Cow Creek Water Quality Monitoring Report 2006-2008

Developed for:

Latah Soil and Water Conservation District
Idaho Soil Conservation Commission
Idaho State Department of Agriculture
Idaho Department of Environmental Quality

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Technical Results Summary KPC-CC-08

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Acronyms and Abbreviations

BLM Bureau of Land Management

BMPs Best Management Practices

C Celcius

cfs Cubic feet per second

cm centimeter(s)

CWA Clean Water Act

CWAL Cold Water Aquatic Life

DEQ Idaho Department of Environmental Quality

DO Dissolved Oxygen

EPA Environmental Protection Agency

GIS Geographical Information Systems

HUC Hydrologic Unit Code

IASCD Idaho Association of Soil Conservation Districts

ISDA Idaho State Department of Agriculture

mg/L milligrams per liter

NH_3 Ammonium

NO_2+NO_3 Nitrate-Nitrite

NRCS Natural Resource Conservation Service

OP Ortho Phosphorus

QA/QC Quality assurance/quality control

SCC Soil Conservation Commission

SCD Soil Conservation District

SSC Suspended Sediment Concentration

TAN Total Ammonia Nitrogen (NH_3 + NH_4^+)

TDS Total Dissolved Solids

TMDL Total Maximum Daily Load

TP Total Phosphorus

USFS United States Forest Service

UIASL University of Idaho Analytical Science Laboratory

WAG Watershed Advisory Group

Introduction

The Idaho Association of Soil Conservation Districts (IASCD) collected water quality data from Cow Creek and Union Flat Creek from April, 2006 through April, 2008.

This monitoring program was intended to provide background data on these two streams. This monitoring project, along with previous efforts by the Idaho Department of Environmental Quality (DEQ) will help land managers to determine where pollutant loads are entering the stream to allow prioritization for the implementation of Best Management Practices (BMPs).

This report reviews monitoring results for the following parameters:

-Total Phosphorus (TP)
-Orthophosphorus (OP)
-Bacteria (*Escherichia coli)*
-Nitrogen Compounds—NO_2+ NO_3, Total Ammonia Nitrogen (TAN)
-Suspended Sediment Concentration (SSC)
-Instantaneous Water Temperature
-Turbidity
-Dissolved Oxygen (DO)
-Percent (%) Saturation
-Total Dissolved Solids (TDS) and Conductivity
-pH

The University of Idaho Analytical Science Laboratory (UIASL) conducted all inorganic parameter testing and Anatek Labs, Inc. performed bacteria analysis. Ken Clark (IASCD Moscow) performed all other measurements.

Cow Creek Subbasin

Cow Creek is located in the Palouse River Basin, approximately 10 miles south of Moscow, Idaho. The headwaters of Cow Creek originate on the south slopes of Paradise Ridge, south of Moscow. From Paradise Ridge, the stream flows south through the city of Genesee, then flows west, finally entering Union Flat Creek approximately one mile from the Idaho-Washington border. For ease of use, this entire project area will be referred to as the Cow Creek watershed.

The watershed elevation varies from approximately 3,000 feet above sea level at the headwaters to just under 2,500 feet near Uniontown, WA. The drainage area of Cow Creek watershed is 35,757 acres.

The climate of the Cow Creek watershed is typical for the Palouse region, located in southeastern Washington and northern Idaho. Due to the high elevation (greater than 2000 feet), this area receives higher precipitation than much of the surrounding lower area. The combination of rich less soil and abundant rainfall results in a very fertile agricultural area. Temperatures range from average daily high temperatures of 85 degrees Fahrenheit in the summer to 35 degrees in the winter. Average daily minimum temperatures are around 50 degrees in the summer, reaching as low as 23 degrees in the winter. Precipitation for the area ranges from 20 to 27 inches per year. The greatest amount of rainfall occurs in the months of November, December and January. The summer months of July and August receive the least amount of precipitation, usually less than one inch per month (Barker, 1981).

Dryland farming dominates the land use in the upper half of Cow Creek. The creek then flows through the City of Genesee, where it receives effluent discharge from the waste water treatment lagoon, as well as storm water runoff. The lower portion of the stream, located west of State Highway 95, has a mixed use of dryland farming and cattle grazing.

Monitoring Site Descriptions

Five monitoring sites were selected for this project, in order to assess the effects of different land uses on water quality in the watersheds. Below is a general description of site locations; these sites are also illustrated graphically in Figure 1.

CC-1: Located near the headwaters of Cow Creek.

CC-2: Located upstream of Genesee on Cow Creek, at the Stout Road bridge.

CC-3: Located on Cow Creek, just upstream of the Genesee wastewater lagoon.

CC-4: Located on Cow Creek, just downstream of the Genesee wastewater lagoon.

CC-5: Located on Union Flat Creek, at the Idaho state line. This is considered the watershed TMDL compliance point by DEQ.

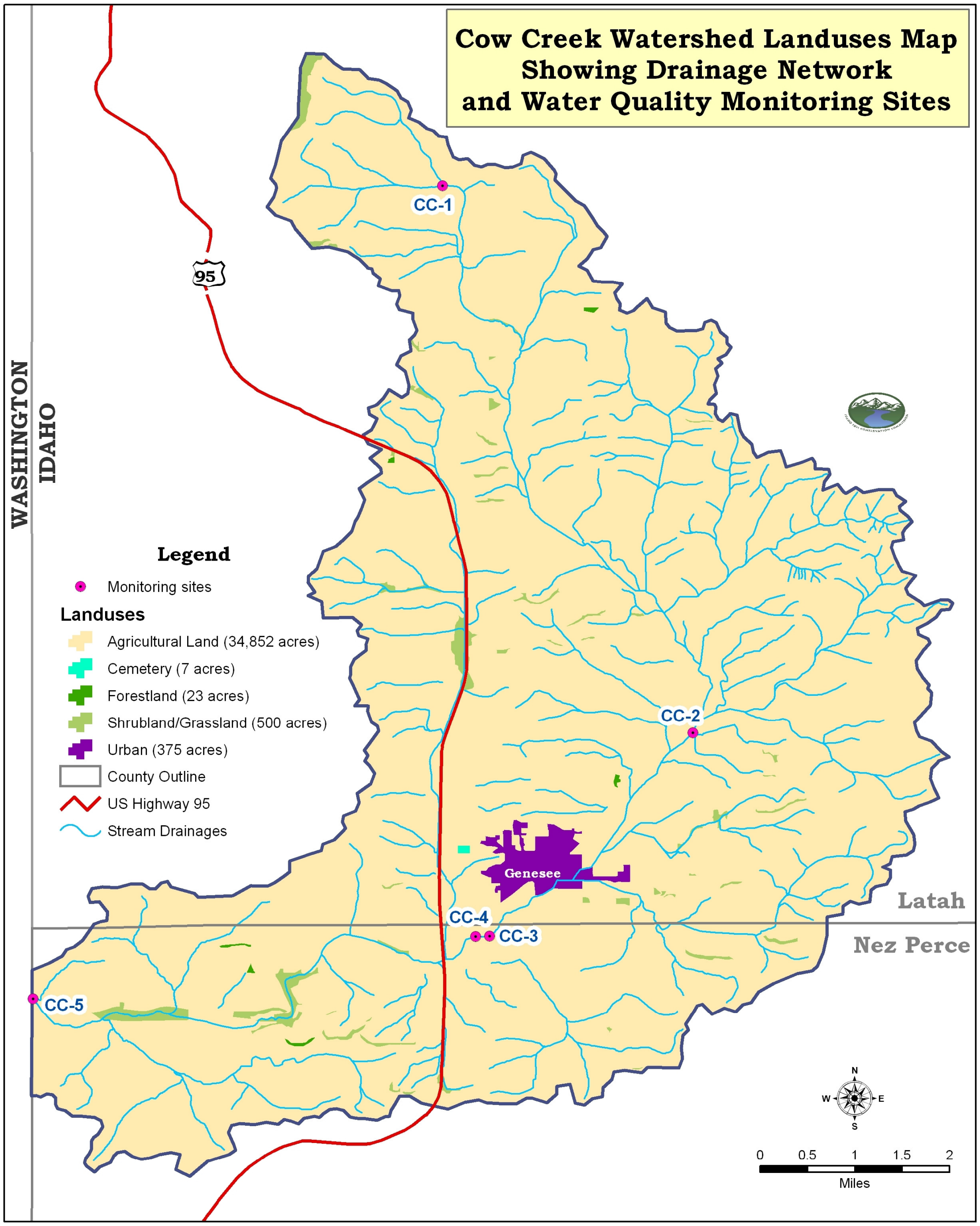

Figure 1. Cow Creek watershed IASCD monitoring sites.

Methods and Materials

Water Quality Limited Segments

The Clean Water Act (CWA) requires restoration and maintenance of the chemical physical and biological integrity of the nation's water (Public Law 92-500 Federal Water Pollution Control Act Amendments of 1972). Section §303 (d) of the CWA establishes requirements for states to identify and prioritize waterbodies that are water quality limited (i.e. do not meet water quality standards). Cow Creek is listed as water quality limited in Idaho's §303(d)/ §305(b) Integrated Report. For the purposes of this document the Idaho DEQ considers the section of Union Flat Creek in Idaho part of Cow Creek. The stream is listed for the following pollutants: habitat alteration, temperature and nutrients.

Sampling Protocols

Approximately four liters of stream water were collected at each site, using a DH-81 depth-integrating suspended-sediment sampler. The samples were collected and transferred into a 2.5-gallon polyethylene churn splitter. The polyethylene churn splitter was rinsed with ambient water at each location prior to sample collection. The resultant composite sample was thoroughly homogenized before filling the appropriate sample containers. Water samples requiring preservation (NO_2+NO_3, TAN, and TP) were transferred into preserved (H_2SO_4 pH <2) 500 mL sample containers. Water quality samples (SSC, NO_2+NO_3, TAN, and TP) were then analyzed at the UIASL in Moscow, Idaho.

Bacteriological samples (*E. coli*) were collected directly from the thalweg into sterile sample containers. The samples were delivered to Anatek Labs, Inc. in Moscow for analysis. Most probable number (MPN) multiple tube fermentation was used to determine *E. coli* levels in the water sample.

A list of parameters, sample sizes, preservation, holding times, and analytical methods are displayed in Table 1. All sample containers were labeled with waterproof markers with the following information: station location, sample identification, date of collection, and time of collection. Samples were placed on ice and transported to the laboratory the same day as collection. Chain-of-custody forms accompanied each sample shipment.

Table 1. Water Quality Parameters

Parameters	Sample Size	Preservation	Holding Time	Method
Suspended Sediment Concentration (SSC)	1L	Cool 4°C	7 Days	ASTM 3977-97
Nitrogen Compounds: NO_3+NO_2 Ammonia	60 mL 60 mL	Cool 4°C, H_2SO_4 pH < 2	28 Days	EPA 353.2 EPA 350.1
Total Phosphorus Orthophosphorus	100 mL	Cool 4°C, H_2SO_4 pH < 2	28 Days	EPA 365.4 EPA 365.2
Escherichia coli	100 mL	Cool 4°C	30 Hours	SM 9223B

Field Measurements

At each location, field parameters for dissolved oxygen, specific conductance, pH, temperature, turbidity, and total dissolved solids were measured. Calibration of all field equipment was in accordance with the manufacturer specifications. Field measurement parameters, equipment and calibration techniques are shown in Table 2.

Table 2. Field Measurements

Parameters	Instrument	Calibration
Dissolved Oxygen	YSI Model 55	Ambient air calibration
Temperature	YSI Model 55	Centigrade thermometer
Conductance & TDS	Orion Model 115	Specific Conductance (25°C standard)
pH	Orion Model 210A	Standard buffer (7,10) bracketing for linearity
Turbidity	Hach Model 2100P	Formazin Primary Standard

All field measurements were recorded in a field notebook along with pertinent observations about the site, including weather conditions, flow rates, personnel onsite, and any problems observed that might affect water quality.

Flow Measurements

Flow measurements were collected at each site using a Marsh McBirney Flow Mate Model 2000 flow meter. The six-tenths depth method (0.6 of the total depth from the surface of the water surface) was used. A transect line was established at each monitoring station, across the width of the stream at an angle perpendicular to the flow, for the calculation of cross-sectional area. Discharge was computed by summing the products of the partial areas (partial sections) of the flow cross-sections and the average velocities for each of those sections. Stream discharge was reported as cubic feet per second (cfs).

Quality Assurance and Quality Control (QA/QC)

The UIASL utilizes methods approved and validated by the EPA. A method validation process, including precision and accuracy performance evaluations and method detection limit studies, is an element of UIASL Standard Methods. Method performance evaluations include quality control samples analyzed with a batch to ensure sample data integrity. Internal laboratory spikes and duplicates are part of UIASL's quality assurance program. Laboratory QA/QC results generated from this project can be provided upon request.

QA/QC procedures from the field-sampling portion of this project included a duplicate sample and a blank sample (one set per sampling day). The field blanks consisted of laboratory-grade deionized water, transported to the field and poured off into the appropriate sample containers. The blank sample was used to determine the integrity of the field teams handling of samples, the condition of the sample containers and deionized water supplied by the laboratory and the accuracy of the laboratory methods. Duplicate samples were obtained by filling two sets of sample containers with homogenized composite water from the same sampling site. The duplicate and blank samples were not identified as such to laboratory personnel to ensure laboratory precision.

Data Handling

All of the field data and analytical data generated from each survey were reviewed in the Moscow field office and then submitted to the Idaho State Department of Agriculture (ISDA) in Boise for further review. These reviews ensure that all necessary observations, measurements, and analytical results were properly recorded. The analytical results were evaluated for completeness and accuracy. Any suspected errors were investigated and resolved, if possible. The data were then stored electronically and made available to any interested entity upon request.

Results and Discussion

Analysis of the data was done, and descriptive statistics such as maximum, minimum, median, and mean values for each parameter measured were determined. The number of exceedances per year was calculated based on the number of sampling events whose respective values exceeded TMDL targets or State of Idaho water quality standards, whichever was more restrictive. These descriptive statistics are presented for each site in Table 3.

Table 3. Descriptive statistics for select parameters at Cow Creek IASDC monitoring sites.

CC-1	D.O.	% Sat	Temp	Cond	TDS	pH	Turbidity	NO2+NO3	TAN	OP	TP	SSC	*E-coli*
	(mg/L)	(%)	(°C)	(µS/cm^2@25°C)	(mg/L)	(H$^+$)	(NTU)	(mg/L)	mg/L	(mg/L)	(mg/L)	(mg/L)	(MPN/100mL)
Maximum	11.41	113.60%	21.00	247.00	125.00	8.55	49.30	11.00	0.05	0.33	0.46	29.00	108.60
Minimum	10.14	75.00%	0.00	157.90	78.10	7.17	23.20	6.10	0.05	0.097	0.15	6.40	56.30
Mean	10.93	87.56%	5.96	196.42	100.08	7.74	39.46	7.98	0.05	0.181	0.262	17.48	82.45
Median	10.95	80.50%	2.60	196.00	98.00	7.53	47.00	7.80	0.05	0.16	0.25	13.00	82.45
# exceedance	0.0		0.0			0.0		5.0	0.0	4	5		0.00
% exceedance	0.0%		0.0%			0.0%		100.0%	0.0%	80.00%	100.0%		0.0%

CC-2	D.O.	% Sat	Temp	Cond	TDS	pH	Turbidity	NO2+NO3	TAN	OP	TP	SSC	*E-coli*
	(mg/L)	(%)	(°C)	(µS/cm^2@25°C)	(mg/L)	(H$^+$)	(NTU)	(mg/L)	mg/L	(mg/L)	(mg/L)	(mg/L)	(MPN/100mL)
Maximum	16.10	181.50%	26.80	593.00	304.00	9.15	253.00	15.00	0.16	0.36	0.57	170.00	1119.90
Minimum	8.10	74.10%	0.00	206.00	107.00	7.22	4.93	0.05	0.05	0.003	0.046	4.40	7.40
Mean	12.42	118.53%	12.96	297.26	151.00	8.27	44.93	6.61	0.06	0.1	0.218	38.51	213.71
Median	12.04	117.70%	12.30	269.00	135.00	8.25	16.35	7.85	0.05	0.1	0.18	22.00	76.10
# exceedance	0.0		6.0			0.0		16.0	0.0	10	14		2.00
% exceedance	0.0%		28.6%			0.0%		76.2%	0.0%	47.6%	66.7%		12.5%

CC-3	D.O.	% Sat	Temp	Cond	TDS	pH	Turbidity	NO2+NO3	TAN	OP	TP	SSC	*E-coli*
	(mg/L)	(%)	(°C)	(µS/cm^2@25°C)	(mg/L)	(H$^+$)	(NTU)	(mg/L)	mg/L	(mg/L)	(mg/L)	(mg/L)	(MPN/100mL)
Maximum	15.99	183.10%	23.80	383.00	194.00	9.46	258.00	15.00	0.50	0.45	0.85	350.00	648.80
Minimum	7.50	64.80%	0.20	217.00	110.00	7.47	4.96	1.00	0.05	0.003	0.042	2.00	6.10
Mean	12.58	115.87%	10.89	307.11	156.61	8.19	49.25	6.69	0.09	0.12	0.246	74.00	93.33
Median	12.49	101.20%	9.85	311.50	159.00	8.17	16.60	7.45	0.05	0.1	0.175	24.00	41.60
# exceedance	0.0		1.0			0.0		20.0	0.0	10	12		1.00
% exceedance	0.0%		5.0%			0.0%		100.0%	0.0%	50.0%	60.0%		6.7%

CC-4	D.O.	% Sat	Temp	Cond	TDS	pH	Turbidity	NO2+NO3	TAN	OP	TP	SSC	*E-coli*
	(mg/L)	(%)	(°C)	(µS/cm^2@25°C)	(mg/L)	(H$^+$)	(NTU)	(mg/L)	mg/L	(mg/L)	(mg/L)	(mg/L)	(MPN/100mL)
Maximum	14.09	156.90%	23.70	455.00	247.00	8.94	274.00	15.00	0.61	0.81	1.00	400.00	2419.20
Minimum	7.89	65.80%	0.20	215.00	112.00	7.34	6.84	1.00	0.05	0.027	0.067	0.42	14.80
Mean	11.67	104.00%	10.19	321.11	165.11	8.13	45.56	6.78	0.20	0.19	0.336	43.13	281.31
Median	11.62	96.20%	8.10	336.00	169.50	8.18	15.90	7.55	0.15	0.155	0.28	14.00	49.10
# exceedance	0.0		1.0			0.0		20.0	0.0	14	18		2.00
% exceedance	0.0%		5.0%			0.0%		100.0%	0.0%	70.0%	90.0%		13.3%

CC-5	D.O.	% Sat	Temp	Cond	TDS	pH	Turbidity	NO2+NO3	TAN	OP	TP	SSC	*E-coli*
	(mg/L)	(%)	(°C)	(µS/cm^2@25°C)	(mg/L)	(H$^+$)	(NTU)	(mg/L)	mg/L	(mg/L)	(mg/L)	(mg/L)	(MPN/100mL)
Maximum	15.52	154.70%	18.90	460.00	231.00	8.60	388.00	14.00	0.24	0.79	2.3	990.00	579.40
Minimum	6.42	54.10%	0.30	163.00	116.00	7.20	2.65	0.51	0.05	0.02	0.067	0.12	4.10
Mean	10.41	89.99%	9.05	333.29	178.39	7.89	36.01	5.14	0.06	0.159	0.304	53.78	117.30
Median	10.33	83.00%	8.80	348.00	125.00	7.86	7.90	3.90	0.05	0.13	0.18	7.90	39.90
# exceedance	0.00		0.00			0.00		29.00	0.00	20	24		1.00
% exceedance	0.0%		0.0%			0.0%		100.0%	0.0%	69.0%	82.8%		4.3%

Parameters

Dissolved Oxygen

Dissolved Oxygen (DO) is found in microscopic bubbles of oxygen that are mixed in the water and occur between water molecules. DO is a very important indicator of a water body's ability to support aquatic life. Fish "breathe" by absorbing dissolved oxygen through their gills. Oxygen enters the water by absorption directly from the atmosphere or via photosynthesis by aquatic plant and algae. Oxygen is removed from the water by respiration and decomposition of organic matter.

The State of Idaho standard for DO states that dissolved oxygen must exceed 6.0 mg/L for cold water biota at all times. No DO violations were observed during this monitoring project. In the Cow Creek TMDL, the DEQ documented several DO violations during late summer of 2002, when flows were well below one cubic foot per second (cfs). During this most recent monitoring project, Cow Creek was dry during the months that the DEQ documented DO violations (July-August). No DO violations were observed at the watershed compliance point on Union Flat Creek (CC-5) during this monitoring project or the DEQ monitoring project.

Water Temperature

Water temperature is a very important indicator of overall water quality. Many of the physical, biological and chemical characteristics of a river are directly affected by temperature. For example, temperature influences the:

-amount of oxygen that can be dissolved in water.
-photosynthetic rate of algae and larger aquatic plants.
-metabolic rates of aquatic organisms.
-sensitivity of organisms to toxic wastes, parasites and diseases.

Cool water can hold more oxygen than warm water, because gases are more easily dissolved in cool water. The reduction of oxygen solubility at high water temperatures can compound the stress on fish caused by marginal dissolved oxygen concentrations.

The cold water aquatic life (CWAL) criteria of 19 ^{o}C daily average and 22 ^{o}C as a daily maximum apply to Cow Creek/Union Flat Creek year-round.

Exceedances of the temperature criteria occurred at sites CC-2, CC-3, and CC-4, but no exceedances were observed at CC-5, the watershed compliance point. The cooler water found at the Union Flat Creek site (CC-5) is likely attributable to the inflow of springs at the headwaters, which are located less than a mile upstream of CC-5. Figure 2 shows the instantaneous water temperature measurements for each site. The dashed red line represents 22^{o} C CWAL criteria.

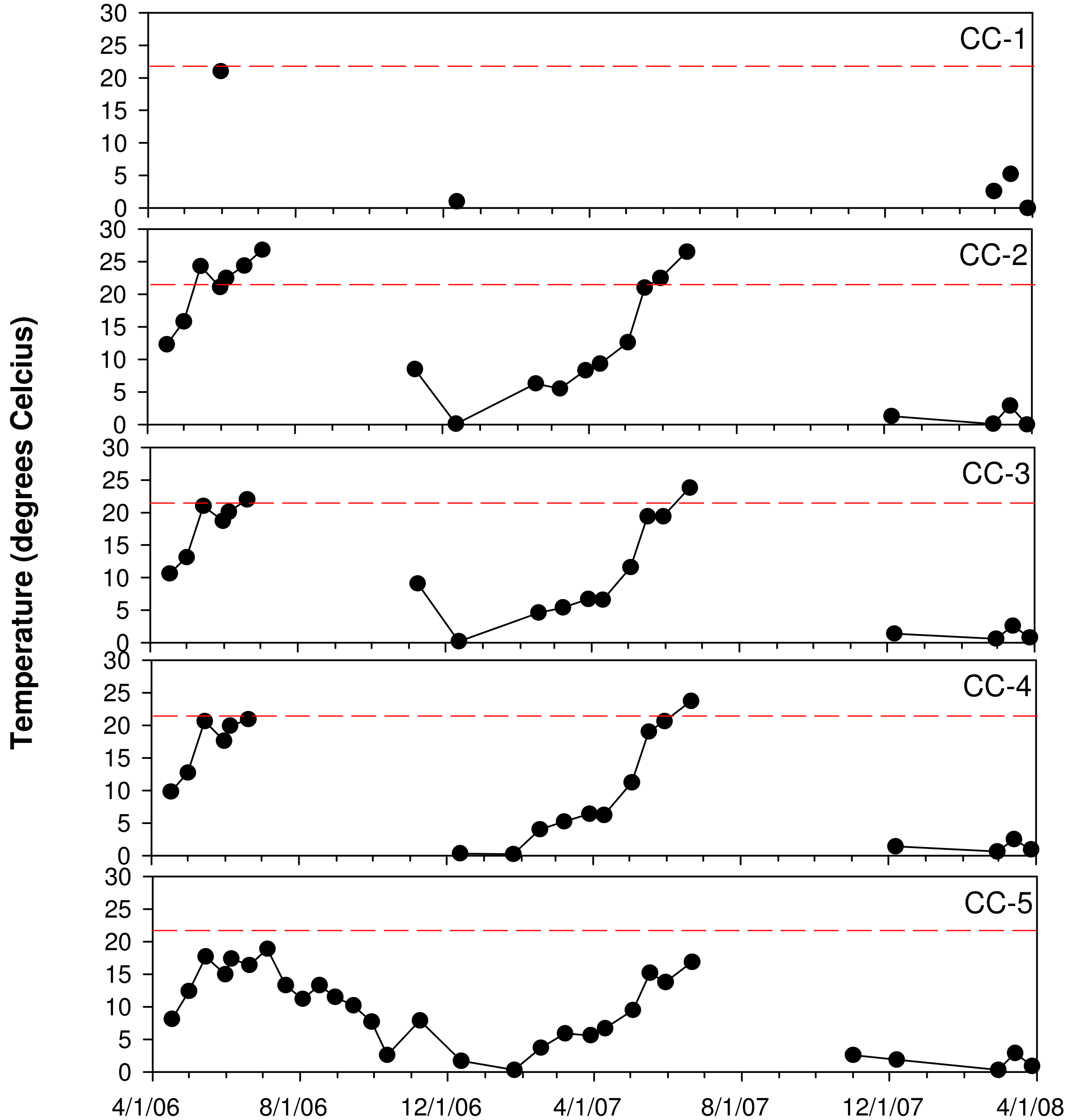

Figure 2. Instantaneous water temperature for Cow and Union Flat Creeks. The dashed red lines represent the 22° C targets.

Specific Conductance and Total Dissolved Solids

Total Dissolved Solids (TDS) is a measure of the total amount of minerals, salts, organic matter, and nutrients dissolved in water. Specific Conductance (SC) is a measure of how well water can conduct an electrical current. Conductivity increases with increasing concentrations and mobility of dissolved ions. These ions, which come from the breakdown of compounds, conduct electricity because they are negatively or positively charged when dissolved in water. Therefore, SC is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron, and can be used as an indicator of water pollution.

No surface water standards or criteria exist that set limits on SC or TDS.

Figure 4 shows the levels of SC and TDS found at all sites throughout the sampling period.

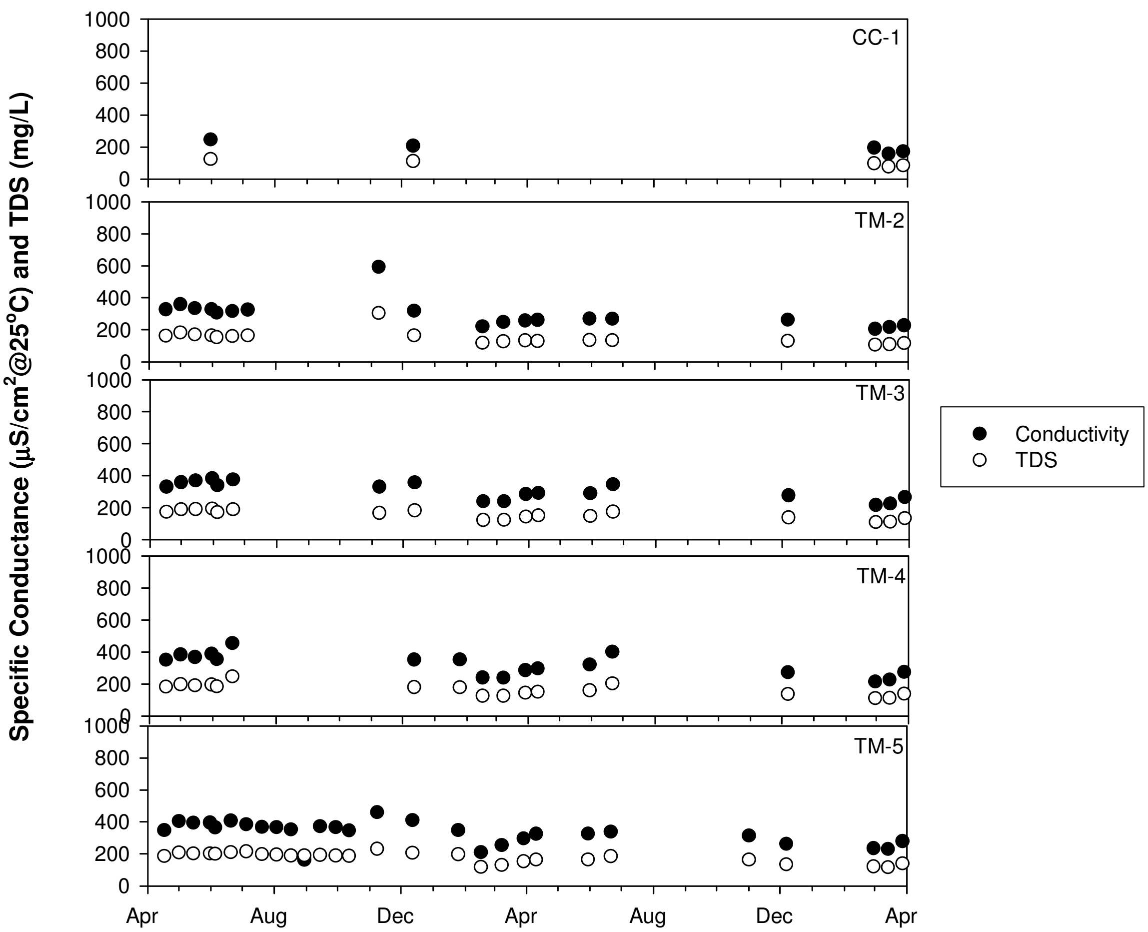

Figure 3. Specific Conductivity and Total Dissolved Solids levels for Cow and Union Flat Creeks.

pH

pH represents the effective concentration (activity) of hydrogen ions (H^+) in water. The activity of hydrogen ions can be expressed most conveniently in logarithmic units. pH is defined as the negative logarithm of the activity of H^+ ions:

- $pH = -\log [H^+]$,
- where $[H^+]$ is the concentration of H^+ ions in moles per liter.

The State of Idaho surface water quality criteria for Aquatic Life Use designations states that Hydrogen Ion Concentration (pH) values must fall within the range of 6.5 and 9.5 (IDAPA 58.01.02.250.01.a). No samples during this monitoring period were outside of this range.

Turbidity and Suspended Sediment Concentration

Suspended sediment concentration (SSC) includes both sediment and organic material suspended in water. Suspended sediment can cause problems for fish by clogging gills. In addition, excessive sediment provides a medium for the accumulation and transport of other constituents such as phosphorus and bacteria.

The sediment standard in Idaho is a narrative standard that states sediment shall not exceed, "…in the absence of specific sediment criteria, quantities which impair designated beneficial uses." The State of Idaho water quality standard for Turbidity states that measurements shall not exceed background turbidity by more than 50 NTU instantaneously or more than 25 NTU for more than ten consecutive days.

A comparison between turbidity (lack of water clarity due to particulate matter in the water column), SSC concentration, and discharge is presented in Figure 4. In addition, Pearson correlation analysis was done to compare SSC and Turbidity. There was a strong correlation between these two parameters throughout the watershed, with a correlation coefficient greater than 0.9 at all sites, except for CC-1, where very low flow rates and dense aquatic vegetation likely affected sampling results. In the future, it may be possible to use turbidity as a surrogate for SSC, in order to save both time and money.

SSC and turbidity appear to be associated with increases in stream flow during spring runoff. However, increases in SSC and turbidity during the rest of the year do not appear to be a function of stream discharge. Instead, these increases are likely the result of land use practices in the watershed (i.e. grazing, road building/maintenance and farming).

The average SSC level at the lowest point in the Cow/Union Flat Creeks watershed was 53.8 mg/L, and averages increased substantially from the headwaters to the State line. Median levels decreased from the headwaters to the State line, because many more samples were taken at CC-5 than at the other sites. These extra base-flow samples, taken when the upper sites were dry, had very low SSC levels that caused the median value to be quite low. Although a general trend of increasing sediment from CC-1 to CC-5 can be shown, mean SSC levels at CC-4 were actually slightly lower than at CC-3. CC-4 is located below the Genesee wastewater lagoon and a much higher density of aquatic vegetation was present than at CC-3, which was above the lagoon. The aquatic vegetation likely caused sediment to drop out of suspension, resulting in slightly lower overall SSC levels. Literature suggests that levels below 25 mg/L are ideal for the protection of fisheries and produce no harmful effects on fish or fisheries (DFO, 2000). Figure 5 shows the average SSC levels at all monitoring stations.

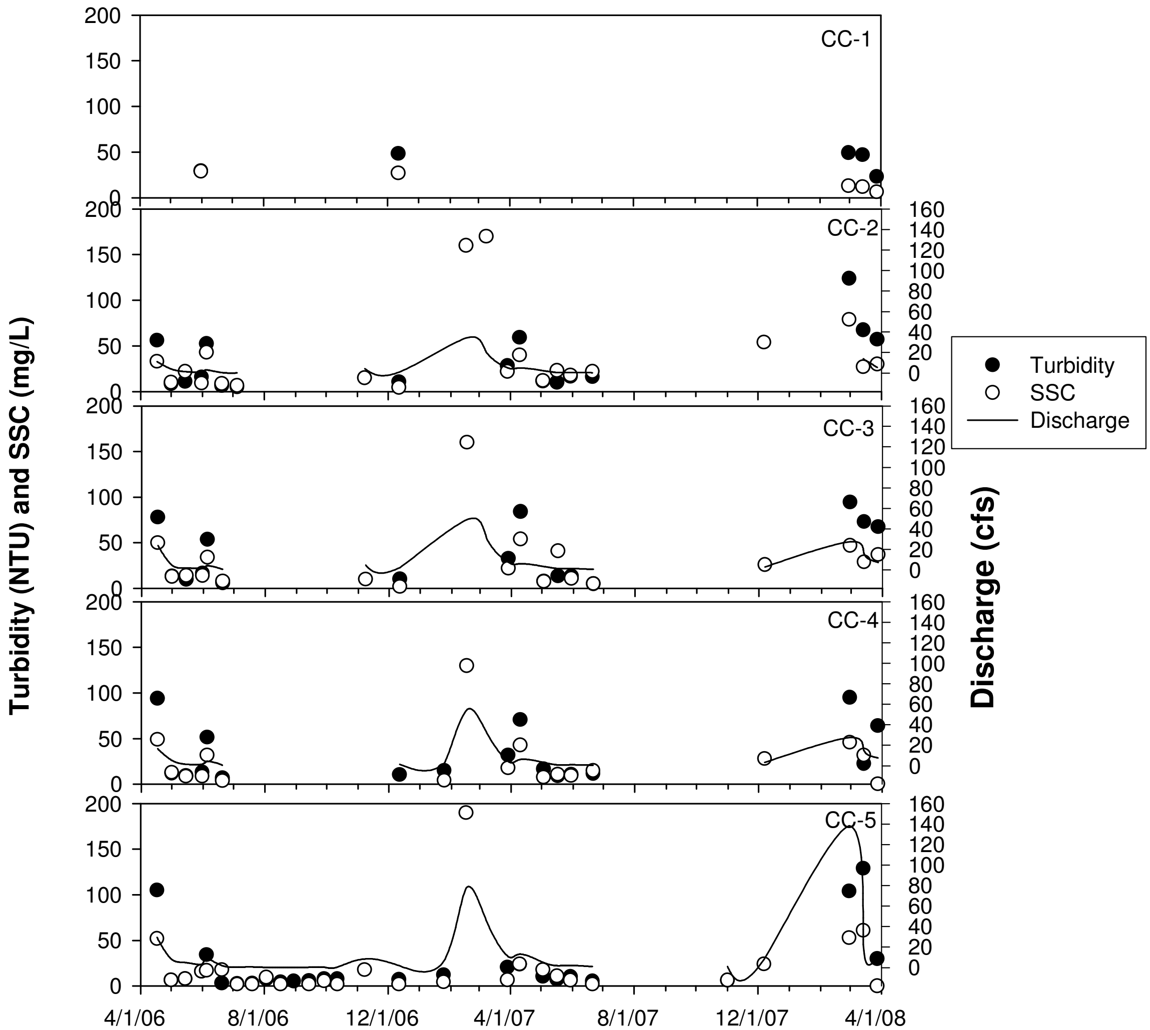

Figure 4. Turbidity, SSC and Discharge rates for Cow and Union Flat Creeks.

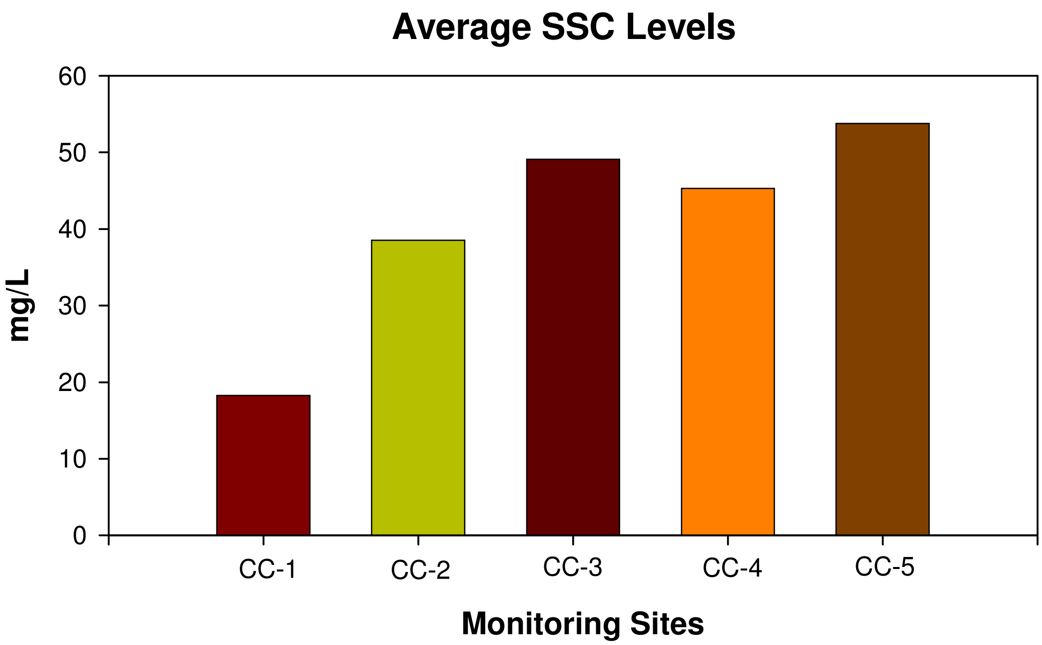

Figure 5. Average SSC levels for Cow and Union Flat Creeks.

Nitrate+Nitrite (NO_3+NO_2) and Ammonia (TAN)

Excessive concentrations of nitrate and/or nitrite can be harmful to humans and wildlife. Although there is no aquatic numeric standard in place, numbers above 0.30 mg/L can cause excessive plant growth and possible eutrophication (Cline, 1973 & Golterman, 1975).

Idaho administrative code employs a narrative standard for nutrients, which states that "surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses" (DEQ IDAPA 58.01.02).

High concentrations of nitrate and/or nitrite can also produce "brown blood disease" in fish. Nitrite enters the bloodstream through the gills and turns the blood a chocolate-brown color. As in humans, nitrite reacts with hemoglobin to form methemoglobin. Brown blood cannot carry sufficient amounts of oxygen, and affected fish can suffocate despite adequate oxygen concentration in the water. This accounts for the gasping behavior often observed in fish with brown blood disease, even when oxygen levels are relatively high (Mississippi State University, 1998).

Ammonia is the least stable form of nitrogen in water. Ammonia concentrations can affect hatching and growth rates of fish; changes in tissues of gills, liver, and kidneys may occur during structural development.

NO_3+NO_2 levels were extremely high throughout the watershed, with the average value being 6.46 mg/L. CC-1 (n=6), CC-3 (n=20), CC-4 (n= 20) and CC-5 (n=29) all exceeded the 0.3 mg/L guidance target 100% of the time. CC-2 (n=20) exceeded the guidance target 76.2% of the time.

Much of the nitrogen is likely coming from agricultural fields in the Cow Creek watershed. An extensive network of subsurface drain tiles has been installed in the Cow Creek watershed, and empty directly into the creek. Nitrate loss can be quite high from drained land. Because nitrate is very soluble, it flows easily through the soil and into tile lines. In this watershed, nitrogen fertilizers are often applied in the fall and again in early spring. Spikes in nitrate levels were observed directly after winter and spring rains, likely as a result of applied nitrogen fertilizers being flushed into tiles and then into Cow Creek.

Although ammonia levels were somewhat elevated at sites CC-4 and CC-5, they were still well below the State of Idaho’s acute criterion for ammonia. It is possible that the increases in ammonia levels are attributable to effluent inflow from the Genesee waste water lagoon, as well as increases in the number of cattle accessing the stream along the lower reach.

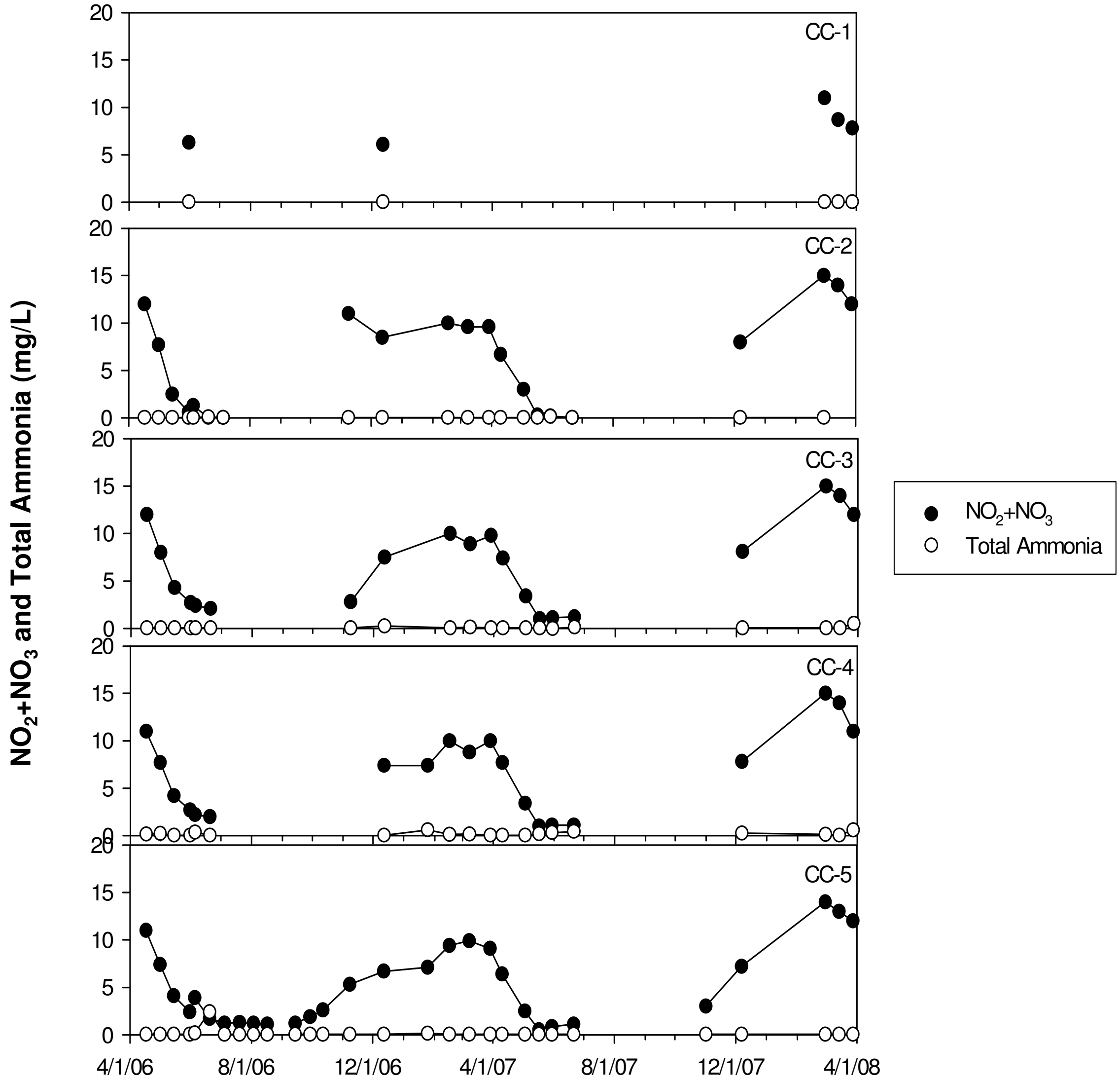

Figure 6. NO_2+NO_3 and TAN levels for Cow and Union Flat Creeks, 2006-2008.

Phosphorus

In freshwater lakes and rivers, phosphorus is often found to be the growth-limiting nutrient, because it occurs in the least amount relative to the needs of plants. If excessive amounts of phosphorus and nitrogen are added to the water, algae and aquatic plants can be produced in large quantities. When these algae die, bacteria decompose them, and use up oxygen. As a result, dissolved oxygen concentrations can drop too low for fish to breathe; leading to fish kills. The loss of oxygen in the bottom waters can free phosphorus previously trapped in the sediments, further increasing the available phosphorus.

The Department of Environmental Quality (DEQ) has set a Total Phosphorus (TP) target of 0.1 mg/L for Cow and Union Flat Creek in Idaho. Exceedances of the 0.1 mg/L target were observed at all of the sites in this study. Pearson correlation analysis was done to compare SSC and TP. There was a strong correlation between these two parameters throughout the watershed, with a correlation coefficient greater than 0.9 at all sites, except for CC-1, where very low flow rates and dense aquatic vegetation likely affected sampling results.

Phosphorus sources exist in both inorganic and organic forms. Some important sources of TP include commercial fertilizers and manure, land application of biosolids, wastewater treatment plants (WWTP), livestock grazing, non-agricultural fertilization, and septic systems. Over time, excess phosphorus input causes a phosphorus surplus, which accumulates in soil. Stream bank erosion and re-suspension of phosphorus in stream sediments can contribute significant portions of the overall TP load, and seems like a probable mechanism for TP mobilization, as both instream and bank erosion was extensive in this watershed.

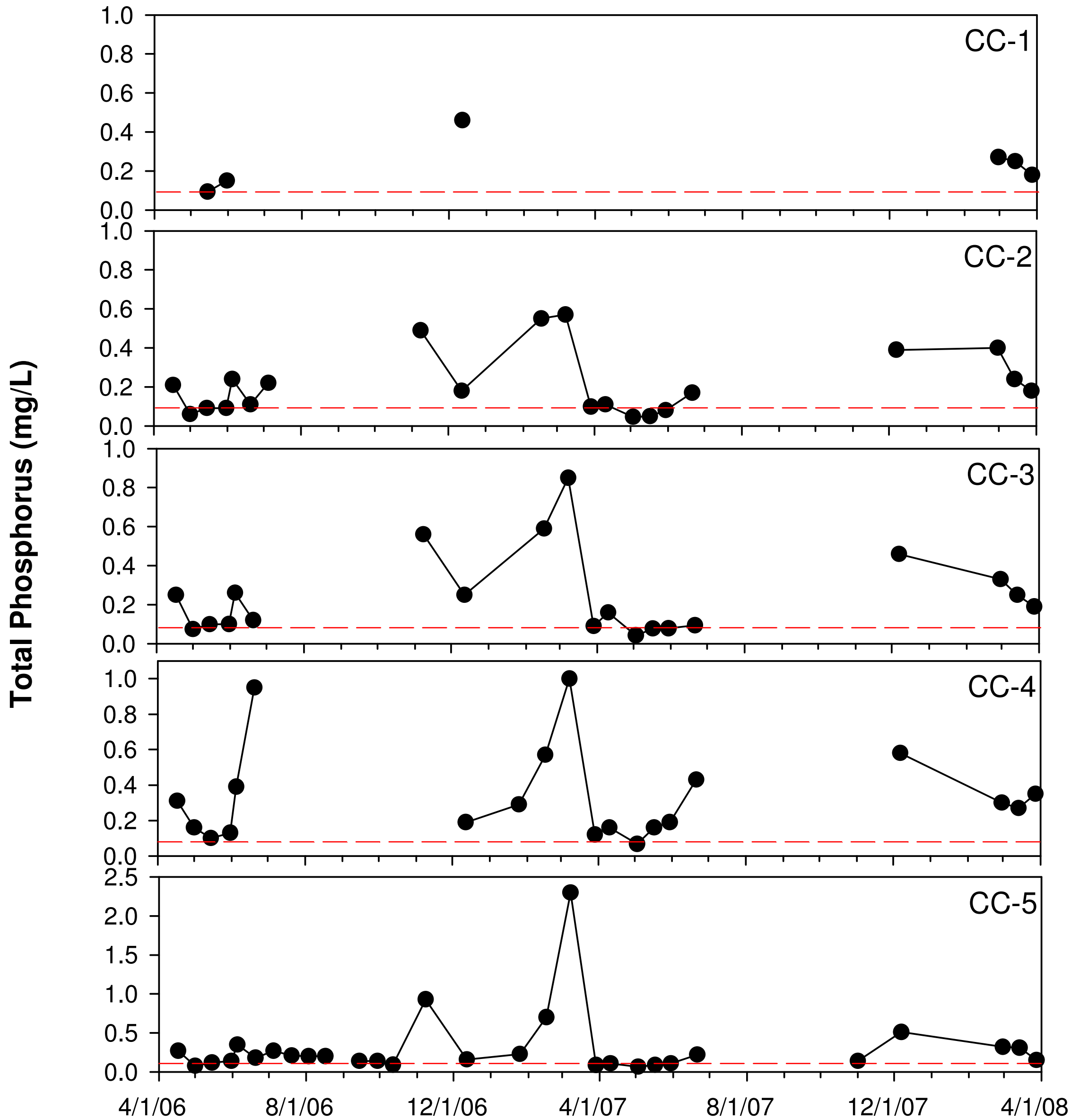

Figure 7. TP levels for Cow and Union Flat Creeks, 2006-2008.

Bacteria (*Escherichia coli*)

The coliform bacteria group consists of several genera of bacteria belonging to the family *enterobacteriaceae*. These mostly harmless bacteria live in soil, water, and the digestive system of animals. *Escherichia coli* (*E. coli)* is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. The presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination.

The *E. coli* standard for primary contact is not to exceed 406 organisms/100 mL at any time and not to exceed 576 organisms/100 mL at any time for secondary contact (IDAPA 58.01.02.251.02.a). Both Cow Creek and Union Flat Creeks are listed for secondary contact recreation. A single exceedance over the criterion does not constitute a violation of water quality standards (IDAPA 58.01.02.080.03). Five samples must be taken within a 30-day period to assess against the geometric mean criterion of 126 cfu/100 ml to determine a violation. An assessment of the geometric mean criterion was not conducted during this study due to time considerations, and the low number of overall criterion exceedances.

No site had more than two exceedances of the instantaneous bacteria criterion during this monitoring project. The exceedances that were observed all happened in June of 2006, and June of 2007, immediately following rain showers, which resulted in an increase in all measured parameters.

Conclusions

The monitoring program for Cow Creek and Union Flat Creek was completed as planned. Protocols were followed, QA/QC standards were met, and specific information per parameter for each watershed was collected. Data collected from this monitoring project will be used as baseline data to better ascertain the current condition of the watershed, to help define critical areas within the watershed for placement of agricultural BMPs, and to evaluate changes in water quality over time.

Elevated stream temperatures were observed several times during this monitoring project, primarily at site CC-2. However, average stream temperature decreased as one moved downstream from CC-2, and no exceedances of the 22^{o} C CWAL criterion was observed at CC-5, which is located at the Idaho-Washington border, and is considered the compliance point for this watershed.

Excessive nutrient levels constitute the biggest pollutant to this system. The Cow Creek watershed has been listed by the Idaho DEQ as one of 25 nitrate priority areas in Idaho, due to the high levels of nitrate documented in the catchment. In 2001, DEQ carried out a reconnaissance level evaluation of springs and wells in the watershed. Five springs were sampled, and nitrate levels ranged from 4.3 to 13.7 mg/L, with an average of 10.5 mg/L in the springs. Twenty-five deep wells (>100 ft) were also sampled and nitrate levels in those wells averaged 1.5 mg/L. According to the study, most of the groundwater samples collected had nearly identical chemical compositions, which indicates that the general ground water quality across the watershed is relatively uniform. Nitrogen isotope data suggest that animal or human waste, and commercial fertilizers are both likely sources of nitrogen in the ground water, although the authors of the study admit that "a larger nitrate isotope sample size is probably necessary to more clearly describe nitrate source contribution" (Strausz, 2001).

In this surface water monitoring project, NO_2+NO_3 levels exceeded the 0.3 mg/L surface water guidance criterion nearly 100% of the time at every monitoring site. Phosphorus levels were also quite high, with levels exceeding the 0.1 mg/L target 82.8% at CC-5 (the compliance point). The combination of high nutrient levels, high summer temperatures and low flows can lead to dissolved oxygen levels below the 6.0 mg/L state criterion.

No DO violations were documented during this monitoring project. However, in the late summer and early fall of 2002, the DEQ documented several DO violations in the Cow Creek watershed. In both 2006 and 2007, Cow Creek was without water from mid June to late October. No DO violations were observed at the compliance point on Union Flat Creek in either monitoring project.

Erosion and the resultant sedimentation of streams is one of the key concerns in the Cow Creek watershed. While some sediment in streams is natural, excessive loads of sediment can have negative effects on stream ecosystems. Some effects of erosion and sediment deposition include loss of agricultural soils and increased flood frequency. Also of concern is the effect sedimentation can have on biotic communities, including the reduction of fish diversity and other animal communities, and the overall lowering of productivity in aquatic populations. Erosion and re-suspension of sediment can also contribute significant portions of the overall phosphorus load of streams that drain both agricultural and non-agricultural areas, since phosphorus often binds to particulate matter in aquatic systems. A Pearson correlation analysis on SSC and TP showed a correlation coefficient of 0.926 (n=29) at the watershed compliance point (CC-5), indicating a strong correlation between these two parameters.

Bacteriological contamination appears to be a minor problem in this watershed. No monitoring site had more than two exceedances of the 576 organisms/100 mL criterion, and those violations were likely due to waterfowl in the area, as field notes indicated their presence on each of the monitoring days when exceedances occurred.

Recommendations

Nutrients are the major pollutant in this watershed, and steps should be taken to reduce the overall quantity of nitrogen and phosphorus entering Cow Creek. Nutrient management plans should be developed by landowners in the watershed, with assistance from the NRCS and SCD's, so that producers have a tool to increase net returns while protecting water quality. Producers in this watershed often apply nitrogen fertilizer as anhydrous ammonia in the fall. Winter and spring rains wash much of this soluble fertilizer into drain tiles which empty into Cow Creek. Nitrogen does not accumulate in the soil, so the high nitrate levels observed in this study are a result of seasonal applications. Therefore, changes in application timing and rates could very well contribute to an immediate benefit to water quality in this catchment. It is recommended that the Idaho State Department of Agriculture initiate a ground water study in the Cow Creek drainage, in order to better evaluate long-term trends and to more accurately identify the sources of nutrient enrichment in the watershed.

Significant erosion is evident throughout this watershed, both in-stream and from adjacent farmland, and treatment should be applied to areas undergoing the most severe erosion. In most areas of the Cow Creek watershed, there is no riparian buffer between the stream and the adjacent farm lands. The re-vegetation of stream banks throughout the Cow Creek watershed will help to reduce sediment transport, as healthy riparian vegetation is effective in reducing bank erosion. Riparian vegetation will also filter sediment being transported in surface water runoff.

Excessive stream temperature is another difficult problem to overcome, and can likely be addressed by re-establishing natural full potential canopy shade. Reducing sediment loads within critical reaches will also assist in reducing stream temperatures, since suspended particles tend to absorb more heat.

Some specific BMPs that would help to improve water quality in the Cow Creek drainage are: tree and shrub plantings, grassed waterways, stream bank stabilization, conservation cropping and tillage practices, protected riparian zones, and detailed nutrient management plans developed by landowners and local SCD’s.

References:

Barker, R.I. 1981. Soil Survey of Latah County Area, Idaho. U.S. Department of Agriculture, Soil Conservation Service. Washington, D.C. 168pp plus maps.

Cline, C.. The effects of forest fertilization on the Tahuya River, Kitsap Peninsula, Washington. Washington State Department of Ecology. p. 55 (1973).

DFO, 2000. Effects of sediment on fish and their habitat. DFO Pacific Region Habitat Status Report 2000/01.

EPA method 365.4-Methods for Chemical Analysis of Water and Wastes, US Environmental Protection Agency, Cincinnati, OH. 1983.

EPA method 365.2-Methods for Chemical Analysis of Water and Wastes, US Environmental Protection Agency, Cincinnati, OH. 1983.

EPA method 353.2-Methods for Chemical Analysis of Water and Wastes, US Environmental Protection Agency, Cincinnati, OH. 1983.

EPA method 351.2-Methods for Chemical Analysis of Water and Wastes, US Environmental Protection Agency, Cincinnati, OH. 1983.

EPA method 350.1-Methods for Chemical Analysis of Water and Wastes, US Environmental Protection Agency, Cincinnati, OH. 1983.

EPA method 160.2-Methods for Chemical Analysis of Water and Wastes, US Environmental Protection Agency, Cincinnati, OH. 1983.

Federal Water Pollution Control Act Amendments of 1972, Pub. L. No. 92-500 (1972)

Golterman, H.L. Physiological Limnology and Approach to the Physiology of Lake Ecosystems. Elserview Scientific Publication Co. New York, NY. p. 489 (1975).

Idaho Department of Environmental Quality, IDAPA 58.01.02. Water Quality Standards and Wastewater Treatment Requirements.

Idaho Department of Environmental Quality, Cow Creek Subbasin Assessment and Nutrient TMDL, 2005.

Idaho Department of Environmental Quality, Water Body Assessment Guidance-Second Edition, 2002.

Mississippi State University. 1998. Information Sheet 1390.

Strausz, David. 2001. Ground Water Quality Technical Report No.18: A Reconnaissance of Groundwater Nitrate/Nitrite in the Cow Creek Watershed, Latah and Nez Perce County, Idaho. Vol. I of II. Idaho Department of Environmental Quality, Lewiston Regional Office.

Glossary

§303(d) — Refers to section 303 subsection "d" of the Clean Water Act. 303(d) requires states to develop a list of waterbodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.

Bedload — Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.

Beneficial Use — Any of the various uses of water, including, but not limited to, aquatic biota, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.

Best Management Practices (BMPs) — Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.

Catchment — Land area that contributes runoff (drains) to a given point in a stream or river. Synonymous with watershed and drainage or river basin.

Censored Data — Sample observations for which the complete distribution is not known. Censored data often appear in laboratory reports when the concentration being analyzed is lower than the detection limit or higher than the allowable range for a particular type of laboratory equipment or procedure.

Conductivity — The ability of an aqueous solution to carry electric current, expressed in micro (μ) mhos/cm at 25 °C. Conductivity is affected by dissolved solids and is used as an indirect measure of total dissolved solids in a water sample.

Criteria — In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. EPA develops criteria guidance; states establish criteria.

Cubic Feet per Second — A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, one cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.

Discharge — The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).

Dissolved Oxygen — The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life.

E. coli — Short for *Escherichia Coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans. Their presence is often indicative of fecal contamination.

Exceedance — A violation of the pollutant levels permitted by water quality criteria.

Mean — Describes the central tendency of a set of numbers. The arithmetic mean is calculated by adding all items in a list, then dividing by the number of items.

Median — The middle number in a sequence of numbers. If there are an even number of numbers, the median is the average of the two middle numbers. For example, 4 is the median of 1, 2, 4, 14, 16; and 6 is the median of 1, 2, 5, 7, 9, 11.

Nonpoint Source — A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

Nutrient — Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth.

pH — The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.

Point Source	A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable "point" of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.
Pollutant	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.
Riffle	A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.
Sediments	Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.
Subbasin	A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions.
Surface Runoff	Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and

lakes. Surface runoff is also called overland flow.

Suspended Sediments — Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.

Thalweg — The center of a stream's current, where most of the water flows.

Total Suspended Solids (TSS) — A measure of the suspended organic and inorganic solids in water. Measured in mg/L or ppm.

Tributary — A stream feeding into a larger stream or lake.

Turbidity — A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.

Water Quality Limited — A label that describes waterbodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.

Water Quality Standards — State-adopted and EPA-approved ambient standards for waterbodies. The standards prescribe the use of the waterbody and establish the water quality criteria that must be met to protect designated uses.

Watershed	1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region which contributes water to a point of interest in a waterbody.