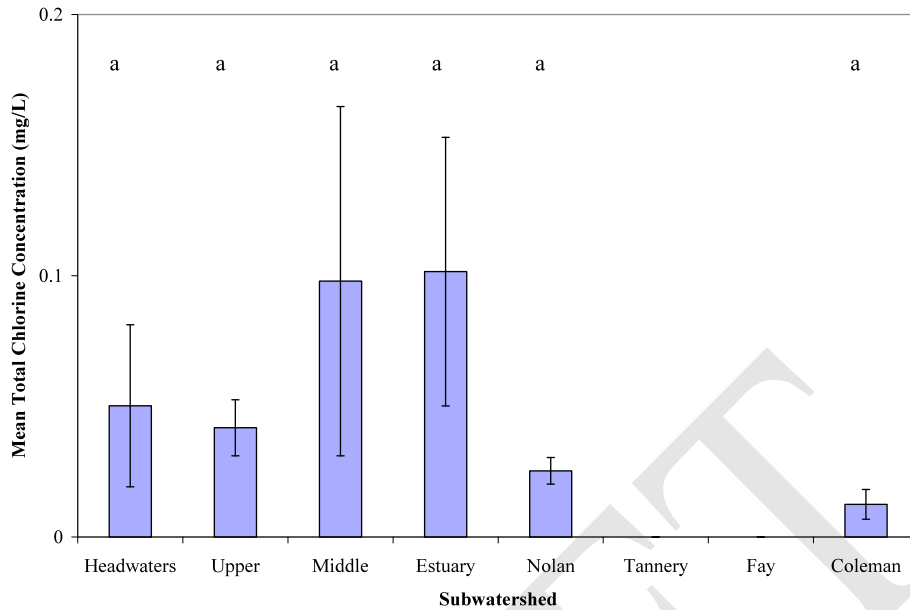


Figure 11: Mean total chlorine concentration by subwatershed with Standard Error bars. Different letter combinations represent significant statistical differences ($P < 0.10$) from LME model results.

Specific conductivity was clearly greatest in the estuary by an order of magnitude. Conductivity was affected by ambient temperature and this was controlled for in the LME model – stream conductivity correlated to ambient air temperature. Similarly, conductivity was reduced during storms and increased as the time since rainfall increased, but this relationship had less statistical power. Upper Salmon Creek had significantly greater conductivity than Nolan Creek and these were not different than the other subwatersheds (Figure 12).

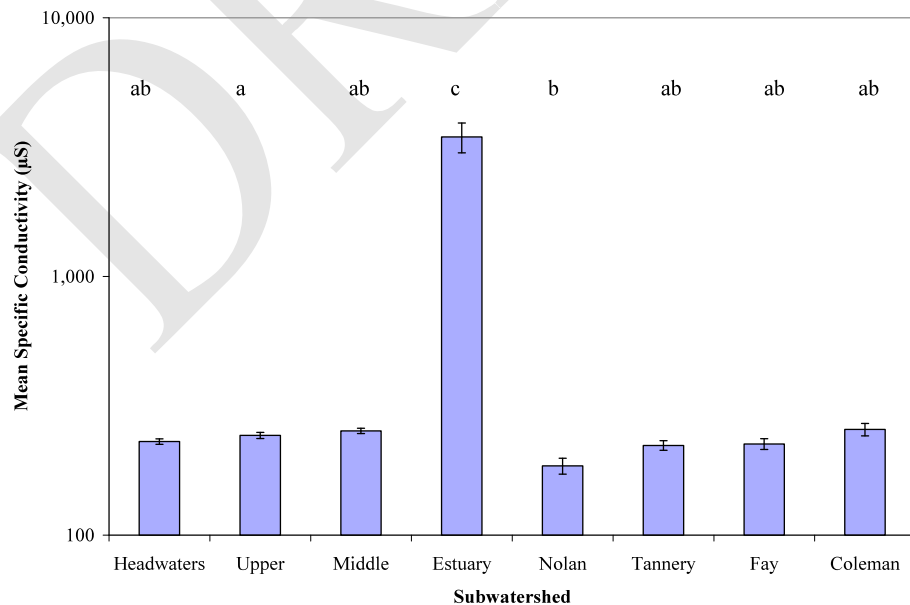


Figure 12: Mean specific conductivity by subwatershed with Standard Error bars. Different letter combinations represent significant statistical differences ($P < 0.10$) from LME model which controlled for ambient temperature.

Stream conductivity also correlated to other water quality parameters, as was expected. Turbidity, total phosphorous, and dissolved oxygen significantly decreased as specific conductivity increased. In contrast, salinity, pH, and water temperature significantly increased as conductivity increased. Nitrate, phosphate, and chlorine did not correlate to specific conductivity.

Mean pH results were highly variable across subwatersheds. pH of stream water was also affected by storm events – pH was reduced during storms and increased as the time since rainfall increased. This is likely the result of surface water directly delivering normal more acidic rainfall to streams during rainfall events. The estuary had clearly higher pH than the other subwatersheds, except for Nolan Creek. Middle Salmon Creek had significantly less pH than Headwaters and Upper Salmon Creek as did Tannery and Fay Creeks.

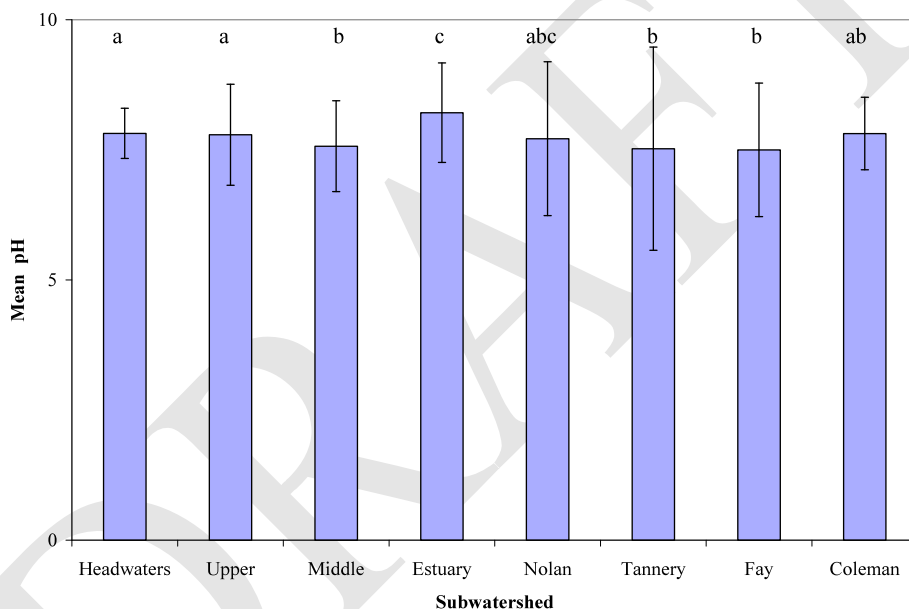


Figure 13: Mean pH by subwatershed with Standard Error bars. Different letters combinations represent significant statistical differences ($P < 0.10$) from LME model which controlled for the time since rainfall.

Future Recommendations & Monitoring Objectives

The Salmon Creek Highlanders (SCH) began conducting a citizen water monitoring program at 5 sites in the upper Salmon Creek Watershed in conjunction with the Community Clean Water Institute (CCWI) in June 2002. The sites are in the headwaters of Salmon Creek, Fay Creek, Thurston Creek and Tannery Creek. A sixth site in the middle reach of Salmon Creek was added a year later and monitoring of all sites has been ongoing. We recommend that the Gold Ridge RCD evaluate the data and reports resulting from this water quality monitoring effort. Integrating CCWI's data set with that produced by the volunteer and RCD monitoring programs may allow for enhanced site comparisons and trend evaluation, which could lead to the identification of problem

sites and possible remediation projects. CCWI's data may also prove useful in establishing natural background conditions for Salmon Creek, particularly as some of their sites were in the more pristine locations in the upper watershed.

We recommend ongoing systematic sampling of RCD sites at the same approximate time and in relation to storm events. If possible, water quality measurements should be taken over consecutive days following each storm to determine persistence of excessive pollutants over time such as turbidity and nutrients. Ideally, sampling would continue until levels are below thresholds for significant impairment. Plus, flow data should also be collected systematically in the future at all sample sites in order to help interpret water quality results given the importance of hydrologic factors.

The sample size for the TSS data was insufficient to identify trends and enable accurate site or subwatershed comparisons. Where possible, TSS data should be collected routinely to increase the sample size and enable the correlation of turbidity with TSS results for the Salmon Creek watershed.

Because high summer temperatures were recorded at several sites within the watershed, it is recommended that continuous data loggers be deployed at the monitoring sites to provide reliable average and maximum summer temperature data to determine limiting factors to coho and steelhead populations. Similarly, 25% of dissolved oxygen samples were below impairment levels at multiple sites and continuous monitoring should be conducted in conjunction with temperature monitoring.

The methods used to sample for nitrate, phosphate and chlorine should be evaluated to insure the highest level of accuracy possible using the equipment. Nitrate as nitrogen cadmium reduction tests conducted with the Hach colorimeter are extremely sensitive to sampling techniques. Shaking samples at a different angle or even using different hands can produce results that vary by greater than ten percent, even when shaken for the same period of time (Hach, personal communication 2009). Obviously, shaking techniques are difficult to standardize among multiple volunteers but making the best effort to do this will result in more reliable data.

In order to test accurately for total phosphates, rather than free phosphates, volunteers using the Hach colorimeter should be trained to use the predigestor required to acquire total phosphate concentrations. Protocols for this technique can be found on the Hach website. Similarly, for the collection of chlorine data, it is recommended that all samplers be trained to perform the treatment outlined in Hach (2009) to account for the effect of oxidized manganese and obtain accurate concentrations of free and total chlorine.

It would be ideal to compare the water quality results with DFG's biological sampling effort to determine how fish presence/absence data correlates to water quality factors. Analyzing this data with future biological sampling would allow for the evaluation of water quality conditions in relation to the presence and abundance of steelhead. This would help identify limiting factors specific to Salmon Creek and its tributaries.

More samples are needed from the Nolan Creek site to provide accurate baseline data for that location. We recommend continued monitoring of that site to document both conditions in Nolan Creek and possible contributions to conditions at the BOD site downstream of the confluence with Salmon Creek.

SUMMARY

Overall, water quality was fair to good in the Salmon Creek Watershed, with tributary streams exhibiting better conditions than the mainstem given the water quality dataset to date. This was supported by benthic macroinvertebrate samples collected from stream substrate. The resulting index of biological integrity (IBI) rated the watershed health as "fair". However, the percent of pollution intolerant invertebrates were 32, 12, and 20 in Fay Creek, and Upper and Middle Salmon Creek, respectively. Tributaries were similar but not equal in water quality and may be ranked in order. The cleanest subwatershed was Tannery Creek, followed by Fay Creek, then Coleman Creek, and then Nolan Creek.

The water quality results presented in this report indicate that, in general, Salmon Creek has reasonable water quality to support the identified beneficial uses for the watershed. Certain constituents, such as turbidity, temperature, dissolved oxygen, and chlorine values that did not meet water quality criteria beyond thresholds at certain points in time. Further investigation and monitoring is needed to document the duration and running average of these parameters. This type of monitoring will require daily and hourly sampling and analysis through a given storm hydrograph to understand if conditions of risk to aquatic organisms persist. In the case of chlorine, additional training and quality control for sample collection and analyses is required to improve the confidence in the results.

With regard to using these results for restoration planning, results indicate that the tributaries generally have higher water quality than the mainstem. However, tributaries like Tannery and Coleman have TSS and turbidity values that are higher than other locations in the watershed. While trends over time could not be established, the water quality monitoring and results summarized in this chapter are useful as the baseline for future trend development. Water quality monitoring is recommended in conjunction with watershed restoration activities to document long-term restoration project effectiveness. Ideally, ongoing water quality monitoring in the Salmon Creek Watershed will be used to document changes in the system over time as a result of both natural factors and human activities, as well as to support the enhancement of conditions that benefit salmon and steelhead.

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APPENDIX A:

To be included in final version of report

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