Salmon Creek Watershed Sediment Reduction and Water Conservation Project

Quarterly Water Quality Monitoring Report

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This quarterly report summarizes data collected by the Gold Ridge Resource Conservation District (GRRCD) from October 2010 to February 2011 under the North Coast Integrated Regional Watershed Management Program funded Salmon Creek Sediment Reduction and Water Conservation Project. The data period included early winter sampling (November 24, 2010), winter storm sampling (December 7-9, 2010), and monthly sampling (January 20, 2011). Turbidity and Total Suspended Solids data from the February 17, 2011 storm sampling event has been included despite the fact that the other analytical results are not yet available. .

Since fine sediment delivery has been identified as a primary habitat and water quality threat in Salmon Creek and its tributaries (Gold Ridge RCD, 2010), GRRCD worked with the Salmon Creek Watershed Council (SCWC) and their citizen monitors to complete a synoptic storm sampling event focused on turbidity levels throughout the watershed during the December 8, 2010 storm. The event could not have occurred without the generous participation of the SCWC volunteer monitors. The results of the event are summarized in the Turbidity section below.

Gold Ridge RCD staff and SCWC volunteer monitors have been working together to coordinate monitoring efforts and standardize water quality data collection for the Salmon Creek Watershed. When possible, future reports will include SCWC data.

Salmon Creek flowing into the Pacific Ocean.

Weather Summary

The first significant rainfall event of water yea[1]r 2011 occurred on October 23-24, 2010 and delivered between 8 and 12 inches of rainfall in the Salmon Creek watershed. The early months of the water year were relatively wet with higher than average rainfall. To date, the watershed has received approximately 38 inches of cumulative rainfall.

Sampling Locations

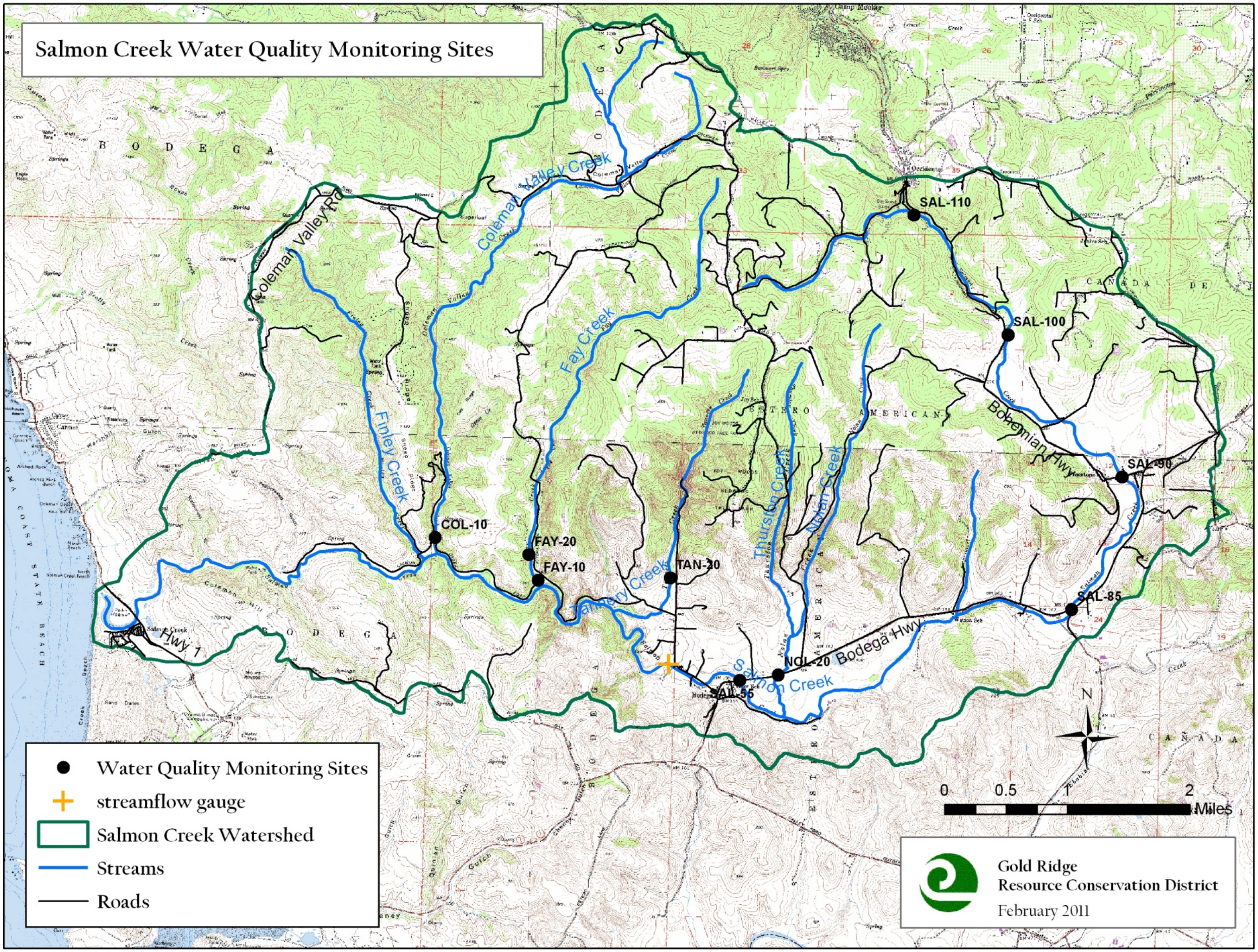
The sampling locations have been renamed to comply with SWRCB naming convention. See the table below and the associated attached map.

Table 1: Revised monitoring station IDs sampled by GRRCD staff

New Station ID	Past Station ID	Description
SAL-110	CMP	Salmon Creek off of Scouts Camp Road
SAL-100	SCL	Salmon Creek from the Salmon Creek Elementary School entrance bridge
SAL-90	FRB	Salmon Creek at the Bohemian Hwy bridge in Freestone
SAL-85	VFFR	Salmon Creek at Bodega Hwy bridge adjacent to Valley Ford-Freestone Road
NOL-20	NOL	Nolan Creek at Bodega Hwy bridge
SAL-55	BOD	Salmon Creek at Bodega Hwy bridge at the upstream end of the town of Bodega
SAL-50		Salmon Creek at the Salmon Creek Road bridge
TAN-20	TAN	Tannery Creek off of Tannery Creek Road on private property
FAY-10	FAY	Fay Creek at Salmon Creek Road bridge
COL-10	COL	Colman Creek at Salmon Creek Road bridge

[1] Water Year 2011 extends from October 1, 2010 through September 30, 2011.

Figure 1: Salmon Creek Watershed map with GRRCD monitoring stations



Water Quality Objectives/Targets

As with previous GRRCD evaluations of water quality in the Salmon Creek Watershed, the Water Quality Objectives or comparative thresholds are listed in the table below. The North Coast Regional Water Quality Control Board (NCRWQCB) has not set numeric standard water quality objectives for the Salmon Creek Watershed, which falls into the "Bodega Bay" water body description (NCRWQCB, 1994). Statewide criteria set by the US Environmental Protection Agency (EPA), Region 9(US Environmental Protection Agency, 2000) and/or the objectives for the nearby Russian River water body by the NCRWQCB (NCRWQCB, 1994) have been used as targets and are outlined in Table 2 below.

Table 2. Water Quality Objectives.

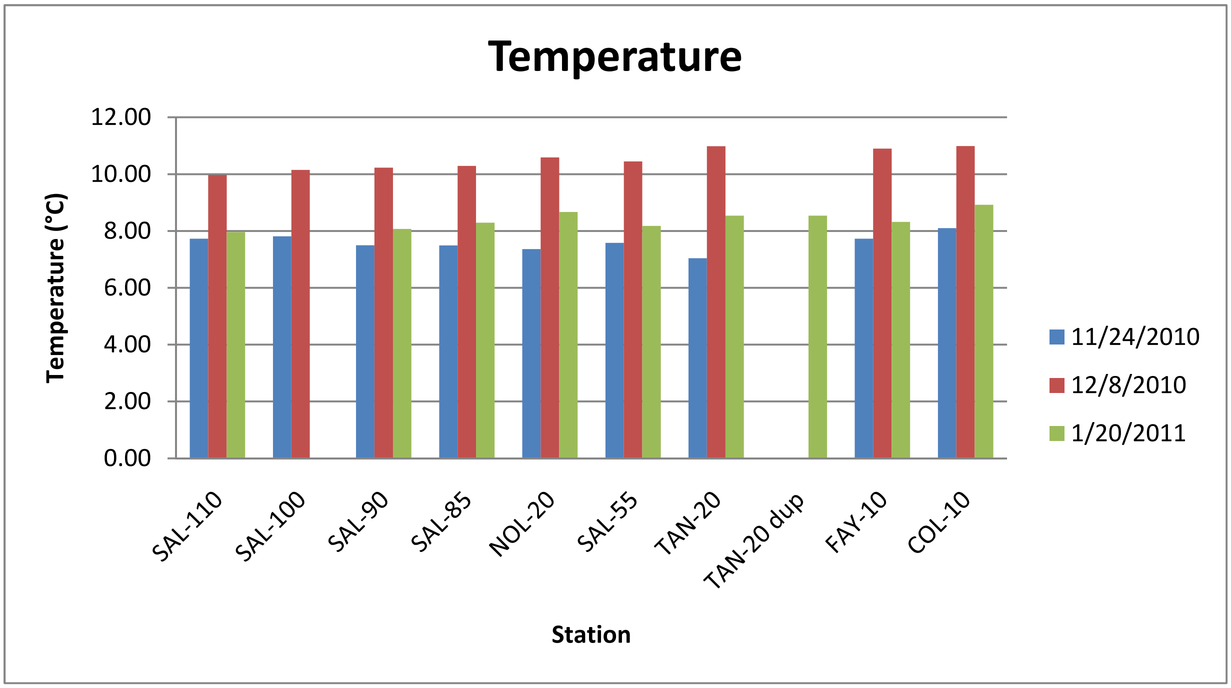
Parameter (reporting units)	**Water Quality Objectives**	**Source of Objective**
Dissolved Oxygen (mg/l or ppm)	Not lower than 7	North Coast Region Basin Plan Objective for Cold Water Fish
pH (pH units)	Not less than 6.5 or more than 8.5	General Basin Plan objective
Water Temperature (°C)	Not to exceed 21.1	USEPA (1999) 20-22 range, supported by Sullivan (2000)
Conductivity (uS)	None established	N/A
Nitrate as N (mg/l)	Not to exceed 1.0	
Ammonia-Nitrogen (mg N/l)	Not to exceed 0.5	USEPA (2009)
Orthophosphate (mg/l)	Not to exceed 0.10	USEPA(2000)
Turbidity	1.Not to exceed 25 NTUs during low flow; not to exceed 150 NTUs during storm events	GRRCD selected threshold, 1. Supported by Sigler (1984); 2. supported by Newcombe (2003)

Results and Discussion

Temperature

Over the data period, temperature measurements varied from 7.04 to 10.99 °C, none of which exceeded the threshold of 21 °C. Since the collected measurements were grab samples, this information is not conclusive that the stream conditions never exceeded the water temperature objective, though considering the winter ambient air conditions it isn't likely. The highest temperatures were observed during highest flow conditions during the December 8 storm sampling.

Figure 2: Temperature Measurements

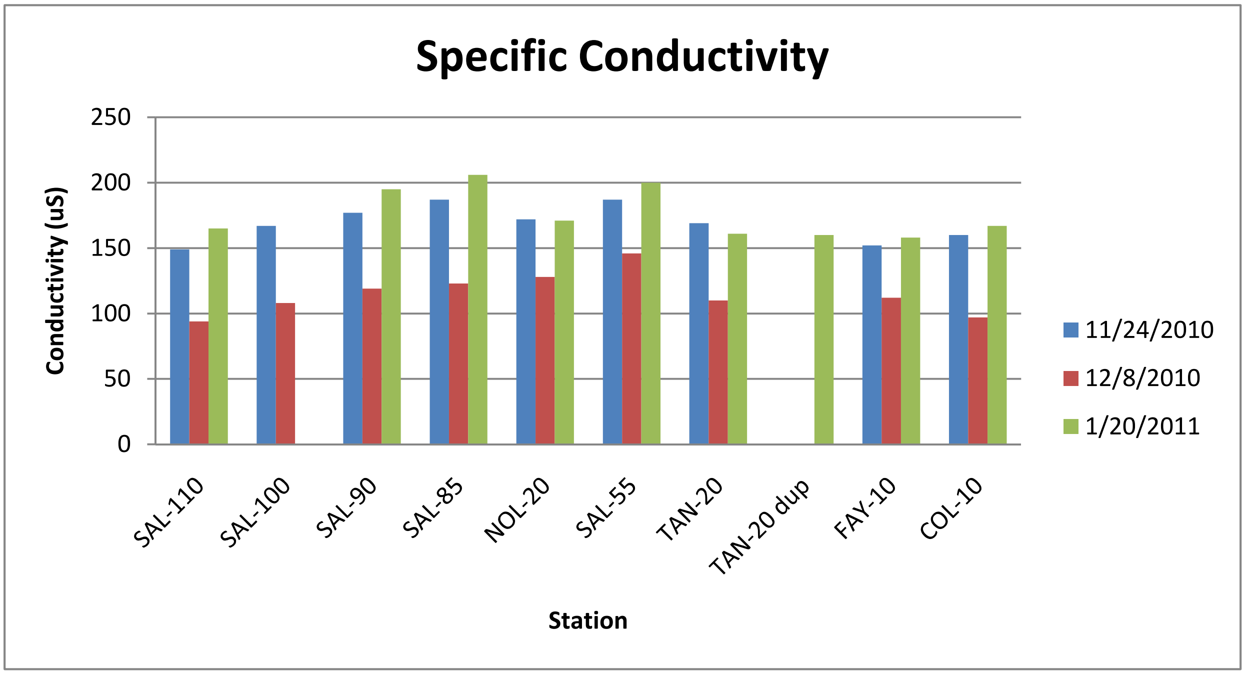


Conductivity

Conductivity is a measure of water's capacity for conducting electricity and is a measure of the ionic (dissolved) constituents present in the sample. While there is no specific water quality objective for conductivity, conductivity can be used as an indicator of pollutant levels.

Over the data period, conductivity ranged from 94 to 206 uS. As expected, specific conductivity levels dropped during the storm event in response to the influx of storm water. Since the conductivity results remained low throughout the storm event, this serves as an indication that there was not delivery of high levels of pollutants.

Figure 3: Specific Conductivity Measurements

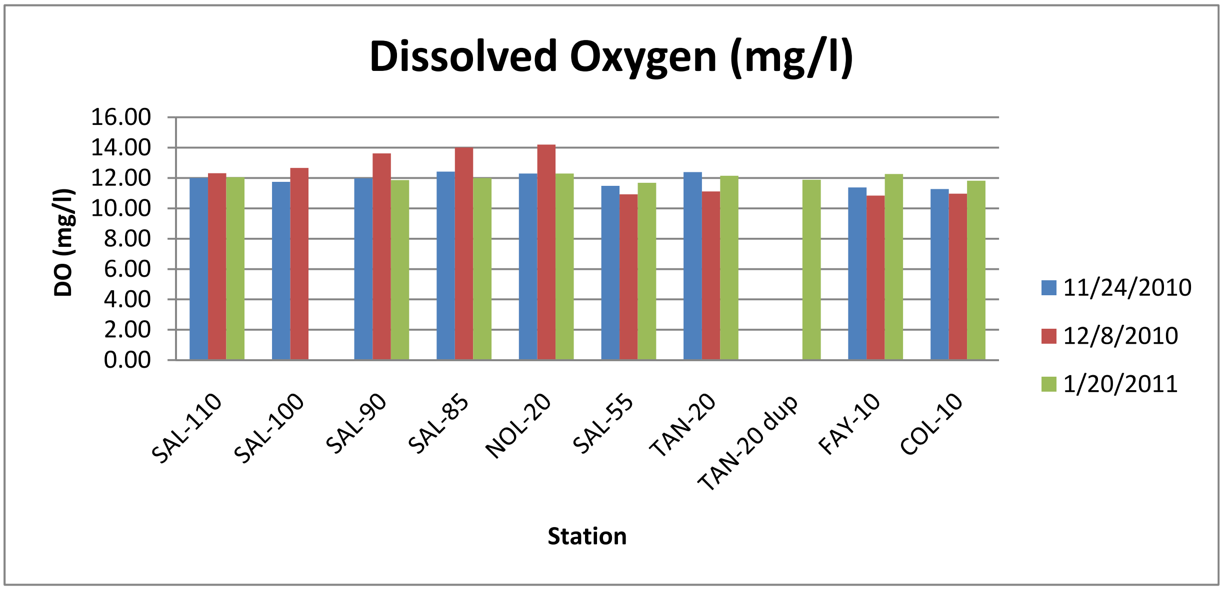


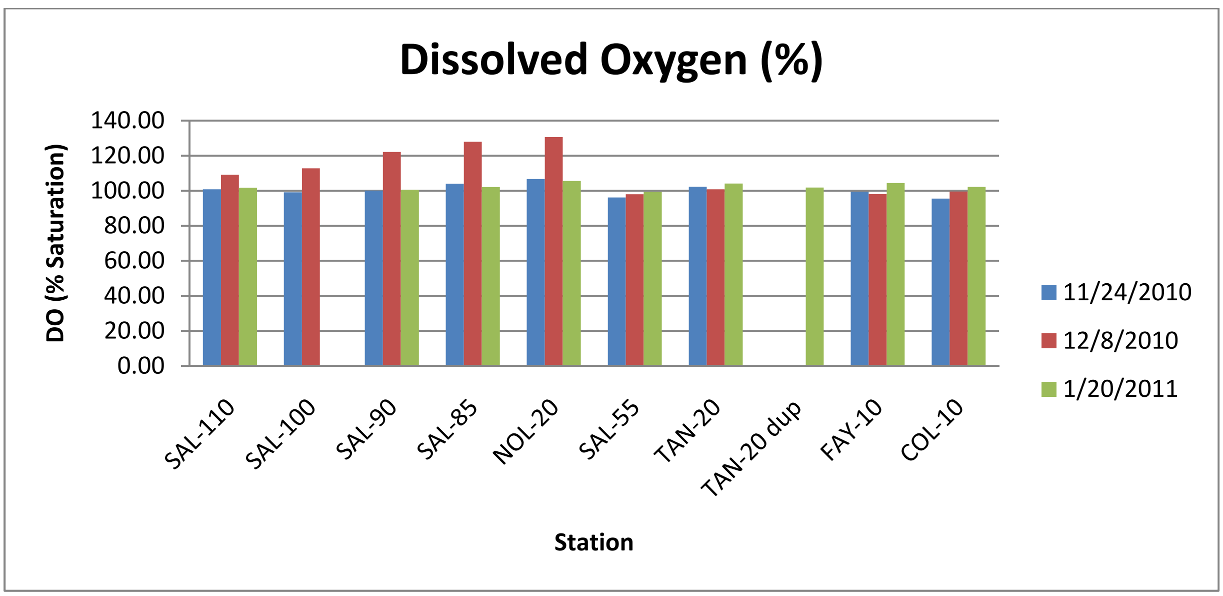
Dissolved oxygen

Dissolved oxygen (DO) refers to the amount of oxygen dissolved in water and available to aquatic organisms. Dissolved oxygen is added to water through diffusion from air, turbulence, and photosynthesis of aquatic plants, and removed through respiration of aquatic organisms, decomposition of organic material, and other chemical reactions that use oxygen.

As expected during winter flow conditions, dissolved oxygen levels met water quality objectives and remained high throughout the sampling period. Super-saturated conditions exceeding 100%, and ranging from 120% to 130%, were measured during the peak flows of the 12/8/10 storm event. Due to the high stream flow velocities the sonde probe was difficult to submerge, so it is not surprising that turbulent surface conditions measured well above 100% saturation.

Figure 4: Dissolved Oxygen Measurements



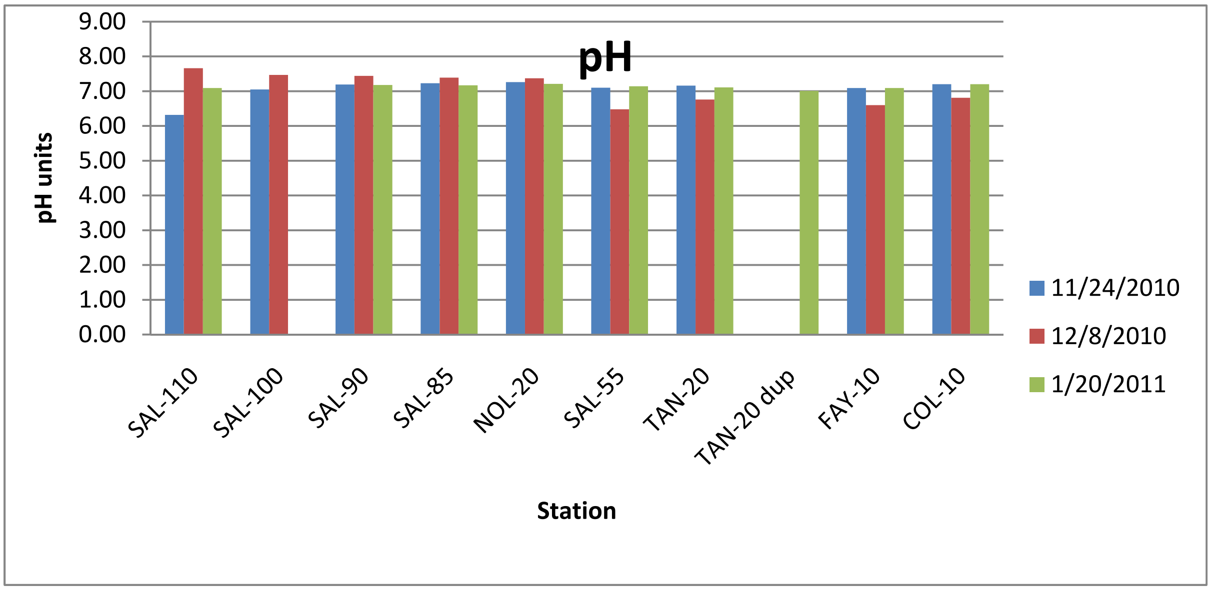


pH

pH refers to the concentration of hydrogen ions in water and determines the acidity or alkalinity of water. Natural pH levels are affected by geology, vegetation, and soil types in the streambed and surrounding the stream, and the availability of carbon dioxide. Changes in pH can have critical effects on water chemistry and the biological systems dependent on the aquatic environment. For example, the solubility and toxicity of metal compounds and nutrients changes greatly with pH.

pH measurements generally fell within the Water Quality Objectives with the exception of one acidic result of 6.32 at SAL-110 on 11/24/10. Two weeks later, during the storm sampling event, conditions at the site met water quality objectives. This acidic condition didn't continue downstream to the next station, nor persist during future sampling events.

Figure 5: pH Measurements



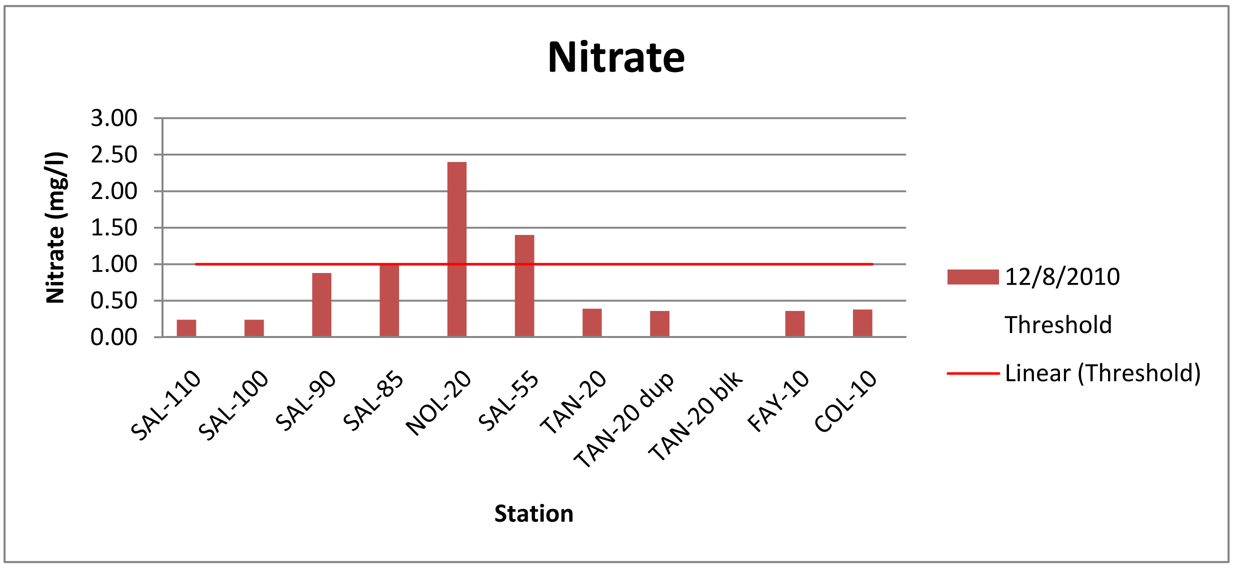
Nutrients

As per the Monitoring Plan for this project, nutrients are measured several times a year to characterize seasonal conditions when they may have water quality impacts. The conditions monitored during the course of this quarterly report include one storm sampling event on December 8, 2010. A second storm sampling event was conducted on February 17, 2011, but the nutrient data was not yet available at the time of this report.

Nitrate (NO_3) is an inorganic form of nitrogen that is soluble and therefore subject to leaching and biological uptake. Nitrate results ranged from 0.24 to 2.40 mg/l, with two occurrences exceeding the 1.0 mg/l Water Quality Objective. There was a general trend of increased nitrate concentration in a downstream direction, with the highest result from NOL-20. A second Salmon Creek mainstem sampling location downstream of the town of Bodega (SAL-50) was added to the 2/17/11 storm sampling event to evaluate if nitrate concentration continues to increase downstream.. It would be desirable to add an additional mainstem sampling location downstream of the Coleman Creek confluence, but no publically accessible locations are currently available.

Total ammonia is composed of two forms; ionized ammonia (NH_4^+), and un-ionized ammonia (NH_3).Un-ionized ammonia, which primarily results from decomposition of manure and other organic debris by microbes, can be toxic to aquatic organisms in small concentrations. The percent of total ammonia in the harmful un-ionized form increase with higher temperatures and pH values. No ammonia was detected at any of the sampling locations during the 12/8/10 sampling.

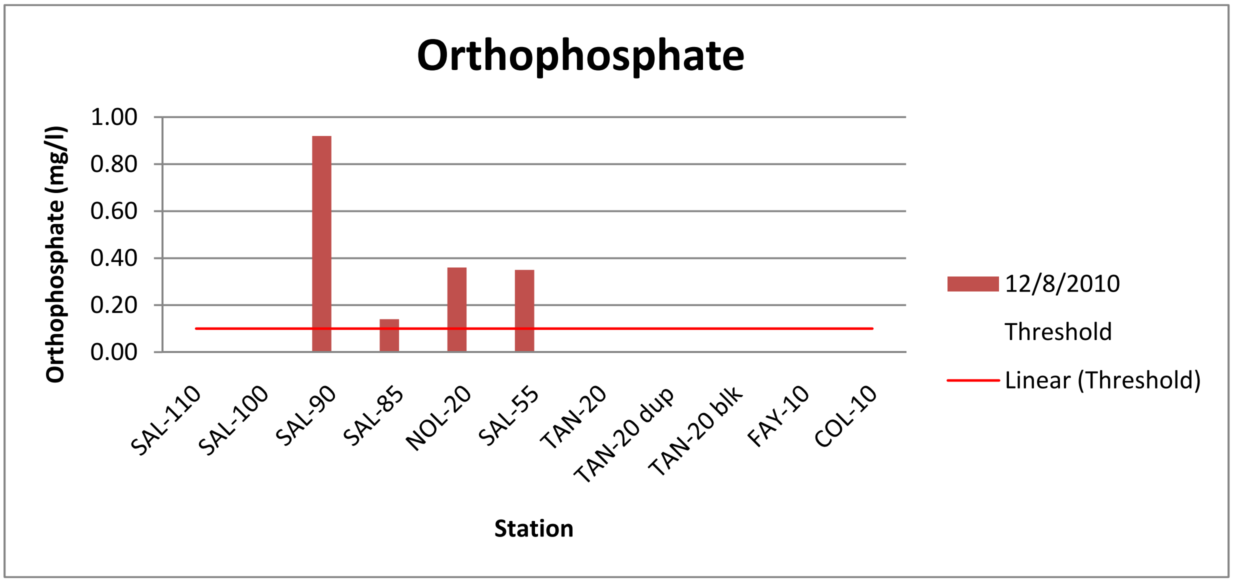
Figure 6: Nitrate Measurements



Nitrate-nitrogen, phosphate and phosphorous are not directly toxic to aquatic organisms but, where sunlight is available, these chemical nutrients act as biostimulatory substances that stimulate primary production. Excessive inputs of these nutrients, known as eutrophication, can result in abundant plant growth and resulting decay which depletes dissolved oxygen and can degrade habitat quality.

Orthophosphate results ranged from <0.02 (not detected) to 0.92 mg/l. Detectable concentrations were measured at four of the nine sites, all of which exceeded the 0.10 mg/l Water Quality Objective. As opposed to the observations of nitrate, the highest orthophosphate concentration was measured near the upstream extent of the sampling area and decreased in concentration downstream. The highest result was observed in the town of Freestone and may be due to soaps and detergents from residential uses. Considering the high flows and low water temperatures, algal growth is not a concern during winter months.

Figure 7: Orthophosphate Measurements



Turbidity and Total Suspended Solids

Turbidity, which can make water appear cloudy or muddy, is caused by the presence of suspended and dissolved matter, such as clay, silt, finely divided organic matter, plankton and other microscopic organisms. Sources of turbidity include soil erosion, streambank erosion, animal waste, road and urban runoff, and excessive algal growth.

Manfred Kittle, DFG releasing an adult coho salmon into lower Salmon Creek on 12/15/2010.

Excess turbidity reduces light, which decreases aquatic plant life, reducing benthic organisms and ultimately fish populations. High turbidity levels increase water temperatures due to suspended particles absorbing heat. High turbidity levels also affect aquatic organisms by causing reduced feeding rates, reduced growth rates, damage to gills, and fatality.

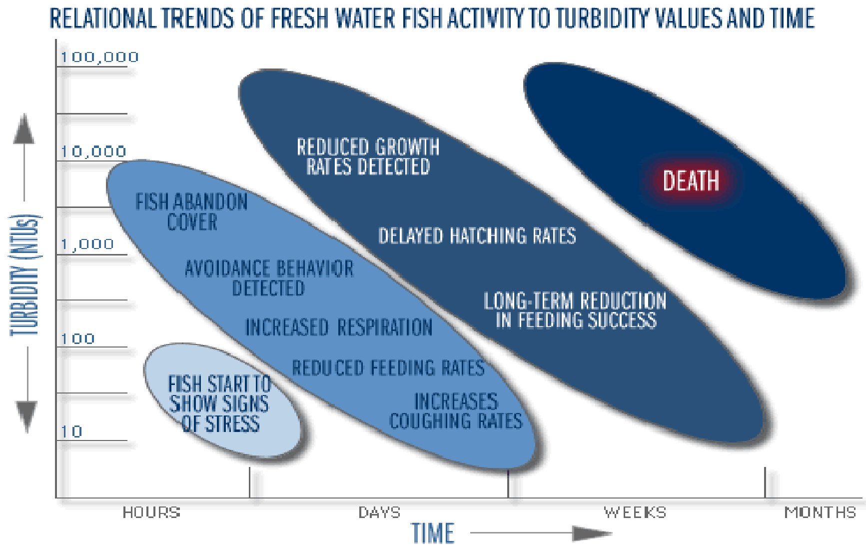
Water quality objectives for turbidity and Total Suspended Solids (TSS) are not definitively established for the Salmon

Creek Watershed. While the North Coast Regional Water Quality Control Board mandates that turbidity levels not be increased more than 20% above naturally occurring background levels (NCRWQCB, 2007), when a background level has not been established (as is the case with Salmon Creek), this objective is difficult to use. Since the recovery of coho salmon is a primary goal for the watershed, clear water fishery objectives have been employed. Newcombe (Newcombe, 2003) described the detrimental impacts to clear water fishes at several turbidity levels. Two turbidity thresholds are depicted on the graphs, 55 NTUs and 150 NTUs. Newcombe states that

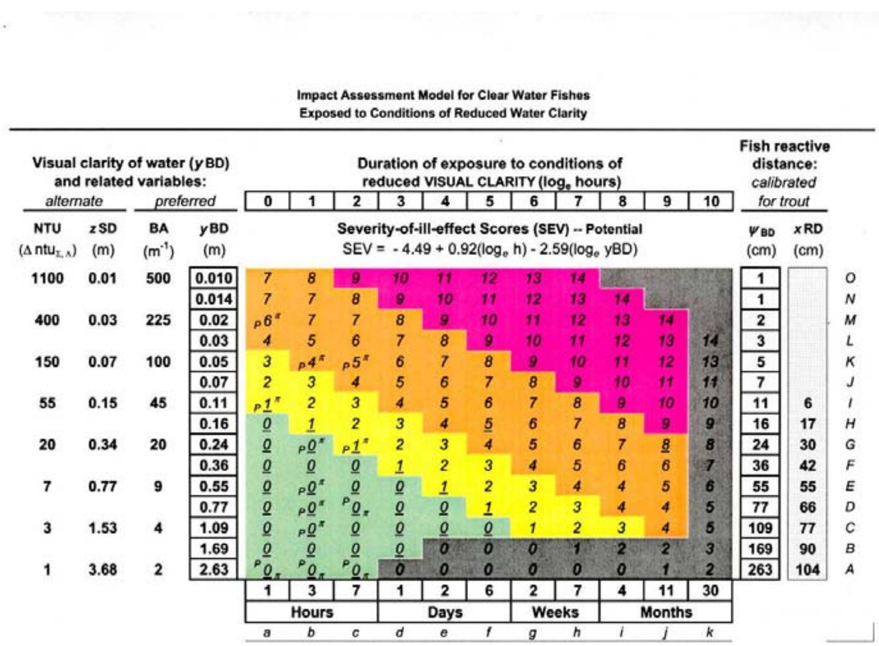
turbidity levels of 55 NTUs caused significant impairment to fish after one day and severe impairment after four months, while turbidity levels of 150 NTUs caused significant impairment after three hours and severe impairment after two weeks.

GRRCD employee, Loren Hulette sampling Fay Creek (FAY-10) during the 12/17/10 storm event.

Figures 8, 9: Representations of impairment relationships between turbidity and fresh water fish



"Figure 8: Idealized model of fish response to increased suspended sediments. Schematic source of above figure is unknown; it is a generic, un-calibrated impact assessment model based on Newcombe, C. P., and J. O. T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management. 16: 693-727. Reprinted, with permission, from: http://wow.nrri.umn.edu/wow/under/parameters/turbidity.html" (Berry, 2003).



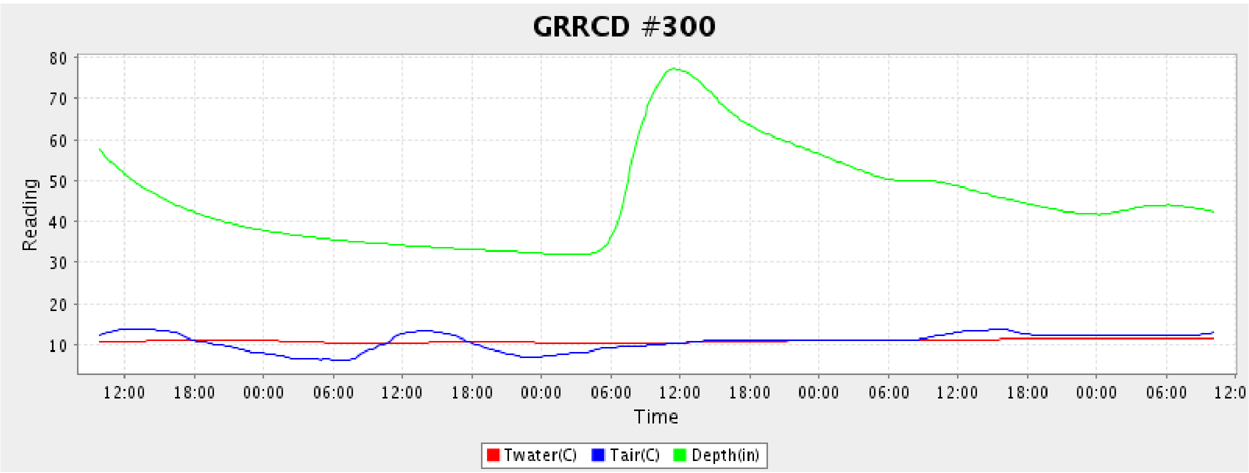
Impact Assessment Model for Clear Water Fishes Exposed to Conditions of Reduced Water Clarity

Visual clarity of water (yBD) and related variables: *alternate*		*preferred*		Duration of exposure to conditions of reduced VISUAL CLARITY ($\log_e$ hours)											Fish reactive distance: *calibrated for trout*		
NTU ($\Delta ntu_{\Sigma,\Lambda}$)	zSD (m)	BA (m^{-1})	yBD (m)	0	1	2	3	4	5	6	7	8	9	10	ψ_{BD} (cm)	xRD (cm)	
				Severity-of-ill-effect Scores (SEV) -- Potential: SEV = - 4.49 + 0.92($\log_e$ h) - 2.59($\log_e$ yBD)													
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	p6*	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	p4*	p5*	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	p1*	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	p0*	p1*	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	p0*	0	0	1	2	3	4	4	5	6	55	55	E
			0.77	0	p0*	p0*	0	0	1	2	3	4	4	5	77	66	D
3	1.53	4	1.09	0	p0*	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	p0*	p0*	p0*	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			

"Figure 9: 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)" (Gold Ridge RCD, 2010).

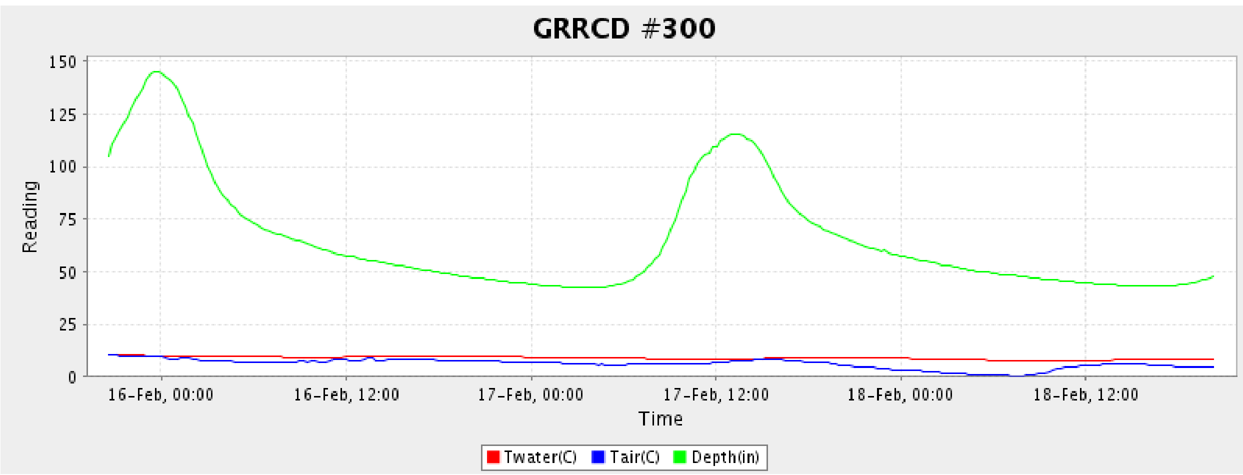
Two storms sampling events are reported here, December 8, 2010 and February 17, 2011. The analytical results from the February 17 sampling event have not yet finalized, but since the turbidity and TSS data makes more sense when compared during storm events, the preliminary results are included in this report.

Figure 10: Hydrograph of Salmon Creek from noonon December 16 to noon December 20, 2010



The hydrograph of the December 8, 2010 storm event illustrates the stream response to the rainfall and resulting runoff. Approximately 1.5" of rainfall occurred on 12/8/10 with a three day cumulative total of 2.7" from 12/6 to 12/8. Sampling occurred between 10:00 and 13:00 and captured peak flows.

Figure 11: Hydrograph of Salmon Creek from midnight on February 16 to noon on February 18, 2011



A second storm sampling was conducted by GRRCD staff during the February 17, 2011 storm event. From the start of the storm cycle on February 14 to 17:00 on February 17, a cumulative 7" of rainfall was measured in Occidental, approximately 2" of which fell during 2/17. This storm flow was right on the heels of a high intensity rainfall and resulting high flow event that occurred from late 2/15 to 2/16. Sampling was conducted on 2/17 from 10:30 to 13:15 and captured peak flows.

Based on the turbidity for all sites sampled during the past quarter, results ranged from 4.69 under winter base flow conditions to 623 NTUs during storm flow conditions. TSS results ranged from 19 mg/l under winter base flow conditions to 440 mg/l during storm flow conditions. As is expected, turbidity levels spiked during peak flows of storm events. After a relatively dry month from mid-January to mid-February, the high intensity storm cycle from 2/15 to 2/17 resulted in high turbidity levels that exceeded the 150 NTU objective at all but the upstream most sampling site and exceeded the 400 NTU threshold (during which exposure for a few hours can cause significant impairment to salmonids) at five sampling sites. The four mainstem Salmon Creek sites showed a trend of increasing turbidity in downstream direction, with the highest measured result at the downsteam-most station, SAL-50. Again, additional mainstem sampling locations downstream of SAL-50 would be instrumental in showing the cumulative impacts of fine sediment in the Salmon Creek Watershed.

Figure 12: Turbidity Measurements

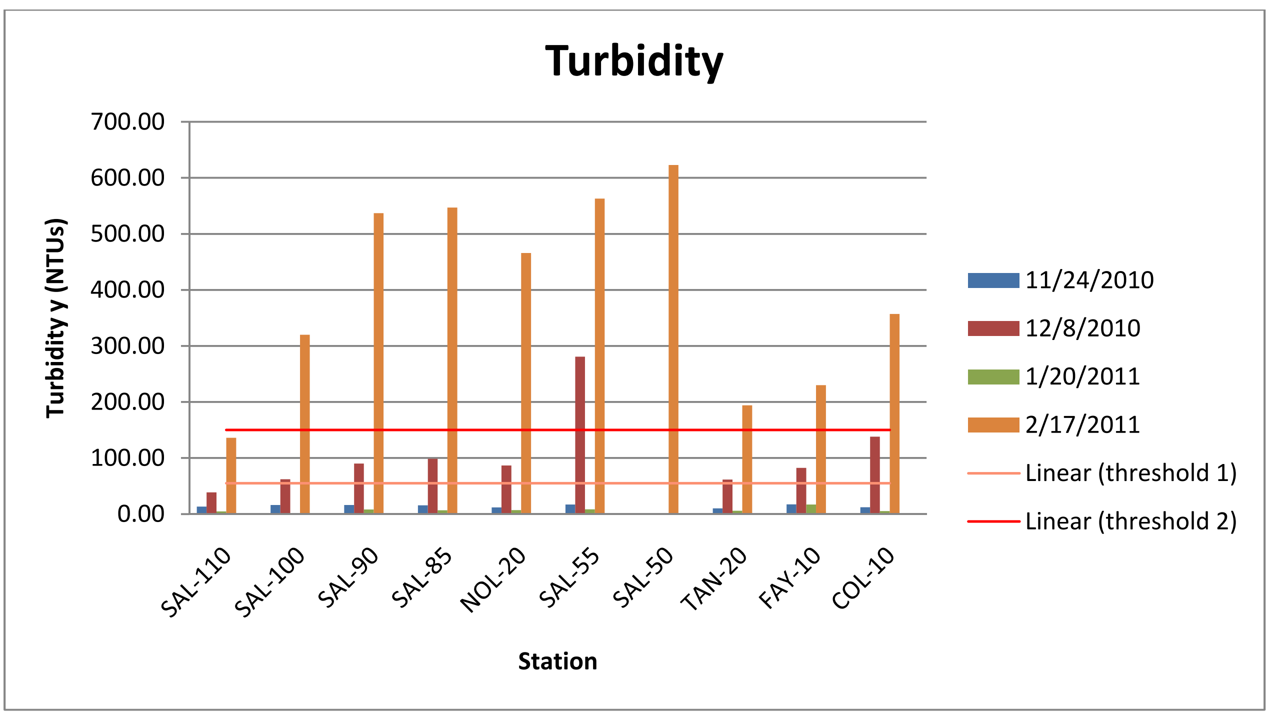
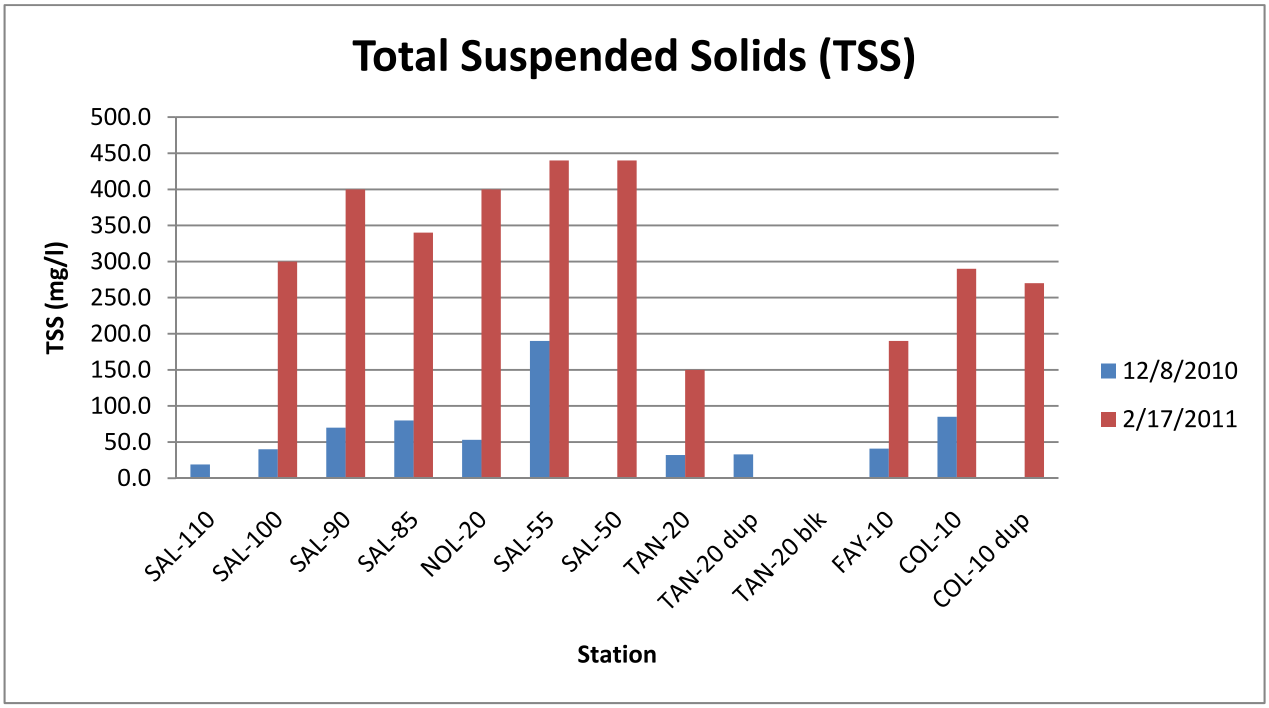


Figure 13: Total Suspended Solids Measurements

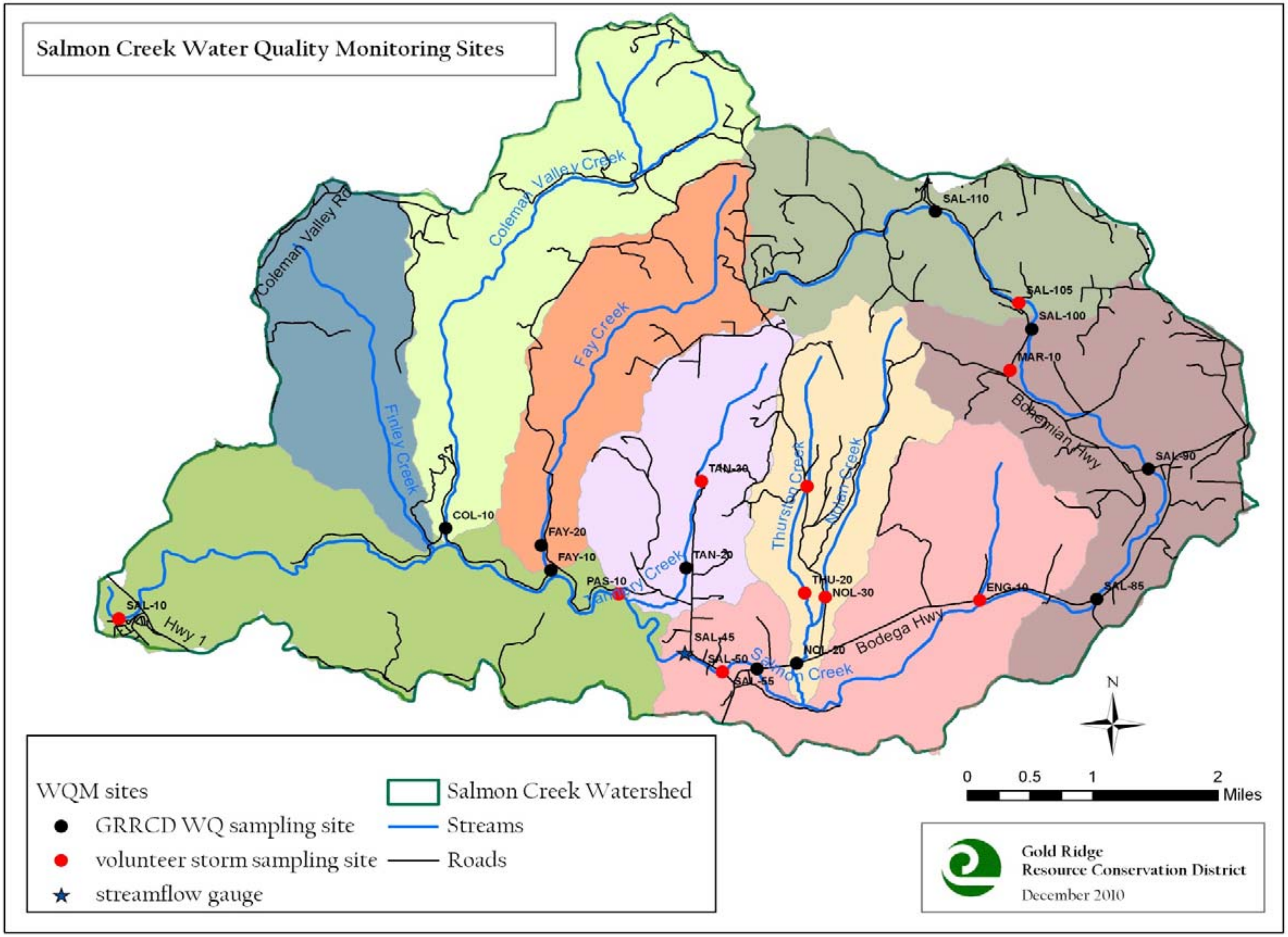


Total suspended sediment concentrations are of concern both due their direct detrimental effects to fish as well as the impacts these sediments have on salmonid eggs when they settle out of the water column into the substrate gravels.

Synoptic turbidity sampling during the December 8, 2010 storm

Because of the episodic nature of storm events and the subsequent stream sediment transport, thresholds should capture not only sediment concentration at peak flows, but also duration and frequency. This can only be done by employing continuous sampling throughout a storm event or season at a number of locations throughout a watershed. Since the requisite equipment isn't currently available to the GRRCD but a knowledgeable group of volunteers is, we took a low tech approach and conducted a synoptic sampling event throughout the December 8, 2010 storm event. Ten people, composed of Salmon Creek Watershed Council volunteer monitors and GRRCD staff, sampled 19 locations (see attached map) throughout the Salmon Creek watershed from 12/7 to 12/9. Since turbidity levels can have both acute and chronic impacts to fish, the storm sampling endeavored to capture not only the peak turbidity levels during peak flows, but also to measure the persistence of the turbidity as flows receded.

Figure14: Salmon Creek Watershed map with GRRCD and Salmon Creek volunteers monitoring stations



The synoptic turbidity storm sampling event, a coordinated sampling at many locations during a single storm event, was designed to yield valuable information about the levels and persistence of turbidity conditions in Salmon Creek and its tributaries. The goals of the sampling event are as follows:

- Continue to document current conditions to allow for comparison with measured baseline conditions. This comparison will provide an ongoing assessment of overall watershed health and document long-term trends in water quality.
- Implement a synoptic turbidity monitoring effort during at least one storm event (coordinated sampling at many locations during a single storm event) to characterize turbidity levels and persistence at a watershed scale throughout a storm cycle.
- Assist with the systematic development and prioritization of watershed restoration projects focused on minimizing turbidity and the delivery of fine sediment from upland sources.

Since overland flow and streamflow response to rainfall depend on the intensity and timing of rainfall events, the sampling event was scheduled after several storm events had occurred. Local experts recommended that synoptic turbidity sampling not occur until a cumulative 8-10″ of rainfall has fallen in the Salmon Creek Watershed, at which time soil saturation conditions are sufficient for overland flow and associated fine sediment delivery (Hammack and Green, personal communication). Storm monitoring rainfall criteria requires a forecasted storm that will deliver 0.5″ rainfall in a 12 hour period and/or 1″ of rainfall in a 24 hour period). The sampling strategy is as follows:

- Synoptic storm sampling will be performed at all sites during one or more storm events. Samples will be collected at as many locations as we have monitors to cover sites within the Salmon Creek Watershed, on both the mainstem and major and minor tributaries.
- Three sets of samples will be collected at each monitoring site: the first during the storm's peak flows (rising limb of the hydrograph); the second approximately 12 hours after the first sample was taken; and the third approximately 24 hours after the first sample was taken (for a total of 3 times at a 12 hour intervals over a 36 hour period).
- Turbidity monitoring is the main goal of the sampling event, and will be taken at all monitored locations. Additional parameters to be measured at as many sites as there is equipment to support include water temperature, conductivity, pH, and dissolved oxygen.

Figure 15: December 8, 2010 hydrograph with the synoptic sampling zones depicted. These sampling zones correspond to the sampling results depicted in Figure 16.

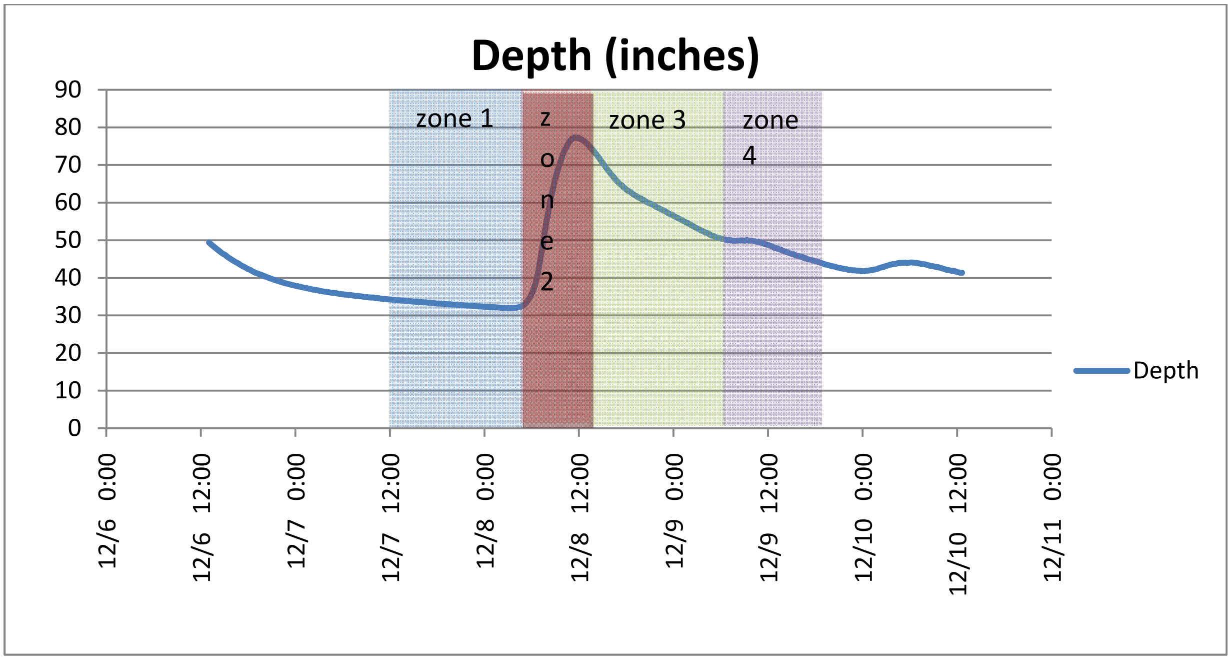
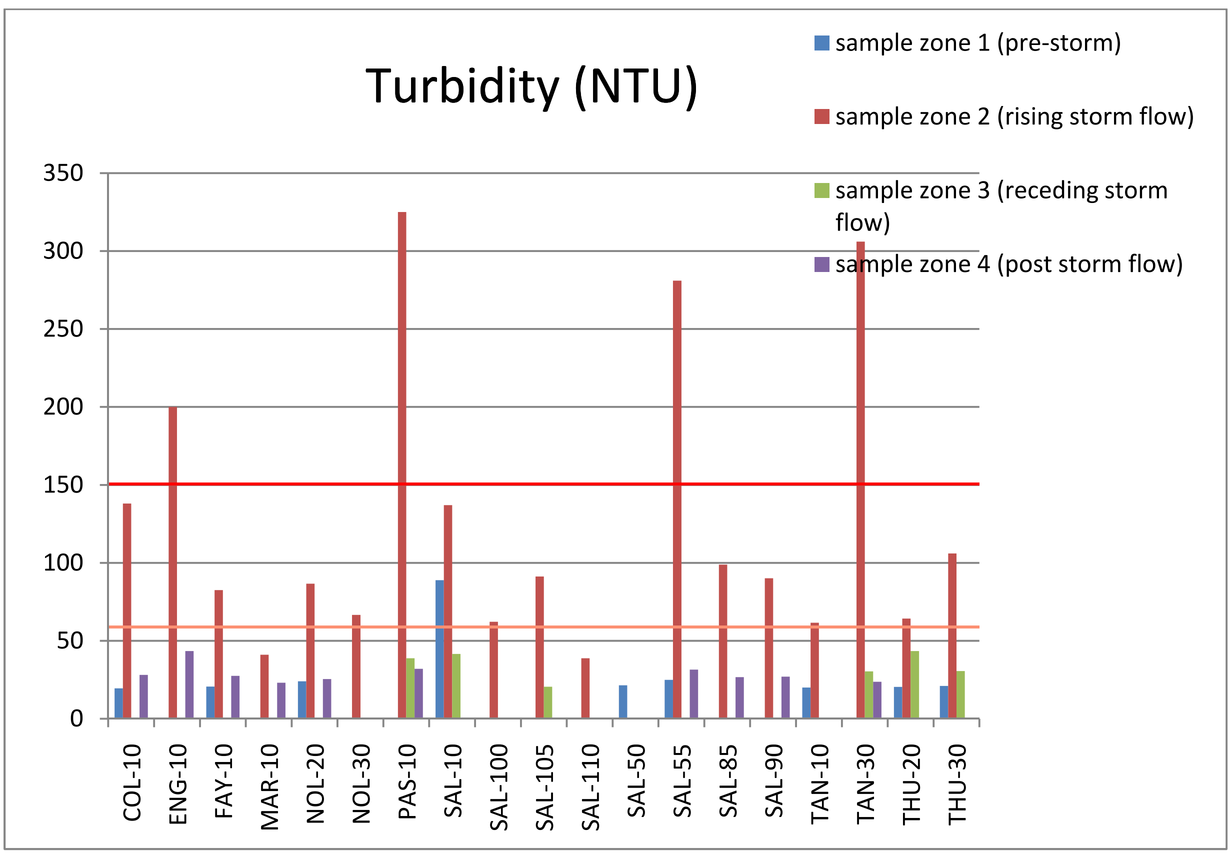


Figure 16: Turbidity measurements taken throughout the December 8, 2010 storm event.



Turbidity samples collected at all stations during the 12/7 to 12/9 synoptic storm sampling

At all sampled locations turbidity levels peaked during the high flow conditions then decreased significantly as flows receded, with all stations meeting the Water Quality Objective within 24 hours after the peak stream flow. Considering the duration of high turbidity conditions is of great concern, the relatively short persistence of high turbidity conditions was a good sign. Additional future events that measure the peak and duration of turbidity levels throughout a storm cycle should be a high priority, particularly for high intensity (a lot of rainfall over a short time period) storm events that occur after an extended dry period.

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