Shoshone Basin Water Quality Monitoring Report

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Idaho Association of
Soil Conservation Districts
Twin Falls, Idaho

Introduction

In 2005, the Idaho Association of Soil Conservation Districts (IASCD) conducted a water quality monitoring program in the Shoshone Creek Subbasin (HUC 1704021306). This drainage consists of 218,600 acres of Snake River Basin/high desert ecosystem located in southern Idaho. The primary water body is Shoshone Creek, which originates in the Sawtooth National Forest and drains south into Nevada and into Salmon Falls Creek. Land ownership is a combination of: U.S. Forest Service (20.3 %), private (33 %), BLM (44.7 %), and State of Idaho (2.0 %). The primary activities in the basin are grazing and recreation.

The purpose of this report is to assist the Idaho Department of Environmental Quality (IDEQ) with the completion of the Salmon Falls Creek Total Maximum Daily Load (TMDL).

Several streams within the Shoshone basin are listed on the state of Idaho §303(d) list. Shoshone Creek, Cottonwood Creek, Big Creek, and Hot Creek are all included on the 303(d) list of impaired streams. The pollutants of concern for these creeks are: sediment, nutrients, dissolved oxygen, temperature, and bacteria.

Formal targets have not yet been established for this subbasin. Therefore, potential TMDL targets, taken from similar established values in nearby subbasins already completed, are used in this report (Table 1).

Table 1. Potential targets for Shoshone Creek.

Pollution	Likely TMDL Target
Suspended Sediment Concentration (SSC)	80 mg/L instantaneous
Total Phosphorous (TP)	0.116 mg/L instantaneous
Bacteria (*E. coli*)	Not to exceed 406cfu/100 mL
Dissolved Oxygen (DO)	> 6.0 mg/L
Max. Temp. (°C) Salmonid Spawning	13°C (May 1- June 30, Sept. 15-Nov. 15)
Max. Temp. Summer (°C)	22°C (June 22 - Sept. 21)

Methods

IASCD monitored four of these streams on a bi-weekly basis (Figure 1). Although monitoring was planned for an entire 12-month season, early heavy snowfall hampered efforts to collect data throughout the winter months. Therefore, the data presented were collected from mid-April through late-October. Site names and descriptions are presented in Table 2.

Table 2. Description of monitoring locations.

Site	Description
SC1	Shoshone Creek 10 meters below Pole Camp Creek
SC2	Shoshone Creek 10 meters below Cottonwood Creek
SC3	Shoshone Creek 10 meters below Hot Creek
BC	Big Creek one mile above confluence with Shoshone Creek
CC	Cottonwood Creek 10 meters below confluence with Langford Flat Creek
HC	1/8 mile above confluence with Shoshone Creek

At each location, samples were collected for suspended sediment concentration (SSC), total phosphorous (TP), orthophosphorous (OP), and *Escherichia coli* (*E. coli*) for the entire season. Stream discharge, temperature, pH, conductivity, total dissolved solids (TDS), and dissolved oxygen (DO) were also measured at all monitoring locations.

Additionally, total Kjeldahl nitrogen (TKN), ammonia, and nitrates were collected for the first four monitoring events at all sites. These samples were discontinued because it was determined that nitrogen was not a major factor contributing to nutrient impairment within the basin.

All sites were monitored from April 14th, 2005 – October 27th, 2005 except: SC1 (monitored from April 18th – October 27th not including the month of September), SC2 (monitored from May 31st – July 18th), and CC (monitored from April 18th – August 23rd). The latter two sites, SC2 and CC, were discontinued because flow became stagnant or non-existent (dry).

Figure 1. 2005 monitoring locations.

Results

Stream Discharge

Stream flow patterns in the Shoshone Basin are representative of typical high desert/ basin and range type streams in the area. Very little summer precipitation tends to fall

and make its way into streams. Flow regimes are generally driven by snow pack melt off in early to late May.

The 2005 snow pack in the Shoshone Basin was roughly 102% of average and total runoff was 122% of the 23-year average (NRCS 2006). This is one of the most 'normal' years that the basin has experienced in the last decade; precipitation and stream flow has been significantly lower than average in the recent past.

Flows measured in 2005 ranged from 'no flow' (CC and SC2) during late summer to 153.0 cfs at SC3 in mid-May. Annual mean flow in the basin ranged from 3.4 cfs at HC to 41.3 cfs at SC3 (Table 3).

The Natural Resource Conservation Service (NRCS) maintains a gauging station in the lower portion of Shoshone Creek just above its confluence with Salmon Falls Creek. This gauge, located roughly 5 stream miles below SC3, measured a seasonal peak flow at 445.6 cfs on May 18th (Appendix A). According to the NRCS gauge, the average flow for the monitoring period (April 18th – October 27th) was 79.2 cfs.

Table 1. Summary of Shoshone Basin flow.

	Mean Flow (cfs)	Min. Flow (cfs)	Max. Flow (cfs)	Range (cfs)	Std. Deviation (cfs)
SC1	16.5	0.1	60.6	60.5	22.4
SC2	21.7	Stagnant	64.3	61.0	19.4
SC3	41.3	3.1	153.0	149.9	53.9
CC1	7.9	0.0	36.9	36.9	12.9
HC1	3.4	2.3	4.5	2.2	0.7
BC1	11.7	2.1	46.5	44.4	14.9

By early July, when the majority of snow had melted, stream flow dropped off precipitously (Figure 2). The majority of these desert streams were losing reaches due to lack of groundwater inflow. Flow in the lower portions of the smaller tributaries to Shoshone Creek often stagnated and/or dry up. This was the case for Cottonwood Creek and the upper and middle reaches of Shoshone Creek.

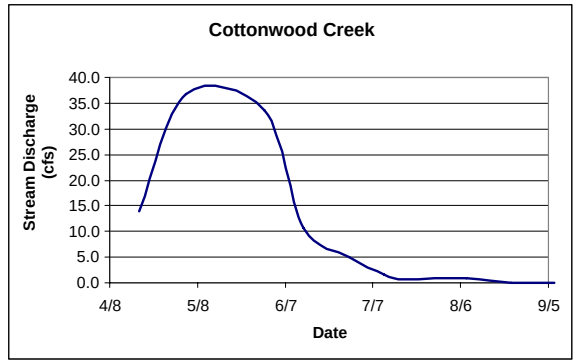

Figure 2. Typical basin and range stream.

Conversely, the upper portion of the Big Creek watershed was dominated by beaver ponds. These ponds create water storage through the summer. As a result, Big Creek generally flowed throughout the entire season. Also, a few of the streams in the Shoshone Basin are unique in that they are fed by springs; Hot Creek is one of these examples. These springs served to augment the normal hydrograph recession curve by delaying and reducing the peak while extending the duration of flow through the year (Figure 3).

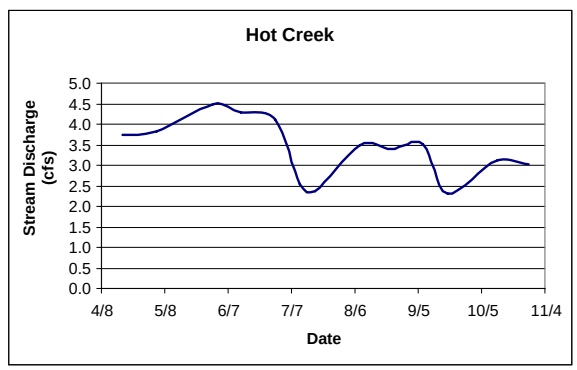

Figure 3. Example of a spring-fed stream.

Suspended Sediment Concentration

Sediment can negatively impact aquatic life. Extended periods of elevated sediment levels can interfere with the ability of fish to feed, damage fish gills, and reduce fish growth rates. High levels of sediment can also lead to a decrease in available fish spawning and rearing habitat. Sedimentation of stream channels makes it difficult for fish to reach the insects that reside in the interstitial spaces in the gravels and rocks in the streambed that they rely on for food.

Additionally, sediment can be a major contributor of nutrients such as phosphorous. This may lead to nuisance vegetation that also hinders fish populations. Most completed sediment TMDLs in the area state that the daily maximum value for SSC should not exceed 80 mg/L for instantaneous measurements (IDEQ 2002). This value will be used as the target for this document.

The highest SSC readings corresponded with peak flow events that occurred during the month of May. With the exception of Hot Creek and Big Creek, SSC figures quickly declined as discharge dropped. Relatively constant SSC readings on spring-fed Hot Creek were likely due to the fact that flow never fluctuated by more than about 2 cfs (50%). Big Creek did not exhibit a peak in SSC at high flow which was likely due to the numerous beaver ponds located within a mile or so of the monitoring location. These ponds often slow water velocity and trap a large portion of the sediment farther up in the watershed.

The highest instantaneous SSC concentration was 59.2 mg/L at SC2 on May 31st. The second highest instantaneous SSC concentration was 37.5 mg/L at SC1 on May 24th. The highest average SSC figure in the basin was found in Shoshone Creek at SC2 (20.4 mg/L) and the lowest average was found at Big Creek (7.4 mg/L). Figure 4 illustrates average SSC during the 2005 monitoring season at all six sites.

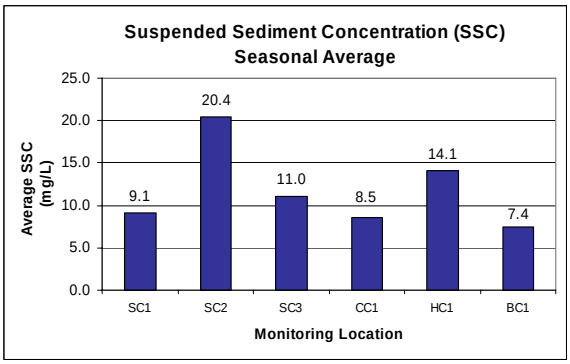

Figure 4. Average SSC for each site.

SSC was multiplied by the flow and the length of the monitoring season to give a general idea of how much soil has likely moved down each stream. SC3, the lowest monitoring location in the watershed, had the greatest transport of sediment (375 tons/monitoring season). This number reflects the cumulative loss of soil within the basin. Hot Creek had the lowest soil loss (26 tons/ monitoring season). Figure 5 shows the cumulative sediment movement past each monitoring location for the season.

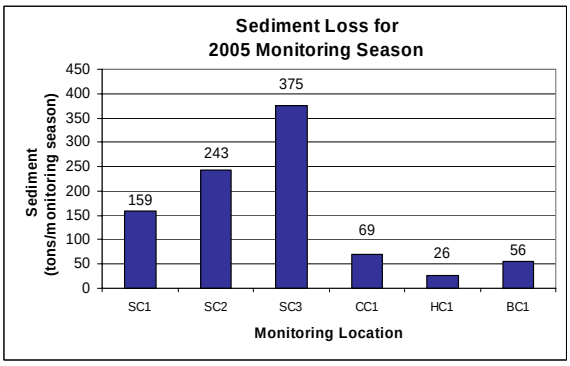

Figure 5. Estimated sediment transport for each site for the entire monitoring season.

Overall, water quality with respect to sediment was very good throughout the year. The IDEQ proposed target of 80 mg/L

was never exceeded in any of the monitored streams in the basin.

Total Phosphorous

Total phosphorous is the measurement of all phosphorous, organic and inorganic, contained in a water sample. A portion of this phosphorus is in a dissolved form (ortho-phosphorus) which can be readily utilized by plants and can lead to impairment of water bodies if the concentration is high enough.

High concentrations of phosphorous can lead to increases in nuisance algae. When the algae die, decomposition requires a massive amount of oxygen. Dissolved oxygen levels may decline and this may lead to increased fish stress and/or mortality. Decomposition may also cause the pH of the water body to increase which can in turn lead to further changes in water chemistry and additional releases of phosphorous stored in the stream substrate (IDEQ 2002).

The expected target for total phosphorous (TP) is 0.116 mg/L for *instantaneous* measurements. This level was exceeded once in every stream (8% of all sampling events) with the exception of: SC1 (18%), HC (15%), and SC2 which never exceeded the target. Regardless, all recorded exceedances ranged between 0.26 mg/L to 0.28 mg/L and occurred near peak runoff when SSC readings were highest.

Average seasonal TP ranged from 0.05 mg/L at SC2 to 0.08 mg/L at SC1. Average seasonal TP at SC3 and CC sites was 0.06 mg/L. Average seasonal TP at BC and HC sites was 0.07 mg/L (Table 4).

Table 2. TP statistics for each site.

	Mean TP (mg/L)	Min. TP (mg/L)	Max. TP (mg/L)	Range (mg/L)	Std. Deviation (mg/L)
SC1	0.08	0.02	0.26	0.23	0.07
SC2	0.05	0.04	0.09	0.05	0.02
SC3	0.06	0.02	0.28	0.03	0.07
CC1	0.06	0.00	0.28	0.28	0.07
HC1	0.07	0.03	0.26	0.23	0.06
BC1	0.07	0.03	0.26	0.23	0.06

Orthophosphorous (OP), that portion of TP that is dissolved and available for aquatic growth, accounted for roughly 25% of TP at all sites except HC. Ortho-phosphorous at HC accounted for 50% of TP. Generally speaking, water quality with respect to TP and orthophosphorous was very good (Table 4).

Temperature

Temperature is a major factor in determining the composition of an aquatic community. It often determines which organisms are present or absent. As temperature increases, the water's ability to hold dissolved oxygen decreases. This can lead to a stressful environment for fish and make them more susceptible to disease and/or lower their reproductive capacity.

Natural factors that effect water temperature include: climate, shade (from riparian plants, etc), aspect, channel shape, and groundwater interaction. The IDEQ has determined that the instantaneous temperature of any stream listed for cold water biota should never exceed 22 ^{o}C and average daily temperature should stay below 19 ^{o}C (IDEQ 2002). Additionally, because Shoshone Creek is listed for salmonid spawning, a more stringent maximum temperature criterion of 13 ^{o}C will likely be mandated for the periods of May 1st – June 30th and September 15th – November 15th.

Instantaneous temperature values exceeded the state criteria at least once at every site. The majority of temperature exceedances in all monitored streams occurred during the salmonid spawning temperature criteria times of the year. HC1 was the leading offender with 46% (Table 5) of total measurements exceeding the temperature standards; SC3 exceeded the standards the fewest times (15%). It should also be noted that these temperature values should be considered conservative. All instantaneous temperature measurements were generally completed before 2:00 PM during the summer months—hours before the warmest part of the day.

Table 3. Instantaneous temperature measurements for each site.

	Mean Temp (°C)	Min. Temp (°C)	Max. Temp (°C)	Range (°C)	Std. Deviation (°C)	% Exceed
SC1	13.9	3.7	25.7	22.0	7.9	36
SC2	15.2	9.7	21.8	12.1	4.7	20
SC3	13.5	6.7	20.0	13.3	3.8	15
CC1	15.1	4.3	22.2	17.9	5.6	31
HC1	16.0	9.9	21.6	11.7	3.4	46
BC1	14.2	6.4	22.9	16.5	4.7	31

Dissolved Oxygen

The state of Idaho mandates that dissolved oxygen (DO) levels in a water body be sufficient enough to support cold water biota in 'cold water biota' listed waters (IDEQ 2002). Shoshone Creek is listed as such; therefore, DO levels must be at or above 6.0 mg/L at all times.

Dissolved oxygen values in the Shoshone Basin look good in general (Table 6). The best DO conditions were observed in the tributaries to Shoshone Creek. This may be partially due to better aeration and water-air mixing generally found in higher gradient streams. Additionally, most DO depletions in these streams occurred in the hottest summer months (July and August) when the stream water was not easily capable of maintaining high DO concentrations.

Table 4. DO measurements for each site.

	Mean DO (mg/L)	Min. DO (mg/L)	Max. DO (mg/L)	Range (mg/L)	Std. Deviation (mg/L)	% Exceed
SC1	7.0	5.3	10.2	4.9	2.5	36
SC2	6.1	5.2	6.9	1.7	0.8	40
SC3	7.6	6.3	9.3	3.0	1.1	0
CC1	6.9	5.5	10.1	4.6	1.4	0
HC1	9.2	6.0	12.2	6.2	1.8	0
BC1	7.9	5.9	9.3	3.5	1.0	8

Bacteria

E. coli is a species of coliform bacteria used by the state of Idaho to indicate the presence of pathogenic organisms. When present in high concentrations, these pathogens can cause sickness or death in humans. They do not have any known effects on aquatic life.

When an *E. coli* measurement exceeds 406 cfu/100 mL in a primary contact area, IDEQ requires that five samples be gathered over a 30-day period in order to compute the geometric mean to determine if the water body is meeting state water quality standards (IDEQ 2002). However, since this amount of monitoring was impractical for this monitoring regime, the 406 cfu/ 100 mL instantaneous number will be used to illustrate the likelihood of water quality impairment with respect to *E. coli*.

E. coli exceedances were observed at SC1, CC, and HC. These exceedances generally occurred from mid-July to early-August when water temperatures were high and flow was relatively low (Table 7). The highest measurement was taken at SC1 on August 8. This site is just below an area commonly frequented by cattle.

Table 5. E. coli measurements for each site.

	Mean *E. coli* (cfu/100mL)	Max. *E. coli* (mg/L)	% Exceed
SC1	270	1600	18
SC2	163	330	0
SC3	54	370	0
CC1	256	1300	23
HC1	92	580	8
BC1	143	310	0

Nitrogen

Like phosphorous, nitrogen can also be a factor in nuisance aquatic plant growth. Generally in stream systems, however, phosphorous is the limiting factor. For nitrogen to have a substantial impact on aquatic development, it must exceed phosphorous concentrations by a ratio of 16:1 (Schindler 1978).

IDEQ requested that total nitrogen (total Kjeldahl nitrogen, total nitrate + nitrite, and ammonia) were sampled. Samples were taken for only four monitoring events from April 18th – June 13th for all sites.

Nitrogen-phosphorous ratios never exceeded 10:1. This suggested that nitrogen was not a significant nutrient input in the basin. Thus, nitrogen monitoring was discontinued.

Conclusions

Overall water quality in the Shoshone Basin was very good. Average SSC concentrations ranged from 7.4 mg/L – 20.4 mg/L. The highest instantaneous measurement was 25% below the proposed DEQ target of 80 mg/L.

Total phosphorous seemed to be a slight issue. All monitoring locations, except SC2, exceeded the proposed instantaneous target for at least 8% of monitoring events; however, average TP only ranged between 0.06 – 0.08 mg/L. The peaks in instantaneous TP seem to reflect high sediment levels at the time of sampling.

Temperature appears to be the most critical parameter with respect to stream quality in the basin. Four of the six locations monitored exceeded the state criteria for temperature for at least 30% of the sampling events. Due to the time of day that temperature measurements were taken, this figure may be conservative. The majority of exceedances occurred during the spring and fall temperature criteria (salmonid spawning). High water temperature measurements may be an expression of riparian conditions and beaver activity in the region. Areas of sparse streamside vegetation and numerous beaver ponds often result in reduced shading and increased solar isolation. This can have a dramatic influence on water temperatures.

With the exception of SC1 and SC2, dissolved oxygen levels were within state standards. The violations at these two sites occurred in July and August when flows were low and air and water temperatures where high.

Bacteria levels were an issue at SC1 and CC, exceeding the state instantaneous bacteria criterion of 406 cfu/ mL. This level was exceeded for 18% of all monitoring events at SC1 and 23% of all events at CC. This may be due to cattle in the stream within close proximity to the monitoring locations.

Nitrogen levels in the basin were well below the 16:1 ratio with phosphorous. This would suggest that phosphorous is generally the limiting component in aquatic growth in the basin.

Recommendations

The major contributors of sedimentation and TP levels in the basin appear to be: natural erosion, animal induced erosion, improper road maintenance, and recreation activities (i.e. ATV traffic). It is recommended that the following BMPs be implemented in each of the water body areas to improve water quality.

SC1

- Develop grazing management plans
- Avoid extensive grazing of animals in or near streams especially when land is wet or saturated or when streams are at low flow
- Fencing off creeks and streams
- Develop off site watering
- Restore riparian corridor (new plantings)

SC2

- Develop grazing management plans
- Avoid extensive grazing of animals in or near streams
- Fencing off creeks and streams
- Restore riparian corridor (new plantings)

SC3

- Develop off site watering
- Change timing and limit duration of cattle grazing (especially during dry periods)
- Conduct comprehensive stream surveys to better identify potential BMPs for the area

CC

- Rework/ replace culvert at main road crossing to stop head cut erosion
- Modify stream channel above main road crossing to better direct high flows through the culvert (not over the road)

HC

- Develop off site watering
- Develop grazing management plan to change timing and limit duration of cattle grazing (especially during dry periods

BC

- Place larger culverts at road crossings
- Perform water mitigation where backflow from beaver damns inundate access roads (i.e. bypass pipes to control water levels)
- Use of beaver deceivers to help manage pond construction

The BMPs listed above are only a general starting place. Many of these BMPs are currently in the planning process or already underway. Offsite watering of cattle is planned for early-2007 near SC1 and culverts have been replaced (after a major flood event this year) at a major road crossing on Big Creek. Although implementation of these strategies may not completely eliminate inputs of pollutants into these streams, they will go a long way to improving water quality in the basin.

Acknowledgements

I would like to thank Jenifer Clawson for collecting all the data used in the report as well as providing input for potential BMP ideas. Kirk Campbell and Gary Bahr have been constant and indispensable technical and editorial resources and important sources of support. I would also like to thank Amy Jenkins for her edits to this document and Clyde Lay at the DEQ for his help with the interpretation of nitrogen results and his expertise in statistical analysis.

References

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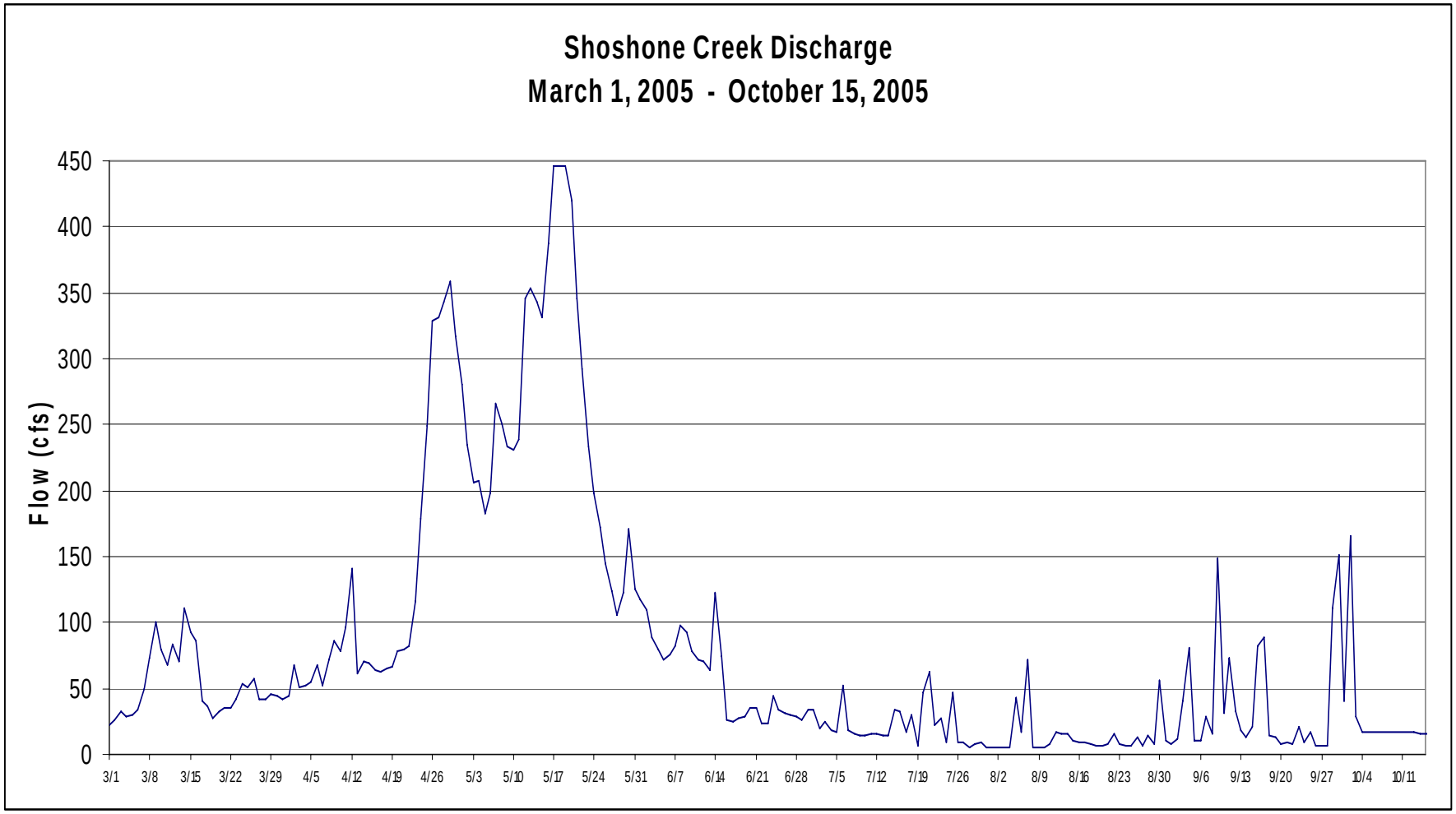
Appendix A: Stream Discharge at the NRCS Gage for the Shoshone Basin at Confluence with Salmon Falls Creek.



Shoshone Creek (SC1) - Pole Camp Creek

Date	Flow (ft^3/s)	Temp (^oC)	DO (mg/L)	% Saturation	Cond (microS)	TDS (mg/L)	pH	SSC (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Total P (mg/L)	Ortho P (mg/L)	E. Coli (cfu/100 mL)	Time
4/18/2005	29.1	3.7	8.6	65.4	49	27	8.6	14.4	<.04	0.25	0.06	0.016	22	
5/4/2005	57.5	6.2	10.2	82.0	45	na	7.0	18.8	<.04	0.33	0.26	0.012	7	1000
5/24/2005	60.6	8.4	7.0	59.7	54	28	7.3	37.5	<.04	0.30	0.06	0.020	13	1010
6/13/2005	19.5	15.3	6.1	61.3	58	30	7.4	4.8	<.04	0.17	0.04	0.016	14	
6/29/2005	7.1	18.0	6.3	66.0	116	58	7.0	3.1	<.04	0.18	0.05	0.016	52	1500
7/11/2005	2.5	25.7	5.3	69.9	59	30	7.6	3.8	<.04		0.05	0.019	240	1445
7/18/2005	2.4	23.4	5.8	67.5	63	32	7.4	3.4	<.04	0.16	0.04	0.024	120	1440
8/8/2005	2.0	18.0	5.8	61.7	72	38	6.5	5.4	<.04	0.20	0.03	0.018	1,600	1400
8/23/2005	0.1	15.9	5.4	53.0	148	79	7.6	2.9	<.04	0.14	0.12	0.020	220	1300
10/12/2005	0.2	9.3	7.9	68.4	631	323	7.2	3.2	<.04	0.12	0.10	0.041	410	1230
10/27/2005	0.2	8.5	8.5	73.2	100	48	6.2	2.5	<.04	0.20	0.02	0.011	64	1330
Average	**16.5**	**13.9**	**7.0**	**66.2**	**127**	**69**	**7.2**	**9.1**	**0.00**	**0.21**	**0.08**	**0.020**	**270**	
April Av	29.1	3.7	8.6	65	49	27	8.6	14.4	<.04	0.25	0.06	0.016	22	**monthly average**
May Av	59.0	7.3	8.6	71	49	28	7.2	28.2	<.04	0.32	0.16	0.016	10	**monthly average**
June Av	13.3	16.7	6.2	64	87	44	7.2	4.0	<.04	0.18	0.04	0.016	33	**monthly average**
July Av	2.4	24.6	5.5	69	61	31	7.5	3.6	<.04	0.16	0.04	0.022	180	**monthly average**
August Av	1.1	17.0	5.6	57	110	59	7.1	4.2	<.04	0.17	0.08	0.019	910	**monthly average**
Sept Av														
October Av	0.2	8.9	8.2	70.8	366	186	6.7	2.9	<.04	0.2	0.1	0.0	237	**monthly average**
Season Av	**17.5**	**13.0**	**7.1**	**66.1**	**120**	**62**	**7.4**	**9.5**	**<.04**	**0.21**	**0.07**	**0.019**	**232**	**seasonal average**
April Load								2,259		39.2	9.4	2.5		**lbs/ day**
May Load								8,953		100.2	50.9	5.1		**lbs/ day**
June Load								283		12.5	3.0	1.1		**lbs/ day**
July Load								47		2.1	0.5	0.3		**lbs/ day**
August Ld								24		1.0	0.4	0.1		**lbs/ day**
Sept Load								0						**lbs/ day**
October Load								3		0.2	0.1	0.0		**lbs/ day**
TOTAL LOAD (192 DAYS)								**317,331**		**4,966**	**2,058**	**293**		**LBS/ PERIOD**
# of Samples		11	11					11		11	11	11	11	
# Exceeded		4	4					0		0	2	0	2	
% Exceeded		**36%**	**36%**					**0%**		**0%**	**18%**	**0%**	**18%**	
Statistics														
Mean	16.5	13.9	7.0	66.2	127	69	7.2	9.1		0.21	0.08	0.020	270	
Stand Dev	22.4	7.9	2.5	20.4	166	86	2.2	10.7		0.09	0.07	0.009	449	
Min	0.1	3.7	5.3	53.0	45	27	6.2	2.5		0.12	0.02	0.011	7	
Max	60.6	25.7	10.2	82.0	631	323	8.6	37.5		0.33	0.26	0.041	1,600	
Range	60.4	22.0	4.9	29.0	586	297	2.4	35.0		0.21	0.23	0.030	1,593	

Shoshone Creek (SC2) - 1/2 mile above Cottonwood Creek

Date	Flow (ft^3/s)	Temp (^oC)	DO (mg/L)	% Saturation	Cond (microS)	TDS (mg/L)	pH	SSC (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Total P (mg/L)	Ortho P (mg/L)	E. Coli (cfu/100 mL)	Time
4/18/2005	na													
5/4/2005	na												110	1100
5/31/2005	64.3	9.7	6.8	61.2	62	32	7.1	59.2	<.04	0.40	0.09	0.027	50	
6/13/2005	22.6	12.2	6.9	64.0	119	60	8.0	16.3	<.04	0.22	0.05	0.019	120	1410
6/29/2005	12.4	15.0	6.3	62.5	95	49	7.0	14.2	<.04	0.20	0.04	0.016	330	1400
7/11/2005	6.0	21.8	5.2	59.4	216	109	8.0	7.4	<.04	0.27	0.05	0.018	220	
7/18/2005	3.3	17.3	5.2	63.2	83	42	7.1	5.1	<.04	0.23	0.04	0.022	150	
8/8/2005	0.0													
8/23/2005	0.0													
9/7/2005	0.0													
9/19/2005	0.0													
Average	**21.7**	**15.2**	**6.1**	**62.1**	**115**	**58**	**7.4**	**20.4**	**< 0.4**	**0.26**	**0.05**	**0.020**	**163**	
April Av														
May Av	64.3	9.7	6.8	61	62	32	7.1	59.2	<.04	0.40	0.09	0.027	80	**monthly average**
June Av	17.5	13.6	6.6	63	107	55	7.5	15.3	<.04	0.21	0.04	0.018	225	**monthly average**
July Av	4.6	19.6	5.2	61	149	75	7.5	6.3	<.04	0.25	0.05	0.020	185	**monthly average**
August Av								0.0		0.00	0.00	0.000		**monthly average**
Sept Av								0.0		0.00	0.00	0.000		
October Av														
Season Av	**28.8**	**14.3**	**6.2**	**61.9**	**106**	**54**	**7.4**	**16.1**	**<.04**	**0.17**	**0.04**	**0.013**	**163**	**seasonal average**
April Load								0		0.0	0.0	0.0		**lbs/ day**
May Load								20,517		138.6	29.8	9.4		**lbs/ day**
June Load								1,440		19.8	4.2	1.7		**lbs/ day**
July Load								155		6.2	1.1	0.5		**lbs/ day**
August Ld								0		0.0	0.0	0.0		**lbs/ day**
Sept Load								0		0.0	0.0	0.0		**lbs/ day**
October Load								0		0.0	0.0	0.0		**lbs/ day**
TOTAL LOAD (60 DAYS)								**486,484**		**3,623**	**773**	**253**		**LBS/ PERIOD**
# of Samples		5	5					5		5	5	5	5	
# Exceeded		1	2					0		0	0	0	0	
% Exceeded		**20%**	**40%**					**0%**		**0%**	**0%**	**0%**	**0%**	
Statistics														
Mean	21.7	15.2	6.1	62.1	115	58	7.4	20.4		0.26	0.05	0.020	163	
Stand Dev	19.4	4.7	0.8	1.8	60	30	0.5	22.2		0.08	0.02	0.004	99	
Min	0.0	9.7	5.2	59.4	62	32	7.0	5.1		0.20	0.04	0.016	50	
Max	64.3	21.8	6.9	64.0	216	109	8.0	59.2		0.40	0.09	0.027	330	
Range	64.3	12.1	1.7	4.6	155	78	1.0	54.1		0.20	0.04	0.011	280	

Shoshone Creek (SC3)

Date	Flow (ft^3/s)	Temp (^oC)	DO (mg/L)	% Saturation	Cond (microS)	TDS (mg/L)	pH	SSC (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Total P (mg/L)	Ortho P (mg/L)	E. Coli (cfu/100 mL)	Time
4/18/2005	73.2	6.7	8.0	65.6	67	34	6.9	15	<.01	0.20	0.07	0.018	16	1315
5/4/2005	142.0	11.1	9.3	84.3	76	33	7.8	16.9	<.04	0.48	0.28	0.023	20	1400
5/31/2005	153.0	15.9	6.4	66.1	72	40	8.7	27.3	<.04	0.40	0.09	0.040	27	1515
6/13/2005	81.4	11.4	7.1	65.8	130	67	7.9	13.6	<.04	0.27	0.06	0.029	41	
6/29/2005	31.5	14.5	6.8	66.9	168	84	8.3	8.7	<.04	0.29	0.05	0.027	72	1045
7/11/2005	15.4	20.0	6.3	69.4	116	79	8.4	16.6	<.04	0.24	0.06	0.027	370	
7/18/2005	7.9	17.9	7.0	73.8	194	96	8.5	8.8	0.13	0.24	0.04	0.050	4	
8/8/2005	8.7	17.3	6.7	69.9	268	149	7.9	8.7	<.04	0.30	0.03	0.025	47	1045
8/23/2005	6.2	14.0	6.7	63.7	241	127	8.0	5.3	<.04	0.14	0.03	0.029	60	950
9/7/2005	5.6	14.4	7.9	77.4	303	158	7.5	3.8	<.04	0.11	0.02	0.011	31	1200
9/19/2005	5.1	13.1	9.1	86.6	208	146	7.6	3.7	<.04	0.10	0.02	0.016	6	1250
10/12/2005	3.1	11.1	9.3	84.3	194	98	7.9	3.6	<.04	0.21	0.02	0.021	2	1330
10/27/2005	3.3	8.5	8.3	71.3	103	51	8.8	11	<.04	0.15	0.02	0.017	8	1100
Average	**41.3**	**13.5**	**7.6**	**72.7**	**164.5**	**89.3**	**8.0**	**11.0**	**<.05**	**0.24**	**0.06**	**0.026**	**54**	
April Av	153.0	15.9	6.4	66	72	40	8.7	27.3	0.1	0.40	0.09	0.040	27	**monthly average**
May Av	56.4	13.0	7.0	66	149	76	8.1	11.2	<.04	0.28	0.05	0.028	57	**monthly average**
June Av	11.7	19.0	6.7	72	155	88	8.5	12.7	<.04	0.24	0.05	0.039	187	**monthly average**
July Av	7.5	15.7	6.7	67	255	138	8.0	7.0	0.1	0.22	0.03	0.027	54	**monthly average**
August Av	5.3	13.8	8.5	82	256	152	7.5	3.8	<.04	0.11	0.02	0.014	19	**monthly average**
Sept Av	5.3	13.8	8.5	82.0	255.5	152.0	7.5	3.8	<.04	0.11	0.02	0.014	19	**monthly average**
October Av	3.2	9.8	8.8	77.8	148.5	74.6	8.4	7.3	<.04	0.18	0.02	0.019	5	**monthly average**
Season Av	**34.6**	**14.4**	**7.5**	**73.2**	**184**	**103**	**8.1**	**10.4**		**0.22**	**0.04**	**0.026**	**52**	**seasonal average**
April Load								24,765		329.9	73.4	33.0		**lbs/ day**
May Load								3,731		85.2	16.3	8.5		**lbs/ day**
June Load								878		15.1	3.1	2.4		**lbs/ day**
July Load								309		8.8	1.2	1.1		**lbs/ day**
August Ld								119		3.0	0.5	0.4		**lbs/ day**
Sept Load														**lbs/ day**
October Load								138		3.1	0.4	0.3		**lbs/ day**
PERIOD (192 DAYS)								**958,084**		**14,243**	**3,037**	**1,463**		**LBS/ PERIOD**
# of Samples		13	13					13		13	13	13	13	
# Exceeded		2	0					0		0	1	0	0	
% Exceeded		**15%**	**0%**					**0%**		**0%**	**8%**	**0%**	**0%**	
Statistics														
Mean	41.3	13.5	7.6	72.7	165	89	8.0	11.0		0.24	0.06	0.026	54	
Stand Dev	53.9	3.8	1.1	8.0	78	45	0.5	6.8		0.11	0.07	0.010	97	
Min	3.1	6.7	6.3	63.7	67	33	6.9	3.6		0.10	0.02	0.011	2	
Max	153.0	20.0	9.3	86.6	303	158	8.8	27.3		0.48	0.28	0.050	370	
Range	150.0	13.3	3.0	22.9	236	126	1.9	23.7		0.38	0.26	0.039	368	

Cottonwood Creek (CC1)

Date	Flow (ft^3/s)	Temp (^oC)	DO (mg/L)	% Saturation	Cond (microS)	TDS (mg/L)	pH	SSC (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Total P (mg/L)	Ortho P (mg/L)	E. Coli (cfu/100 mL)	Time
4/18/2005	13.9	4.3	8.4	64.4	49	25	6.4	11.7	0.01	0.04	0.10	0.022	84	1115
5/4/2005	36.9	9.1	10.1	87.6	52	na	7.7	12.9	0.04	0.13	0.28	0.020		
5/31/2005	33.5	13.3	6.8	64.6	75	32	8.9	22.8	0.04	0.06	0.04	0.037	37	
6/13/2005	10.7	15.4	6.5	62.5	71	36	6.3	16.4	0.04	0.02	0.07	0.031	55	1330
6/29/2005	5.0	15.0	6.5	64.3	94	50	6.8	15.3			0.07	0.028	100	1320
7/11/2005	1.6	22.2	5.5	63.1	219	112	7.7	8.3			0.09	0.039	280	1325
7/18/2005	0.6	20.2	5.9	65.6	80	41	7.0	10.4			0.08	0.044	1,300	1300
8/8/2005	1.0	18.0	6.6	70.1	88	45	6.7	9.4			0.06	0.029	770	1300
8/23/2005	0.1	18.7	6.1	60.0	125	63	7.0	3.5			0.04	0.018	440	1145
9/7/2005	0.0							0.0	0.00	0.00	0.00	0.000	0	
9/19/2005	0.0							0.0	0.00	0.00	0.00	0.000	0	
10/12/2005	0.0							0.0	0.00	0.00	0.00	0.000	0	
10/27/2005	0.0							0.0	0.00	0.00	0.00	0.000	0	
Average	**7.9**	**15.1**	**6.9**	**66.9**	**95**	**51**	**7.2**	**8.5**	**0.03**	**0.06**	**0.06**	**0.021**	**256**	
April Av	13.9	4.3	8.4	64.4	49	25	6.4	11.7	0.01	0.04	0.10	0.022	84	**monthly average**
May Av	35.2	11.2	8.4	76.1	64	32	8.3	17.9	0.04	0.10	0.16	0.029	37	**monthly average**
June Av	7.8	15.2	6.5	63.4	83	43	6.6	15.9	0.04	0.02	0.07	0.030	78	**monthly average**
July Av	1.1	21.2	5.7	64.4	150	76	7.4	9.4			0.09	0.042	790	**monthly average**
August Av	0.6	18.4	6.4	65.1	107	54	6.8	6.5			0.05	0.024	605	**monthly average**
Sept Av	0.0							0.0	0.00	0.00	0.00	0.000	0	
October Av	0.0							0.0	0.00	0.00	0.00	0.000	0	**monthly average**
Season Av	**8.4**	**14.1**	**7.1**	**66.7**	**90**	**46**	**7.1**	**8.7**		**0.03**	**0.07**	**0.021**	**228**	**seasonal average**
April Load								966		3.0	7.7	1.7		**lbs/ day**
May Load								3,726		18.0	30.3	5.4		**lbs/ day**
June Load								737		0.8	2.9	1.2		**lbs/ day**
July Load								60		0.0	0.5	0.2		**lbs/ day**
August Ld								21		0.0	0.2	0.1		**lbs/ day**
Sept Load								0		0.0	0.0	0.0		**lbs/ day**
October Load								0		0.0	0.0	0.0		**lbs/ day**
PERIOD (192 DAYS)								**151,157**		**600**	**1,141**	**236**		**LBS/ PERIOD**
# of Samples		13	13					13		13	13	13	13	
# Exceeded		4	0					0		0	1	0	3	
% Exceeded		**31%**	**0%**					**0%**		**0%**	**8%**	**0%**	**23%**	
Statistics														
Mean	7.9	15.1	6.9	66.9	95	51	7.2	8.5		0.06	0.06	0.021	256	
Stand Dev	12.9	5.6	1.4	8.2	52	31	0.8	7.4		0.05	0.07	0.016	404	
Min	0.0	4.3	5.5	60.0	49	25	6.3	0.0		0.00	0.00	0.000	0	
Max	36.9	22.2	10.1	87.6	219	112	8.9	22.8		0.13	0.28	0.044	1,300	
Range	36.9	17.9	4.6	27.6	171	87	2.6	22.8		0.13	0.28	0.044	1,300	

Hot Creek (HC1) - 10 meters above Shoshone Creek

Date	Flow (ft^3/s)	Temp (^oC)	DO (mg/L)	% Saturation	Cond (microS)	TDS (mg/L)	pH	SSC (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Total P (mg/L)	Ortho P (mg/L)	E. Coli (cfu/100 mL)	Time
4/18/2005	3.7	10.8	9.3	84.3	212	111	8.7	18.5	<.04	0.14	0.06	0.036	4	1330
5/4/2005	3.8	15.9	11.3	114.4	263		9.1	27.0	<.04	0.53	0.26	0.041	2	1430
5/31/2005	4.5	21.6	7.0	78.6	238	117	9.2	21.7	<.04	0.50	0.13	0.065	4	1530
6/13/2005	4.3	15.5	9.3	92.8	257	134	7.8	11.7	<.04	0.44	0.04	0.022	16	1150
6/29/2005	4.1	15.6	9.1	90.5	277	141	9.1	6.9			0.05	0.025	55	1130
7/11/2005	2.5	20.0	9.5	103.9	287	118	8.9	8.7			0.06	0.031	220	
7/18/2005	2.4	20.3	6.0	66.0	224	112	8.9	15.0			0.06	0.031	580	1115
8/8/2005	3.5	17.2	7.8	80.7	225	115	7.9	18.0			0.07	0.043	51	1135
8/23/2005	3.4	14.4	7.9	78.5	268	145	8.2	20.9			0.08	0.039	140	1030
9/7/2005	3.5	16.5	9.1	93.5	302	154	8.6	13.5			0.06	0.030	100	1245
9/19/2005	2.3	16.3	10.1	103.4	285	145	8.1	9.9			0.04	0.026	15	1220
10/12/2005	3.1	14.4	12.2	119.3	199	103	8.0	5.8			0.04	0.035	5	1420
10/27/2005	3.0	9.9	11.7	103.8	210	106	8.3	5.1			0.03	0.021	9	1445
Average	**3.4**	**16.0**	**9.2**	**93.1**	**250**	**125**	**8.5**	**14.1**	**<0.04**	**0.40**	**0.07**	**0.034**	**92**	
April Av	3.7	10.8	9.3	84.3	212	111	8.7	18.5	<.04	0.14	0.06	0.036	4	**monthly average**
May Av	4.2	18.7	9.1	96.5	251	117	9.1	24.4	<.04	0.52	0.20	0.053	3	**monthly average**
June Av	4.2	15.6	9.2	91.7	267	138	8.4	9.3	<.04	0.44	0.05	0.024	36	**monthly average**
July Av	2.5	20.2	7.7	85.0	256	115	8.9	11.9			0.06	0.031	400	**monthly average**
August Av	3.5	15.8	7.8	79.6	247	130	8.0	19.5			0.07	0.041	96	**monthly average**
Sept Av	2.9	16.4	9.6	98.5	294	150	8.3	11.7			0.05	0.028	58	
October Av	3.1	12.2	12.0	111.6	205	105	8.1	5.5			0.03	0.028	7	**monthly average**
Season Av	**3.4**	**15.7**	**9.3**	**92.4**	**247**	**124**	**8.5**	**14.4**	**<0.04**	**0.37**	**0.07**	**0.034**	**86**	**seasonal average**
April Load								373		2.8	1.2	0.7		**lbs/ day**
May Load								547		11.6	4.4	1.2		**lbs/ day**
June Load								211		10.0	1.0	0.5		**lbs/ day**
July Load								157		0.0	0.8	0.4		**lbs/ day**
August Ld								362		0.0	1.3	0.8		**lbs/ day**
Sept Load								184		0.0	0.8	0.4		**lbs/ day**
October Load								90		0.0	0.5	0.5		**lbs/ day**
TOTAL LOAD (192 DAYS)								**52,734**		**668**	**274**	**124**		**LBS/ PERIOD**
# of Samples		13	13					13		13	13		13	
# Exceeded		6	0					0		0	2		1	
% Exceeded		**46%**	**0%**					**0%**		**0%**	**15%**		**8%**	
Statistics														
Mean	3.4	16.0	9.2	93.1	250	125	8.5	14.1		0.40	0.07	0.034	92	
Stand Dev	0.7	3.4	1.8	15.5	34	18	0.5	6.8		0.18	0.06	0.012	161	
Min	2.3	9.9	6.0	66.0	199	103	7.8	5.1		0.14	0.03	0.021	2	
Max	4.5	21.6	12.2	119.3	302	154	9.2	27.0		0.53	0.26	0.065	580	
Range	2.2	11.7	6.2	53.3	103	51	1.4	21.9		0.39	0.23	0.044	578	

Big Creek (BC1)

Date	Flow (ft^3/s)	Temp (^oC)	DO (mg/L)	% Saturation	Cond (microS)	TDS (mg/L)	pH	SSC (mg/L)	Ammonia (mg/L)	TKN (mg/L)	Total P (mg/L)	Ortho P (mg/L)	E. Coli (cfu/100 mL)	Time
4/18/2005	16.9	6.4	8.0	65.1	92	47	6.4	12.8	<.04	0.37	0.12	0.023	25	1220
5/4/2005	46.5	11.4	9.3	89.2	83	na	7.9	5.3	<.04	0.68	0.26	0.027	16	1300
5/31/2005	40.5	15.5	7.3	73.1	88	44	8.9	10.0	<.04	0.40	0.09	0.046	18	
6/13/2005	14.1	13.9	7.1	68.8	133	68	7.3	16.5	<.04	0.27	0.07	0.034	140	1300
6/29/2005	8.1	15.7	6.6	65.2	193	97	7.4	8.3			0.07	0.030	240	1240
7/11/2005	4.4	22.9	5.9	67.9	219	112	7.7	5.3			0.07	0.039	140	1240
7/18/2005	3.4	20.3	6.0	66.0	203	104	8.0	11.1			0.06	0.033	120	1210
8/8/2005	4.7	18.7	6.9	74.2	228	118	7.8	6.1			0.04	0.027	260	1210
8/23/2005	2.9	15.8	7.9	79.2	287	151	8.1	4.4			0.03	0.018	310	1105
9/7/2005	2.1	12.9	7.9	74.4	352	187	8.2	3.7			0.03	0.020	230	1100
9/19/2005	2.3	11.3	8.4	76.6	337	175	8.2	4.1			0.03	0.015	160	1210
10/12/2005	3.1	12.1	8.0	74.2	228	116	7.5	5.5			0.03	0.017	120	1500
10/27/2005	3.1	7.9	8.7	73.7	149	87	6.7	2.8			0.03	0.016	80	1230
Average	**11.7**	**14.2**	**7.5**	**72.9**	**199**	**109**	**7.7**	**7.4**	**<0.04**	**0.43**	**0.07**	**0.027**	**143**	
April Av	16.9	6.4	8.0	65.1	92	47	6.4	12.8	<.04	0.37	0.12	0.023	25	**monthly average**
May Av	43.5	13.5	8.3	81.2	86	44	8.4	7.7	<.04	0.54	0.17	0.037	17	**monthly average**
June Av	11.1	14.8	6.8	67.0	163	83	7.4	12.4	<.04	0.27	0.07	0.032	190	**monthly average**
July Av	3.9	21.6	5.9	67.0	211	108	7.9	8.2			0.07	0.036	130	**monthly average**
August Av	3.8	17.3	7.4	76.7	258	135	8.0	5.3			0.03	0.023	285	**monthly average**
Sept Av	2.2	12.1	8.1	75.5	344.5	181.0	8.2	3.9			0.03	0.018	195	
October Av	3.1	10.0	8.4	74.0	188.5	101.5	7.1	4.2			0.03	0.017	100	**monthly average**
Season Av	**12.1**	**13.7**	**7.6**	**72.3**	**192**	**100**	**7.6**	**7.8**	**<0.04**	**0.39**	**0.07**	**0.026**	**135**	**seasonal average**
April Load								1,166		33.7	10.6	2.1		**lbs/ day**
May Load								1,793		126.6	40.2	8.6		**lbs/ day**
June Load								740		16.1	4.1	1.9		**lbs/ day**
July Load								173		0.0	1.4	0.8		**lbs/ day**
August Ld								108		0.0	0.7	0.5		**lbs/ day**
Sept Load								47		0.0	0.3	0.2		**lbs/ day**
October Load								70		0.0	0.5	0.3		**lbs/ day**
TOTAL LOAD (192 DAYS)								**112,359**		**4,838**	**1,584**	**391**		**LBS/ PERIOD**
# of Samples		13	13					13		13	13		13	
# Exceeded		4	1					0		0	1		0	
% Exceeded		**31%**	**8%**					**0%**		**0%**	**8%**		**0%**	
Statistics														
Mean	11.7	14.2	7.5	72.9	199	109	7.7	7.4		0.43	0.07	0.027	143	
Stand Dev	14.9	4.7	1.0	6.7	90	53	0.7	4.1		0.18	0.06	0.010	96	
Min	2.1	6.4	5.9	65.1	83	44	6.4	2.8		0.27	0.03	0.015	16	
Max	46.5	22.9	9.3	89.2	352	187	8.9	16.5		0.68	0.26	0.046	310	
Range	44.3	16.5	3.5	24.1	269	143	2.5	13.7		0.41	0.23	0.031	294	