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 listed[4] as impaired for that parameter. For example, many streams in the North Coast region[5] 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 met als, 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	
Pathogens	Dairy or Confined Animal Feeding Operation (CAFO)	• Animals (domestic, livestock, wildlife) • Pasture and rangeland • Malfunctioning septic systems • Land application of manure	• Primarily human health risks
Metals	• CAFO • Urban Runoff	• Hazardous waste sites (unknown)	• Aquatic life impairments • Risk to livestock • Fish contamination
Nutrients	• CAFO	• Lawns • Animals (domestic, livestock, wildlife) • Pasture and rangeland • Malfunctioning septic systems • Land application of manure	• Aquatic life impairments • Recreational impacts • Human health impacts • Habitat impacts
Sediment		• Rangeland erosion • Streambank erosion • Landslides & gullies • Urban runoff • Roads • Construction	• Aquatic habitat impairments • Recreational impacts • Navigational impacts • Hydrologic impacts • Habitat impacts
Temperature		• Sediment (turbidity increases stream temperatures) • Lack of riparian shading • Shallow or wide stream channels (due to hydrologic modification)	• Aquatic life impairments • Recreational impacts

Goals

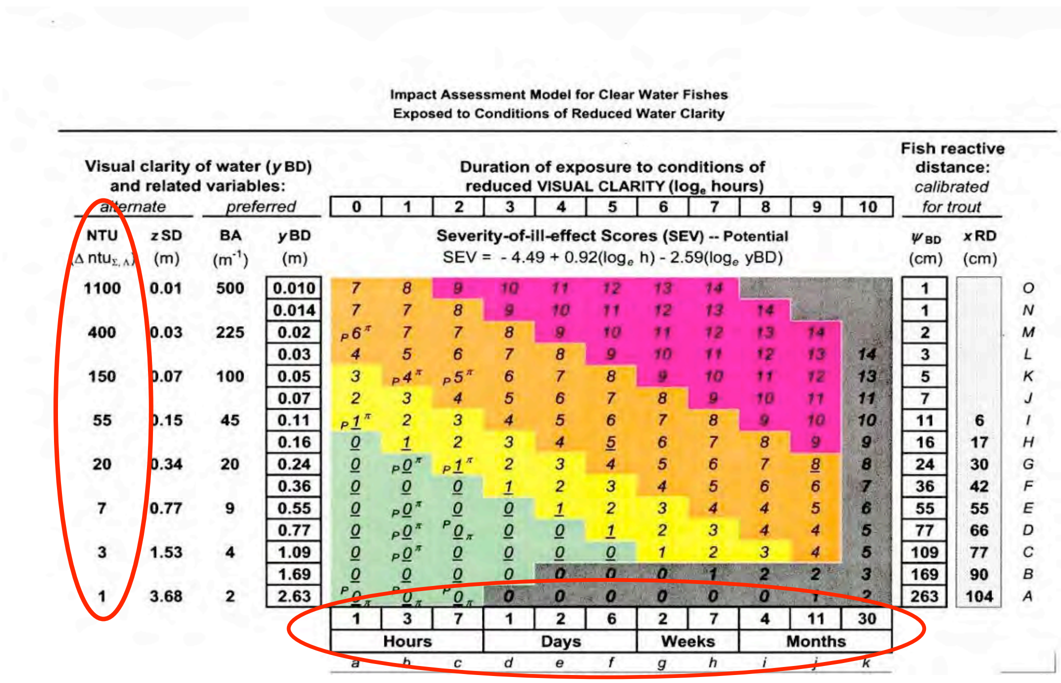
- Water quality conditions in Salmon Creek, its tributaries, and the estuary meet or exceed all regulatory targets.
- Water quality conditions support salmonid fish and other aquatic organisms at all lifestages.
- Sediment and contaminants in the water are at levels that do not harm the health of plants,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

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

Scientific Reasoning

Turbidity, measured in nephelometeric 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.



Impact Assessment Model for Clear Water Fishes
Exposed to Conditions of Reduced Water Clarity

Visual clarity of water (yBD) and related variables: alternate / preferred. Duration of exposure to conditions of reduced VISUAL CLARITY ($\log_e$ hours). Severity-of-ill-effect Scores (SEV) -- Potential: SEV = - 4.49 + 0.92($\log_e$ h) - 2.59($\log_e$ yBD). Fish reactive distance: calibrated for trout.

NTU (Δ ntu$_{\Sigma, \Lambda}$)	zSD (m)	BA (m^{-1})	yBD (m)	0	1	2	3	4	5	6	7	8	9	10	ψ_{BD} (cm)	xRD (cm)	
1100	0.01	500	0.010	7	8	9	10	11	12	13	14				1		O
			0.014	7	7	8	9	10	11	12	13	14			1		N
400	0.03	225	0.02	P6π	7	7	8	9	10	11	12	13	14		2		M
			0.03	4	5	6	7	8	9	10	11	12	13	14	3		L
150	0.07	100	0.05	3	P4π	P5π	6	7	8	9	10	11	12	13	5		K
			0.07	2	3	4	5	6	7	8	9	10	11	11	7		J
55	0.15	45	0.11	P1π	2	3	4	5	6	7	8	9	10	10	11	6	I
			0.16	0	1	2	3	4	5	6	7	8	9	9	16	17	H
20	0.34	20	0.24	0	P0π	P1π	2	3	4	5	6	7	8	8	24	30	G
			0.36	0	0	0	1	2	3	4	5	6	6	7	36	42	F
7	0.77	9	0.55	0	P0π	0	0	1	2	3	4	4	5	6	55	55	E
			0.77	0	P0π	P0π	0	0	1	2	3	4	4	5	77	66	D
3	1.53	4	1.09	0	P0π	0	0	0	0	1	2	3	4	5	109	77	C
			1.69	0	0	0	0	0	0	0	1	2	2	3	169	90	B
1	3.68	2	2.63	P0π	P0π	P0π	0	0	0	0	0	0	1	2	263	104	A
				1	3	7	1	2	6	2	7	4	11	30			
				Hours			Days			Weeks		Months					
				a	b	c	d	e	f	g	h	i	j	k			

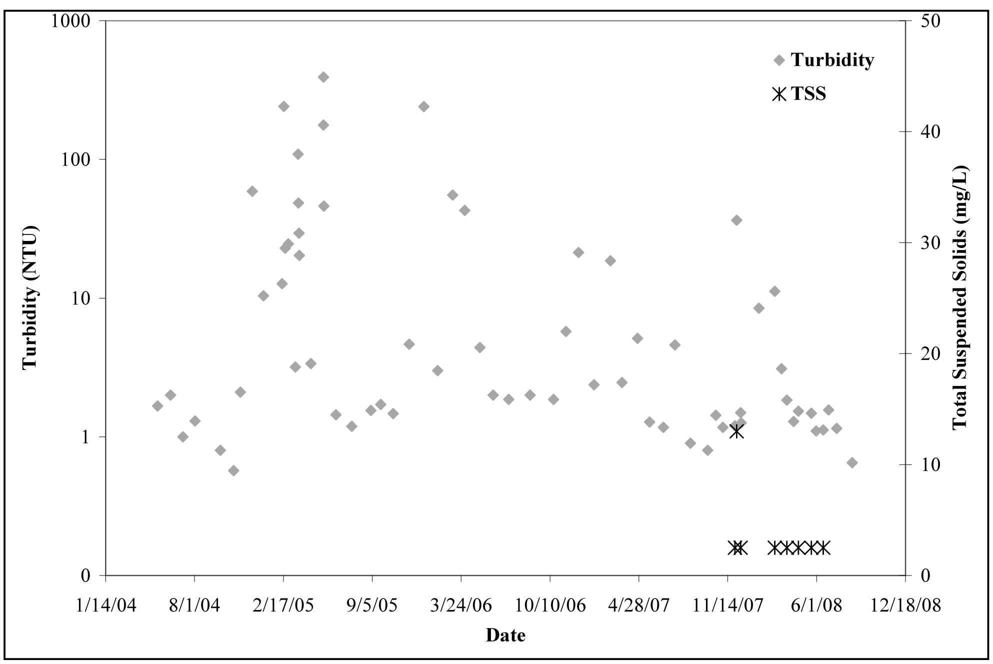
Yellow indicates slight impairment with changes in feeding and other behaviors, orange indicates significant impairment with altered fish growth and habitat quality, and red indicates severe impairment with physiological condition changes and habitat alienation (Newcombe 2001, 2003).

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 longterm 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.

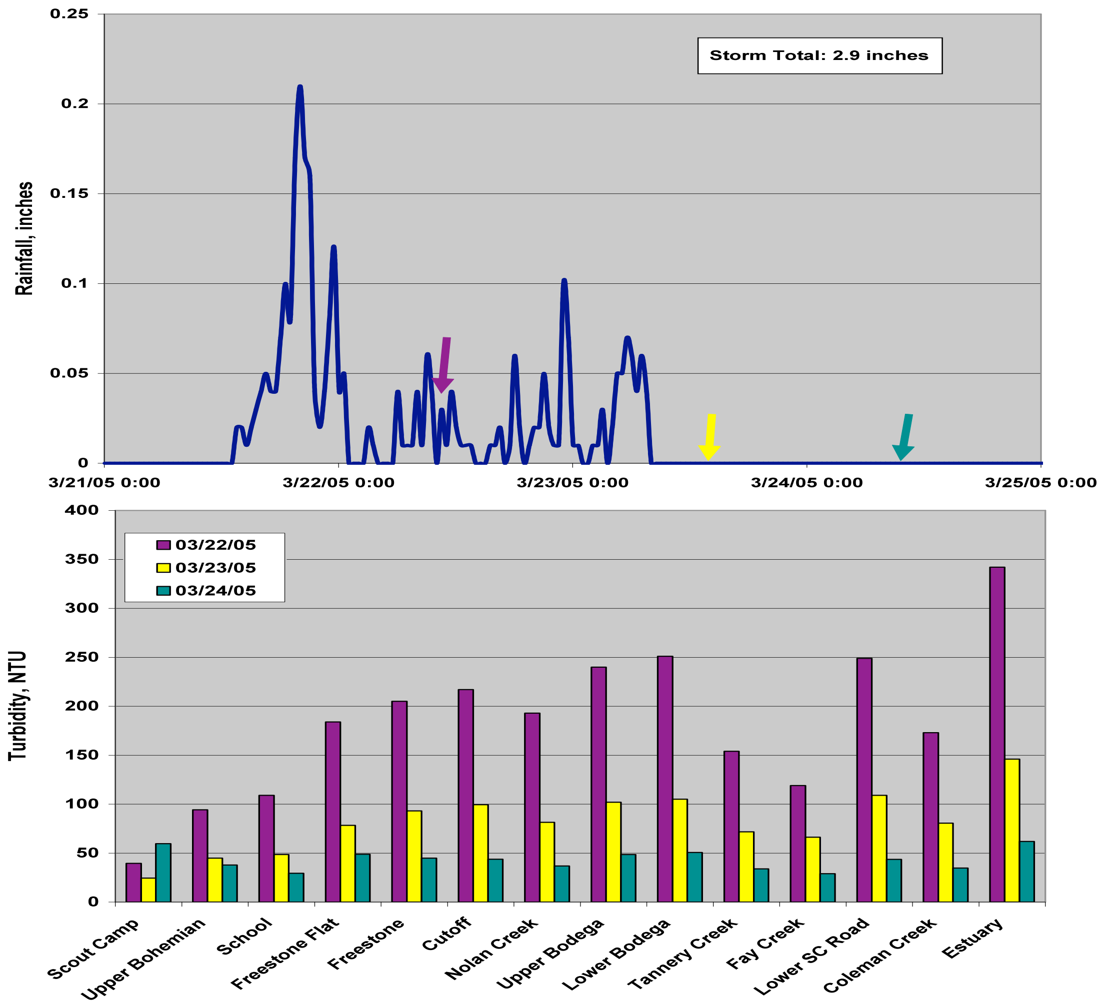


Source: UCCE 2007.

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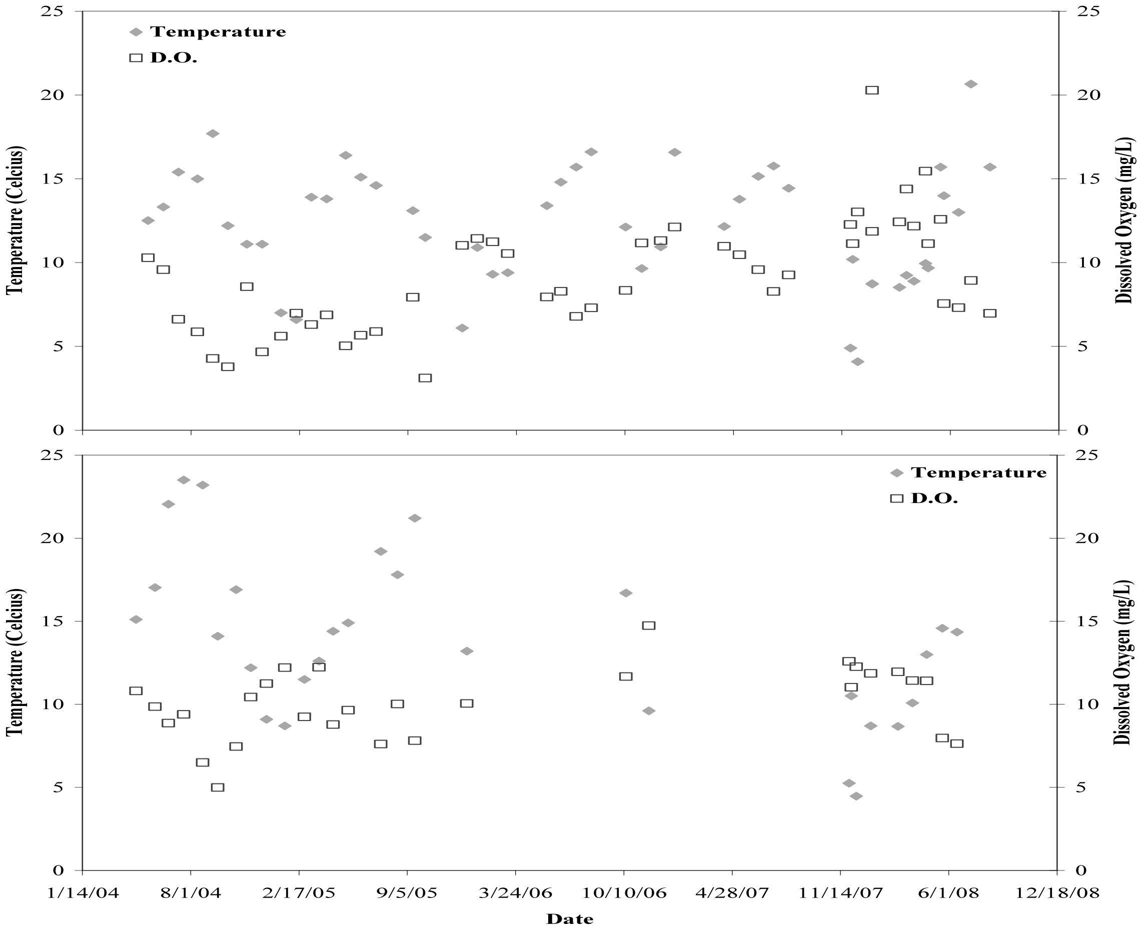
Figure 9. Seasonal water temperature and DO variations in the Freestone Valley.



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 (^{0}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.