

Russian River Middle Reach Stormwater Survey

Winter 2004 to Spring 2005

Final Report

April 30, 2005



Healdsburg Railroad Bridge February 16, 2004 Peak Flow Sampling Event

A Project for the Community Foundation of Sonoma County, acting as fiscal sponsor for the Russian River Watershed Council

By
Don McEnhill
Russian Riverkeeper

Staff of the
Friends of the Russian River
PO Box 1335
Healdsburg, CA 95448
(707) 433-1958
don@russianriverkeeper.org

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Abstract/Executive Summary

The Community Foundation of Sonoma County, acting as fiscal sponsor for the Russian River Watershed Council, contracted with Russian Riverkeeper to perform stormwater sampling in the Middle Reach of the Russian River between Healdsburg and Forestville in 2004/2005. Six sampling stations were chosen to represent the 4 main tributary inputs to the middle reach with upstream and downstream controls on the Mainstem. A total of 216 data points were collected in 4 sample collection events that represented a 10-year and a 1-year peak flow and two smaller run-off events.

The survey results show that higher flows contain higher concentrations of stormwater pollutants. The flood event of 2/16/04 produced the highest levels pollutants including Simazine, an herbicide, that was detected in 10 of 12 samples that day. Temperature, Dissolved Oxygen, Conductivity and pH showed good to very good water quality over the four events. Poor water quality was exhibited by the nutrients; Ammonia-Nitrogen, Nitrate and Orthophosphate, and by Turbidity and Simazine.

Background and Project Purpose

The Community Foundation of Sonoma County (Foundation) acting as fiscal sponsor for the Russian River Watershed Council (Watershed Council) received funding earmarked for studying stormwater quality in the Middle Reach of the Russian River. The Foundation and Watershed Council representative Fred Euphrat developed a scope of work for the project and contracted with Friends of the Russian River (FORR) to implement the project.

The scope of work entailed:

- Providing project direction and staffing,
- Training and supervision of monitoring crews,
- Provision of water sample collection materials and laboratory analysis and field data collection devices
- Interpreting and providing a written report of the water monitoring data
- Distributing the written report

Methods

Study Questions

The Watershed Council representative and FORR developed three study questions:

- What is the midwinter quality of stormwater in the Russian River and Middle Reach tributaries?
- What are the dominant factors affecting the stormwater quality?
- How does stormwater quality change over the period of a winter and spring?

Sampling Locations

Six locations were prescribed by the scope of work listed below and in the map in Appendix A

Waterbody	Station Name	Map ID	Station ID	Station Location	Latitude	Longitude
Russian River	Healdsburg Railroad Bridge	1	RR1	West Bank of RR at Front St. - walk under RR bridge to bridge foundation platform	38.60533	-122.86079
West Slough	West Slough/ Foss Creek	2	WS1	Westside Road to Kinley southbound, park at bridge by Oppermans, downstrm side of bridge	38.60284	-122.86879
Dry Creek	Lambert Bridge	3	DC1	Lambert Bridge Rd upstream side on west bank	38.653791	-122.92744
Dry Creek	Westside Road Bridge	3A	DC2	Westside Road Bridge Upstream side	38.60427	-122.88239
Mill Creek	Mill Crk at Westside Rd	4	MC1	Westside Rd bridge - downstream side	38.58235	-122.88034
Porter Creek	Porter at Westside Rd	5	PC1	Westside Rd. bridge - downstream side	38.517753	-122.890142
Russian River	Wohler Bridge	6	RR2	Wohler bridge - between bridge supports, upstream side	38.5075	-122.88329

The locations were chosen to cover the four major tributaries to the Middle Reach and to have an upstream and downstream control point that would bracket the four tributaries. One tributary, Foss Creek/ West Slough contains a large portion of urban run-off from Healdsburg and some run-off from vineyards in the Northeast end of Dry Creek Valley. The other stations are predominantly rural with varying mixes of vineyards, timberlands, rural residents and undeveloped land. Porter Creek and Mill Creek have the most undeveloped land area. Dry Creek is the largest tributary followed by Mill and Porter Creek and Foss Creek/West Slough is the smallest.

Sample Timing

Our intent was to capture a winter, spring and mid-winter run-off event with varying flow heights. Ideally we wanted to sample in a peak flow (5-10 year event), a moderate flow (1-year) event and an average winter event. Our timing for sampling during a storm event was focused on the tributary peaks rather than the Mainstem due to the large influence on Mainstem flows from outside the study area in the Middle Reach.

Field and Lab Parameters

The parameters were pre-selected by RRWC to match the RR First Flush and Snapshot Day using similar protocols so we could compare results to those studies. Field measurements collected were Temp, pH, electrical conductivity, turbidity and dissolved oxygen. Laboratory parameters we sampled for were Ammonia-Nitrogen, Nitrate and Orthophosphate (nutrients) and a semivolatile organic compound screening able to detect hundreds of pollutants that include many pesticides and herbicides.

Flow information was collected from USGS gauges on the Russian River at Healdsburg $\frac{3}{4}$ mile upstream from the Healdsburg sample collection station and the Hacienda Bridge about 5 miles downstream from the Wohler Bridge station. The Dry Creek Stage stream height gauge was used estimate flow on Dry Creek at Westside Road. The other three stations were measured by float trails and creek water surface relative to fixed points on bridges combined with cross section measurements after each event. Rain data was gathered from the CDEC rain gauge station in Venado in the headwaters of Mill Creek in the center of the middle reach tributary headwaters.

Field measurements were collected using a Hydrolab Quanta electronic meter and probe that were calibrated before and after each sampling event to determine the accuracy of each result. Data quality objectives are listed in Table 1.1. The EQI lab at UNC-Asheville analyzed nutrients using EPA methods described below in Table 1.2. KPrime Labs of Santa Rosa performed the Semi-volatile analysis using EPA method 8270c that employs Gas Chromatography and Mass Spectrometry or GCMS, table 1.3 lists the data quality objectives.

Flow was measured by USGS stream gauges or where not available by measuring cross sections of the channel and performing float trails and performing calculations to determine flow in cubic feet per second.

Data Quality Objectives

Table 1.1 Data Quality Objectives for Conventional Water Quality Parameters

Parameter	Method/range	Units	Detection Limit	Sensitivity	Precision	Accuracy	Completeness
Temperature	Elect. meter (-5 to 50)	$^{\circ}$ C	-5	+/- 0.2 $^{\circ}$ C	\pm 0.5 $^{\circ}$ C	\pm 0.5 $^{\circ}$ C	100%
pH	Elect. meter (range 2 to 12)	pH units	2.0	+/- 0.2 unit	\pm 0.5 units	\pm 0.5 units	100%
Conductivity	Elect. meter 0 to 1000 μ S/cm	μ S/cm	0.1	1.0 μ S/cm	\pm 5%	\pm 5%	100%

Dissolved Oxygen	Elect. meter 0 to 50mg/L	mg/L	0.1	+/- 0.2 ≤ 20mg/L	+/- 10%	+/- 10%	100%
Turbidity	Elect. meter 0 to 1000ntu	NTU	0.1	0.1	+/- 5%	+/- 5%	100%

Table 1.2. Data Quality Objectives for Nutrients Using Colorimeters or Spectrophotometers

Parameter	Method & Range	Unit	Detection Limit	Sensitivity	Precision	Accuracy	Completeness
Ammonia Nitrogen	Nessler method	mg/l	0.05	0.01	±0.2 (<2.0) ±10% (>2)	±0.2 (<2.0) ±10% (>2)	80%
Nitrate Nitrogen	Cadmium reduction	mg/l	0.05	0.01	±0.2 (<2.0) ±10% (>2)	±0.2 (<2.0) ±10% (>2)	80%
Ortho-Phosphate	Ascorbic acid	mg/l	0.07	0.01	±0.2 (<2.0) ±10% (>2)	±0.2 (<2.0) ±10% (>2)	80%

Table 1.3 Data Quality Objectives for Semi-Volatile Organics

Parameter	Precision	Accuracy	Recovery	Completeness
Pesticides	Standard Reference Materials (SRM, CRM, PT) within 95% CI stated by provider of material. If not available then with 50% to 150% of true value	Field replicate or MS/MSD ± 25% RPD. Field replicate minimum.	Matrix spike 50% - 150% or control limits at ± 3 standard deviations based on actual lab data.	80%

Survey Results

Table 1-5 Middle Reach Stormwater Survey Results

Station ID	DATE	TIME	Temp	Cond	DO	pH	Turbidity	Ammonia Nitrogen	Nitrate Nitrogen	Ortho-Phosphate	Flow	SVC Panel (Simazine)
			Celsius	uS	mg/L	pH	NTU	mg/L	mg/L	mg/L	cfs	µg/L
RR1	2/16/04	14:42	10.79	141	9.87	7.34	1231	6.08	2.1	0.39	8840	2/ 2.09**
WS1	2/16/04	15:13	11.66	64	9.09	6.84	551	0.58	2.6	0.47	1377	1.97/1.80
DC1	2/16/04	15:50	11.48	74	9.25	7.08	1077	4.75	2.4	0.24	3661	1.451.50
MC1	2/16/04	16:50	11.23	72	9.41	7.44	687	3.42	1.1	0.22	1315	ND/ ND
PC1	2/16/04	17:19	11.8	92	9.05	7.25	627	3.00	2.6	0.50	432	0.59/ nm
RR2	2/16/04	17:44	11.28	120	8.94	6.71	990	4.42	1.6	0.39	15600*	2.1/2.21
RR1	12/27/04	16:24	9.98	120	10.09	7.37	552	nm	nm	nm	12700	1.01
WS1	12/27/04	13:36	9.93	135	9.64	6.89	147	nm	nm	nm	342	ND
DC1	12/27/04	14:06	10.39	126	10.22	7.16	160	nm	nm	nm	2630	ND
MC1	12/27/04	14:30	10.31	99	11.08	7.01	117	nm	nm	nm	604	ND
PC1	12/27/04	14:59	10.56	123	10.14	7.39	116	nm	nm	nm	203	ND
RR2	12/27/04	15:12	9.78	133	9.93	7.28	504	nm	nm	nm	16700	ND
RR1	2/28/05	9:19	10.66	155	10.83	7.37	571	0.33	2.0	0.17	6060	nm
WS1	2/28/05	9:58	12.33	241	9.43	6.61	97.7	0.20	1.5	0.17	nm	nm
DC1	2/28/05	10:41	12.34	240	9.40	6.69	98.1	0.28	1.1	0.45	1600	nm
MC1	2/28/05	10:59	11.49	146	11.33	7.13	61.8	0.14	0.2	0.06	nm	nm
PC1	2/28/05	11:33	12.18	170	10.75	6.95	66.2	0.17	0.4	0.12	nm	nm
RR2	2/28/05	11:51	11.29	158	10.79	7.27	519	0.19	0.3	0.14	9680	nm
RR1	3/19/05	8:00	13.18	266	9.95	7.75	71.8	0.23	0.5	0.11	884	
WS1	3/19/05	6:23	12.92	105	9.95	6.61	308	0.59	1.9	0.64	413	
DC2	3/19/05	6:49	12.09	148	10.82	7.03	206	0.37	1.4	0.38	780	
MC1	3/19/05	7:03	12.13	118	10.86	7.41	305	0.48	1.5	0.28	595	
PC1	3/19/05	7:27	12.27	139	10.28	7.5	305	0.52	1.9	0.26	160	
RR2	3/19/05	7:38	12.95	213	9.87	7.62	142	0.27	0.8	0.25	3540	

nm= Not Measured/ ND= Not Detected/ *Measured by USGS at Hacienda Bridge 4 miles downstream
 ** duplicates

Table 1-6 Water Quality Objectives for RR First Flush & Snapshot Day applied to Results

MRSS Parameter	WQO's ¹	Number of Samples	Number with Exceedances	Percent Exceeding WQO's	Min Result	Max Result	Mean	Areas of concern
Conductivity us/cm	320 abv Laguna ²	24	0	0%	64	266	132.7	None
pH	≥ 6.5, ≤ 8.5	24	0	0%	6.61 (2)	7.75	7.15	None
Water Temp (°C)	≤ 22	24	0	0%	9.78	13.18	11.31	None
Dissolved Oxygen mg/L								
Turbidity (NTU)	≤ 20	24	24	100%	61.8	1231	285.12	only 4 under 100
Ammonia-N (mg/L)	≤ 0.50	18	8	44%	0.14	6.08	0.63	5 over 1.0mg/L
Nitrate (mg/L)	≤ 1.0	18	13	72%	0.2	2.6 (2)	1.16	5 over 2mg/L
Ortho—Phosphate (mg/L)	≤ 0.10	18	17	94%	0.06	0.64	0.25	9 over 0.25mg/L
Simazine (µg/L)	4.0	18		%	ND (

1. Water Quality Objectives sources: Cond, pH, Temp from North Coast Regional Water Quality Board Basin Plan; Turbidity, Ammonia, Nitrate, Ortho-phosphate, Simazine from EPA MCL.

2. Refers to locations above the confluence with Laguna de Santa Rosa (Mark West Creek & Mainstem RR) or below the confluence. All creeks draining into Laguna and Mark West Creek are “below”.

Discussion

Sampling Events

In the 12/27/04 event the flow criteria was met but we knew our nutrient lab at UNC Asheville was closed over the holidays. We attempted to analyze the nutrients in our own lab but could not due to reagent or standard degradation. Although our reagents and standards were within expiration our calibration curve results were well out of the acceptable range. The decision was made to conduct a separate sampling event to collect additional nutrient samples and field measurements except for flow. This additional event was the 2/28/05 sampling event. The final event was 3/19/05 and a full suite of parameters was analyzed, the only change in the 3/19/05 event was a relocation of the Dry Creek sampling station from Lambert Bridge downstream 4.5 miles to the Westside Road bridge closer to the confluence with the Russian River. The relocation was prompted by a large influence from Warm Springs Dam at the time that would have dominated the Lambert Bridge station, moving downstream allowed a larger percentage of run-off to be sampled.

Hydrology

5 to 10-year Peak Flow Event - 2/16/04

The 2/16/04 event consisted of 4.32 inches over 13 hours, a heavy rain event. Based on observation of debris depositing on tributaries we know our sample collection for the tributaries was near the peak of the hydrograph for this run-off event. The hydrograph is a graph depicting a streams response to a rainfall event. The sample timing coincided with relatively low Mainstem flow to tributary flow as the Mainstem responded with its peak about 12 to 18 hours later. The next afternoon the tributaries had greatly receded but the Mainstem was finally in flood.



Picture of flooded middle reach vineyards 2/16/04

1- year Peak Flow Event - 12/27/04

The 12/27/04 event had much more proportionate levels of flow between the Mainstem and the tributaries and the sampling was preceded by 2.76 inches of rain in 24 hours. The sample timing on all stations was just past the peak of the hydrograph.



Station RR1- Hbg average storm 2/28/05



Station RR2 at Wohler Bridge on 2/28/05

Average Stormwater Events - 2/28/05 & 3/19/05

The 2/28/05 event was the smallest rain event and produced 1.44 inches of rain in 24 hours. This event was intended mainly to gather the nutrient samples we missed in the previous event so we did not measure flow on the non-gauged stations. Looking at debris flows and rainfall patterns we believe

these samples were taken about 6 hours past the peak of the hydrograph on the tributaries. The final 3/19/05 event consisted of 2.88 inches over 24 hours and sample collection occurred at or just prior to the smaller tributary peaks.

Data Quality

The instrument used to measure the field parameters was calibrated before and after each sampling event and the accuracy was calculated. All field measurements were well within accuracy objectives listed in Table 1.1. A replicate field measurement was taken with each field measurements to assess measurement precision, and all reported results meet the precision objective in Table 1.1

For laboratory analysis parameters all holding times were met.

The UNC Asheville EQI laboratory analyzed the nutrient samples and used a calibration curve and batch duplicates to assess precision and accuracy. All data quality objectives were met. The Semi-Volatile Organic panel screening data met data quality objectives as well.

Data completeness objectives were easily met with 100% completeness over the four events.

Conclusions

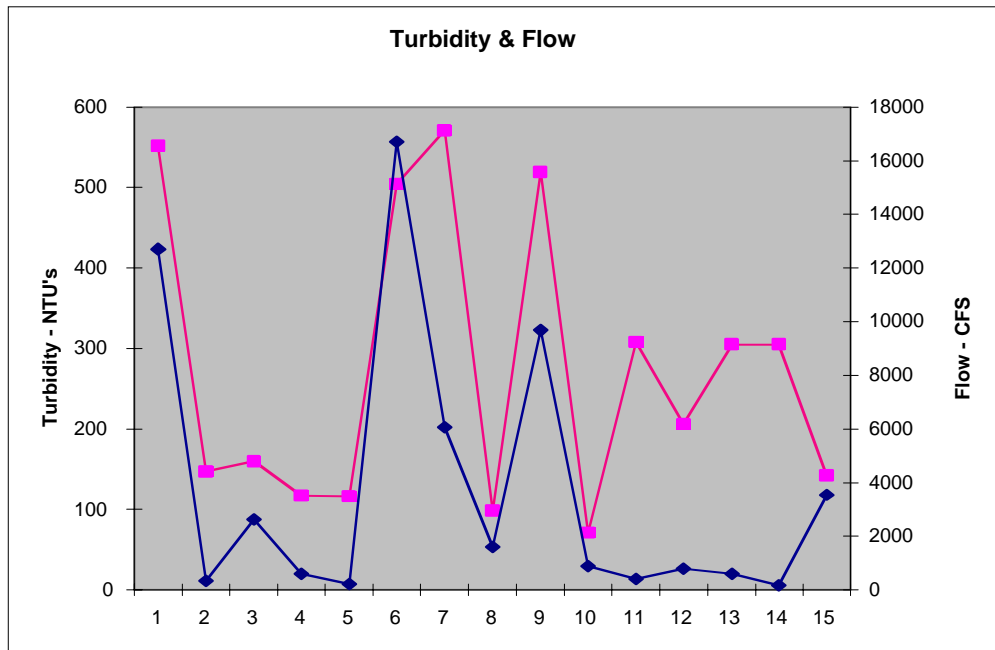
The reader should bear in mind that the Data set is limited by number of samples and the stormwater focus giving us a couple snapshots in time and shouldn't be extrapolated to every day conditions.

What is the midwinter quality of stormwater in the Russian River and Middle Reach tributaries?

According to our data set midwinter stormwater quality is mixed some physical parameters are very good while many of the chemical parameters were poor. Temperature, Dissolved Oxygen, pH and Conductivity were well within water quality objectives. Turbidity was very poor from a standpoint of salmonid recovery but sediment impairment is well acknowledged in the Russian River watershed. Nutrient concentrations were also poor with the majority of Nitrate and Orthophosphate results over Water Quality Objectives. The implications of elevated nutrients are negative for salmonid recovery as water quality favors plants over fish. Although we found Simazine below EPA Maximum Contaminant Levels of 4.0 it is alarming to find 50% of that level in peak flow events, when significant dilution occurs.

What are the dominant factors affecting the stormwater quality?

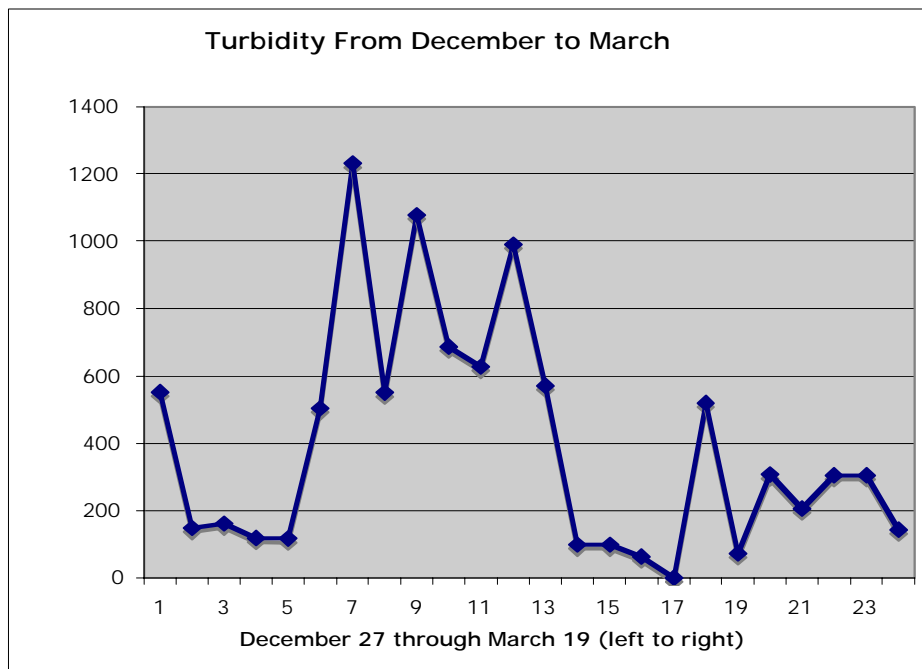
Stream flow levels appear to be one of the dominant factors affecting stormwater quality in the Middle Reach. The peak flow event on 2/16/04 resulted in the highest concentrations of pollutants across all parameters. In particular, nutrients were far higher in the peak flow event than the other events. High turbidity correlated well with higher flow events in this data set as it does in data from Sonoma County Water Agency continuous monitoring instruments deployed on the Mainstem upstream from Healdsburg. Rainfall intensity appears to be a factor in pollutant delivery as the 2/16/04 event was not only the highest rainfall total but the highest per hour rain rate. Using turbidity as a proxy for pollutants we can see in graph 1 that flow is the greatest factor for turbidity.



Graph 1: Flow (pink) and turbidity (blue) correlation over 4 events

How does stormwater quality change over the period of a winter and spring?

The range of sampling dates over the survey was December 27 to March 19th a period of 80 days. The average rainfall season averages to roughly 130 days. Our window was big enough to partially answer this question but our sample set size is very limited in order to answer this question with any certainty. Regardless, looking at this data set, it is not apparent that seasonality has a significant impact on water quality. The higher turbidity didn't correlate to season, whereas it did correlate with flow.



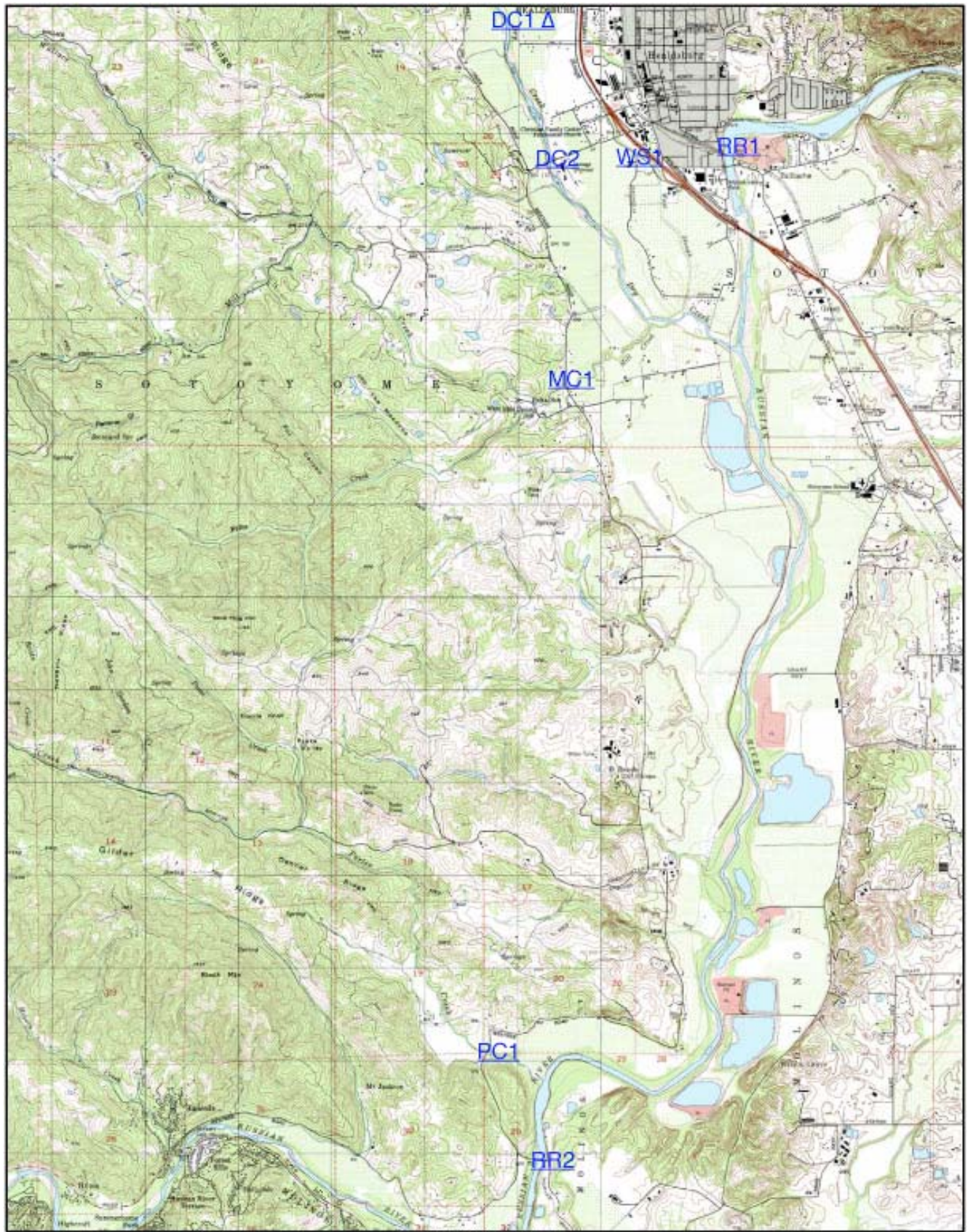
Graph 2: Turbidity levels from 4 sampling events displayed by month

Recommendations and Future Steps

This data set further reinforces the need for erosion control to reduce sediment delivery to streams. Erosion control is a vital restorative measure. Benefits such as reducing turbidity and total suspended solids are needed to improve conditions for endangered fish but also reduce fouling to municipal and domestic wells. One overlooked benefit of erosion control measures is reduction of sediment bound phosphates. Phosphate is the limiting nutrient in freshwater ecosystems like the Russian River and must be greatly reduced to control nuisance algae and aquatic plants. The detection of Simazine lends more support to efforts by the agricultural community to continue reducing or replacing pesticides and herbicides with more non-toxic controls.

The data set also shows urban stormwater to be a significant source of pollutants when comparing Foss Creek/West Slough with the more rural tributaries. Foss Creek produced the highest average concentration of Nitrate and Orthophosphate in 3 samples sets and had roughly equal turbidity results. Looking at the watershed scale, if we only focus on rural stream restoration without improving urban stream stormwater pollutants we will not make restorative progress but more likely lose ground as more development occurs increasing the volume of urban stormwater over time.

Appendix A: Sampling Station Map



Appendix B: Glossary

Paste in from Talking to Cities and CWT

Term or Word	Definition	Definition source
Accuracy (D1)	How close is our measurement to the real truth: the extent of agreement between an observed value (measurement result) and the accepted, or true, value of the parameter being measured.	CWT
Algae	Rootless plants that grow in bodies of water at rates in relative proportion to the amounts of nutrients available in the water.	CWT
Calibration Adjustment	The action of adjusting the readings of an instrument to have them match a “true” value as represented by known natural conditions or by a Standard Solution. Calibration adjustment is always preceded by an Accuracy Check.	CWT
Calibration	Comparison of a measurement standard, instrument, or item with a standard or instrument of higher accuracy to detect and quantify inaccuracies and to report or eliminate those inaccuracies by adjustments [this definition includes both accuracy checks and calibration adjustments as separated by CWT].	EPA
Chain of Custody	Complete documentation of sample handling from field collection through analysis and storage, including presence of custody seals placed during shipping.	CWT
Characteristic	A catch-all word for: physical attribute, analyte, constituent, substance, property, etc; equivalent to the (misused) sense of the word "parameter". Characteristics are often measured within a medium, and include properties such as acidity (pH) or electrical conductivity, particulates such as suspended solids or bacteria, and analytes such as ammonia or heavy metals.	CWT
Compound	Two or more elements combined; a substance having properties different from those of its separate elements.	CWT
Concentration	The amount of a substance in a given volume of a solution, usually expressed in units of weight (e.g., gram) per unit of volume (e.g., liter).	CWT
Conductivity	A measure of the ability of water to pass an electrical current. Conductivity of water is a function of the concentration and type of dissolved solids such as chloride anions (ions that carry a negative charge) or sodium cations (ions that carry a positive charge).	CWT
Continuous Monitoring	A methodology that utilizes sensors connected to data loggers and provides multiple Results of a given characteristics, spaced at pre-determined time intervals.	CWT
Data Quality Objectives (DQOs)	Statements about the level of uncertainty that a decision maker is willing to accept in data used to support a particular decision (NWQMC 1998). They include specifications of how good the Results should be (e.g., tolerable measurement error) and what each result should represent.	CWT

Term or Word	Definition	Definition source
Detection Limit (D1)	Applied to both methods and equipment, detection limits are the lowest concentration of a target analyte that a given method or piece of equipment can reliably ascertain and report as greater than zero.	CWT
Dilute	To thin out, or having been thinned out; less than full strength.	CWT
Dissolved Oxygen (DO)	Oxygen dissolved in water and available for living organisms to use for respiration, usually expressed in milligrams per liter or percent of saturation.	CWT
Enrichment	The addition of nitrogen, phosphorous, carbonaceous compounds, or other nutrients into a waterway that greatly increase the growth potential for algae and other aquatic plants.	CWT
Environment	All the factors that act upon an organism or community of organisms, including climate, soil, water, chemicals, radiation, and other living things.	CWT
Eutrophication	The normally slow aging process by which a lake or a standing body of water fills with organic matter, evolves into a bog or marsh, and ultimately disappears.	SCMI
Headwaters	The origins of a stream.	CWT
Herbicide	A pesticide designed to kill specific plants.	CWT
Holding time (sample)	the period of time a sample may be stored before analysis. While exceeding the holding time does not necessarily negate the veracity of analytical results, it causes the qualifying of "flagging" of any data not meeting all of the specified acceptance criteria.	EPA
Instrument	a probe, electrode, reagent kit, indicator strip, or any other type of device used for field or laboratory measurements.	CWT
Instrument Detection Limit	The instrument detection limit is the lowest concentration of a given substance or analyte that can be reliably detected by analytical equipment or instruments (see detection limit).	CWT
Matrix	A matrix is a specific type of medium, such as surface water or sediment, which the analyte of interest may be contained.	CWT
Matrix Spike sample	a sample prepared by adding a known amount of the target analyte to a specified amount of matrix. Spiked samples are used, for example, to determine the effect of the matrix on the method's recovery efficiency.	EPA
Mean	An arithmetic derivation: the sum of all measurement result values divided by the number of measurements. Example: $4+5+6+10+35=60$; $60/5=12$. Also referred to as Average.	CWT
Measurement Range	The range of reliable measurements of an instrument or measuring device.	CWT
Method	a body of procedures and techniques for performing an activity (for example, chemical analysis, quantification), systematically presented in the order in which they are to be executed.	EPA
Method Detection Limit (MDL)	The MDL is the lowest concentration of a given substance or analyte that can be reliably detected by an analytical procedure (see detection limit).	CWT
Milligrams Per Liter (mg/l)	A weight per volume designation used in water and wastewater analysis. Equivalent to parts per million (1 ppm = 1 mg/l).	CWT

Term or Word	Definition	Definition source
Nephelometer	An instrument that measures scattered light in a liquid.	CWT
Nephelometric (NTU)	A standard unit of turbidity measurement using a Nephelometer.	CWT
Nitrates	One form of nitrogen, when it is combined with oxygen, that plants can use for growth.	CWT
Nitrogen	One of the most important atoms for life. Nitrogen (combined with hydrogen or oxygen) is an essential nutrient for plant and animal development. Too much of this nutrient can cause algal blooms and increase the amount of material available for decomposition (which lowers dissolved oxygen).	CWT
Nonpoint Source Pollution	Pollution that enters water from sources that cannot be traced to a single point. Generally initiated by stormwater runoff from agricultural, urban, forestry, marina, construction, and other land uses.	CWT
Nutrient	Any of a necessary complement of organic or inorganic elements or compounds that are considered essential to the life and growth of an organism.	CWT
Organic Matter	Chemical compounds based on carbon chains or rings, and also containing hydrogen with or without oxygen, nitrogen, or other compounds.	CWT
Orthophosphate	Phosphorus atom combined with 4 oxygen atoms in the 'ortho' molecular configuration to form an anion (PO ₄) with two negative charges. It is one of the forms of inorganic, 'reactive' phosphate, and can form salts such as K ₃ PO ₄ (potassium phosphate).	CWT
Parameter	see "characteristic"	CWT
Parts Per Million (ppm)	The unit commonly used to represent the degree of pollutant concentration where the concentrations are small. 1 ppm is equivalent to 1 milligram per liter (mg/l) in water or 1 mg/kg in sediment.	CWT
pH	Numerical measure of the hydrogen ion concentration used to indicate the alkalinity or acidity of a substance. Measured on a scale of 1.0 (acidic) to 14.0 (basic); 7.0 is neutral.	CWT
Phosphorus	One of the most important atoms for life. A nutrient that is essential for plants and animals.	CWT
Point Source Pollution	Pollution discharged into a waterbody from any discrete pipe or other conveyance. Easier to identify, and often less expensive to cleanup than non-point sources of water pollution.	CWT
Precision	A data quality indicator that provides a measure of how close repeated trials are to each other, i.e., indicates the repeatability of measurements or reproducibility of a sampling and analyses process.	CWT
Probe (or Sensor)	A measurement device. Probes and sensors are often connected to another unit for the purpose of display or data logging of the measurement Results.	CWT
Quality Assurance	Quality Assurance (QA) QA is an integrated management system designed to ensure that a product or service meets defined standards of quality with a stated level of confidence.	CWT
Reagent	A chemical substance that reacts with our target analyte to produce a measurable response.	CWT

Term or Word	Definition	Definition source
Recovery	The act of determining whether or not the methodology measures all of the analyte contained in the sample.	EPA
Recovery (percent)	The amount of analyte actually measured in a sample to which a known amount of that analyte has been previously added, expressed as a percentage of the nominal (added) value).	CWT
Relative Percent Difference (RPD)	An expression of precision based on how close two measurements are to each other. RPD is the difference between the two values as a percentage of the mean of these values.	CWT
Replicate Measurement	A repeated measurement conducted on the same sample, e.g., in two test tubes with liquid from the same sample jar.	CWT
Replicate Samples	two or more test tubes taken from the same sample container and analyzed in parallel, or repeated titrations of the same fixed sample (i.e., measurements relating to a common Sample ID).	CWT
Representativeness	The degree to which a measured Result realistically portrays the conditions in the environment being monitored. It is a function of why, where, and when that Results was measured.	CWT
Resolution	The smallest increment that can be discerned on the scale of a measuring device, or the capability of a method to discriminate between measurement responses.	CWT
Result	The outcome of a measurement or an observation. Results can be expressed in numbers, words (“verbal categories”), or ranges or numbers (“numeric range categories”).	CWT
Runoff	Water from rain, melted snow or agricultural or landscape irrigation that flows over the land surface from where it falls to another place.	CWT
Sediment	Mud, sand, silts, clay, shell debris, and other particles that settle on the bottom of waterways.	CWT
Sedimentation	The deposition of suspended matter carried by water, wastewater, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material. Also called settling.	CWT
Sensitivity	A combined descriptor for detection limits and resolution of a method or instrument, sometimes also used for "quick to response" or "fragile"	CWT
Spiked Samples	Used for quality control purposes, a spiked sample is a sample to which a known concentration of the target analyte has been added and the recovery of the analyte is noted.	CWT
Standard Material	An umbrella term for the following: a Standard solution (e.g., pH standard buffer), or a certified device (e.g., NIST thermometer), or natural conditions that reflect a known value (e.g., water or humid air saturated with oxygen).	CWT
Standard Reference Materials (SRM)	An SRM is a certified material or substance with an established, known and accepted value for the analyte or property of interest.	CWT

Term or Word	Definition	Definition source
Standard Solution	A solution containing a known concentration of a substance, prepared or purchased for use in the field or in the analytical laboratory. It is used for accuracy checks and calibration adjustments of instruments or lab procedures.	CWT
Study Question – (a.k.a. ‘monitoring objective’ or ‘specific objective’)	a specific question or hypothesis that a study is intended to answer. One monitoring project can have several study questions.	CWT
Suspended Sediments	Particles of soil, sediment, living material, or detritus suspended in the water column	CWT
Temperature	A measure of the hotness or coldness of anything as usually determined by a thermometer. Temperature is a determining factor for biological and chemical processes.	CWT
Transparency	A measure of water clarity as defined by how far we can see through it. Secchi disks and transparency tubes are commonly used to measure the transparency of water.	CWT
Tributaries	A body of water that drains into another, typically larger, body of water.	CWT
True Value	A value thought to represent the real value of a measurable property. Standard solutions represent the True value and are used for the calibration of instruments, or to check whether their reading is accurate.	CWT
Turbidimeter	An instrument for measuring turbidity in which a standard suspension is used for reference.	CWT
Turbidity	A measure of how much the suspended material in water results in the scattering and absorption of light rays. Turbidity is determined by measurements of light diffraction and its "quantity" is reported in nephelometric turbidity units (NTU).	CWT
Water Quality Benchmarks	Also called WQ Criteria, WQ Objectives, or WQ Standards. Maximum concentrations of constituents that should not be exceeded in a given water body. The actual values are often derived to be protective of aquatic life.	CWT
Water Quality Criteria	Criteria that comprise numerical and narrative criteria. Numerical criteria are scientifically derived ambient concentrations developed by the USEPA or the States for various pollutants of concern so that human health and aquatic life can be protected.	NWQMC
Water Quality Parameters	Any of the measurable qualities or contents of water. Includes temperature, salinity, turbidity, nutrients, dissolved oxygen, and others; also known as characteristics.	CWT
Water Quality Standards	A law or regulation that consists of the beneficial designated use or uses of a water body, the numerical and narrative water-quality criteria that are necessary to protect the use or uses of that particular water body, and an antidegradation statement (USEPA Region 5).	NWQMC
Watershed	The entire area of land from which the runoff of water (and all the sediments and dissolved materials such as nutrients or contaminants it contains) drains into a given river, lake, estuary, or ocean.	CWT

Appendix C: QA/ QC file (Available upon e-mail request, separate Excel Workbook)

Appendix D: Chain of Custody Forms & Lab Reports (Available upon request, not in electronic form)