B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

Assess Current and Potential Salmonid Production in Rattlesnake Creek Associated with Restoration Efforts

Underwood Conservation District

Annual Report 2002 - 2003 | February 2004 | DOE/BP-00006301-2

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P.O. Box 3621
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Assess Current and Potential Salmonid Production in Rattlesnake Creek Associated with Restoration Efforts.

2002-2003 Annual Report
for the period
July 1 2002 to June 30 2003

August 2003

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Project Number: 200102500

Introduction

This project addresses existing habitat conditions, fish population status, and restoration priority sites within the Rattlesnake Creek watershed, a sub-basin of the White Salmon River. Our partners in this project are the United States Geological Service (USGS), and the Yakama Indian Nation (YIN). Underwood Conservation District (UCD) is involved in the project via accomplishment of water quality monitoring, sampling for stable isotopes, and characterization of the watershed geomorphology. These work items are part of an effort to characterize the stream and riparian habitat conditions in Rattlesnake Creek, to help guide habitat and fish restoration work.

Water chemistry and temperature information is being collected both on Rattlesnake Creek, and on other tributaries and the main stem of the White Salmon River. Information on the entire system enables us to compare results obtained from Rattlesnake Creek with the rest of the White Salmon system. Water chemistry and temperature data have been collected in a manner that is comparable with data gathered in previous years. The results from data gathered in the 2001-2002 performance period are reported in appendix A at the end of this 2002-2003 report.

Additional work being conducted as part of this study includes; an estimate of salmonid population abundance (YIN and USGS); a determination of fish species composition, distribution, and life history (YIN and USGS), and a determination of existing kinds, distribution, and severity of fish diseases (YIN and USGS).

The overall objective is to utilize the above information to prioritize restoration efforts in Rattlesnake Creek.

Objective 1: Characterize stream and riparian habitat conditions in the Rattlesnake Creek drainage

This study is intended to establish Rattlesnake Creek sub-basin baseline conditions prior to the anticipated development of removal of Condit Dam, or establishment of fish passage around that Dam in 2006. This baseline information, along with water quality monitoring accomplished in the early to mid 1990s, will help in development of future watershed restoration strategies and evaluation of the projects accomplished. The baseline conditions can be compared with conditions following restoration activities, to assess project effectiveness.

Task 1a: Measure water quality, water quantity, stream habitat, and riparian conditions (UCD, YIN, USGS)

Within the White Salmon River basin, UCD has established 19 sites to monitor various water quality parameters (Map 1). Eight (8) sites are monitored for continuous water temperature, general water chemistry (pH, conductivity, turbidity, dissolved oxygen, and temperature), and advanced laboratory water chemistry (total phosphorus (TP), nitrate (NO3) and nitrite (NO2) as nitrogen, and total suspended solids (TSS)). Six (6) sites are monitored for continuous temperature and general water chemistry. Two (2) sites are only monitored for continuous temperature, and three (3) sites only general chemistry. Six rounds of water quality sampling were conducted in the White Salmon basin during the 2002-2003 performance period. Seventeen (17) out of the nineteen (19) sites were tested for the routine water chemistry parameters of pH, conductivity, turbidity, dissolved oxygen, and temperature. Four of the sample rounds were conducted quarterly through out the year, and two were discretionary rounds - a large storm event (January 31 2003), and a base flow at low water levels (September 2002).

Map 1
White Salmon River Watershed
Water Quality Monitoring Sites

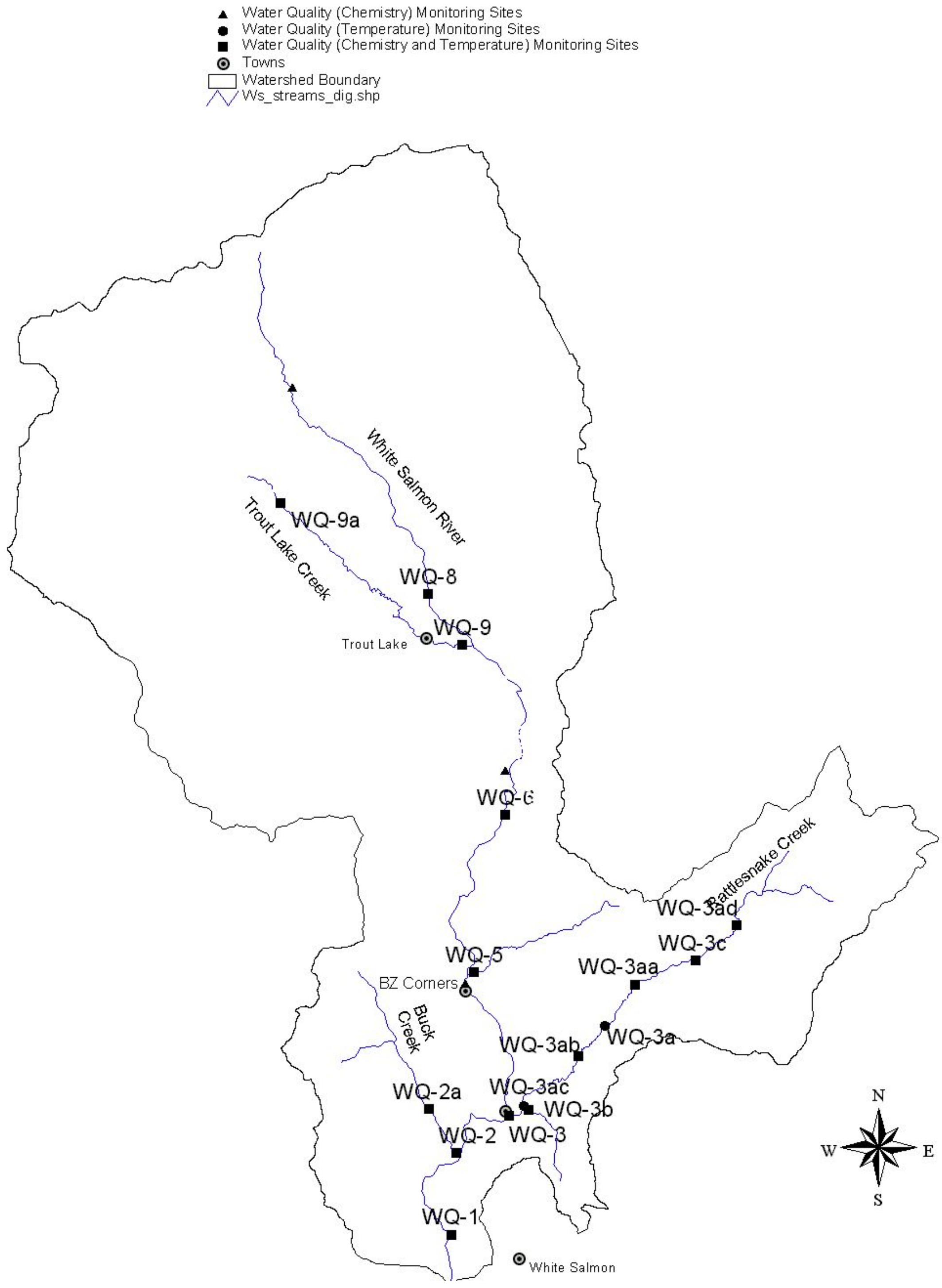


Table 1. Site locations and analysis carried out at each location.

Site ID	Site Description	Distance from mouth of White Salmon km	General water chemistry (pH,Conductivity, DO, temp)	Laboratory Analyses. Nitrate + Nitrite as Nitrogen ,T. Phos. and TSS	Continuous Temperature
1	White Salmon at base (USFWS)	2.50	●	●	●
2	Buck Creek at base (Big Buck Rd)	8.35	●		●
2a	Buck Creek at DNR boundary	11.62	●		●
3	Rattlesnake Creek at base	12.50	●	●	●
3b	Indian Creek at base	13.25	●	●	●
3ac	Rattlesnake Creek above INC	13.27			●
3ab	Rattlesnake Creek (at base of alluvial reach)	18.10	●	●	●
3a	Rattlesnake Creek at DNR	20.27			●
3aa	Rattlesnake Creek below upper canyon	23.8	●	●	●
3c	Mill Creek	26.52	●	●	●
3ad	Rattlesnake Creek upper canyon	29.40	●	●	●
4	White Salmon River at BZ boat launch	20.13	●		
5	Gilmer Creek (above falls)	21.38	●	●	●
6	White Salmon River (below Trout lake valley)	31.5	●		●
7	Trout Lake Water Co. Ditch (Sunnyside Rd)	57.01	●		
8	White Salmon River (upper)	67.00	●		●
9	Trout Lake Creek at base (Old Creamery Rd)	63.88	●		●
9a	Trout Lake Creek at 8810 rd	77.26	●		●
10	Cascade Creek	81.38	●		

The results of the water quality monitoring during performance period July 2002 to June 2003 will be reported in the 2003 annual report. See Appendix A for a discussion of water quality monitoring elements and 2001-2002 performance period results.

Continuous water temperature data is being collected at 16 of the 19 sites. Stream temperature information is collected using Onset Stowaway Temperature Loggers. The loggers are located at 8 stations throughout the main White Salmon watershed, and 8 stations in Rattlesnake Creek (sub basin of the White Salmon River) The loggers have been recording data year round (1st deployed in spring 2001). In May 2002 (the previous performance period) 15 of the loggers were brought back to the office (one was stuck under rocks). They were downloaded and the accuracy was checked against a NIST

(National Institute of Standards and Technology) certified thermometer. They were reinstalled in May 2002. The loggers were checked periodically during the summer. The stuck logger was retrieved, downloaded, and relocated. In September 2002 the loggers were downloaded in the field and reinstalled for the winter. Only one logger was lost during the 50yr flood event on 31st January 2003. The rest (except two that were stuck) were brought back to the office in May, where they were downloaded and the accuracy was again checked against a NIST certified thermometer. The loggers were reinstalled within one week of being removed. Data collected from summer 2003 will be summarized in the next performance period.

A permanent stream monitoring station was installed on lower Rattlesnake Creek in spring 2003 by River Measurement, LLC. Located near the base of Rattlesnake Creek, this gage will enable monitoring of discharge in the basin. Following installation, River Measurement began (and is continuing within Performance Period 2003) site visits to take current-meter discharge measurements and to download data from the monitoring station. River Measurement will also document stream and channel conditions that affect the stage-discharge rating, and will compare staff gage readings to the monitoring station information to ensure the instrument is working properly. This station will allow continuous monitoring of stream levels throughout the year. They will also develop a discharge rating table and will compute mean, minimum, and maximum discharge data.

Task 1b: **Describe geomorphology of the watershed**

Clark Conservation District Cluster Engineer Russ Lawrence completed a report in June 2003, following field work in Rattlesnake Creek. Russ surveyed and described a 5-mile reach in middle Rattlesnake creek. Russ described the geomorphology, including valley type classifications, stability, and channel condition. Russ included recommendations for work to enhance channel stability, reforestation and other restoration work. UCD will use the report for further planning of additional work in the watershed. The Washington Conservation Commission has reassigned UCD to be part of a different engineering cluster, a change that started in July 2003. We will work with the new engineer to plan future work, using this report as a basis.

Task 1c: **Determine background levels of stable carbon and nitrogen isotopes in the Rattlesnake Creek drainage. (UCD, USGS)**

Two rounds of field sampling were conducted by UCD and USGS staff in the 2002-2003 Performance period. Field samples were collected in October 2002 and in June 2003. The samples were collected at five sites in the Rattlesnake Creek drainage. Samples consist of terrestrial and aquatic plant materials, macroinvertebrates, and fish. Water quality parameters were also taken at each site on the day of collection (pH, conductivity, turbidity, dissolved oxygen, temperature, TP, N+N, TSS). Between July 2002 and June 2003, two sets of samples were processed by UCD staff at the USGS facilities in Cook WA., those collected in June 2002 (the previous performance period) and those collected in October 2002. Samples collected in June 2003 will be processed in the next performance period. Once processed the samples are sent for isotope ratio analysis by an outside contractor (University of California, Davis). A summary of the information will be compiled in Performance Period 2003-2004.

Report F: Budget Summary

Expenditures by Category:

Underwood Conservation District
Rattlesnake Creek Project
BPA Project No. 2001-025-00
Contract 00006301
July 1, 2002- June 30, 2003

Category	**Expended**	**Unexpended**
Personnel:	35,471.26	(3,361.26)
Supplies:	1,614.51	1,335.49
Overhead:	3,953.27	(114.27)
Travel:	869.63	1455.37
Subcontractors:	18,337.56	1,557.44
Other:	140.60	859.40
Total:	60,386.83	1,732.17

Appendix A

Water Quality Results for the period July 1 2001 to June 30 2002

December 2003

Prepared by:
Jim White and Rozalind Plumb
(Underwood Conservation District)

This report addresses the results from the water quality monitoring performed by UCD during the performance period July 1 2001 to June 30 2002.

Introduction

This study was intended to collect information to aid in the establishment of baseline water quality conditions of Rattlesnake Creek and the White Salmon River, a sub basin of the Columbia River in SW Washington, prior to the return of anadromous fish following the expected passage around Condit Dam, or the removal of the dam at 5.44 km above the mouth of the White Salmon.

UCD has established 19 sites throughout the White Salmon and Rattlesnake Creek basins. During the 2001-2002 performance period, data was gathered on general water chemistry, (temperature, pH, conductivity, dissolved oxygen, and turbidity) at seventeen (17) sites (table 1). In addition nitrate and nitrite nitrogen and total phosphorus were analyzed at six (6) of those sites along Rattlesnake Creek and occasionally at Gilmer Creek. Continuous temperature was also monitored at sixteen (16) of the sites (table 2 and map 1).

Sampling took place on five separate occasions during the project period, September 2001, October 2001, January 2002, mid January 2002, April 2002 (table 1). September 2001 was intended to represent the annual base flow and the samples collected in early January represent a flush flow event. *The mean values in this report are therefore based on a relatively small sample size, and two dates are missing from Mill Creek, Cascade Creek and upper Rattlesnake Creek as access was not possible during the two January sample rounds.*

Table 1 Sampling Schedule.

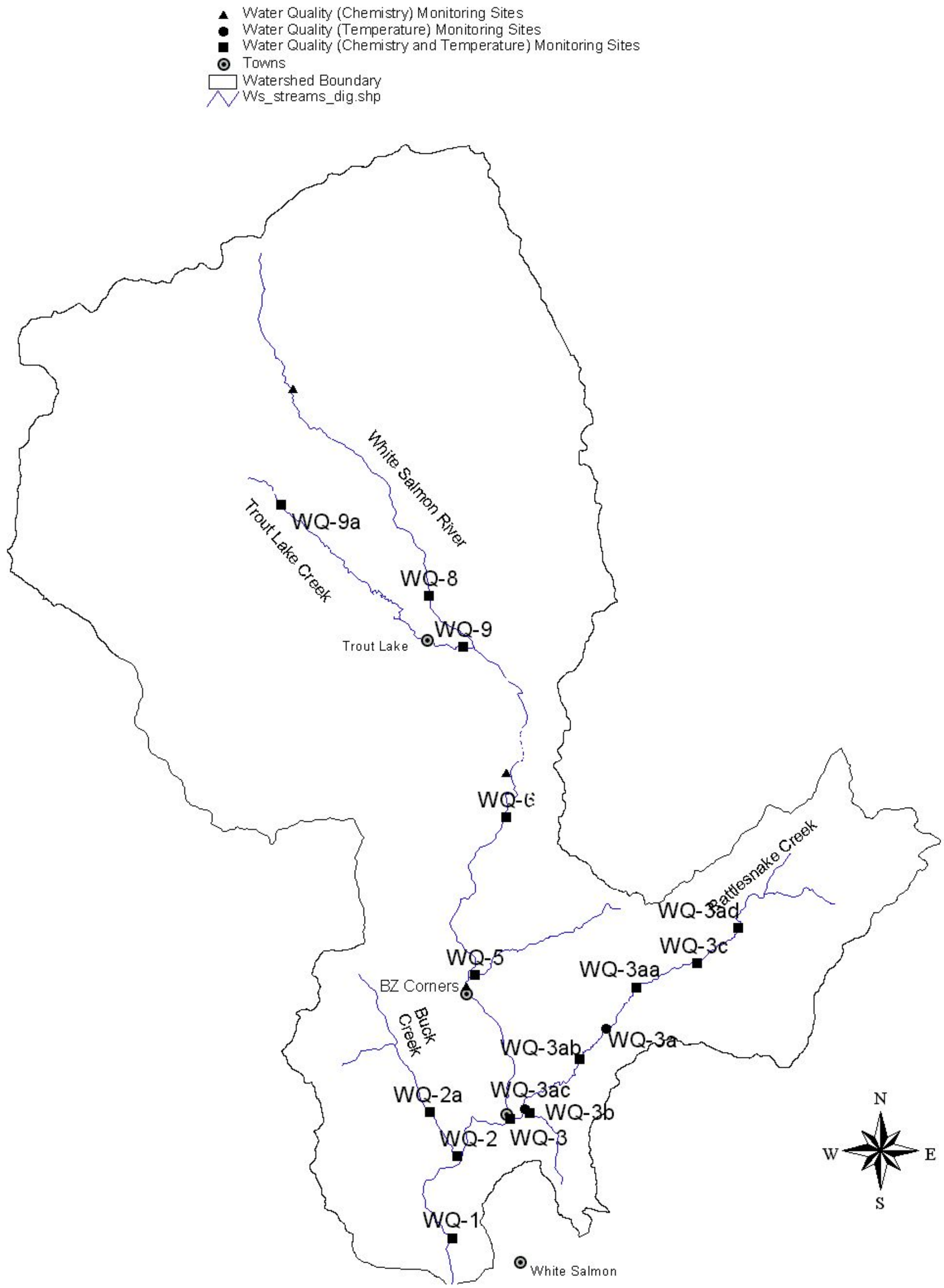
DATE	TYPE OF FLOW
11-12 September 2001	Base flow
9-10 October 2001	Fall
8-9 January 2002	Flush flow
15-16 January 2002	Winter
2-4 April 2002	Spring

Table 2 Site locations and analyses carried out during 2001-2002 performance period.

Site ID	Site Description	Distance from mouth of White Salmon km	General water chemistry (pH, Conductivity, turbidity, DO, temp)	Nitrate + Nitrite as Nitrogen and Total Phos.	Continuous Temperature
1	White Salmon at base (USFWS)	2.50	●		●
2	Buck Creek at base (Big Buck Rd)	8.35	●		●
2a	Buck Creek at DNR boundary	11.62	●		●
3	Rattlesnake Creek at base	12.50	●	●	●
3b	Indian Creek at base	13.25	●	●	●
3ac	Rattlesnake Creek above INC	13.27			●
3ab	Rattlesnake Creek (at base of alluvial reach)	18.10	●	●	●
3a	Rattlesnake Creek at DNR	20.27			●
3aa	Rattlesnake Creek below upper canyon	23.8	●	●	●
3c	Mill Creek	26.52	●	●	●
3ad	Rattlesnake Creek upper canyon	29.40	●	●	●
4	White Salmon River at BZ boat launch	20.13	●		
5	Gilmer Creek (above falls)	21.38	●	●*	●
6	White Salmon River (below Trout lake valley)	31.5	●		●
7	Trout Lake Water Co. Ditch (Sunnyside Rd)	57.01	●		
8	White Salmon River (upper)	67.00	●		●
9	Trout Lake Creek at base (Old Creamery Rd)	63.88	●		●
9a	Trout Lake Creek at 8810 rd	77.26	●		●
10	Cascade Creek	81.38	●		

* occasional samples.

Map 1
White Salmon River Watershed
Water Quality Monitoring Sites



General Water Chemistry

General indicators of stream health commonly used by the US Environmental Protection Agency (EPA) and Washington Department of Ecology (DOE) include temperature, pH, turbidity, conductivity, and dissolved oxygen (DO). Similar to a doctor assessing pulse and blood pressure in a patient, these are basic parameters that may indicate problems that require more in depth analysis. Continuous temperature and advanced chemistry will be approached later in this report.

Washington State Standards

Washington State has set limits for temperatures, dissolved oxygen (DO),and turbidity in different class streams. Washington State has 4 classes ranging from Class AA (extraordinary), through Class C (fair). A majority of the sites in this study are required to meet Class A standards (excellent) (table 3). Two sites, Cascade Creek and upper Trout Creek (8810 rd.) are on federal land (US Forest Service) and are required to meet Class AA standards.

Table 3 Washington State surface water quality standards.

Class	Temperature *C shall not exceed	DO mg/L shall exceed	pH range shall be within
A	18	8.0	6.5 - 8.5
AA	16	9.5	6.5 - 8.5

pH

pH is a measure of how acidic or basic a water body is. The pH can directly affect the survival of aquatic organisms. Pure water is neutral, with a pH of 7.0. pH readings below 7.0 indicate acidic conditions. Waters with pH less than 4.0 generally have no vertebrate life forms in them. pH readings above 7.0 indicate basic conditions. 'pH affects many chemical and biological processes in water. For example, different organisms flourish within different ranges of pH. The largest variety of aquatic organisms prefer a range of 6.5 – 8.0. pH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can reduce reproduction. Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life, particularly to sensitive species like rainbow trout. Changes in acidity can be caused by atmospheric deposition (acid rain), surrounding rock, and certain wastewater discharges.' (EPA ref 2)

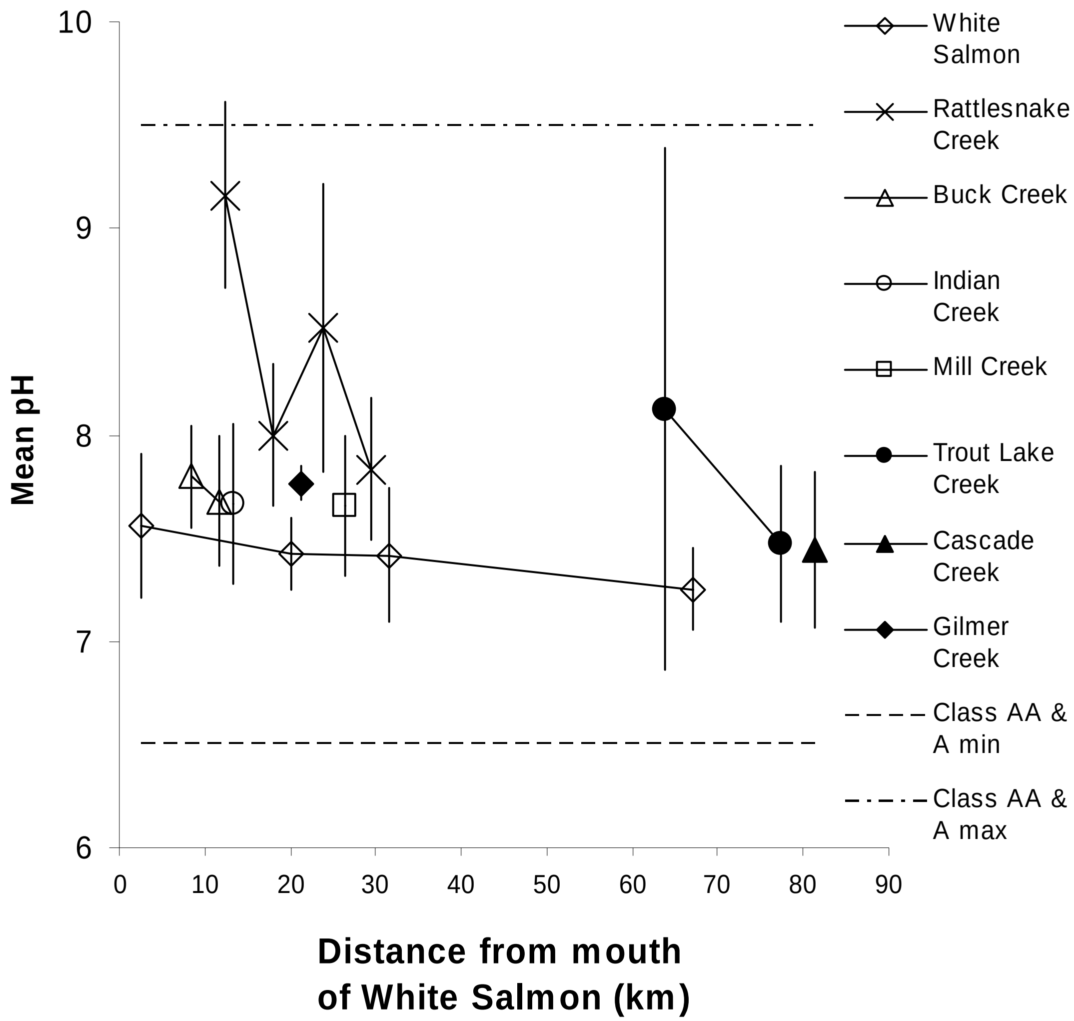


Figure 1 Mean pH recorded for each site (2001-2002) with standard deviation displayed as vertical bars.

Rattlesnake Creek has mean pH readings noticeably higher than most of the other sites in the project area (Figure 1). Note that these means are based on a relatively small sample size, since this was the first year of the survey. Data were collected on 5 separate occasions between September 2001 and April 2002. In addition, two dates are missing from Mill Creek, Cascade Creek and upper Rattlesnake Creek as access was not possible in winter. Also, pH data was not collected for most sites for the 15 January 2001 as the pH meter was malfunctioning in the cold. pH data was only gathered for this round at sites 9a, 2a, 3aa, 3ab, and 3b. Trout Lake Creek also shows a relatively high pH at the lower site (Old Creamery Rd.) and a large standard deviation. The large deviation can be attributed to one reading (9.92) in September 2001 (see appendix B for tables of results). This reading exceeded the state standard of 8.5 and coincided with the highest temperatures (15.5^{o}C). Note that on this date the sampling site was slow and shallow. The site was moved after this date to the opposite bank where a more representative section of the creek could be reached.

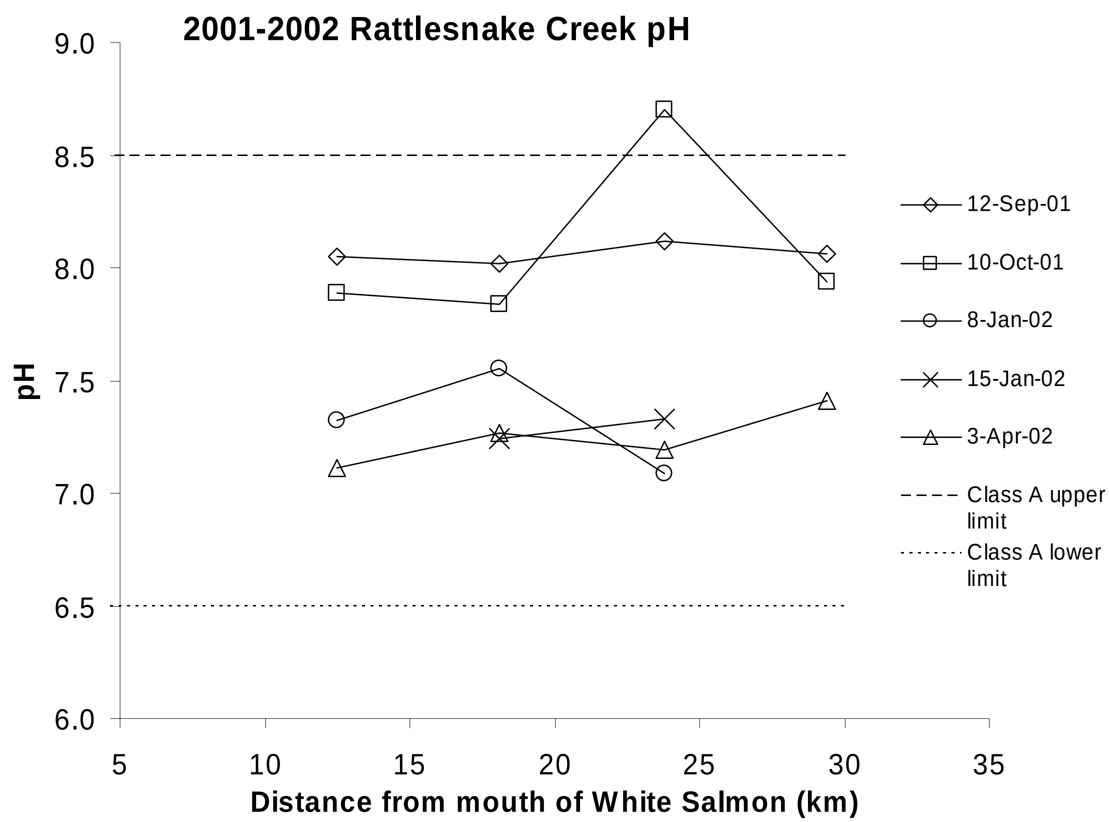


Figure 2. Actual pH readings (2001-2002) for Rattlesnake Creek sites 3, 3ab, 3aa, and 3ad.

Although Rattlesnake Creek shows higher pH readings than the rest of the White Salmon, it is still within levels preferred by aquatic organisms. All readings for pH are above pH 7.0. September and October have higher readings which coincide with the lowest flows of the year. 2001 was a low water year, and Rattlesnake Creek was dry in places as the water ran beneath the rocky creek bed. By going subterranean, the creek water may have picked up more minerals from the soil and rock. In October, site 3aa (below upper canyon rkm 23.8) had a pH value of 8.70, which is above the state limit for Class A waters. The fact that the pH jumps, from pH 7.94 in the upper canyon (3ad), to pH 8.70 at the base of the canyon (3aa), and then down again to pH 7.84 at the base of alluvial reach (3ab), may be indicative of measurement error. No infield duplicates were taken during this sample set to verify the accuracy of the measurements.

Data from the mid-1990s show similar results. pH values throughout the White Salmon were around neutral, with average site values ranging from 6.95 to 7.64. Rattlesnake Creek (measured only at the base in the mid-1990s) showed a maximum value of 7.77. None of the earlier data indicate pH levels that are out of the range most desirable for aquatic organisms.

Dissolved Oxygen

Dissolved oxygen is a measure of the amount of oxygen dissolved in water. It is important for determining whether the water body can support organisms which require oxygen – aerobic organisms – such as fish and zooplankton. High dissolved oxygen levels are better. Generally, levels of 5-6 mg/L can support diverse forms of aquatic life (USGS ref 1).

Dissolved oxygen (DO) is both produced and consumed in the stream system. Oxygen is acquired from the atmosphere and from plants as a result of photosynthesis. Running water dissolves more oxygen than still water as the turbulence at the water surface traps more air. Aquatic animal respiration, decomposition, and various chemical reactions consume oxygen.

'Oxygen is measured in its dissolved form as DO. If more oxygen is consumed than is produced, DO levels decline and some sensitive animals may move away, weaken, or die.' (EPA ref 3).

'DO levels fluctuate seasonally and over a 24-hour period. They vary with water temperature and altitude. Cold water holds more oxygen than warm water, and water holds less oxygen at higher altitudes. Aquatic animals are most vulnerable to lowered DO levels in the early morning on hot summer days when stream flows are low. Water temperatures are high, and aquatic plants have not been producing oxygen since sunset.' (EPA ref 3).

The results shown in figures 3 and 4 below, indicate that while DO fluctuates by up to 5mg/L at some sites over the course of the project period, the amount of oxygen dissolved in the waters is above the minimum State standard. Site 9, Trout Lake Creek (Old Creamery Rd) has one reading below the Class A Standard of 8.0 mg/L (figure 4). This may be attributed to poor flow, as the sample was taken in slow moving water. Later samples were taken from a more representative flow for the creek, which is in a fast moving channel (see also the high pH reading at this site on the same date (appendix B)).

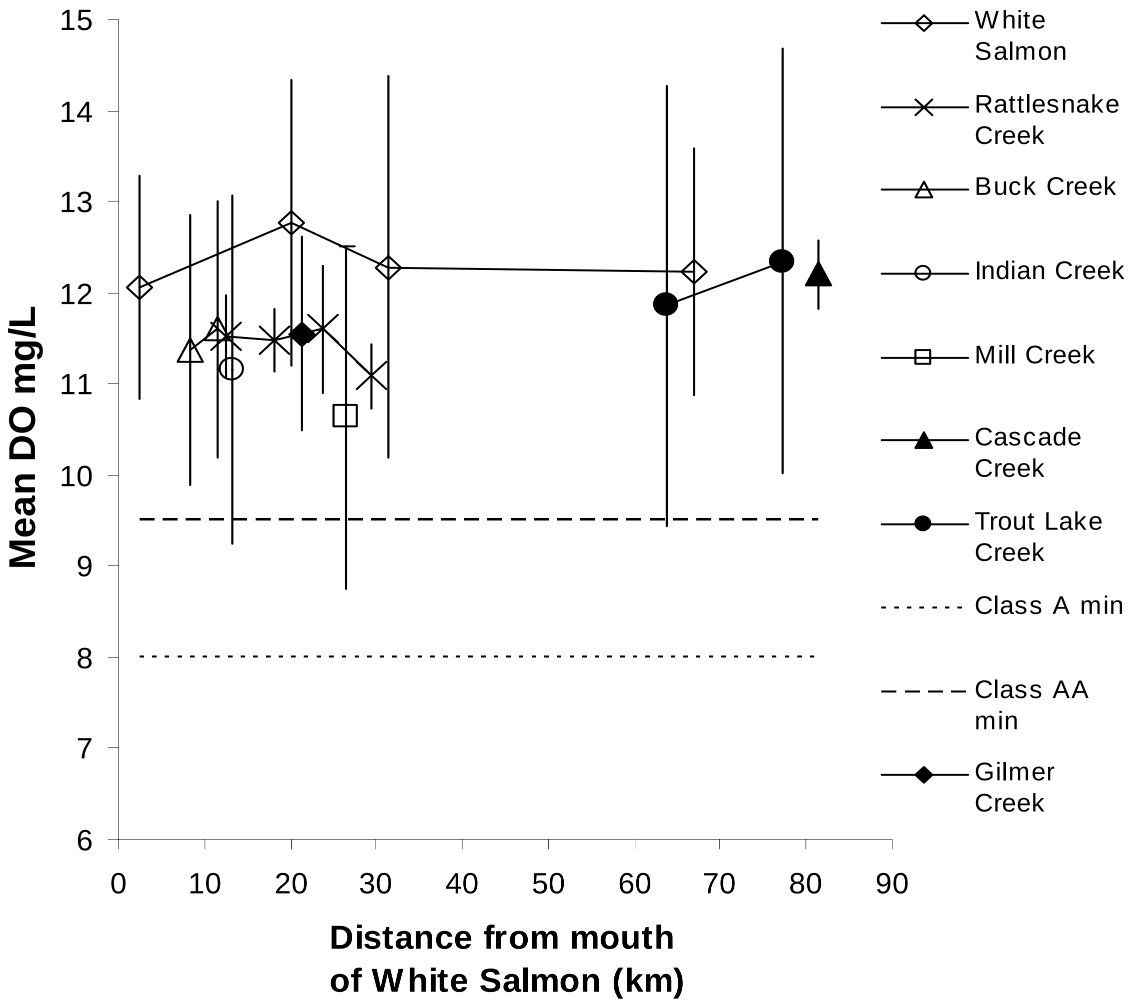


Figure 3. Mean DO mg/L for all sites (2001-2002) with standard deviation shown as vertical bars

Based on this one year data set, DO levels appear to be adequate for support of aquatic species for both the entire watershed (Fig. 3) and Rattlesnake Creek (Fig. 4). Similar results were obtained during monitoring of the White Salmon in the mid-1990s (Stampfli 1994). Since 2002 was the first set of data collected throughout Rattlesnake Creek, (except for site 3 at the mouth of the Creek), 2003 data will help to further determine variability of DO in that sub basin.

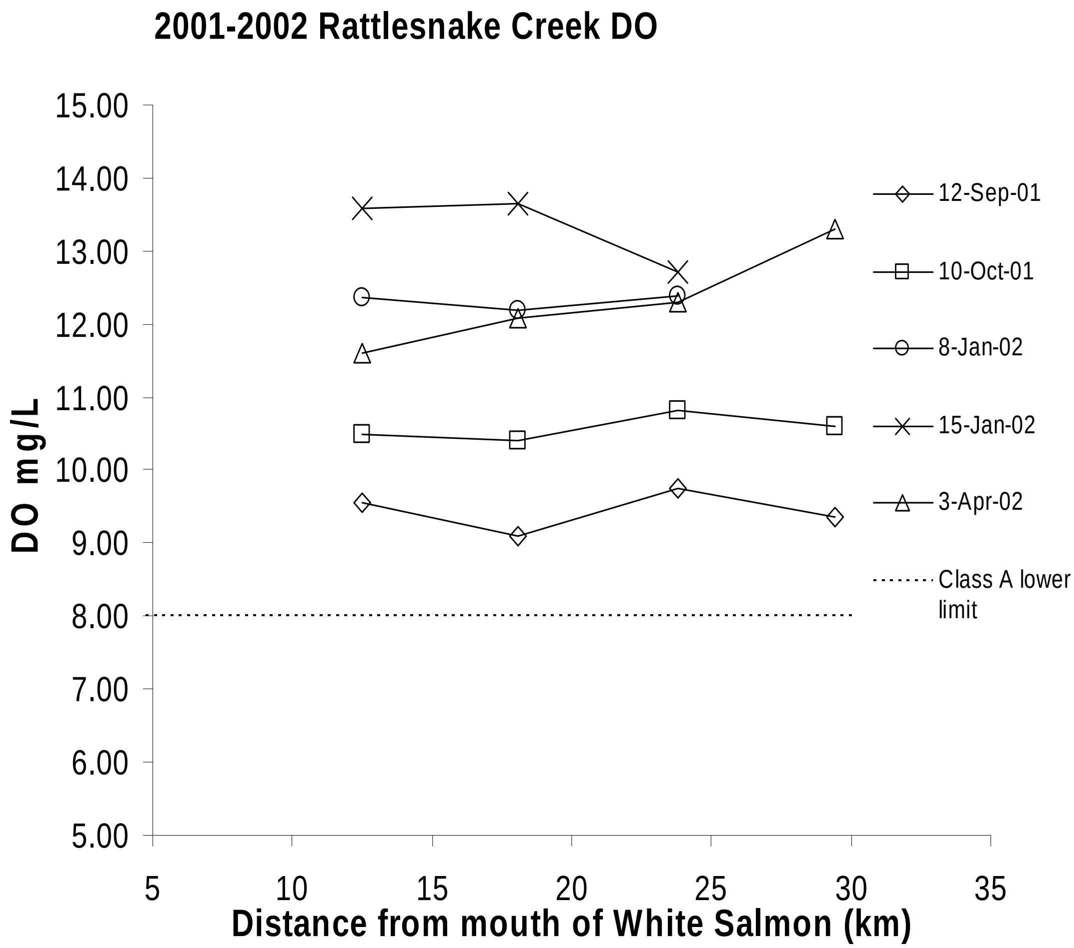


Figure 4. Actual DO mg/L for Rattlesnake Creek sites by river km (2001-2002).

Turbidity

Turbidity is a measure of the clarity of the water. The amount of debris, soil particles, or plankton in the water affects the amount of sunlight that reaches aquatic plants. High turbidity will reduce the amount of light passing through the water column and reduce the plant's ability for photosynthesis, and so reduce the amount of available oxygen in the water. Excess silt and detritus in the water can also smother spawning areas, covering eggs with silt so they cannot breathe.

'Higher turbidity increases water temperatures because suspended particles absorb more heat. This in turn, reduces the concentration of dissolves oxygen (DO) because warm water holds less DO than cold.' (EPA ref 4). 'Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. Sources of turbidity include; soil erosion, waste discharge, urban runoff, eroding stream banks, excessive algal growth' (EPA ref 4).

'Regular monitoring of turbidity can help detect trends that might indicate increasing erosion in developing watersheds. However, turbidity is closely related to stream flow and velocity and should be correlated with these factors. Comparisons of the change in turbidity over time therefore should be made at the same point at the same flow. Turbidity is not a measurement of the amount of suspended solids present or the rate of sedimentation of a stream since it measures only the amount of light that is scattered by suspended particles.' (EPA ref 4).

Figure 5 shows turbidity levels in the White Salmon Watershed during the 2001-2002 performance period. Washington State standards for turbidity rely on knowing what the baseline turbidity is. By collecting this data UCD is gathering baseline information so it may be used in the future should changes occur in the system. Based on this one-year data set, turbidity levels appear to be adequate for aquatic species. Future year samples will help to determine seasonal variations in turbidity, and possibly identify problems and / or improvements, particularly in Rattlesnake Creek.

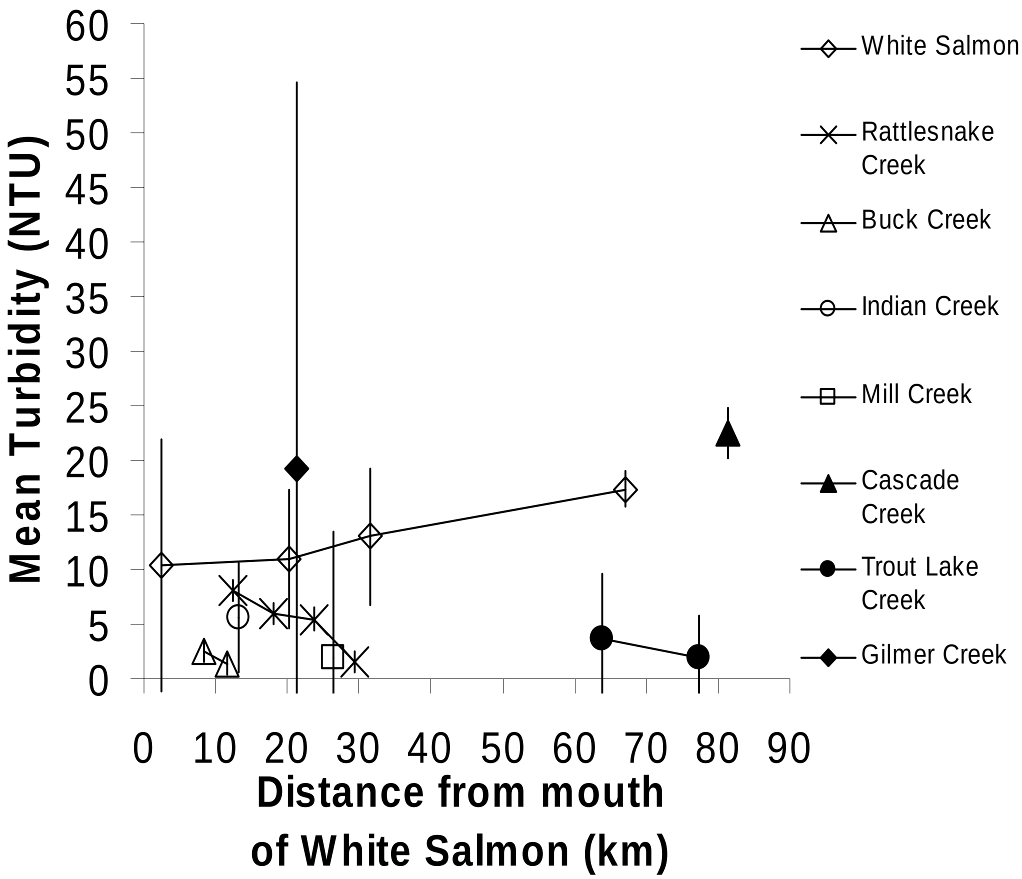


Figure 5. Mean Turbidity Levels for all sites for 2001-2002, with standard deviation shown as vertical bars.

In the above figure 5, turbidity varies the most at Gilmer Creek. However, it should be remembered that these means are based on relatively few data points. Further data is needed before conclusions should be drawn about the quality of the water.

Conductivity

‘Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions. (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have low conductivity when in water. Conductivity is also affected by temperature; the warmer the water, the higher the conductivity. For this reason, conductivity is reported at 25 degrees Celsius (25C). Conductivity in streams and rivers is affected primarily by the geology of the area through which the water flows. Streams than run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Ground water inflows can have the same effects depending on the bedrock they flow through.

The conductivity of rivers in the United States generally ranges from 50 to 1500 us/cm. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 ms/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macroinvertebrates.’ (EPA ref 5)

Conductivity is useful as a general measure of stream water quality. Each stream tends to have a relatively constant range of conductivity that, once established, may be used as a baseline for comparison with regular conductivity measurements. Significant changes in conductivity could then be an indicator that a discharge or some other source of pollution has entered a stream (EPA ref. 5).

Based on this one-year data set, conductivity levels are relatively low, but fairly consistent within the watershed. Future year samples will help to determine seasonal variation in conductivity, and establishment of the baseline, especially in Rattlesnake Creek, which showed more variation, probably due to sample size.

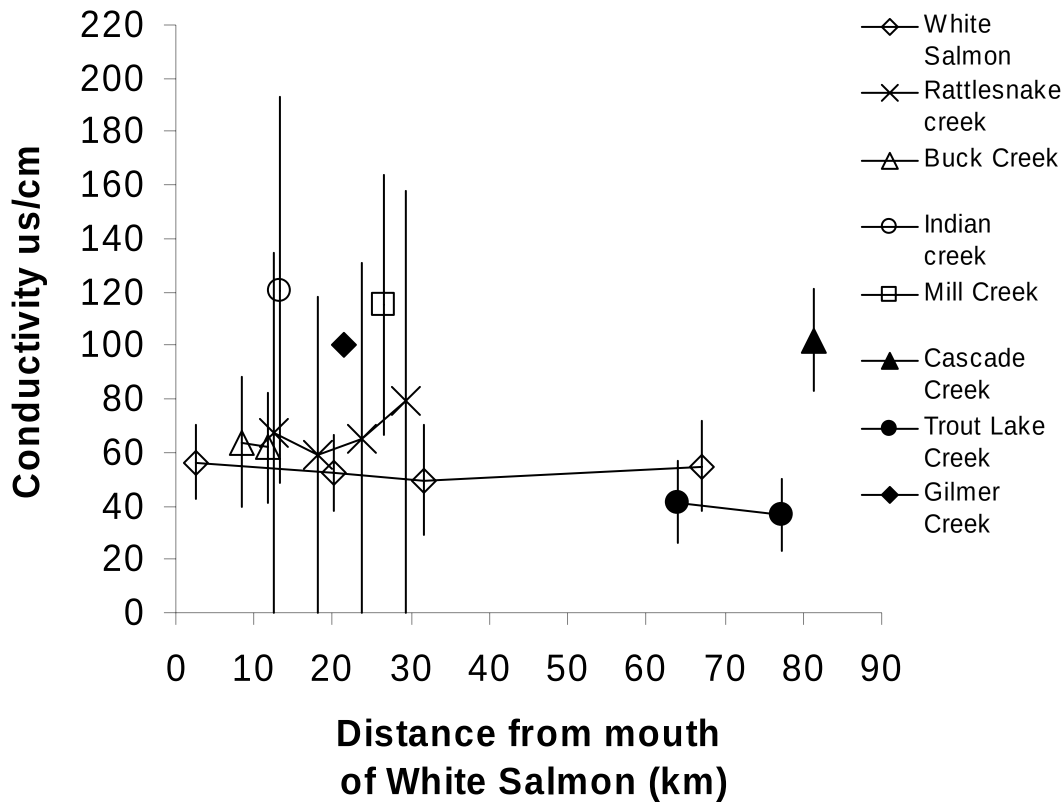


Figure 6. Mean Conductivity Levels for all sites (2001-2002), with standard deviation shown as vertical bars.

Advanced Laboratory Analysis.

For this study UCD was able to send collected samples to a certified laboratory for analysis. The Laboratory used was Columbia Analytical Services (CAS).

Columbia Analytical Services
1317 South 13th Avenue,
Kelso, WA 98626

CAS provided UCD with prepared sample bottles and coolers. Analysis was conducted using EPA standard methods for nitrate and nitrite as nitrogen (EPA Method 353.2), and Total phosphorus (EPA Method 365.3). Only five (5) sites on Rattlesnake Creek were assessed for phosphorus and nitrates. Gilmer Creek was assessed only twice during the sample period.

Phosphorus

'Both phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. Since phosphorus is the nutrient in short supply in most waters, even a modest increase in phosphorus can, under the right conditions, set off a whole chain of undesirable events in a stream including accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals.

There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, and commercial cleaning preparations.

Phosphorus has a complicated story. Pure "elemental" Phosphorus (P) is rare. In nature, phosphorus usually exists as part of a phosphate molecule (PO4). Phosphorus in aquatic systems occurs as organic phosphate and inorganic phosphate. Organic Phosphate consists of a phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate.…Monitoring phosphorus is challenging because it involves measuring very low concentrations down to 0.01 milligrams per liter (mg/L) or even lower. Even such very low concentrations of phosphorus can have a dramatic impact on streams.' (EPA ref 6).

The test for total phosphorus measures all forms of phosphorus in the sample (orthophosphate , condensed phosphate and organic phosphate). The sample is not filtered and therefore measures both dissolved and suspended orthophosphate. The minimum reporting limit (MRL) used by CAS was 0.01mg/L. and the minimum detection limit (MDL) was 0.009mg/L.

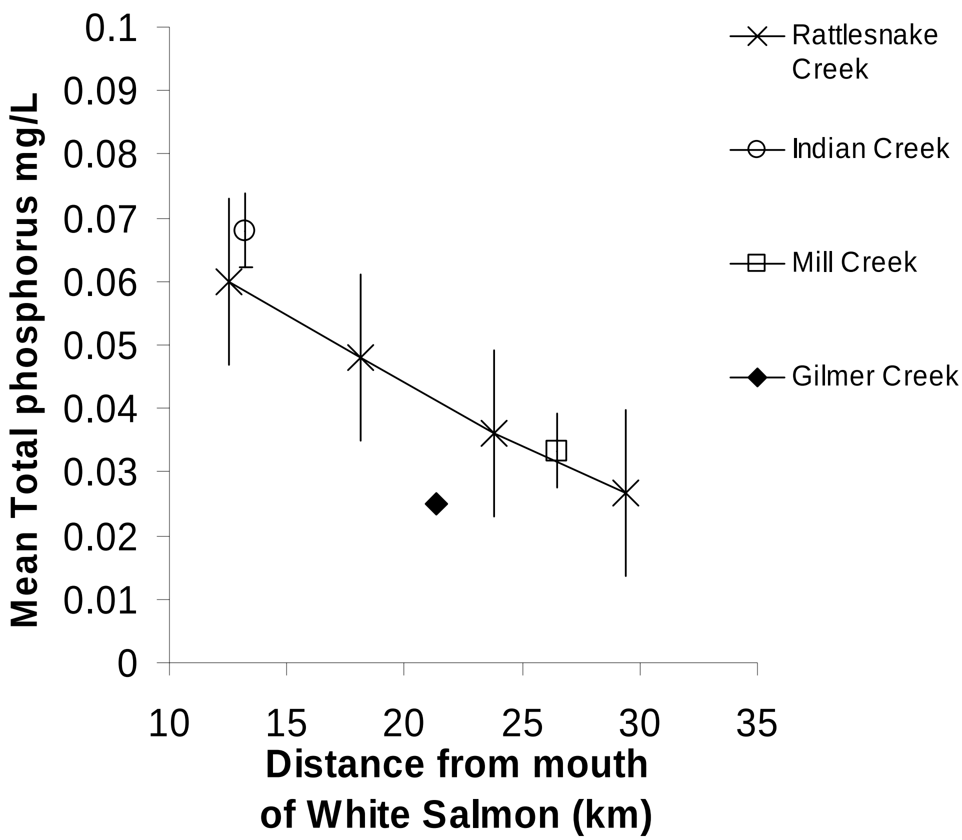


Figure 7. Mean Phosphorus Levels for measured sites on Rattlesnake Creek, Indian Creek, Mill creek and Gilmer Creek during 2001-2002.

Phosphorus levels in 2001-2002 samples were low, but showed a general increase downstream. This trend is evident on Rattlesnake Creek (but less data exists for upper Rattlesnake Creek and Mill Creek due to access problems in the winter. Also Gilmer Creek is only represented by two (2) data points. A 1992-1994 report on the White salmon River (Stampfli, 1994) showed Phosphorus levels in the same range, although a downstream trend was not evident. 2002-2003 sampling will help to establish a baseline for future work, particularly in Rattlesnake Creek.

Nitrate and Nitrite Nitrogen

Nitrogen is found in several different forms in nature including ammonia (NH3), nitrate (NO3), and nitrite (NO2). Plants require nitrate, but like phosphorus too much nitrate can cause water quality problems. If both nitrate and phosphorus increase together they can accelerate plant growth and alter the types of plants and animals in the stream. Such increases can affect dissolved oxygen, temperature, and other indicators. Excess nitrates can decrease dissolved oxygen and become toxic to warm-blooded animals at concentrations in excess of 10mg/L under certain conditions. *Natural levels of nitrates in surface waters are typically less than 1mg/L.*

Nitrate sources include wastewater plants, fertilizer runoff from lawns and crops, failing septic systems, and runoff from animal manure storage areas. Nitrates dissolve in water more readily, and enter the streams faster than phosphorus (they do not attach themselves to soil particles as phosphorus does). Therefore, nitrates are better indicators of possible pollution from sewage during dry weather.

This study is assessing nitrate and nitrite as nitrogen. It is possible that low nitrate readings may be an indication of a stream affected by a high input of nitrogen rich organic matter. The decomposition of organic matter decreases DO levels, which in turn slows down the rate of oxidization of ammonia to nitrite, and then to nitrate. Therefore, just a nitrate reading may not be the best indicator.

CAS analyzed the samples using EPA Method 353.2. This procedure is applicable to determining Nitrate/Nitrite concentrations greater than 0.02mg/L in water. The MRL for this method was 0.2mg/L and the MDL was 0.007mg/L.

The nitrate and nitrite nitrogen results for this project period were nearly all below the method reporting limit (MRL) of the test used (EPA 353.2). Gilmer Creek was monitored twice during the project period giving results of 4.1 and 6.3 mg/L in September and April respectively. Both these results are considered higher than the typical value of 1mg/L for surface waters. Similar results were obtained in sampling during the early 1990s. Most sites had occasional positive samples of nitrogen, with the rest being below reporting limits. The exception was Gilmer Creek, where nitrogen showed up in all samples. 2002-2004 sampling may be enough to give us good baseline information about nitrogen.

Temperature

The temperature of water in a stream can adversely affect the biological and chemical processes that take place in the water body. 'Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Optimal temperatures for fish depend on the species: some survive best in colder water, whereas others prefer warmer water. Benthic macroinvertebrates are also sensitive to temperature and will move in the stream to find their optimal temperature. If temperatures are outside this optimal range for a prolonged period of time, organisms are stressed and can die.' (EPA ref 1).

For fish there are two kinds of limiting temperatures the maximum temperature for short exposures and a weekly average temperature that varies according to the time of year and the life cycle stage of the fish species. Reproductive stages (spawning and embryo development) are the most sensitive stages.' (EPA ref 1) See table 4 for temperature criteria for salmonid fishes found in the Columbia River region.

Table 4. Lethal temperatures for selected salmonid species (Bjornn and Reiser 1991).

Species	Lower Lethal temp. *C	Upper Lethal temp. *C	Preferred Range *C
Coho Salmon	1.7	28.8	12-14
Chinook Salmon	0.8	26.2	12-14
Steelhead	0.0	23.9	10-13
Rainbow Trout	-	29.4	-
Cutthroat trout	0.6	22.8	-

The condition of surface waters is important to the present and potential use of that water. Washington State Department of Ecology has set water quality standards for surface waters (WAC 173-201A). The State maximum temperatures for the two classes of waters assessed in this project are Class A, 18^{o}C, and Class AA, 16^{o}C (Table 3).

'Temperature affects the oxygen content of the water (oxygen levels become lower as temperature increases); the rate of photosynthesis by aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases.' (EPA ref 1) As temperature increases the organisms use up more oxygen as respiration increases while they adjust to cope with the rising temperature.

Factors affecting stream water temperatures include the weather, the amount of vegetation providing shade along the stream bank, groundwater inflows, the volume of water, the depth of the water, impoundments (barriers such as dams that restrict the flow), and the turbidity of the water. Wide shallow streams with slow flows are more likely to have increased temperatures as more of the water body is exposed to sunlight for a longer period of time compared to water in a narrow, deep channel with a rapid flow. 'Stream temperatures can be altered by removal of stream bank vegetation, withdrawal and return of water for irrigation, release of water from deep reservoirs, and cooling of nuclear power plants.' (Bjornn and Reiser, 1991).

We collect temperature information via two methods in this study. One method collected temperature information, using a hand held digital thermometer, while collecting the general water chemistry data (pH, DO, etc.). This temperature data determines the temperature at the same time at which the other variables are collected. This allows for the correlation of temperature to the other variables that may be influenced by temperature (e.g. DO). The data also gives us a snapshot in time of temperature information.

The second method used continuous-reading temperature loggers placed at sixteen (16) of the sites (Table 1). The equipment used were Onset® Stowaway® temperature loggers. The loggers were programmed to record the temperature at 2-hour intervals throughout the time they were in the stream. The data was downloaded into a computer, and a detailed record of stream temperatures was produced. Water temperatures are always recorded as degrees Celsius (^oC). USGS reported in detail the 2001 temperature data for Rattlesnake Creek (Connolly 2003).

Temperature data collected during Water Chemistry Sampling

Mean water temperatures in the main stem of the White Salmon River during water chemistry sampling from September 2001 to April 2002 show a slight increase as the water travels downstream. Figure 8 shows the mean temperatures over the project period with standard deviations indicated by the vertical lines for each project site point. The temperature for the White Salmon is consistently low for the project period. At the mouth the maximum temperature did not exceed 10^{o}C, and the maximum temperature recorded on the main stem of the White Salmon was 11.9 ^{o}C (site WQ-6 White Salmon below the Trout Lake valley). These maximum temperatures are within the preferred range for most salmonids.

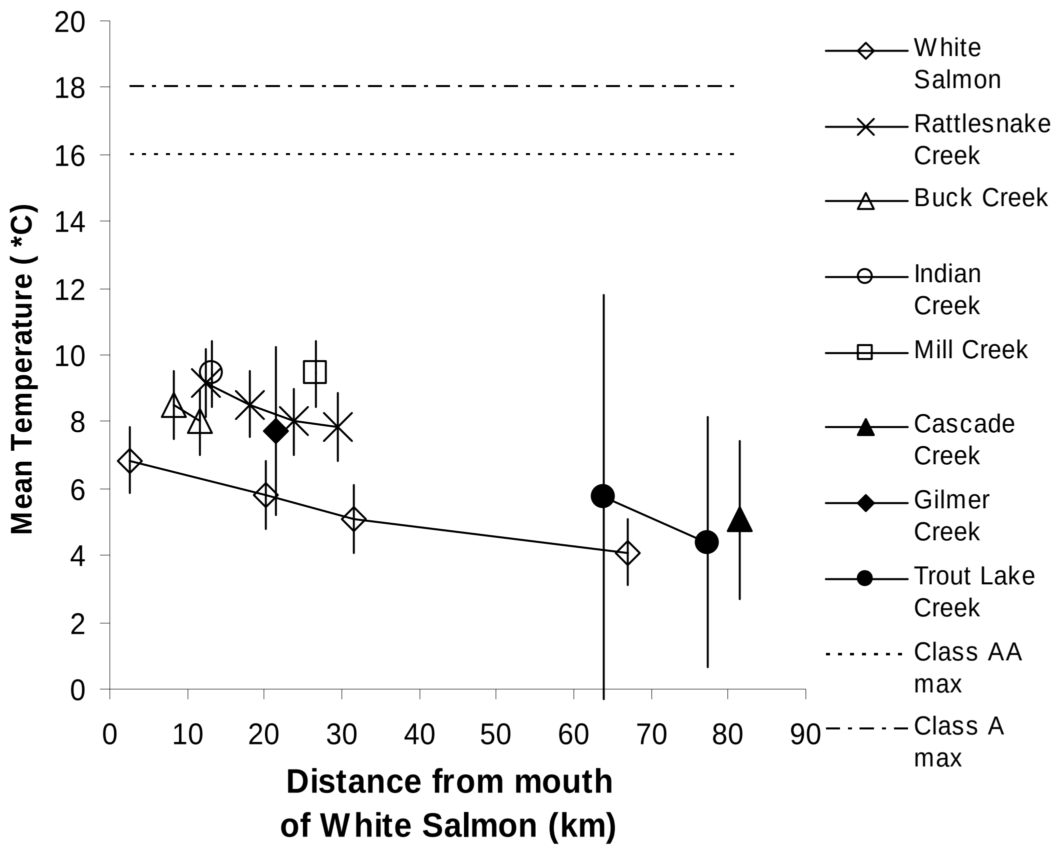


Figure 8. Mean temperatures at each site on each sampling occasion.

The cold water in the main stem of the White Salmon River, throughout the year, may be attributed to glacial melt waters from Mount Adams glaciers. Figure 9 displays the actual temperatures recorded for the White Salmon by the date it was collected. The September data shows the temperature increases between WQ-8 on the upper White Salmon and the middle section (WQ-6) below Trout Lake valley. This increase may be due to water being diverted trough several irrigation ditches in the Trout Lake Valley. The other sampling dates do not show this trend, they all increase gradually as they approach the mouth. However, the temperature is still within Washington State standards. In addition the water temperature decreases between site WQ-6 and WQ-4. This may be attributed to the inflow of ground water to the White Salmon between these points. It has been documented that the volume of water in the White Salmon River doubles in the canyon from numerous springs entering from the canyon walls (Stampfli 1994).

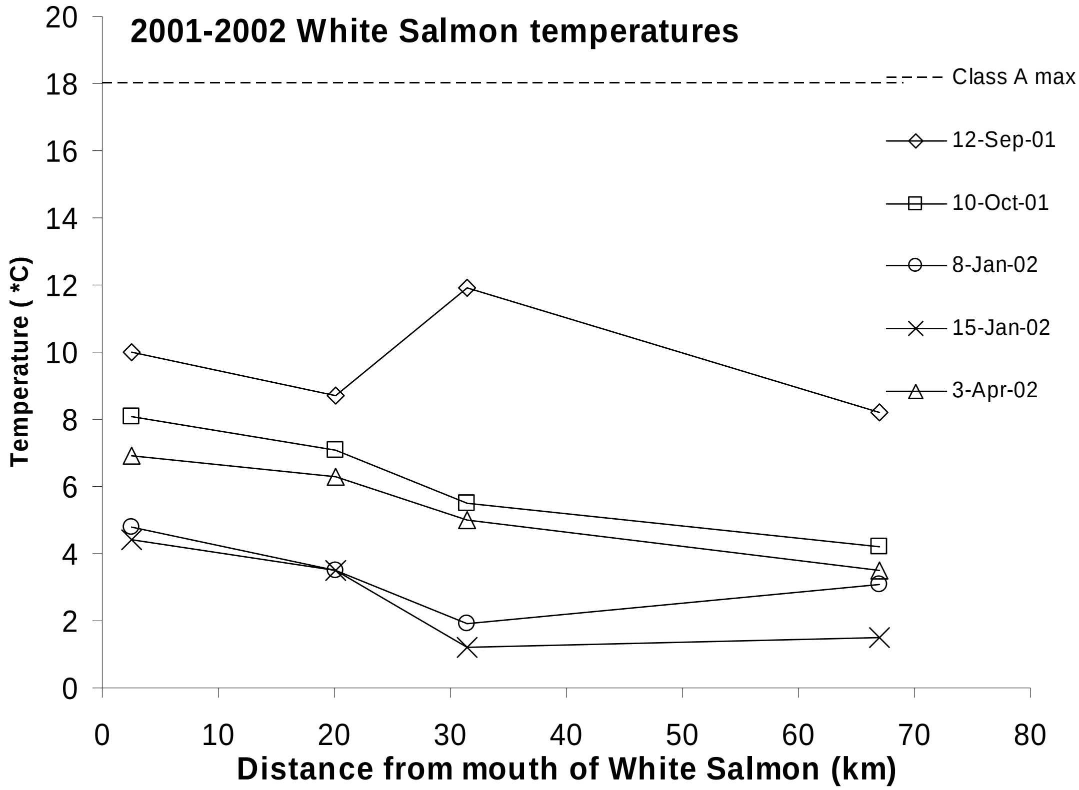


Figure 9. Actual temperatures recorded at sampling sites along the White Salmon.

Trout Lake Creek has a large temperature fluctuation range over the year (fig. 8). A closer look at the data shows that the September temperature was the highest recorded (15.5 °C) at the lower Trout Lake Creek site. This may be attributed to the low flow and slow flowing water. More recent sampling has taken place on the opposite bank of the creek, where the majority of the water flows during the summer period, in an attempt to gather a more representative sample of the water.

Rattlesnake Creek shows the mean temperatures to be approximately 2 °C higher than the White Salmon (fig 8). The actual temperatures do not exceed Washington State Class A standards (figure 10), but the September temperatures would exceed the preferred temperature ranges for anadromous fish if they were able to return to the stream. It should also be noted that 2001 was a drought year. The water levels in Rattlesnake Creek were very low. In many places the creek was subterranean, running below the cobble and rock substrate.

It should be noted that the sites in upper Rattlesnake Creek and upper White Salmon River, were always monitored in the morning and so may be biased towards cooler temperatures than if they were monitored in the afternoon. Likewise, the temperatures recorded nearer the mouth of Rattlesnake Creek were usually collected in the late afternoon, and may therefore reflect a bias toward higher temperatures than if they were recorded in the morning. *The data collected using continuous temperature* *monitoring equipment will be better suited for reporting downstream trends (Connolly 2003 for Rattlesnake Creek).*

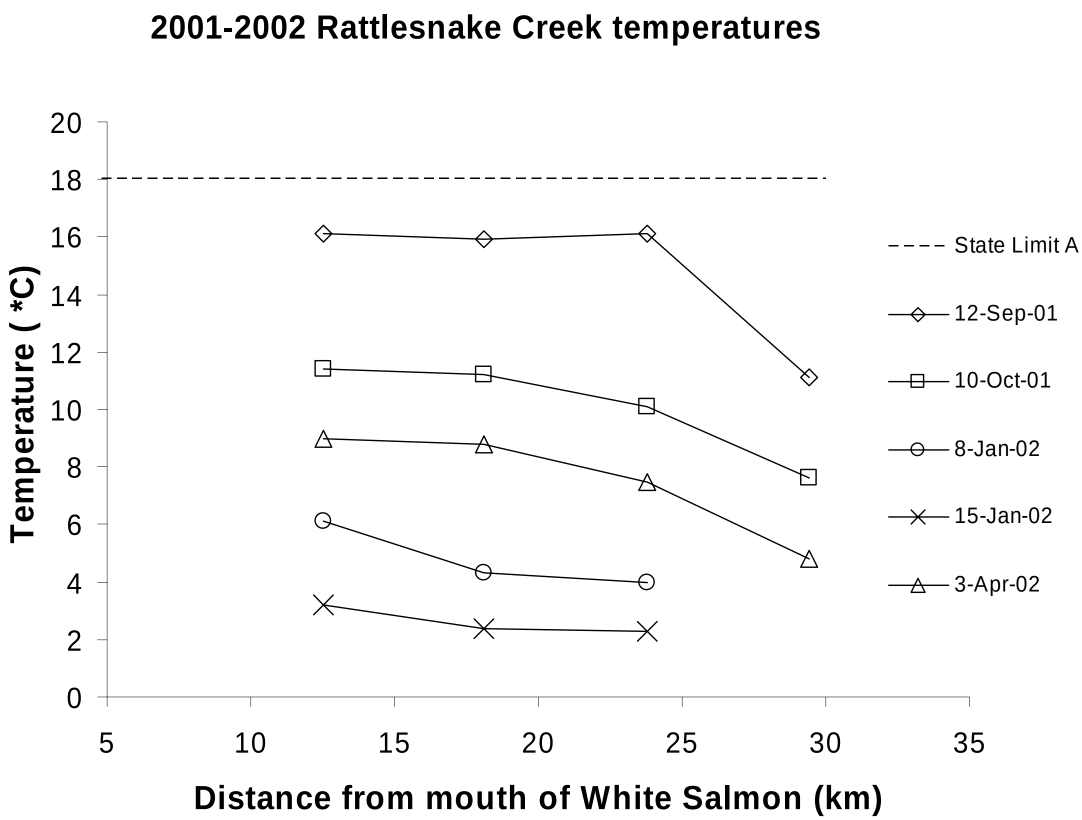


Figure 10. Actual data recorded in the 2001 and 2002 performance period at each site on Rattlesnake Creek at time of water quality sampling.

Temperature data collected via continuous temperature loggers

Continuous water temperature information in Rattlesnake Creek and the White Salmon was collected via Onset® Stowaway® loggers. The loggers recorded temperatures every 2 hours, and provide a detailed picture of water temperature. UCD maintained 8 thermographs in Rattlesnake Creek and its tributaries, and an additional 8 loggers in the White Salmon basin (table 1). Following are graphs and information about 2001 summer data from each site, moving from up stream to downstream. Daily maximum and daily minimum temperatures are shown, along with State of Washington Class A or AA surface water standards (table 3).

Upper White Salmon,, WQ-8

This site on the White Salmon is above Trout Lake Creek and receives glacial melt waters from Mount Adams. Much of the drainage above this location runs through US Forest Service land which is required to meet Class AA temperature standards. Although this site is next to a road it is well below the state standard, with a maximum temperature of 13.25°C for the sampling period.

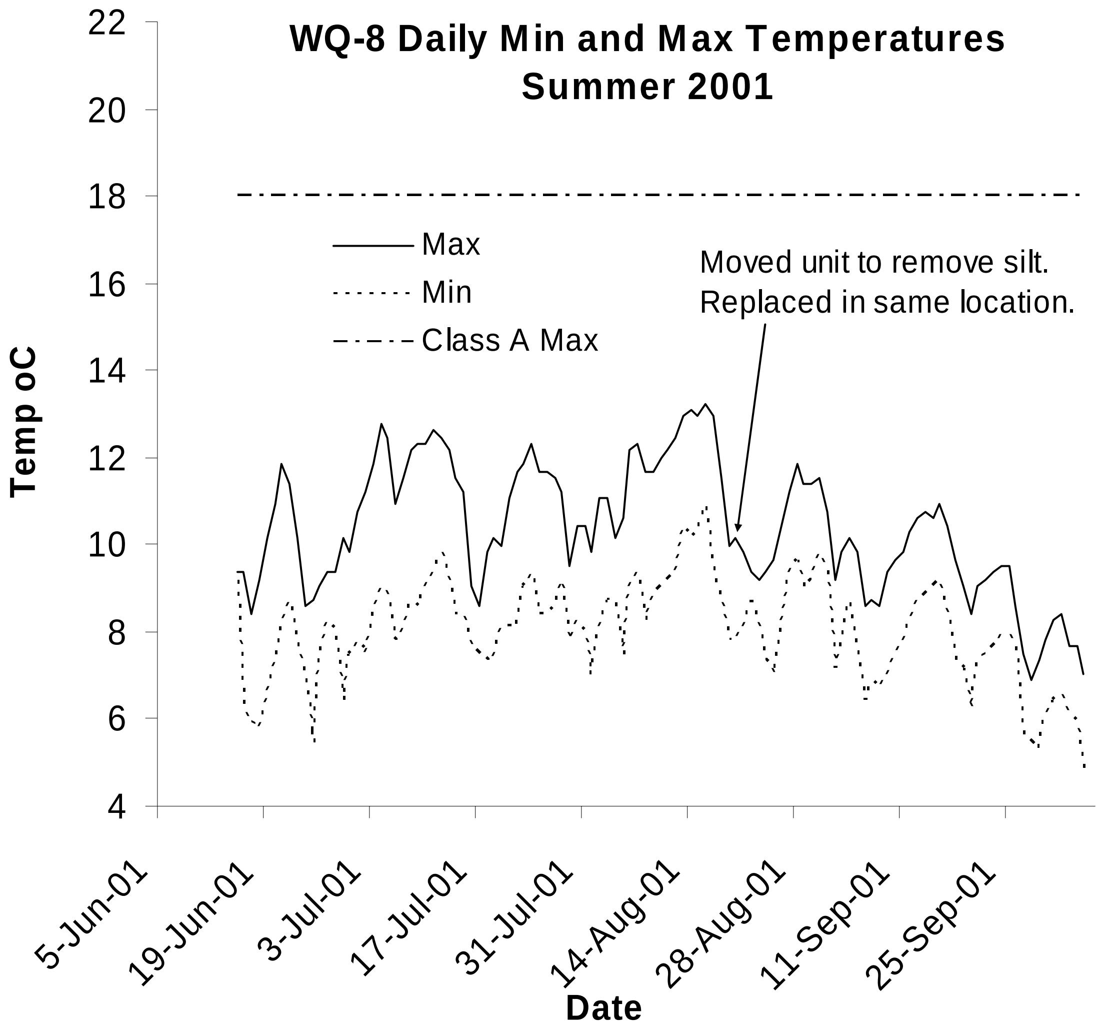


Figure 11. Daily minimum and maximum temperatures at upper White Salmon River WQ-8 from June 15 to October 5.

Trout Lake Creek at USFS Road 8810, WQ-9a

This site, located above Trout Lake, is much cooler than the lower Trout Lake Creek site (Figure 13). It appears that the Creek warms up quite a lot when it hits the valley. The stream becomes much wider in between sites 9 and 9a, as it flows through the wide, flat Trout Lake wetland. This site is on US Forest Service property and is therefore required to meet Class AA standards for water temperature (16^{o}C). 22 days exceed 16 ^{o}C. The maximum temperature was 17.94 ^{o}C.

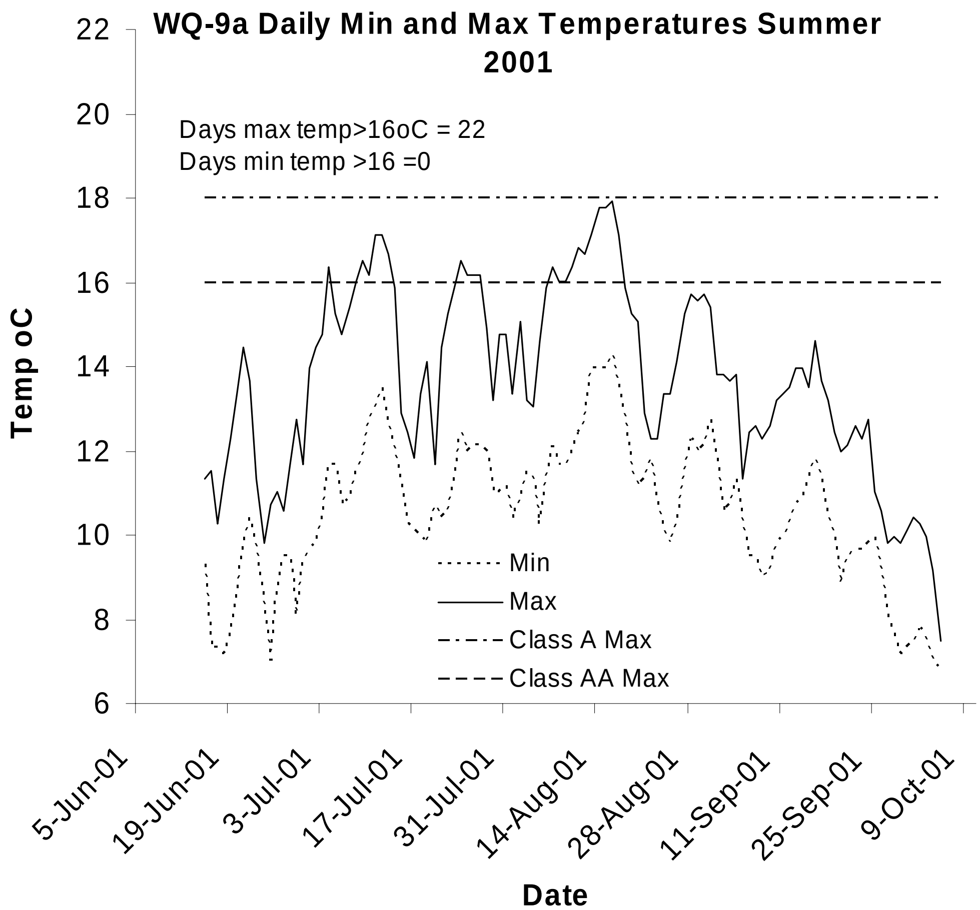


Figure 12. Daily minimum and maximum temperatures at Trout Lake Creek at USFS 8810 Rd. WQ-9a from June 15 to October 5.

Trout Lake Creek at Base, WQ-9

Trout Lake Creek was very warm, with 64 days exceeding 18°C, 7 days did not drop below 18°C, and 88 days exceeded 16 °C. In August the logger was moved from slow shallow water into the main flow, but temperatures still exceeded 18°C through September. Maximum temperature was 25.21 °C.

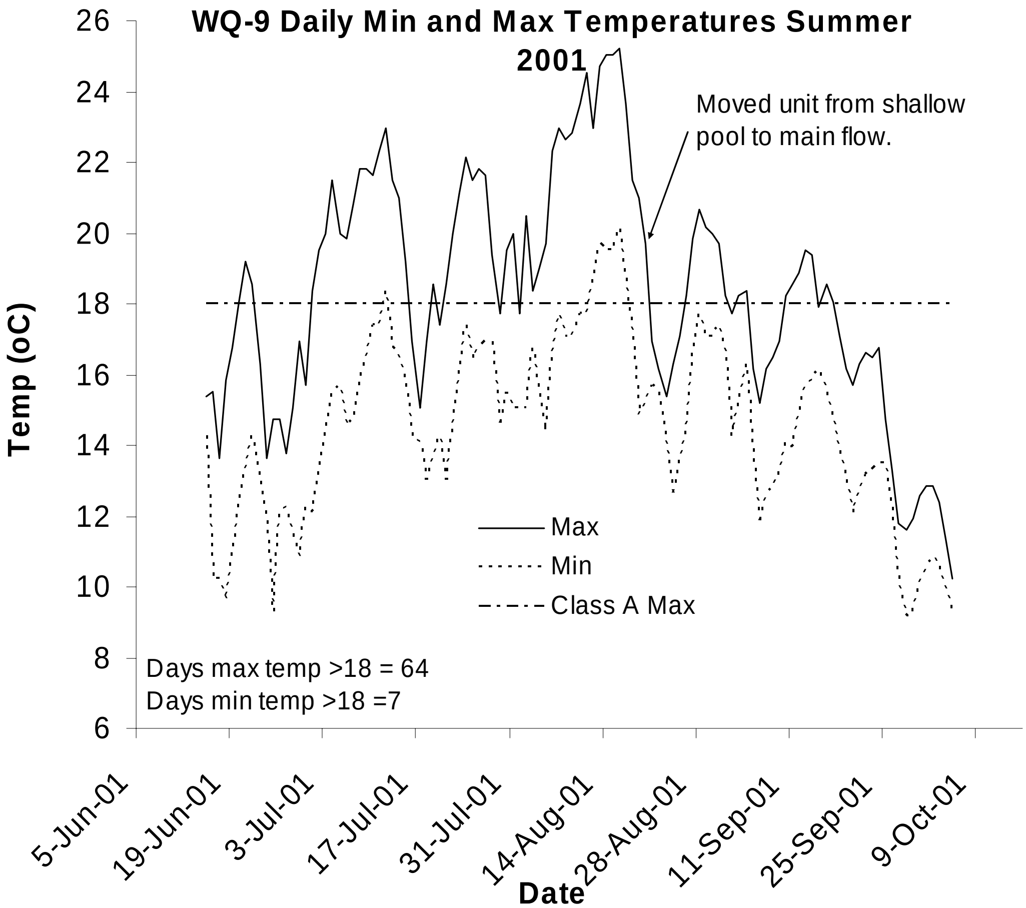


Figure 13. Daily minimum and maximum temperatures at base of Trout Lake Creek WQ-9 from June 15 to October 5.

White Salmon River below Trout Lake Valley, WQ-6

This station showed a total of 8 days when the high temperature exceeded 18 ^oC, all of which were in August. 34 days exceeded 16 ^oC.

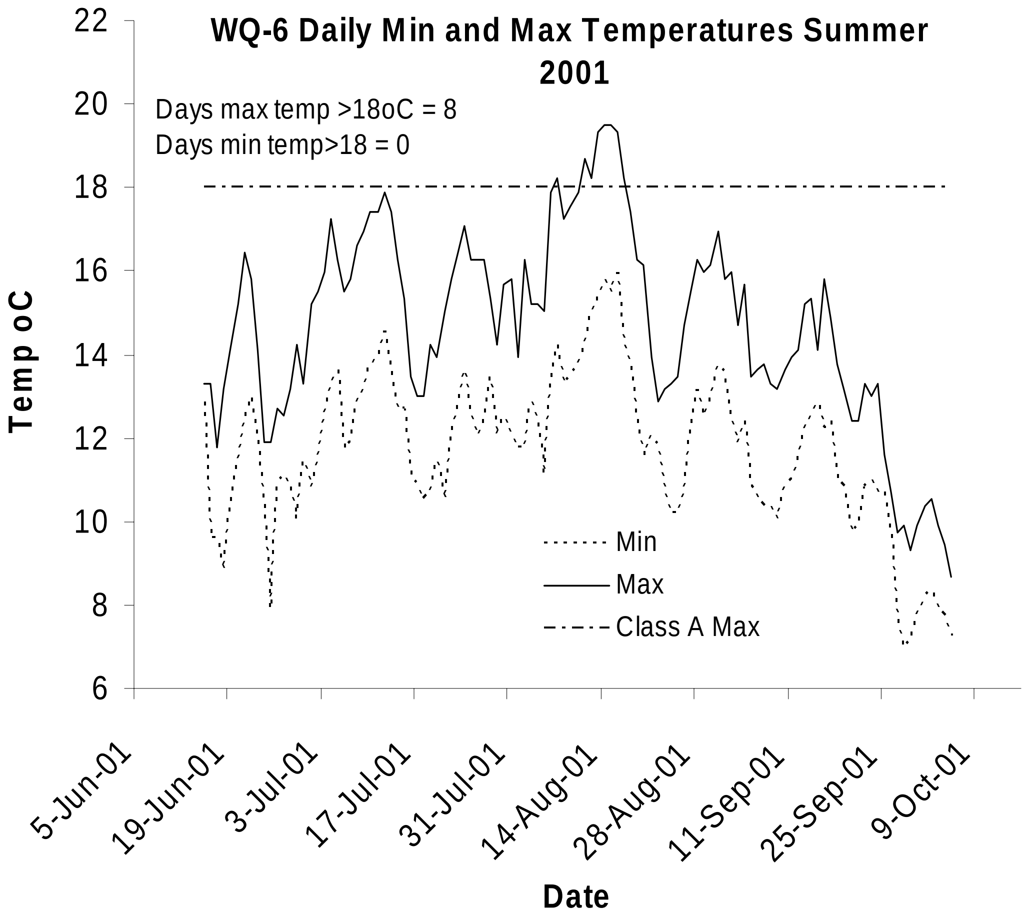


Figure 14. Daily minimum and maximum temperatures at White Salmon River below Trout Lake valley WQ 6, from June 15 to October 5.

Gilmer Creek at Base, WQ-5

Gilmer Creek stayed much cooler than Rattlesnake Creek, never exceeding 16 ^{o}C during the sampling period.

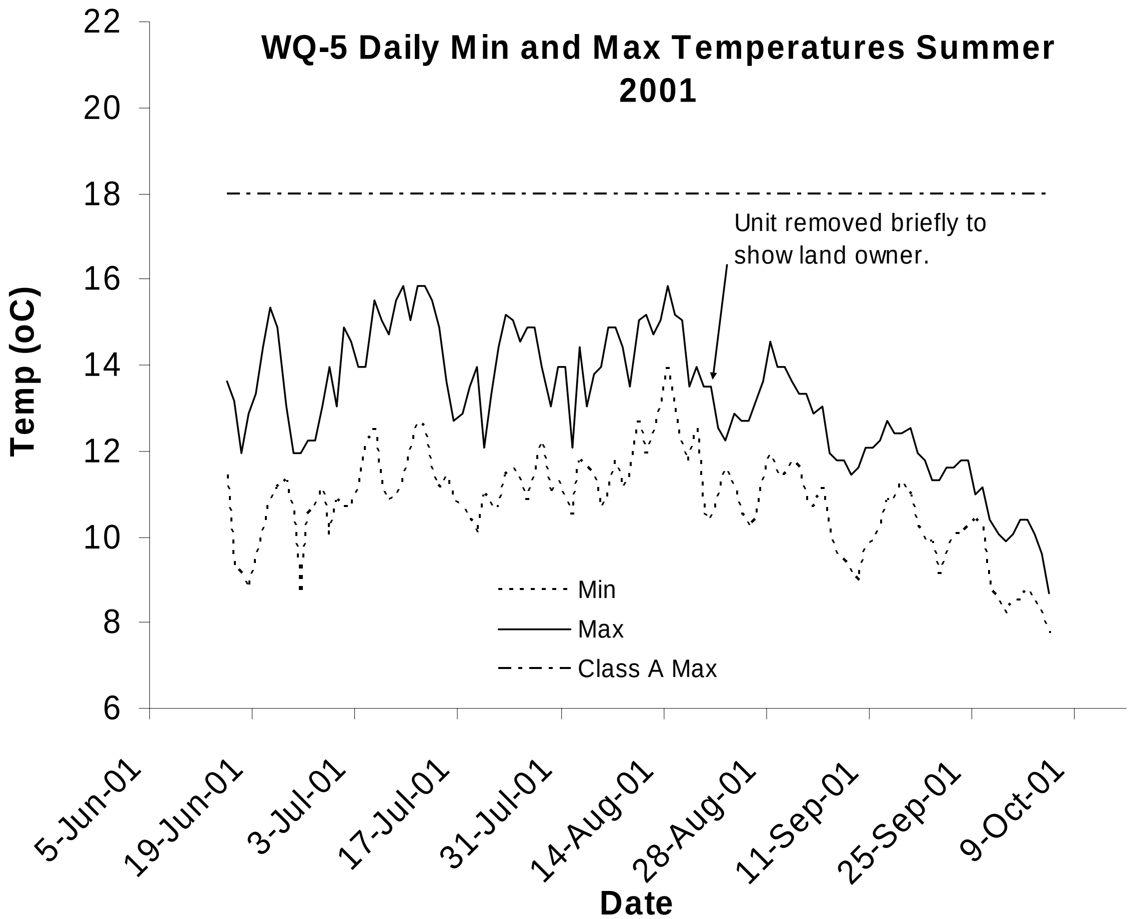


Figure 15. Daily minimum and maximum temperatures at Gilmer Creek WQ 5 from June 15 to October 5.

Rattlesnake Creek at top of Upper Canyon, WQ-3ad

This upper Rattlesnake Creek location exceeded 18°C on 15 days, fewer days than for sites further downstream. 47 days exceeded 16°C. The maximum temperature was 19.52°C.

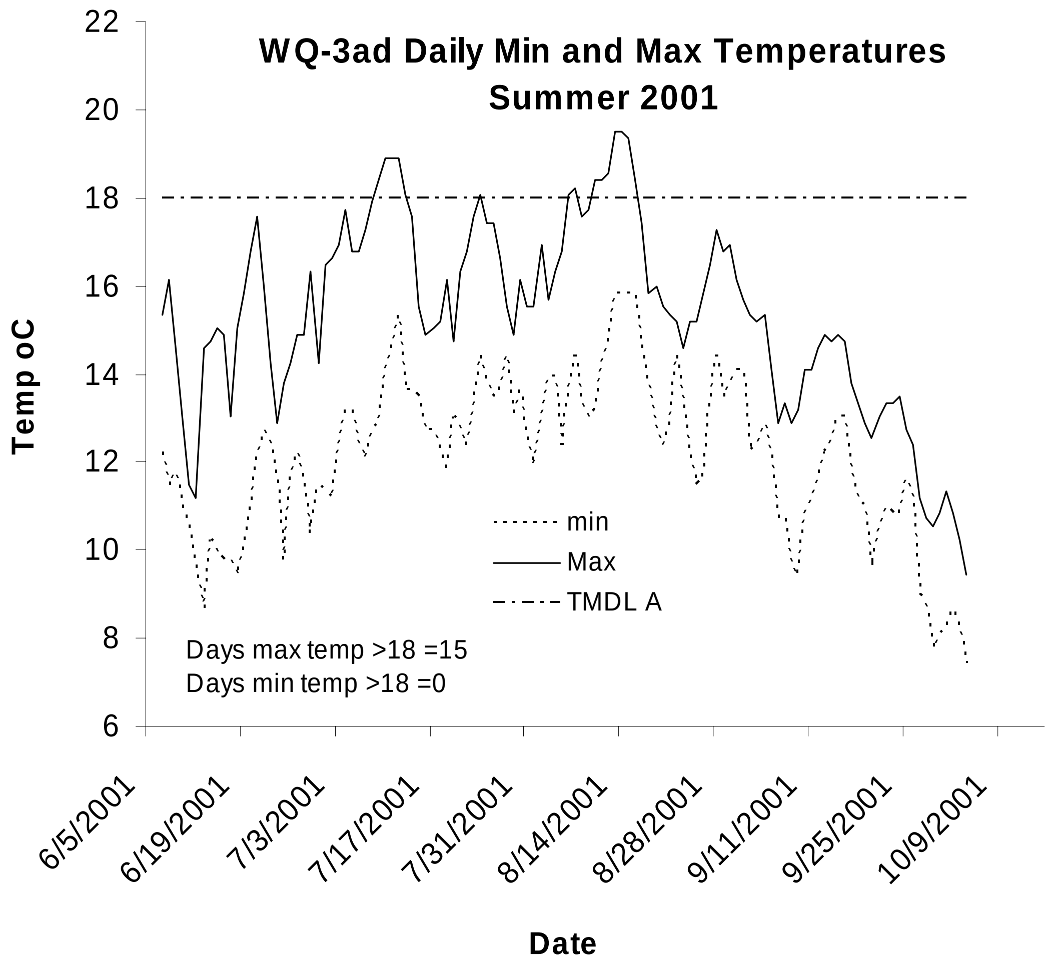


Figure 16. Daily minimum and maximum temperatures at Rattlesnake Creek upper canyon WQ 3ad from June 8 to October 4.

Mill Creek above confluence with Rattlesnake Creek, WQ-3c

Mill Creek stayed much cooler than Rattlesnake Creek in 2001, never exceeding 16°C. The maximum temperature was 15.68°C. This tributary to Rattlesnake Creek is shaded and runs through a fairly steep canyon.

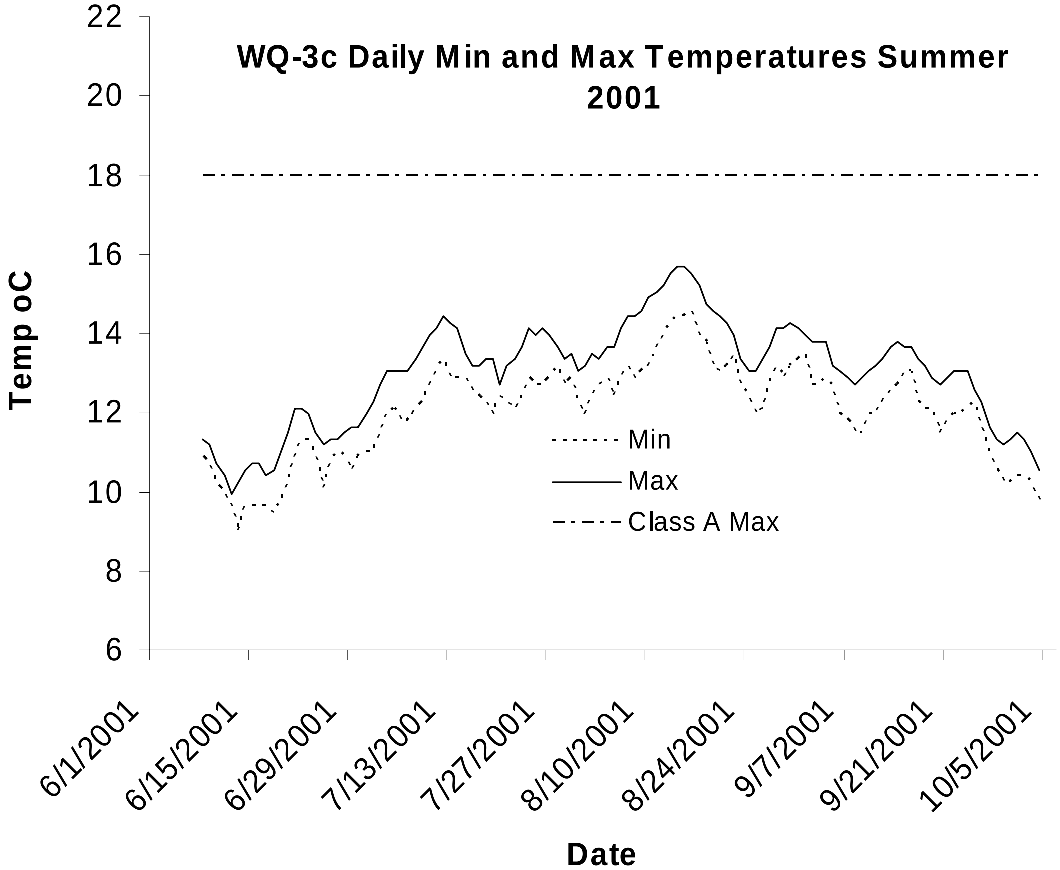


Figure 17. Daily minimum and maximum temperatures at the base of Mill Creek WQ 3c from June 8 to October 4.

Rattlesnake Creek below Upper Canyon, WQ-3aa

WQ-3aa exceeded 18 ^oC on 48 days between June 21 and September 1. 3 days did not drop below 18 ^oC. 82 days exceeded 16^oC and 11 did not drop below 16^oC. The creek was observed to be intermittent above this site and in several places the water ran just below the surface, through the cobbles between pools. Maximum temperature was 21.43^oC.

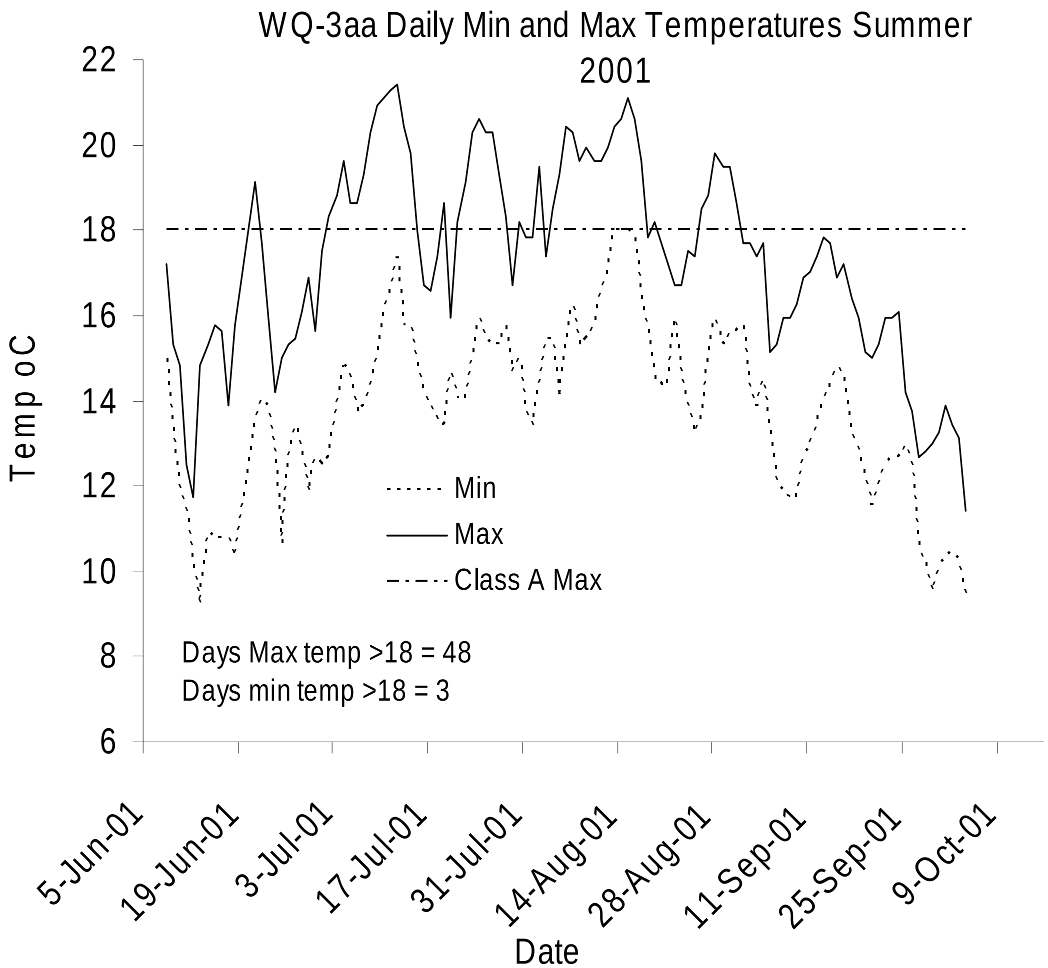


Figure 18. Daily minimum and maximum temperatures at Rattlesnake Creek below upper Canyon WQ 3aa from June 7 to October 5.

Rattlesnake Creek at mid alluvial section, WQ-3a

This site in middle Rattlesnake Creek is on DNR property. Maximum water temperature exceeded Class A standards of 18°C on 51 days between June 19 and August 31. Ten days did not drop below 18 °C. The logger was moved to slightly deeper water on August 14, at which time the creek was very low.

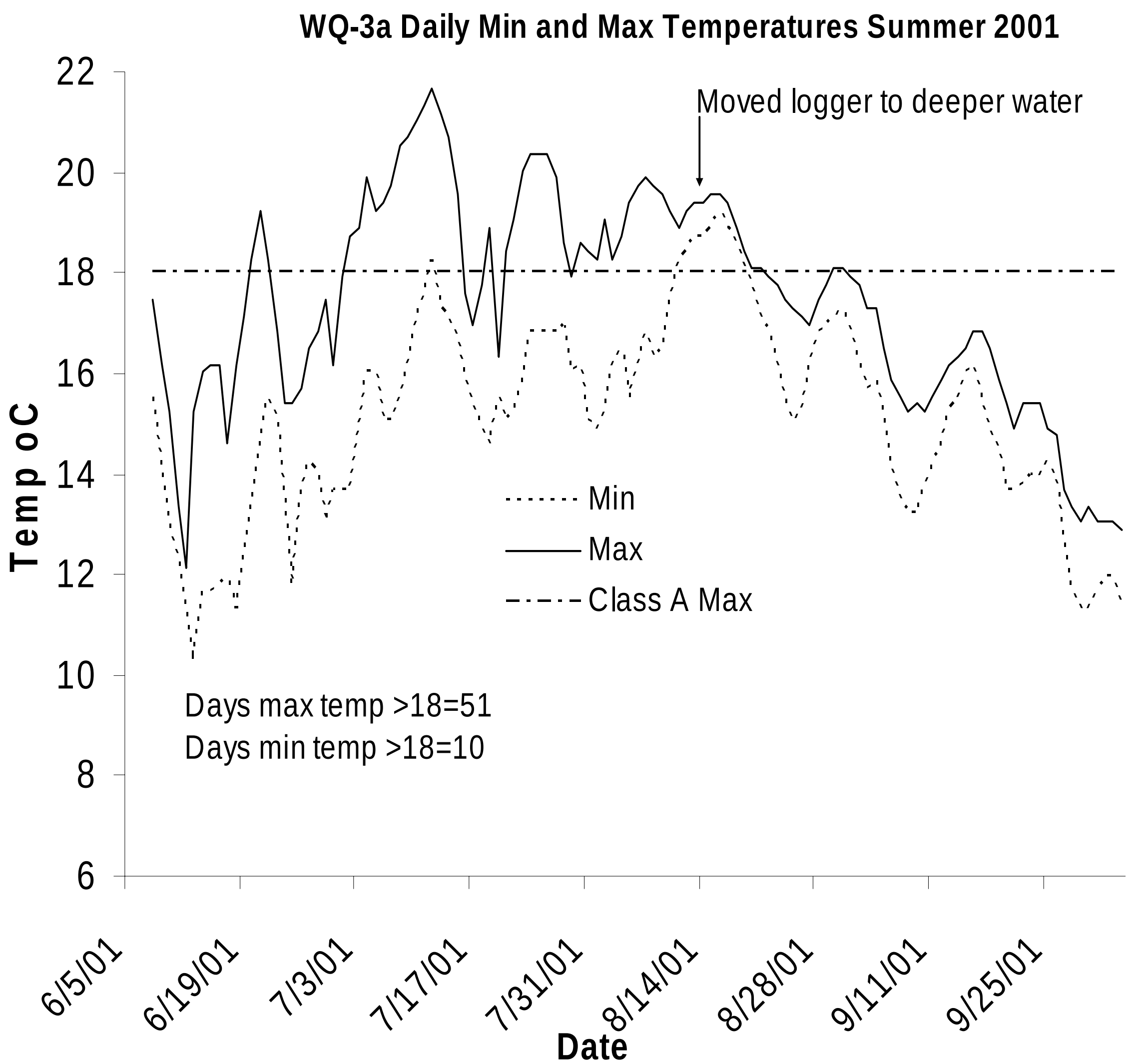


Figure 19. Daily minimum and maximum temperatures at Rattlesnake Creek mid alluvial section WQ 3a from June 7 to October 5.

Rattlesnake Creek at Base of Alluvial Reach, WQ-3ab

Daily maximum temperatures exceeded Class A state standards on 23 days. This logger was located in a deep pool and appears to be considerably cooler than other Rattlesnake Creek sites. It is possible that the pool receives cooler ground water input at this location. WQ-3ab also exceeded 16^{o}C for 79 days during the summer of 2001.

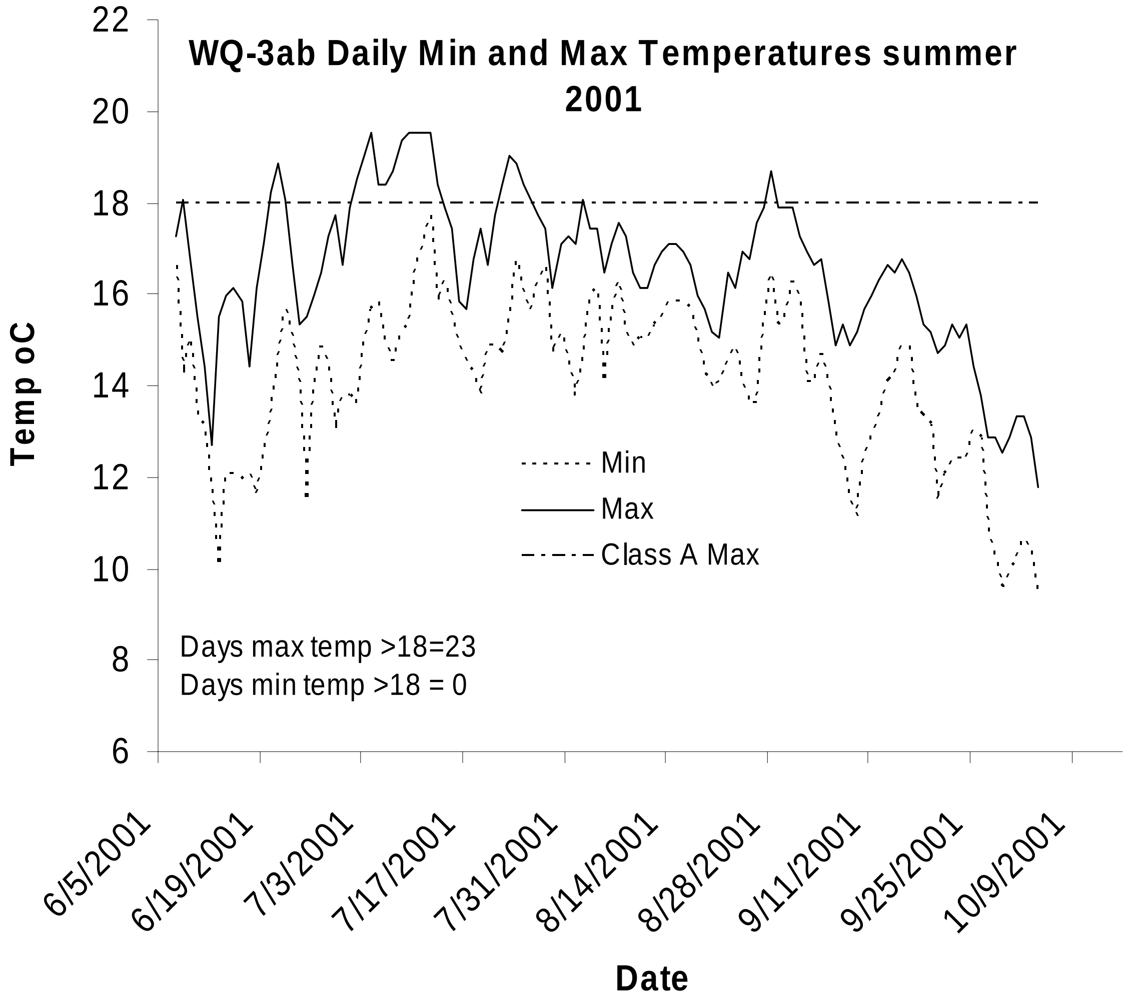


Figure 20. Daily minimum and maximum temperatures at Rattlesnake Creek at base of alluvial section WQ 3ab from June 7 to October 5.

Rattlesnake Creek above Indian Creek Confluence, WQ-3ac

This site on lower Rattlesnake Creek is just upstream from the confluence with Indian Creek, and exhibited a very similar pattern to WQ-3b. Maximum water temperature exceeded Class A standards of 18^{o}C on 73 days between June 19 and August 31. Eight days did not drop below 18 ^{o}C.

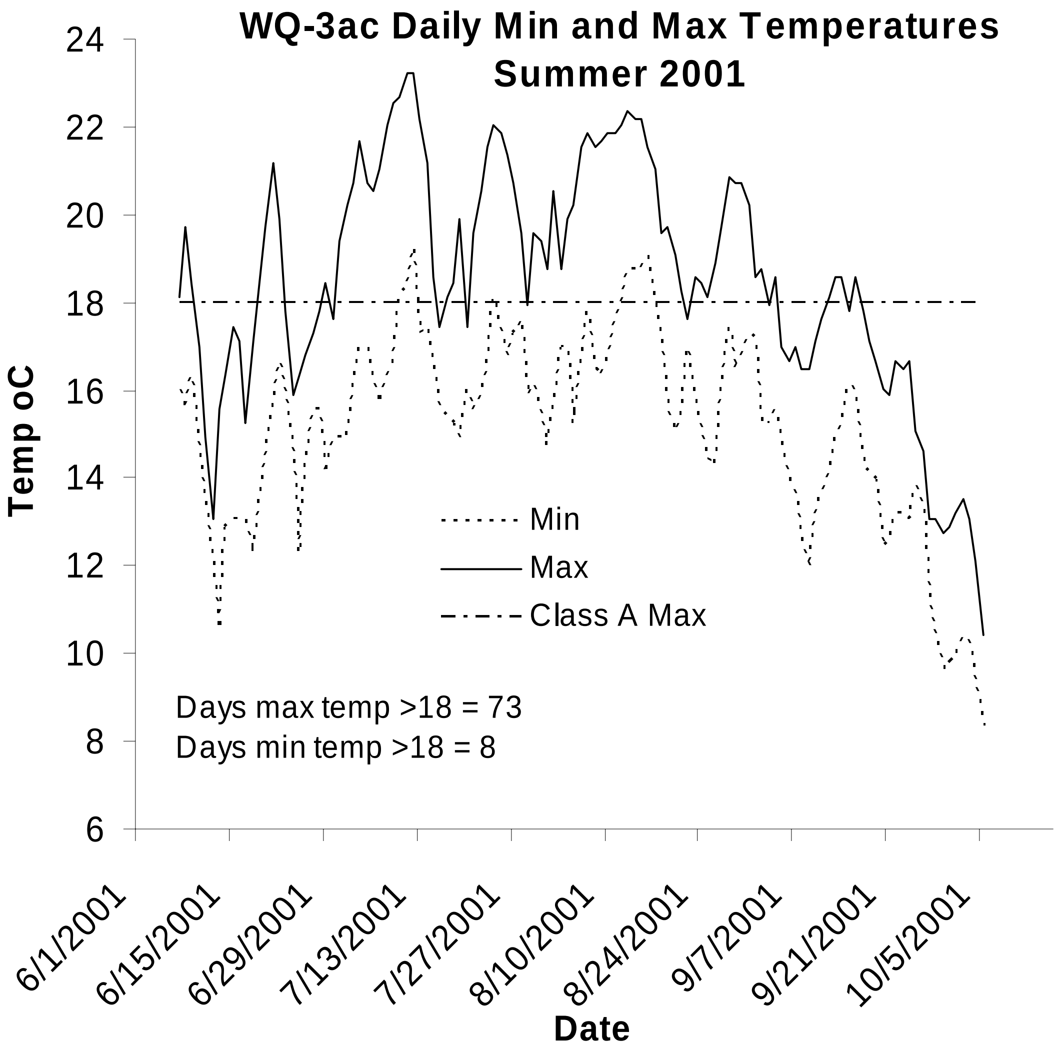


Figure 21. Daily minimum and maximum temperatures at Rattlesnake Creek above Indian Creek WQ 3ac from June 7 to October 5.

Indian Creek at Base, WQ-3b

Indian Creek's maximum daily temperatures exceeded 18°C for 41 days between June 7 and October 4. There were also 86 days when it exceeded 16 °C, with a maximum temperature of 20.8 degrees on August 13.

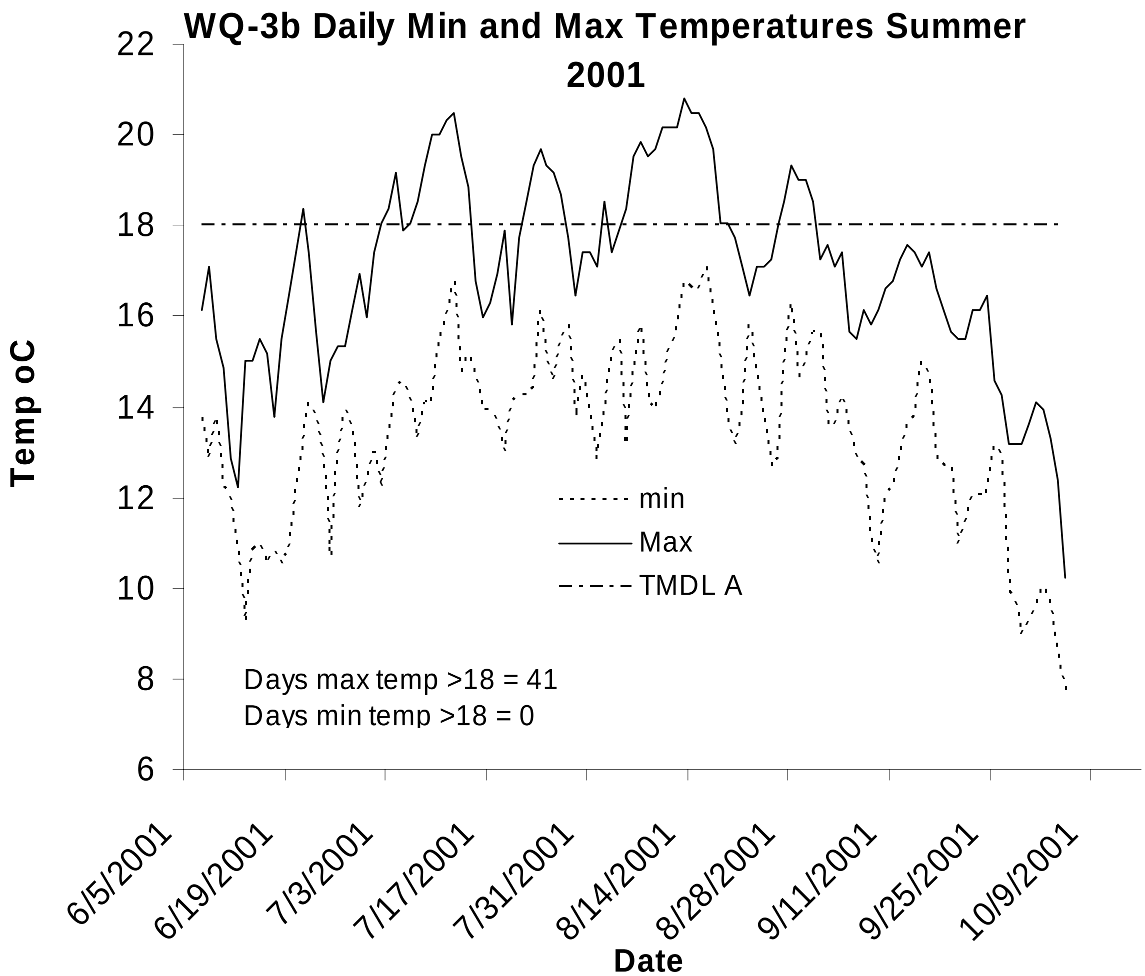


Figure 22. Daily minimum and maximum temperatures at Indian Creek WQ 3b from June 7 to October 4.

Rattlesnake Creek at Base, WQ-3

Lower Rattlesnake Creek should meet Class A Standards of 18 ^{o}C. During the summer of 2001 58 days exceeded 18 ^{o}C, and 98 days exceeded 16 ^{o}C. The maximum temperature recorded was 21.13 (July 4). On six days even the minimum temperatures exceeded 18 ^{o}C (36 days did not drop below 16 ^{o}C). Class A maximum temperatures were exceeded as early as June 7th (the first day of sampling) and as late as September 5. The high temperatures follow the weather / air temperatures also monitored in the area (Fig. 24) and may be exacerbated by low, shallow flows observed during the summer.

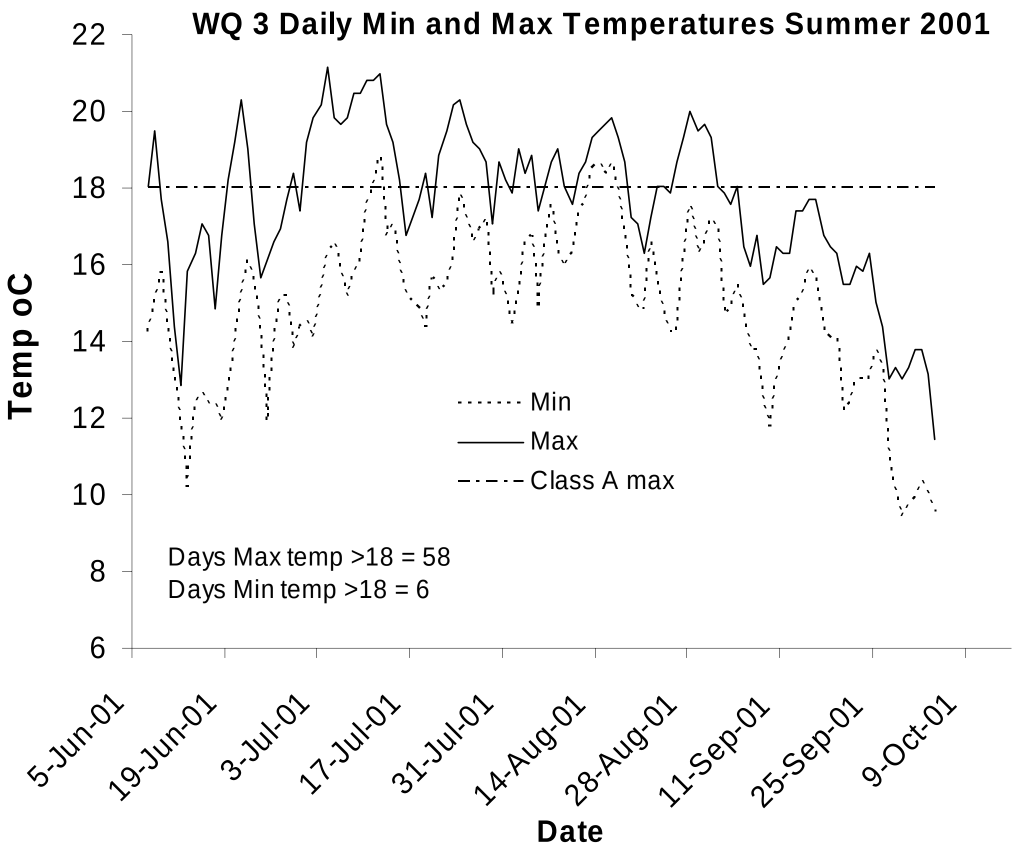


Figure 23. Daily minimum and maximum temperatures at WQ-3 Rattlesnake Creek at base June 7 to October 4.

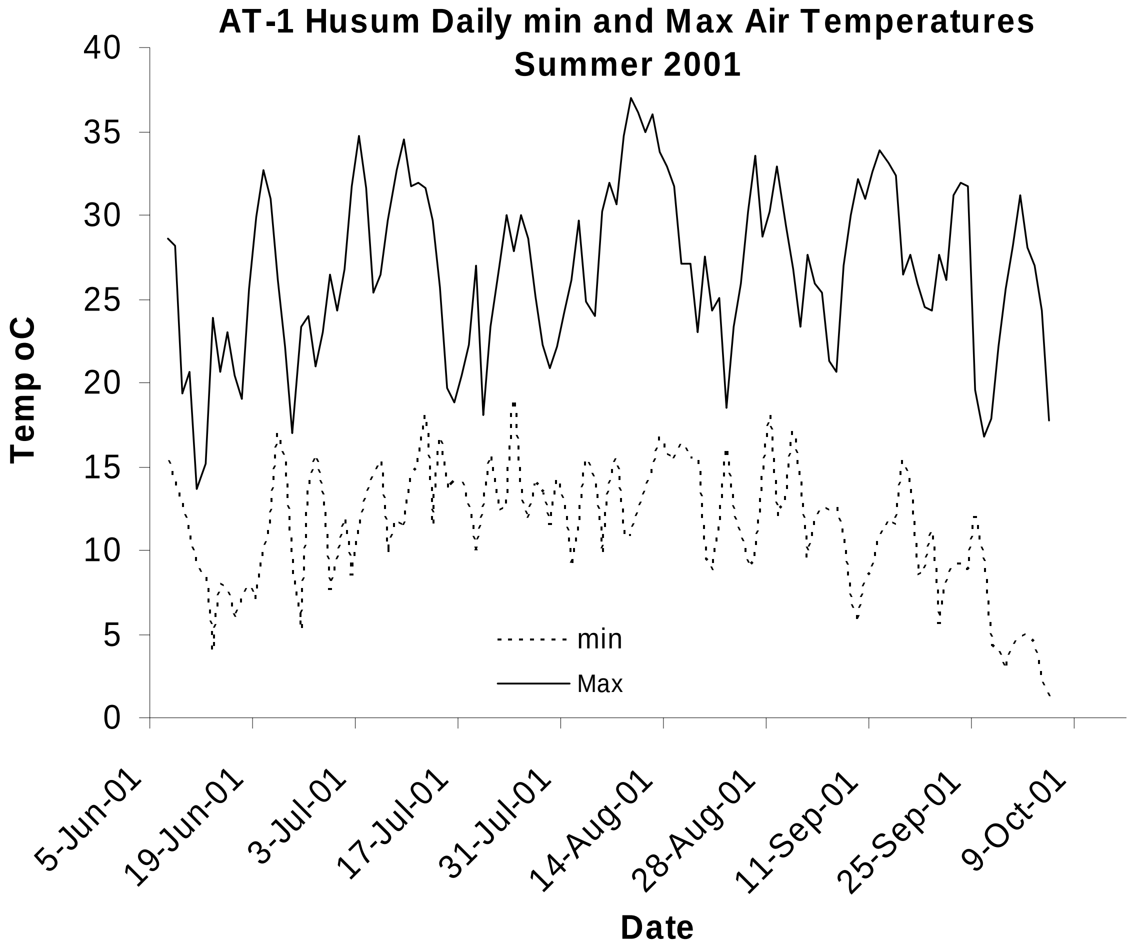


Figure 24. Daily minimum and maximum air temperatures at Husum (close to WQ-3 Rattlesnake Creek at base) June 7 to October 5.

Buck Creek at DNR Boundary, WQ-2a

This site on upper Buck Creek had a very similar temperature profile to WQ-2 (figure 26), with temperatures about 2 degrees cooler than the lower site. WQ-2a did not exceed 15.2 ^{o}C throughout the summer of 2001, well below the Class A standard of 18^{o}C.

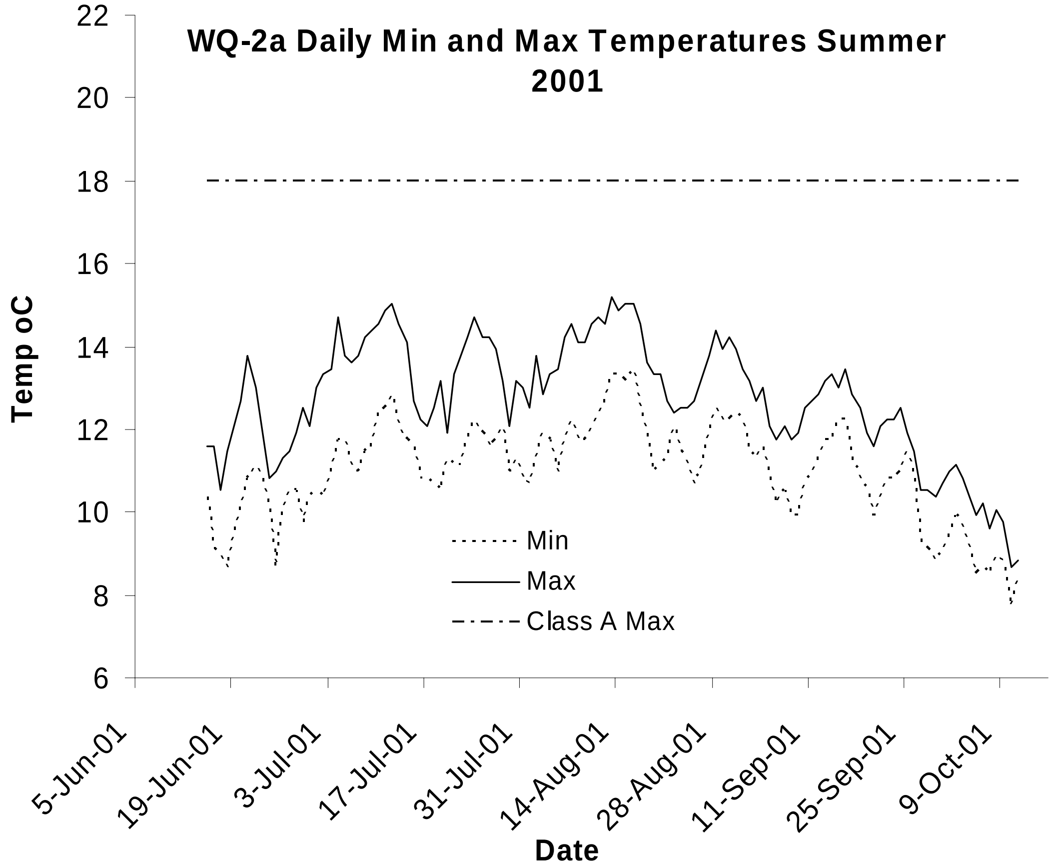


Figure 25. Daily minimum and maximum temperatures at WQ-2a Buck Creek at DNR from June 15 to October 11.

Buck Creek at base, WQ-2

Buck Creek is much warmer than the White Salmon. However, it did not record temperatures over the state Class A standard of 18 °C

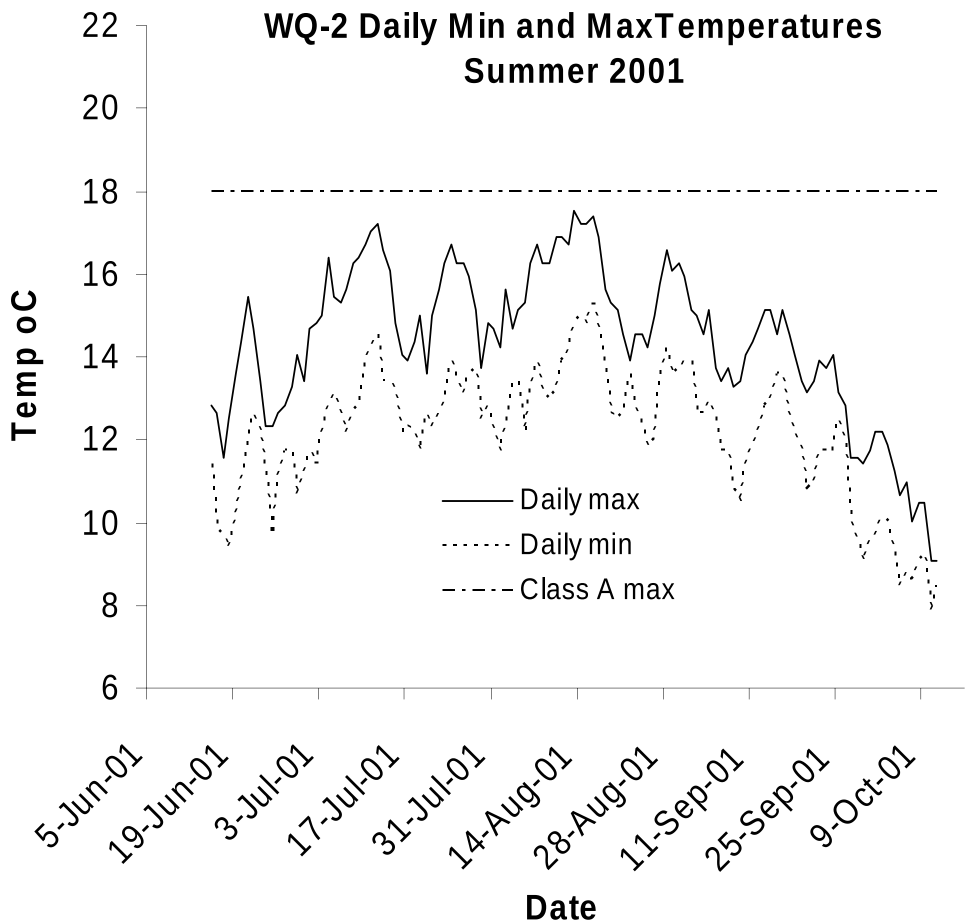


Figure 26. Daily minimum and maximum temperatures at WQ-2 Buck Creek at base from June 15 to October 11.

White Salmon River near the Base (site WQ-1)

As mentioned earlier, the main stem of the White Salmon stays consistently low. Recorded maximum temperature at WQ-1 did not exceeded 13 degrees C, with a maximum of 12.58 on July 27 (fig. 27).

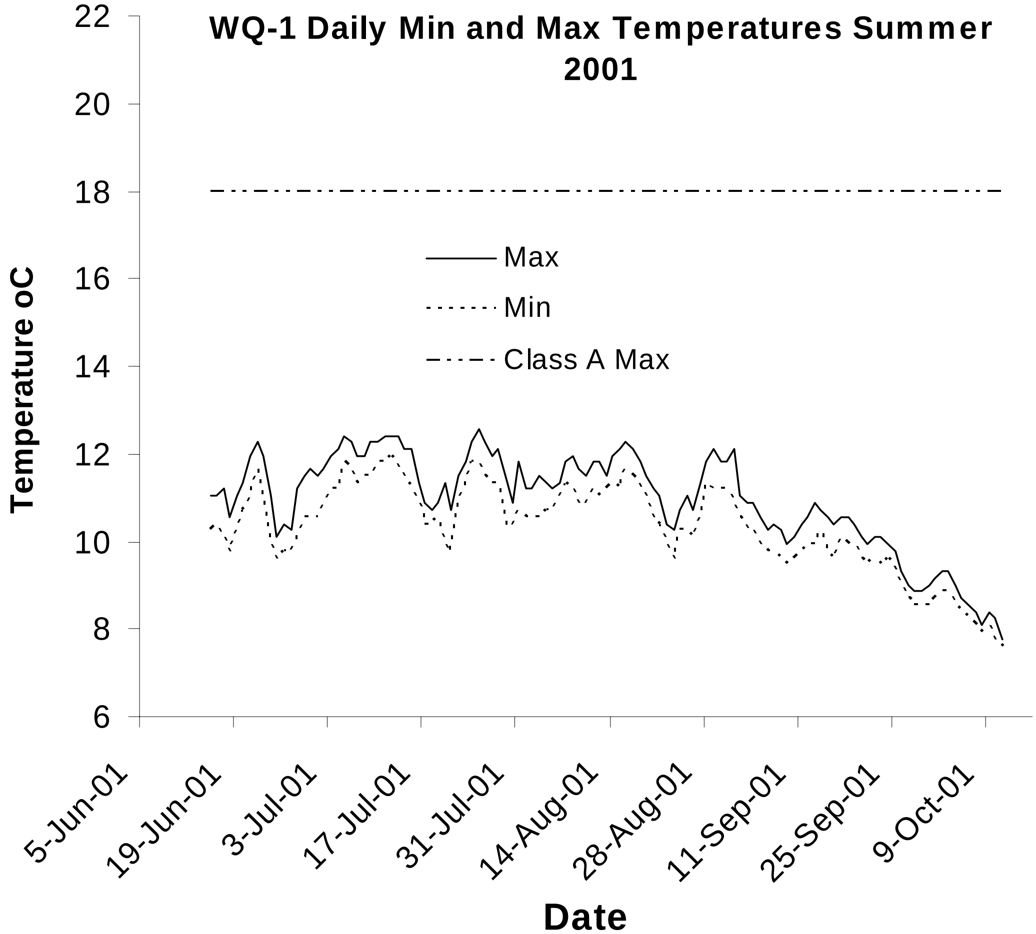


Figure 27. Daily minimum and maximum temperatures at WQ-1 White Salmon from June 15 to October 11.

It is evident that the White Salmon provides temperatures that are suitable for various fish species. All the tributaries of Buck Creek, Rattlesnake Creek, Gilmer Creek, and Trout Lake Creek contributed higher temperatures. Rattlesnake Creek was obviously temperature impaired during the sample period, with all but Mill Creek exceeding state Class A standards of 18^{o}C. Mill Creek contributed cool water to the upper reach of Rattlesnake Creek but not enough to significantly decrease temperatures.
It should be noted that 2001 was a drought year, and as such the results may be extreme when compared to other years. Future years of monitoring will provide a better insight to ‘normal’ conditions in the streams.

Summary

Based on this one year data set;

- pH readings were all within the State standards of 6.5-8.5 with the exception of one reading on rattlesnake Creek, and measurement error cannot be ruled out for this data point.
- DO levels appear to be adequate for support of aquatic species for both the entire watershed and Rattlesnake Creek.
- Turbidity levels appear to be adequate for aquatic species. Future years of sampling will help to determine seasonal variations in turbidity, and possibly identify problems and / or improvements, particularly in Rattlesnake Creek.
- Conductivity levels are relatively low, but fairly consistent within the watershed. Future year samples will help to determine seasonal variation in conductivity, and establishment of the baseline in Rattlesnake Creek, which showed more variation, possibly due to the small sample size.
- Phosphorus levels in 2001-2002 samples were low, but showed a general increase downstream. This trend is evident on Rattlesnake Creek (but less data exists for upper Rattlesnake Creek and Mill Creek due to access problems in the winter. Also Gilmer Creek is only represented by two (2) data points. 2002-2003 sampling will help to establish a baseline.
- Nitrate and nitrite nitrogen results for this project period were nearly all below the method reporting limit. The two results for Gilmer Creek exceed the typical value of 1mg/L for surface waters. Similar results were obtained in sampling during the early 1990s. 2002-2004 sampling may enable further confirmation of what the normal levels of nitrates are in the sample streams.
- The temperatures taken at the time of general water chemistry sampling did not exceed State standards. Some correlation was observed between increased temperatures and decreased DO. The Continuous temperature loggers gave a much more detailed pattern of temperature and highlighted Rattlesnake Creek and Trout Lake Creek as impaired for fish.

To summarize the continuous temperature data it is evident that the White Salmon provides a cool refuge for various fish species. All the tributaries (Buck Creek, Rattlesnake Creek, Gilmer Creek, and Trout Lake Creek) contributed higher temperatures. Rattlesnake Creek was obviously temperature impaired during the sample period with all but Mill Creek exceeding state Class A standards of 18^oC (see Connolly 2003 for more details).

It should be noted that 2001 was a drought year, and as such the results may be extreme when compared to other years. Future years of monitoring will provide a better insight to ‘normal’ conditions in the streams.

Overall the condition of the White Salmon River and its tributaries is good. Temperature is the biggest problem on Rattlesnake Creek and Trout Lake Creek. And Gilmer Creek appears to be receiving higher than typical amounts of nitrates. But has comparatively lower phosphates than Rattlesnake Creek. However, given the small sample sizes it is best not to jump to conclusions at this point. The collection of more data in the future will help to establish a better baseline of information from which to make management decisions.

Apendix B

Tables of water quality results

WATER TEMP oC																	
site #	1	2	3	4	5	6	7	8	9	10	2a	3aa	3ab	3ad	3b	3c	9a
Riverkm	2.50	8.35	12.5	20.13	21.38	31.50	57.01	67.00	63.88	81.38	11.62	23.80	18.10	29.40	13.25	26.52	77.26
12-Sep-01	10	14.2	16.1	8.7	10.8	11.9	10.5	8.2	15.5	7.5	12.8	16.1	15.9	7.6	16.4	12.4	10.3
10-Oct-01	8.1	8.5	11.4	7.1	8.1	5.5	5.1	4.2	6.8	2.8	8.4	10.1	11.2	11.1	11.5	9.7	5.8
8-Jan-02	4.8	6.9	6.1	3.5	6.8	1.9	2	3.1	0.7		6	4	4.3		6.1		1.9
15-Jan-02	4.4	5	3.2	3.5	4	1.2	0.6	1.5	0.9		5.4	2.3	2.4		4.2		1.3
3-Apr-02	6.9	7.9	9	6.3	8.9	5	6.5	3.5	4.7	4.9	7.1	7.5	8.8	4.8	9	6.2	2.6
Min	4.4	5	3.2	3.5	4	1.2	0.6	1.5	0.7	2.8	5.4	2.3	2.4	4.8	4.2	6.2	1.3
Max	10	14.2	16.1	8.7	10.8	11.9	10.5	8.2	15.5	7.5	12.8	16.1	15.9	11.1	16.4	12.4	10.3
Mean	6.84	8.5	9.16	5.82	7.72	5.1	4.94	4.1	5.72	5.066667	7.94	8	8.52	7.833333	9.44	9.433333	4.38
STDEV	2.328734	3.451811	4.95207	2.287357	2.535153	4.24	3.900385	2.496998	6.047479	2.354428	2.947541	5.448853	5.40805	3.156475	4.782573	3.10859	3.737245

pH																	
site #	1	2	3	4	5	6	7	8	9	10	2a	3aa	3ab	3ad	3b	3c	9a
Riverkm	2.50	8.35	12.5	20.13	21.38	31.50	57.01	67.00	63.88	81.38	11.62	23.80	18.10	29.40	13.25	26.52	77.26
12-Sep-01	7.92	7.96	8.05	7.48	7.85	7.69	7.74	7.3	9.92	7.01	7.98	8.12	8.02	7.94	8.06	7.85	7.78
10-Oct-01	7.74	7.99	7.89	7.65	7.82	7.69	7.54	7.51	7.7	7.67	7.92	8.7	7.84	8.06	8.1	7.85	7.74
8-Jan-02	7.12	7.79	7.32	7.31	7.69	7.05	7.36	7.08	7.91		7.78	7.09	7.55		7.28		7.73
15-Jan-02											7.24	7.33	7.24		7.55		7.08
3-Apr-02	7.46	7.45	7.11	7.26	7.71	7.24	7.1	7.11	6.97	7.66	7.47	7.19	7.27	7.41	7.34	7.26	7.04
min	7.12	7.45	7.11	7.26	7.69	7.05	7.1	7.08	6.97	7.01	7.24	7.09	7.24	7.41	7.28	7.26	7.04
max	7.92	7.99	8.05	7.65	7.85	7.69	7.74	7.51	9.92	7.67	7.98	8.7	8.02	8.06	8.1	7.85	7.78
ave	7.56	7.7975	7.5925	7.425	7.7675	7.4175	7.435	7.25	8.125	7.446667	7.678	7.686	7.584	7.803333	7.666	7.653333	7.474
stdev	0.349094	0.247841	0.449027	0.177106	0.07932	0.324076	0.271968	0.19883	1.262656	0.378197	0.314356	0.69723	0.344137	0.345881	0.391254	0.340637	0.378656

CONDUCTIVIY

site #	1	2	3	4	5	6	7	8	9	10	2a	3aa	3ab	3ad	3b	3c	9a
Riverkm	2.50	8.35	12.5	20.13	21.38	31.50	57.01	67.00	63.88	81.38	11.62	23.80	18.10	29.40	13.25	26.52	77.26
12-Sep-01	73.2	96	193.3	69.9	122.7	76.8	76.2	77.3	60.2	115.9	89.4	174.1	174.3	191.8	209	148.8	52.4
10-Oct-01	66	84.1	162.7	62.3	141.6	64.2	64.2	66.7	53.3	110.5	78	175.8	157.6	192.5	188.8	137.8	46.8
8-Jan-02	40	43	54	34	59.8	26.4	26	35.6	22		43.4	52	54.6		60.2		19
15-Jan-02	47	44	51.8	43.1	65	35.9	35	46.7	31.3		48.6	56.4	58		66.2		30.8
3-Apr-02	56	52.1	64.8	52.3	113.4	44.5	43.6	48.2	40.4	80	50.3	59.1	62.9	55.3	78.9	59.6	34.9
min	40	43	51.8	34	59.8	26.4	26	35.6	22	80	43.4	52	54.6	55.3	60.2	59.6	19
max	73.2	96	193.3	69.9	141.6	76.8	76.2	77.3	60.2	115.9	89.4	175.8	174.3	192.5	209	148.8	52.4
ave	56.44	63.84	105.32	52.32	100.5	49.56	49	54.9	41.44	102.1333	61.94	103.48	101.48	146.5333	120.62	115.4	36.78
stdev	13.52657	24.54838	67.40354	14.39868	36.28085	20.64541	20.7668	16.77513	15.60779	19.35726	20.42763	65.29485	59.22176	79.01116	72.13218	48.6362	13.22694

DISOLVED OXYGEN

site #	1	2	3	4	5	6	7	8	9	10	2a	3aa	3ab	3ad	3b	3c	9a
Riverkm	2.50	8.35	12.5	20.13	21.38	31.50	57.01	67.00	63.88	81.38	11.62	23.80	18.10	29.40	13.25	26.52	77.26
12-Sep-01	10.17	9.25	9.56	10.9	10.21	8.77	8.33	9.92	7.77	11.23	9.44	9.76	9.09	10.59	8.06	8.9	8.75
10-Oct-01	11.49	10.43	10.48	11.24	10.83	11.88	11.61	12.27	11.65	13.02	11.21	10.82	10.4	9.35	10.65	10.35	11.23
8-Jan-02	13.22	11.98	12.36	13.96	11.6	13.54	13.37	12.69	13.7		11.74	12.39	12.18		11.99		13.61
15-Jan-02	12.74	12.84	13.58	14.08	12.88	13.69	14.14	13.4	13.42		12.43	12.72	13.64		12.94		13.85
3-Apr-02	12.64	12.34	11.61	13.65	12.24	13.49	11.47	12.88	12.73	12.36	13.17	12.29	12.09	13.3	12.15	12.64	14.28
min	10.17	9.25	9.56	10.9	10.21	8.77	8.33	9.92	7.77	11.23	9.44	9.76	9.09	9.35	8.06	8.9	8.75
max	13.22	12.84	13.58	14.08	12.88	13.69	14.14	13.4	13.7	13.02	13.17	12.72	13.64	13.3	12.94	12.64	14.28
ave	12.052	11.368	11.518	12.766	11.552	12.274	11.784	12.232	11.854	12.20333	11.598	11.596	11.48	11.08	11.158	10.63	12.344
stdev	1.22893	1.487605	1.571662	1.560795	1.067881	2.092828	2.243051	1.354684	2.415995	0.905226	1.413425	1.259813	1.761122	2.020074	1.917517	1.885656	2.333277

TURBIDITY

site #	1	2	3	4	5	6	7	8	9	10	2a	3aa	3ab	3ad	3b	3c	9a
Riverkm	2.50	8.35	12.5	20.13	21.38	31.50	57.01	67.00	63.88	81.38	11.62	23.80	18.10	29.40	13.25	26.52	77.26
12-Sep-01	1.52	1.33	0.81	9.78	2.5	29.1	125	58	1.91	56.6	1.24	0.75	1.09	0.58	1.29	0.71	0.38
10-Oct-01	1.73	1.42	0.59	1.48	1.26	3.46	4.45	3.13	1.12	8.44	0.9	0.48	0.62	0.67	0.88	0.89	0.42
8-Jan-02	44.6	7.42	28.1	40.9	82.4	29.7	22.1	22.6	13.5		2.48	15.6	16.1		13.1		8.28
15-Jan-02	3.15	1.98	7.38	1.68	6.57	1.62	1.15	1.79	1.01		1.6	6.99	7.72		7.73		0.47
3-Apr-02	1.38	0.53	3.32	1.06	3.09	1.15	1.39	1.14	0.65	2.49	0.48	3.41	4.07	3.43	4.83	3.93	0.33
Min	1.38	0.53	0.59	1.06	1.26	1.15	1.15	1.14	0.65	2.49	0.48	0.48	0.62	0.58	0.88	0.71	0.33
Max	44.6	7.42	28.1	40.9	82.4	29.7	125	58	13.5	56.6	2.48	15.6	16.1	3.43	13.1	3.93	8.28
ave	10.476	2.536	8.04	10.98	19.164	13.006	30.818	17.332	3.638	22.51	1.34	5.446	5.92	1.56	5.566	1.843333	1.976
STDEV	19.08898	2.778782	11.54224	17.11573	35.40486	14.99198	53.35663	24.42882	5.532176	29.67232	0.76	6.25193	6.358337	1.620093	5.055406	1.809346	3.524419

Nitrate +Nitrite as nitrogen

site #	1	2	3	4	5	6	7	8	9	10	2a	3aa	3ab	3ad	3b	3c	9a
Riverkm	2.50	8.35	12.5	20.13	21.38	31.50	57.01	67.00	63.88	81.38	11.62	23.80	18.10	29.40	13.25	26.52	77.26
12-Sep-01	.	.	ND	.	4.1	.	.	.	.	.	.	ND	ND	ND	ND	ND	.
10-Oct-01	.	.	ND	.	.	.	.	.	.	.	.	ND	ND	ND	ND	ND	.
8-Jan-02	.	.	ND	.	.	.	.	.	.	.	.	ND	ND	.	ND	.	.
15-Jan-02	.	.	ND	.	.	.	.	.	.	.	.	ND	ND	.	ND	.	.
3-Apr-02	.	.	ND	.	6.3	.	.	.	.	.	.	ND	ND	ND	ND	ND	.
Min	0	0	ND	0	4.1	0	0	0	0	0	0	ND	ND	ND	ND	ND	0
Max	0	0	ND	0	6.3	0	0	0	0	0	0	ND	ND	ND	ND	ND	0
ave	#DIV/0!	#DIV/0!	ND	#DIV/0!	5.2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	ND	ND	ND	ND	ND	#DIV/0!
STDEV	#DIV/0!	#DIV/0!	ND	#DIV/0!	1.555635	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	ND	ND	ND	ND	ND	#DIV/0!

Total Phosphorus

site #	1	2	3	4	5	6	7	8	9	10	2a	3aa	3ab	3ad	3b	3c	9a
Riverkm	2.50	8.35	12.5	20.13	21.38	31.50	57.01	67.00	63.88	81.38	11.62	23.80	18.10	29.40	13.25	26.52	77.26
12-Sep-01	.	.	0.06	.	0.03	.	.	.	.	.	.	0.04	0.06	0.03	0.08	0.04	.
10-Oct-01	.	.	0.04	.	.	.	.	.	.	.	.	0.03	0.04	0.03	0.07	0.03	.
8-Jan-02	.	.	0.12	.	.	.	.	.	.	.	.	0.06	0.07	.	0.08	.	.
15-Jan-02	.	.	0.05	.	.	.	.	.	.	.	.	0.03	0.04	.	0.06	.	.
3-Apr-02	.	.	0.03	.	0.02	.	.	.	.	.	.	0.02	0.03	0.02	0.05	0.03	.
Min	0	0	0.03	0	0.02	0	0	0	0	0	0	0.02	0.03	0.02	0.05	0.03	0
Max	0	0	0.12	0	0.03	0	0	0	0	0	0	0.06	0.07	0.03	0.08	0.04	0
ave	#DIV/0!	#DIV/0!	0.06	#DIV/0!	0.025	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.036	0.048	0.026667	0.068	0.033333	#DIV/0!
STDEV	#DIV/0!	#DIV/0!	0.035355	#DIV/0!	0.007071	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0.015166	0.016432	0.005774	0.013038	0.005774	#DIV/0!

References