2001

Changes in water quality in Deckers Creek from 1974 to 2000

Jason Allen Stewart
West Virginia University

Follow this and additional works at: <https://researchrepository.wvu.edu/etd>

Recommended Citation

Stewart, Jason Allen, "Changes in water quality in Deckers Creek from 1974 to 2000" (2001). *Graduate Theses, Dissertations, and Problem Reports*. 1319.
<https://researchrepository.wvu.edu/etd/1319>

This Thesis is protected by copyright and/or related rights. It has been brought to you by the The Research Repository @ WVU with permission from the rights-holder(s). You are free to use this Thesis in any way that is permitted by the copyright and related rights legislation that applies to your use. For other uses you must obtain permission from the rights-holder(s) directly, unless additional rights are indicated by a Creative Commons license in the record and/ or on the work itself. This Thesis has been accepted for inclusion in WVU Graduate Theses, Dissertations, and Problem Reports collection by an authorized administrator of The Research Repository @ WVU. For more information, please contact researchrepository@mail.wvu.edu.

Changes in Water Quality in Deckers Creek from 1974 to 2000

Jason A. Stewart

**Thesis submitted to the
College of Agriculture, Forestry and Consumer Sciences
at West Virginia University
in partial fulfillment of the requirements
for the degree of**

**Master of Science
in
Plant and Soil Sciences**

**Jeffrey G. Skousen, Ph. D., Chair
Gary K. Bissonnette, Ph. D.
John C. Sencindiver, Ph. D.
Paul F. Ziemkiewicz, Ph. D.**

Department of Plant and Soil Sciences

**Morgantown, West Virginia
2001**

Keywords: water quality, acid mine drainage

Abstract

Changes in Water Quality in Deckers Creek from 1974 to 2000

Jason A. Stewart

The Deckers Creek drainage basin covers approximately 16,600 hectares (62.9 square miles) in Monongalia and Preston Counties of West Virginia. Throughout the twentieth century, this watershed has received high levels of pollution in several forms. A 1974 study examined the water chemistry in Deckers Creek over a six-month period at 29 sample points. Water samples from the same sites were collected and analyzed monthly from March 1999 through October 2000 for acidity, alkalinity, total iron, aluminum, manganese, and other metals, as well as for fecal coliform and fecal streptococcus concentrations. Most of the tributaries sampled in 1999-2000 showed reduced metal loads and acidity as compared to 1974, as did the main stem of Deckers Creek above the town of Richard. Little improvement, however, was detected in the portion of Deckers Creek below Richard due to the input of untreated acid mine drainage from an underground mining complex. Decreased mining activity, increased reclamation, and improved water quality of drainage from mined areas have led to improved water conditions in the upper portion of Deckers Creek. Improved chemical properties in the majority of the creek may, however, allow for increased survival of fecal coliforms and could present a new water quality problem.

Acknowledgments

I would first like to thank my major adviser, Dr. Jeff Skousen, for giving me the opportunity to pursue a Master's degree in Plant and Soil Science, and for never accepting anything less than my best effort. I wish to thank the members of my advisory committee; Dr. Gary Bissonnette, Dr. John Sencindiver, and Dr. Paul Ziemkiewicz, for their patience and guidance throughout this project. I am indebted to Dr. Louis McDonald and Dr. Joe Donovan for their creative, entertaining, and thorough approaches to teaching environmental chemistry. I am especially thankful to Jen Demchak, Kelly Flemming, Joan Wright, and Dr. Jim Gorman for their invaluable assistance in all phases of my research. I would also like to thank Dr. William Thayne for his help in the statistical analyses in this study.

I wish to thank my mother Debbie, my stepfather Tom, my father Norman, and my stepmother Jewel for their unwavering love and encouragement. Their confidence in me has been a source of strength throughout my entire academic career. They instilled in me the strong work ethic and sense of self-respect that helped me through the long days and nights of study and research.

Finally, I would like to thank my friends and fellow graduate students who shared in all the laughter, headaches, failures, and triumphs. Their support has meant more to me than I will ever be able to express.

Table of Contents

	<u>Page</u>
ABSTRACT	ii
ACKNOWLEDGMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vi
LIST OF FIGURES	viii
INTRODUCTION and LITERATURE REVIEW	1
Geography	1
History	3
Chemistry	5
Microbiology	12
OBJECTIVES	17
METHODS AND MATERIALS	18
1974 Sampling Procedures	18
1999-2000 Sampling Procedures	18
1974 Flow Estimation	20
Microbiological Procedures	23
Statistical Analyses	25
RESULTS AND DISCUSSION	26
Chemistry	26
Fecal Coliforms	42
Fecal Coliform : Fecal Streptococcus ratio	47
CONCLUSIONS	50
LITERATURE CITED	51

Page

APPENDIX A. 1999-2000 CHEMISTRY DATA.....	55
APPENDIX B. 1974 CHEMISTRY DATA.....	88
APPENDIX C. MICROBIOLOGICAL DATA	99
APPENDIX D. SAMPLE SITE LOCATIONS AND DESCRIPTIONS.....	107

List of Tables

<u>Table</u>	<u>Page</u>
1. Comparison of stream flow, rainfall, and estimated stream flow at Morgantown in 1974 and 1999-2000	21
2. Comparison of stream flow, rainfall, and estimated stream flow at Morgantown in 1946-1948	22
3. Mean values for five selected parameters across all sampling points during low, medium, and high flow periods for the 1999 – 2000 data	26
4. Means and ranges for data presented in figures 3 – 6 for eight representative sites along Deckers Creek.....	28
5. Chemical parameters in Kanes Creek during a period of AMD treatment vs. a period of no AMD treatment.....	35
6. Chemical parameters 1500 m downstream from Kanes Creek during a period of AMD treatment vs. a period of no AMD treatment.....	35
7. Aluminum and manganese concentrations at mainstem sampling points (1999-2000) as compared to West Virginia state water quality standards.	39
8. Aluminum and manganese concentrations at tributary sampling points (1999-2000) as compared to West Virginia state water quality standards.	40
9. Fecal coliform and fecal streptococcus levels at five selected sites in Deckers Creek from February through May 2000	44

<u>Table</u>	<u>Page</u>
10. Descriptive statistics for fecal coliform concentrations (cfu/100 mL) at eight selected sites in Deckers Creek from May 1999 through October 2000.....	46

List of Figures

<u>Figure</u>	<u>Page</u>
1. Deckers Creek from the headwaters to its confluence with the Monongahela River at Morgantown	2
2. Concentrations of aluminum species in solution as a function of pH.....	8
3. Average pH from February through May (high flow conditions) at eight selected sites for 1974 and 1999-2000	32
4. Average alkalinity levels from February through May (high flow conditions) at eight selected sites for 1974 and 1999-2000	33
5. Average acidity levels from February through May (high flow conditions) at eight selected sites for 1974 and 1999-2000	36
6. Average total iron levels from February through May (high flow conditions) at eight selected sites for 1974 and 1999-2000	37
7. Geometric mean fecal coliform levels from May 1999 through October 2000	43

Introduction and Literature Review

Geography

The Deckers Creek watershed lies within the drainage basin of the Monongahela River in western Preston and eastern Monongalia Counties in northern West Virginia. The stream is approximately 38.1 km (23.6 miles) in length, originating in the southeast corner of Monongalia County at an elevation of 737 m (2,427 ft). The creek flows southeast to Reedsville, where it loops to the northwest (Figure 1). Relief is very gradual from the headwaters to Masontown before becoming steep from Masontown to Dellslow. After Dellslow, the creek again flows over gently sloping terrain until reaching the Monongahela River at an average elevation of 237 m (793 ft.) (Teti 1974).

Most of the exposed geology is part of the Pennsylvania Period, namely the Monongahela, Conemaugh, and Pottsville Groups and the Allegheny Formation (Natural Resources Conservation Service 2000). The dominant rock types include sandstone, siltstone, shale, limestone, and coal (Teti 1974). Major soils in the area include the Gilpin and Dekalb Series in the higher elevations and the Atkins, Brinkerton, and Pope Series in the bottomlands (Natural Resources Conservation Service 2000).

Seventy percent of the land surface in the watershed is covered by forest. Oak-hickory (*Quercus* - *Carya*) and northern hardwoods are the dominant timber types. Farmland comprises 15% of the watershed, with nearly all of the active farming occurring in the upper portions of the watershed in Preston County. Urban land, found around the towns of Masontown and Morgantown, makes up roughly 10% of the area. Mined lands account for the remaining 5% (Natural Resources Conservation Service 2000).

Figure 1. Deckers Creek from the headwaters to its confluence with the Monongahela River at Morgantown. Twenty-nine sampling sites visited in 1974 and 1999-2000 are shown. Eight sampling sites, along with the Cheat and Monongahela Rivers, are named which represent different sections of the stream.

History

Industry, in one form or another, has existed in the Deckers Creek Valley for over two hundred years. Even before there was a permanent settlement at Morgantown, people were removing natural resources from the Deckers Creek area. In 1772 one of the first settlers in northern West Virginia, Michael Kerns, was given a 250-ha (600-acre) tract along Deckers Creek near Morgantown. Kerns quickly built a mill, factory, and a covered bridge. By 1798 one of the first iron works west of the Blue Ridge Mountains was located at Rock Forge beside a steep portion of the creek. Iron ore was available in the area, as were seemingly inexhaustible deposits of high quality coal. The focus of the regional iron market quickly shifted away from Monongalia County to Pittsburgh and other areas of Pennsylvania, but the coal deposits of northern West Virginia remained a valuable commodity. Throughout the middle of the nineteenth century and into the early twentieth century, numerous small-scale coal mines opened throughout both Monongalia and Preston Counties. This early coal mining activity had not yet led to the environmental impacts now apparent in Deckers Creek, as evident in this nineteenth century description, "...taking its rise among the rocks and crags of our grand old mountains, (Deckers Creek) comes first sweeping and creeping then roaring and pouring along its picturesque course until passing at the very threshold of our homes when as if tamed by the influences of our civilization with a calm and dignified mien, mingles its pure waters with those of the placid Monongahela." (Moreland 1885)

As the twentieth century progressed, more and more mines removed ever-growing volumes of coal from the earth. The increased industrial activity led to the addition of higher amounts of acid mine drainage, chemicals, and sediment to Deckers Creek.

Population throughout the region was booming, creating the need for fuel and lumber. Many of these new homes used the creek as a means of sewage disposal. High levels of pollutants from soaps, oil, and sediments, as well as nitrogen, phosphorus, and pathogens in sewage were introduced to the stream. Eventually the pollution levels exceeded the natural attenuation capacity of the creek, resulting in widespread deterioration of water quality. By 1935, recreational use of Deckers Creek had stopped and the State Health Department had identified it as a possible health hazard due to its high levels of sewage contamination. A sewage system was completed in the Morgantown area by 1962, but coal mine drainage and sewage continued to enter the creek at various uncontrolled points along its stretch (Natural Resources Conservation Service 2000). Numerous point sources of sewage exist in the upper half of the watershed, most noticeably at and upstream of the town of Masontown. While sewage inputs need to be eliminated, a much more noticeable impact to the stream is the large scale input of untreated acid mine drainage near the community of Richard.

Mining first began at Richard in 1903, when the West Virginia Coal Company opened a drift mine into the Upper Freeport coal along the north bank of Deckers Creek. By the end of that first year, 52 miners and laborers had produced enough coal to yield over 6,350 Mg (7,000 tons) of coke. The 75 original beehive coke ovens grew in number to 125 as coal production increased over the next few years. During 1910, the Elkins Coal and Coke Company took over operations. More employees were added and production continued to increase. At the end of 1918, two entries were delivering coal to the surface at a rate of 60,820 Mg (66,980 tons) per year. The vast majority of this coal was used in the on-site coke ovens, yielding 41,200 Mg (45,377 tons) per year of coke needed by the

steel industry to the north. The mine was equipped with the latest ventilation fans and “new engines to handle coal by rope haulage” (Paul 1904). Mining continued until the 1950’s, when production ceased. Water accumulated in the shafts until seeps eventually appeared at the surface. In the years since active mining ceased, several homes were constructed in the immediate vicinity of the old coke ovens. These homes were threatened by the orange water flowing out of the mountainside. The West Virginia Division of Environmental Protection (WVDEP) Office of Abandoned Mine Lands reclaimed the surface around the deep mine portals and coke ovens in 1984. As a part of the reclamation, they constructed a 100-m concrete channel to carry all the drainage from inside the mine through a wet seal at the portal and convey the water to the creek. The houses remained unscathed, and Deckers Creek continued to receive this large volume flow of metal laden, acidic water.

Chemistry

Deckers Creek and its tributaries flow through a high-sulfur coal region of West Virginia, where the coal and associated strata contain high levels of sulfur in the mineral form of pyrite. When exposed to water and oxygen, pyrite undergoes a series of chemical reactions, ultimately resulting in the release of sulfate, proton acidity, and iron (Banks et al. 1997). About thirty percent of 318 Appalachian stream sites sampled in 1965 had higher iron and sulfate levels than U.S. Public Health Services drinking water standards (National Research Council 1979).

Once iron has been introduced into natural waters, aerobic bacteria may catalyze the oxidation and promote precipitation of ferrous iron to ferric hydroxide. In the presence of

oxygen, this reaction is thermodynamically favorable and thus can be used as an energy source. Some of the ferric hydroxide produced as a result of natural and biological oxidation can be encrusted in the cellular sheaths of iron-oxidizing bacteria such as *Crenothrix* or *Leptothrix*. Colonies of these organisms may form gelatinous masses of such material in places where water containing ferrous iron is exposed to oxygen (National Research Council 1979). Acidity and iron serve to accelerate normal geochemical weathering in a self-perpetuating sequence of reactions, and much of the metal oxyhydroxides precipitate out of solution upon contacting natural waters (Younger 1998). These precipitates form coatings in stream channels, smothering native biology (Gray 1995). The accompanying increase in weathering can also lead to the dissolution of silicate minerals, causing the release of metals such as aluminum and manganese into the environment in more reactive forms (Younger 1998).

Aluminum accounts for roughly 8% of the earth's crust by weight. While aluminum is naturally present to a great extent throughout the lithosphere as various forms of aluminum oxides, it becomes a water quality concern when aluminum is introduced in its trivalent state (Al^{+3}) into natural waterways as a result of anthropogenic processes. One significant source of Al^{+3} is the acidic drainage from surface and deep mines. Under normal conditions, aluminum is typically bound as an oxide in tetrahedral and octahedral crystals of aluminosilicates in rocks and soil. At neutral to alkaline pH (6.0 to 8.0), aluminum occurs as various insoluble and less harmful forms of $\text{Al}(\text{OH})_x$. Coal mining in this region of West Virginia often causes accelerated weathering and subsequent acidification of nearby water to a pH below 5.5. At lowered pH, some of the aluminum

bound as oxides is released from silicate minerals and may be dissolved in water.

Aluminum is most harmful to aquatic life when it exists in this dissolved (Al^{+3}) state.

Most fish species are highly sensitive to dissolved aluminum. Driscoll and others (1980) found that fish are sensitive to all forms of aqueous aluminum (Figure 2). Two mechanisms of aluminum toxicity have been identified in fish: asphyxiation and impairment of ion regulation.

Asphyxiation occurs in the pH range from 5.5 to 6.5, and is caused by the precipitation of $\text{Al}(\text{OH})_3$ on the gill surfaces of fish. This precipitate stimulates gill mucification and inflammation, blocking diffusion of O_2 and CO_2 across membranes (Neville and Campbell 1988). Oxygen deprivation is manifested by increased gill ventilation rates and volumes, increased coughing rates, and gill tissue damage (Neville 1985). This process can be particularly damaging in areas where acid mitigation measures are employed. Mixtures of limestone cobble or sand can raise the pH in a stream from 4.0 to 7.0 over a short mixing zone. The sudden rise in pH and the resulting drop in aluminum solubility can cause rapid precipitation of aluminum hydroxides on the gills of nearby fish (Rosseland and Skogheim 1986; Rosseland et al. 1992). Toxicity to fish in the upper half of the Deckers Creek watershed may be due to aluminum-induced asphyxiation.

At pH levels 5.4 and below, impaired ion regulation is the dominant mechanism of aluminum toxicity. This process is characterized by losses of electrolytes from blood and body fluids and increased H^+ and CO_2 levels in the blood (Neville 1985). Aluminum displacement of calcium in this low pH range causes the disruption of electrolyte regulation, allowing diffusion of sodium and chloride out of the gills and the influx of H^+ (Sparling and Rowe 1996). Below the Richard Mine discharge, pH levels in Deckers

Figure 2. Concentrations of aluminum in solution as a function of pH.

Creek are depressed enough to make this an important mechanism.

The concentration of dissolved aluminum in a stream also plays a role in determining the degree of toxicity that will exist. Levels from 100 to 500 $\mu\text{g/L}$ (0.1 to 0.5 mg/L) are commonly needed to cause a physiological response or death when a fish species is within its individual species pH range. Below this range, levels under 100 $\mu\text{g/L}$ may be harmful (Sparling and Rowe 1996). The typical aluminum concentration in the Richard Mine discharge is around 70,000 $\mu\text{g/L}$ (70 mg/L), and the concentrations in Deckers Creek at Morgantown are usually around 200 $\mu\text{g/L}$ (0.2 mg/L). The average level of aluminum in Deckers Creek below Richard is normally higher than the toxicity limit established by Sparling and Rowe (1996).

Aquatic invertebrates can also be affected by aluminum toxicity, but comparative studies indicate they are generally much less sensitive than fish. Above pH 5.5, many invertebrate species can tolerate aluminum levels as high as 23,000 $\mu\text{g/L}$ (23 mg/L) (Wren and Stephenson 1991). Below pH 5.5, ion regulation and calcium uptake are affected in much the same way as in fish, but less severely. An interesting method of aluminum accumulation exhibited by some invertebrates is the direct accumulation of aluminum precipitates on their bodies. Sadler and Lynam (1988) found that body burdens under typical ambient levels of aluminum frequently exceed 1000 mg/kg and may exceed 16,000 mg/kg in experimental situations, and that free-living freshwater insects have been shown to accumulate as much as 4900 mg/kg . Bioconcentration factors on outer shell surfaces and gills ranged from 0 at pH 4.5, to 10,000 times at pH 6.5 (Havas 1985). The bulk of this aluminum is lost with the exuviae, showing that the metal had been adsorbed rather than assimilated.

In an extensive survey of benthic macroinvertebrate life in Deckers Creek, Mains et al. (1999) found that most of the stream contains a very low diversity of organisms, and that the total number of organisms is also very low. The most heavily damaged section of the stream was found to be below the Richard Discharge, where the creek rated “very poor” by the Save Our Streams macroinvertebrate survey weighted point system. In this system, points are given based on the number and type of benthic macroinvertebrate species present in a given section of stream. It is possible that aluminum toxicity plays a role in suppressing these numbers.

Little direct correlation between aluminum levels in invertebrates and either pH or water concentration has been found. However, Sadler and Lynam (1988) and Ormerod et al. (1988) showed that phosphorus levels in insects were inversely related to aluminum levels. This may indicate an aluminum-phosphorus complexation in aquatic insects.

Numerous small sources of iron and aluminum can be located throughout the Deckers Creek watershed, but the discharge flowing from the Richard Mine, a large abandoned underground mining complex, dominates any examination of deleterious impacts to the stream due to its volume, chemistry, and proximity to population centers. The abandoned Richard Mine stretches beneath 850 hectares (2,100 acres) of northern Monongalia County. With an average seam height of 107 cm (42 inches), the mine accounts for a 9.9 million m³ (350 million ft³) void space under the communities of Brookhaven, Dellslow, Rock Forge, and Tyrone. The geologic strata of the area dips to the southwest, causing drainage from the mine to flow toward Deckers Creek. The untreated water flows into Deckers Creek at a rate of 500 to 1100 L/min (150 to 300 gallons per minute), carrying with it high levels of iron, aluminum, manganese, and acidity. During drought conditions

in the summer of 1999, the flow from the mine was the largest input to the mainstem of Deckers Creek, which accounted for more water than any other tributary in the watershed. Upon contacting the higher pH of the natural stream water, metals in the water begin to precipitate out of solution and settle to the stream bottom, creating a red, concrete-like coating. The coating destroys benthic macroinvertebrate habitat and directly smothers out benthic life, while high acidity and aluminum levels make the water toxic. Tests examining the short-term toxicity of coal mine drainage have shown that two species of sunfish, *Lepomis machrochirus* and *Lepomis gibbosus*, experience respiratory distress within a few hours after being introduced into water having pH values between 3.0 and 3.5 with corresponding total acidity values of 50 mg/L (Pegg 1984). The pH of the Richard Mine water is usually less than 3.5 and the acidity values are much higher (1200 mg/L) than these waters tested for fish, so the creek is thus rendered almost completely sterile for its remaining 6.4 km (4 mi.) to the confluence with the Monongahela River in Morgantown.

Another geochemical reaction seen in certain areas of the Deckers Creek watershed is the dissolution of calcium carbonate. In its upper reaches, the creek flows through actively-limed agricultural fields, which contribute direct surface runoff into the stream during rain events. Housing developments are scattered throughout the watershed, most having driveways and foundations employing crushed limestone gravel. The largest and most influential limestone input to the creek comes from an active limestone quarry, Greer Limestone, which stores alkaline tailings along a 500-m (1640-ft) section of floodplain about halfway between the headwaters and the confluence of the creek with the Monongahela River at Morgantown. The presence and subsequent dissolution of this

material into the creek is particularly important to Deckers Creek because of its capacity to generate acid-neutralizing anions such as hydroxide, carbonate, and bicarbonate (Donovan 1999). The alkaline additions at this point are largely responsible for the improved nature of the stream from the town of Greer down to the inflow of untreated mine water near the town of Richard. Below Richard, the creek displays the extreme effects of acid mine drainage and metal precipitation.

Microbiology

In addition to acid mine drainage, Deckers Creek also receives high volumes of fecal bacteria from bordering residential areas and agricultural fields. Fecal coliforms (FC) and fecal streptococci (FS) are two of the more commonly isolated organisms found in the gastrointestinal tract of mammals. The extent to which natural waters have been impacted by fecal matter from warm-blooded organisms may be determined through the isolation and subsequent enumeration of indicator bacteria such as FS and FC.

Fecal bacteria may be introduced into surface and ground waters via several pathways. One of these is through surface runoff from agricultural areas. Livestock grazing and other agricultural land use practices such as feedlots, sewage sludge application, and manure amendments to crops can distribute fecal matter over large areas. Thelin and Gifford (1983) list several factors that determine the potential of grazing livestock to serve as a nonpoint source of pollution. These include stocking density, length of grazing period, average manure loading rate, manure spreading uniformity, and disappearance of manure with time. When rainfall exceeds infiltration rates, surface runoff may occur. The magnitude of this flow is dependent upon rain volume, soil surface characteristics,

slope, and pre-existing moisture conditions in the soil. Fecal bacteria can become suspended and subsequently carried to nearby streams.

Bacteria in surface runoff is not confined to rural areas. Young and Thackston (1999) found that high levels of both FC and FS were present in runoff from urban sewered watersheds in western Tennessee. These observations were attributed to dense human population, a large percentage of impervious ground surface, and high domestic animal population. Failing septic systems and overflow from storm sewers could also represent sources of fecal bacteria present in urban runoff.

The direct deposition of fecal material into streams is another means by which indicator bacteria reach waterways. Grazing cattle and sheep may defecate into small streams running through pastures. A more likely direct-deposition source of pollution is sewage lines running from homes straight into nearby creeks. Farrell-Poe et al. (1997) observed significant increases in both fecal and total coliform counts downstream of several rural municipalities in Utah without wastewater treatment plants. This can be observed in many rural areas throughout the United States and world, including the upper reaches of the Deckers Creek watershed. A major problem input of this type exists near Masontown, where a large volume discharge of untreated sewage flows directly into Deckers Creek.

A somewhat indirect route by which fecal bacteria reach surface and groundwater may be the existence of semi-permanent land stores of enteric bacteria, as discussed by Hunter et al. (1999). In Hunter's 1999 study, discrepancies between high grazing intensity and low bacteria levels in several adjacent stream sites were observed. The sites with the highest bacteria counts were immediately downstream from areas that received

little grazing pressure due to wet soil conditions and undesirable plant species. It was hypothesized that large amounts of bacteria were present here, despite low inputs, due to prolonged survival. Unchannelized, diffuse surface-water flows were present, allowing the unhindered transport of fecal bacteria to stream channels while avoiding the filtering action of the soil matrix. The presence of these microbes in a water sample could indicate the presence of a number of pathogenic microorganisms (Edwards et al. 1996).

Watersheds usually contain three sources of fecal bacteria: humans, domestic animals, and wild animals (Howell et al. 1995). As these microbes exist in different and predictable amounts relative to each other in the feces of humans and animals, research has suggested that the ratio of FC to FS in a water sample may indicate the specific origin of the organisms. Knowing the origin of a contaminant is a crucial step in planning any type of remediation scheme (Howell et al. 1995). It has been hypothesized that a FC : FS ratio smaller than 0.7 indicates contamination from animal waste, while a value higher than 4 is characteristic of human waste. The ratio may be further broken down, with values less than 0.1 representing pollution from wild animals, between 0.1 and 0.7 representing pollution from domestic animals, and greater than 4 representing pollution from primarily humans (Howell et al. 1995). This ratio, however, has shown variable results suggesting that it may not be a reliable method of determining pollutant source. New research has indicated that other techniques, including antibiotic resistance, may be a more effective means of distinguishing between animal and human sources of waste (Wiggins 1996).

After fecal microorganisms reach streams, several factors affect the accuracy with which they can be isolated. Primarily, differing die-off rates between fecal coliforms and

fecal streptococci will alter ratio values obtained through the membrane filtration method. Howell et al. (1996) noted that ambient temperature and sediment particle-size have significant effects on fecal coliform and fecal streptococcus mortality rates. Under controlled conditions using physiological saline to reduce osmotic shock, fecal coliform mortality rates exceeded fecal streptococci mortality rates. The differences in the two rates declined as particle-size shrank and as temperature decreased, with both species having greater survival rates in sediment-laden waters. This may be attributed to increased organic matter and nutrients held by clays and physical protection in macropores. Fecal coliforms were also found to have high regrowth rates during warmer weather, giving ratios indicative of human contamination when none is evident. Coyne and Howell (1994) made similar observations, noting that warm, shallow streams high in organic carbon permit fecal coliform regrowth. Samples taken under these conditions could give misleading results when used to compute a FC : FS ratio. To minimize the effect of differential die-off rates, it is desirable to collect samples within twenty-four hours of feces discharge into the water being tested. In addition, water pH needs to be between 4 and 9. Also, when fewer than 100 fecal streptococcus cells per 100 mL are present, it becomes difficult to distinguish between sewage sources and naturally present sources (Howell et al. 1995).

Ideally, the microbiological safety of water should be determined by looking for specific pathogens of concern. However, several hundred different waterborne pathogens can cause disease in man. It would be impractical to routinely analyze water for all of them. It may be difficult to grow target bacteria that have been injured by environmental stressors such as acid mine drainage, detection procedures for protozoans are often

inaccurate, and many enteric viruses simply cannot be cultured from water samples. The use of indicator bacteria allows for the reliable detection of water conditions favorable for the presence of pathogens.

Objectives

In 1974, James Teti, a graduate student in the Geology Department of West Virginia University, conducted a water quality study of Deckers Creek (Teti 1974). He located 29 sampling points along the creek and collected water samples during a six-month period. The purpose of this study was to revisit the sites that were sampled 25 years ago and after conducting water quality analyses, illustrate changes in water quality between 1974 and 1999-2000. Major point sources of acid mine drainage and sewage were identified, and the present levels of fecal coliform contamination were measured. Also, seasonal fluctuations in water quality parameters were investigated for the 1999-2000 data set.

Methods

1974 Sampling Procedures

Samples were collected in collapsible, plastic one-liter bags at 29 established sample sites along Deckers Creek and its tributaries (Figure 1) on eight occasions between January 1974 and June 1974. Teti (1974) reports withdrawing each sample from a flowing part of the stream in order to avoid any increases in ionic concentrations due to evaporation from standing pools. Sample containers were filled completely to minimize any reaction between the water and atmospheric gases trapped in the container. Water samples were put on ice and later analyzed in the laboratory for total acidity, total alkalinity, specific conductance, and dissolved metals (total iron, calcium, magnesium). Teti did not measure flow when he collected water samples during the 1974 sampling period.

1999-2000 Sampling Procedures

Beginning in March 1999, water samples were collected at 31 sites along Deckers Creek and several of its tributaries on a monthly basis. These sites correspond to sites originally sampled by Teti (1974) (Figure 1), plus three additional sites. A YSI 3500 Water Quality Meter was used to measure temperature, electrical conductivity, and pH in the field. Field pH was used instead of lab-determined pH in all subsequent data analyses. Two water samples were collected at each site. Each sample was collected from the same point in the creek each month. The water bottles were filled completely to

eliminate interactions between the sample and any air left in the head space. The first sample was collected in a 250-ml plastic bottle and was neither filtered nor acidified. A second sample of 20 ml was filtered with a 0.45 μm filter and acidified to pH 2.0 with 0.5 ml of concentrated hydrochloric acid. Both samples were placed on ice and transported to the laboratory. The first sample was analyzed for pH, acidity, and alkalinity using a TitraLab autotitrator (Radiometer/Copenhagen, Denmark), while the second sample was analyzed for total iron, aluminum, manganese, magnesium, zinc, barium, and calcium using an Inductively Coupled Spectrophotometer, Plasma 400 (Perkin Elmer, Norwalk, CT). All titrations were performed within six hours of sample collection. Alkalinity titrations were carried to an endpoint pH of 4.2, while acidity titrations proceeded to an endpoint pH of 8.2. Final acidity and alkalinity levels were determined using the following equation:

$$\text{mg/L as CaCO}_3 = \frac{(\text{ml of titrant})(\text{titrant normality})(50,000)}{\text{ml of sample}}$$

Flow determinations were made at the same time water samples were taken. At the beginning of the study at each sample point, the depth of the stream channel was measured at one-foot intervals from the high water mark on one bank to the corresponding mark on the opposite bank. A reference point was chosen near the center of this transect in the stream. The point was marked either by driving a steel post into the streambed or by placing a brightly colored brick on the streambed. At subsequent sampling times, the depth of the water was measured at this reference point and used to calculate depths across the stream transect. Water velocity readings were taken using a

Global Water Flow Probe FP101 (Global Water, Gold River, CA). This probe features a function that computes an average velocity over a ten-second period. The probe was moved vertically through the creek at the reference point to compute an average velocity for the entire stream column. Multiplying the cross-sectional area of the water in the stream by velocity provided a good estimate of flow.

1974 Flow Estimation

In order to accurately compare stream quality data sets from two different time periods, the flow levels during each sampling phase should be comparable. If flows vary greatly between sampling phases, any observed differences in chemical parameters may be due to localized dilution or concentration effects rather than changes in baseline conditions (Skousen 2000). As no flow data were collected during the 1974 study, it was necessary to make an estimation of stream flow to determine whether or not data from the two studies could be compared. Monthly stream flow at Morgantown for the entire year of 1974 was calculated using the following equation:

$(\text{rainfall cm/month})(1\text{month}/2592000\text{s})(\text{area of watershed in m}^2) = \text{total amount of water hitting the surface of the watershed each month in m}^3/\text{s} \times \text{a seasonal runoff factor} = \text{calculated stream flow at the outlet of the watershed (Morgantown)}.$

Table 1 lists the calculated monthly flows for the mainstem of Deckers Creek at Morgantown in 1974 and 1999-2000, as well as measured monthly flows for the 1999-2000 period. Table 2 shows calculated versus measured flows for two other years (1947 and 1948) for which both monthly rainfall and monthly flow data were available at the

Table 1. Comparison of rainfall, stream flow, and estimated stream flow in Deckers Creek at Morgantown for 1974 and 1999-2000.

* = no data

Year	Month	Measured average rainfall (cm)	Estimated flow at Morgantown (m ³ /s)	Measured flow at Morgantown (m ³ /s)
1974	Jan	13.4	3.3	*
1974	Feb	5.2	1.3	*
1974	Mar	8.0	2.0	*
1974	Apr	8.6	2.1	*
1974	May	16.0	3.9	*
1974	Jun	21.2	5.2	*
1974	Jul	10.0	2.4	*
1974	Aug	11.9	2.9	*
1974	Sep	9.8	2.4	*
1974	Oct	3.9	1.0	*
1974	Nov	6.3	1.5	*
1974	Dec	9.4	2.3	*
Average		10.3	2.5	*
1999	Jan	14.8	3.6	*
1999	Feb	6.4	1.6	*
1999	Mar	11.5	2.8	*
1999	Apr	7.6	1.9	*
1999	May	9.4	2.3	0.8
1999	Jun	5.5	1.3	0.7
1999	Jul	7.8	1.9	0.5
1999	Aug	7.0	1.7	0.3
1999	Sep	7.2	1.8	0.2
1999	Oct	9.4	2.3	0.3
1999	Nov	10.6	2.6	0.8
1999	Dec	7.9	1.9	4.0
2000	Jan	4.7	1.2	2.8
2000	Feb	13.1	3.2	3.3
2000	Mar	7.3	1.8	7.3
2000	Apr	12.2	3.0	3.3
2000	May	11.7	2.9	3.4
2000	Jun	15.3	3.7	6.4
2000	Jul	11.7	2.9	2.7
2000	Aug	10.1	2.5	1.2
Average		9.6	2.3	2.4

Table 2. Comparison of rainfall, stream flow, and estimated stream flow in Deckers Creek at Morgantown for 1947 and 1948.

* = no data

Year	Month	Measured average rainfall (cm)	Estimated flow at Morgantown (m ³ /s)	Measured flow at Morgantown (m ³ /s)
1947	Jan	10.9	2.8	*
1947	Feb	4.1	1.0	2.0
1947	Mar	5.3	1.3	2.1
1947	Apr	4.7	1.2	2.7
1947	May	10.8	2.7	3.4
1947	Jun	9.4	2.4	*
1947	Jul	15.0	3.8	1.5
1947	Aug	8.4	2.1	1.2
1947	Sep	10.3	2.6	0.2
1947	Oct	3.6	0.9	0.1
1947	Nov	7.6	1.9	2.3
1947	Dec	4.2	1.1	*
average		7.9	2.0	1.7
1948	Jan	10.2	2.6	3.5
1948	Feb	10.1	2.5	1.0
1948	Mar	11.0	2.8	6.1
1948	Apr	16.8	4.2	3.1
1948	May	11.4	2.9	12.9
1948	Jun	15.1	3.8	0.7
1948	Jul	18.4	4.6	3.9
1948	Aug	9.8	2.5	*
1948	Sep	9.3	2.3	0.1
1948	Oct	4.9	1.2	0.1
1948	Nov	10.4	2.6	0.2
1948	Dec	13.0	3.3	0.3
average		11.7	2.9	2.9

Morgantown site. While monthly rainfall amounts were quite variable across months, the 1974 and 1999-2000 average monthly rainfalls were quite similar (10.3 cm vs 9.6 cm). The average monthly measured flow ($2.4 \text{ m}^3/\text{s}$) by our method was also very similar to the average monthly estimated flow ($2.3 \text{ m}^3/\text{s}$) in 1999-2000. However, there was generally a poor match between monthly values of estimated flow and measured flow. For example, the measured flow during May-June 1999 was roughly $0.74 \text{ m}^3/\text{s}$. Estimated flows during this period were nearly three times higher than measured flows. Further, monthly estimated flows during 1947-1948 did not compare closely to the monthly measured flows. Nevertheless, monthly rainfall was used as an indicator of the high or low flow conditions when water samples were collected during 1974. The high or low flow conditions as calculated by our estimation technique were then tied to our measured flow conditions in 1999-2000 to coordinate data. Reasons for these discrepancies are relatively obvious. Average monthly rainfall may have been distributed unevenly across the watershed. Variable slopes, seasonal changes in both antecedent soil moisture conditions and amount of vegetative ground cover, and snow melt events may account for varying runoff rates. Increases in the proportion of impervious ground surface throughout the watershed over the last 50 years may also explain some of the discrepancies.

Microbiological procedures

A separate water sample was collected several days after chemistry samples were taken each month and tested for the presence of fecal coliforms and, for a few months, fecal streptococci. The membrane filtration technique was used (Greenberg et al. 1985).

Most of the 31 sites were sampled at least once until it was determined which sites warranted further monitoring. Eight representative sites were chosen and re-sampled monthly beginning in June 1999. Samples were collected in one-liter plastic sterilized bottles that had been treated with 3 ml of sodium thiosulfate to bind any residual chlorine present in the creek water. Six volumes were analyzed (0.1, 1.0, 5.0, 10.0, 50.0, and 100.0 ml) in an effort to produce plates with between 20 and 60 countable colonies. Both the 0.1 ml and the 1.0 ml volumes of sample were combined with 12 ml of peptone buffer in order to pass a sufficient volume of fluid through the filters. The 5.0-ml sample was added to 8.0 ml of peptone, while the 10-ml sample was mixed with 4.0 ml of peptone. The tests were done with 0.7-um filters instead of 0.45-um filters, as this larger size filter allows for improved recovery of organisms possibly damaged by acidic conditions in the stream (Bissonnette 1999). Samples being analyzed for FS were plated onto m-Enterococcus agar, while FC analysis was done using m-FC agar. All microbiological media had been prepared 24 hours in advance. FS plates were incubated at $35^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$ for 48 hours. The selective properties of the media were responsible for limiting plate growth to FS only. Individual colonies with a bright red color were counted as FS. FC plates were incubated at $44.5^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$ for 24 ± 2 hours. The high incubation temperature and the selective properties of the media helped in restricting growth to FC bacteria. Individual colonies with a bright blue color were counted. The plates were then examined to determine the number of colony forming units (CFU's) per 100 ml.

Statistical analyses

Chemistry data

Statistical software (SAS) was used to perform an analysis of variance (ANOVA) on the 1974 and 1999-2000 flow and chemistry data sets. An analysis was first performed on measured parameters across flow periods to determine whether flow significantly affected concentrations. Finding significant differences, the means for pH, metals, acidity, and alkalinity were compared between 1974 and 1999-2000 high flow periods. The null hypothesis $H_0 : u_1 = u_2$ was used, where u_1 = arithmetic mean for parameter i at site j during 1974, and u_2 = arithmetic mean for parameter i at site j during 1999-2000. The null hypothesis was rejected when resulting P values were less than 0.05. The P value represents the probability of making a Type I error, or rejecting the null hypothesis when it is actually true.

Microbiological data

Analysis of variance was performed on the fecal coliform data set using SAS statistical software. Site-to-site differences and season-to-season differences were examined. Interactions between site and season were ignored. In order to compensate for the large variations in fecal coliform counts normally seen in microbiological studies, geometric means were analyzed. When working with a data set with large variations, geometric means give a better measure of centrality than do arithmetic means (Hunter et al. 1999).

Results and Discussion

Chemistry

Based on estimated and measured flows as previously described, the 1974 and the 1999-2000 monthly data were divided into low flow (June, July, August, September, and October), medium flow (November, December, and January), and high flow (February, March, April, and May) conditions.

Table 3. Mean values for five selected parameters across all sampling points during low, medium, and high flow periods for the 1999-2000 data.

Flow Conditions	pH s.u.	Acidity -----mg/L as CaCO ₃ -----	Alkalinity	Iron -----mg/L-----	Aluminum	n
High flow (Feb.- May)	6.0 ^a	23.8 ^a	1.8 ^a	3.7 ^a	1.8 ^a	7
Medium flow (Nov.-Jan.)	6.1 ^a	78.6 ^{ab}	2.9 ^{ab}	8.9 ^{ab}	2.9 ^{ab}	3
Low flow (Jun.-Oct.)	5.8 ^b	108.9 ^b	5.2 ^b	11.7 ^b	5.2 ^b	9
P Value	<0.05	<0.05	<0.01	<0.01	<0.01	

The use of high flow values, which show the lowest pollution levels, probably suggests that the improvement in Deckers Creek is better than it actually is. At low flow where little dilution from surface runoff is occurring, the resulting poor water quality may have a very detrimental impact on aquatic life since these organisms must live in the water during all flow conditions. These periods of low flow and high acid and metals

may be the reason for slow recovery of acid mine drainage impacted streams even when the chemistry indicates that stream health should be better than observed. Nevertheless, the high flow conditions in 1974 (n=5) versus the low flow (n=1) and medium flow conditions (n=2) were used to compare the 1974 to 1999-2000 data.

Data from eight of the 29 sites were selected to represent specific sections of the stream, and data for all 31 sites (including #27a and b, and #25a and b) can be found in appendix A. The Headwater (site #29) sampling location was the most upstream sampling point and represented an area of limited pollution from households and land disturbances. Two sampling locations were located below the inflow of two major tributaries draining areas heavily surface mined in the 1970's and 80's (Kanes, #27 and Dillan, #23, Creek). The Masontown site (#21) was just below the town of Masontown where a low-flow sewage input occurs. Greer (#17) is the location of a large limestone aggregate mine. Limestone materials of various sizes are introduced into the stream at this point. At Dellslow (#12), the limestone and water have mixed and several more relatively good quality tributaries have entered the creek. But most important, this site is upstream from a major acid mine drainage input from the Richard underground mine complex. Tramps (#9) is immediately downstream from the Richard acid mine drainage input to Deckers Creek, while the Morgantown site (#1) is near the mouth just before Deckers Creek enter the Monongahela River. The high flow averages (February through May data) of pH, alkalinity, acidity, and total iron are presented for these eight representative sites. The ranges for each data point are presented in Table 4. Data from 1974 and 1999-2000 are plotted on the same graph so as to illustrate the changes in water

Table 4. Means and ranges for data presented in figures 3-6 for eight representative sites along Deckers Creek.

Headwaters		
	1974 mean(range)	1999-2000 mean(range)
pH	5.1 (4.9 - 5.3)	5.3 (4.9 - 5.7)
alkalinity	1.0 (1.4 - 0.6)	5.0 (3.1 - 8.4)
acidity	6.6 (4.4 - 8.2)	3.1 (0 - 6.2)
total iron	0.2 (0.1 - .04)	0.1 (0 - 0.4)

Kanes Creek		
	1974 mean(range)	1999-2000 mean(range)
pH	3.7 (3.4 - 3.9)	5.6 (4.7 - 6.7)
alkalinity	0	8.9 (3.7 - 25.7)
acidity	45.7 (33.6 - 56.0)	9.3 (4.1 - 21.7)
total iron	5.4 (2.9 - 12.5)	0.7 (0.2 - 3.1)

Dillan Creek		
	1974 mean(range)	1999-2000 mean(range)
pH	4.2 (4.0 - 4.8)	5.5 (4.8 - 6.4)
alkalinity	0	10.4 (4.7 - 26.3)
acidity	30.4 (18 - 37.4)	14.4 (6.5 - 27.8)
total iron	3.6 (2.4 - 4.8)	0.7 (0.3 - 1.8)

Table 4 (continued). Means and ranges for data presented in figures 3-6 for eight representative sites along Deckers Creek.

Masontown		
	1974 mean(range)	1999-2000 mean(range)
pH	3.8 (3.7 - 3.9)	5.4 (4.9 - 6.5)
alkalinity	0	7.2 (4.4 - 14.5)
acidity	42.2 (39.9 - 50)	13 (7.1 - 26.1)
total iron	5 (3.7 - 6.0)	4.3 (1.8 - 25.2)
Greer		
	1974 mean(range)	1999-2000 mean(range)
pH	4.3 (4 - 4.7)	6.3 (5.6 - 6.8)
alkalinity	0.2 (0 - 1)	10.4 (5.2 - 21.2)
acidity	30.8 (26 - 36)	5 (1.3 - 9.6)
total iron	3.3 (2.1 - 4.5)	0.6 (.1 - 1.3)
Dellslow		
	1974 mean(range)	1999-2000 mean(range)
pH	5.2 (4.7 - 6.9)	6.4 (5.87 - 7.2)
alkalinity	1.9 (0.4 - 6)	14.7 (8.5 - 28.3)
acidity	15.1 (6 - 19)	3.3 (0.8 - 8.7)
total iron	1.6 (0.3 - 3)	0.2 (0 - 0.8)

Table 4 (continued). Means and ranges for data presented in figures 3-6 for eight representative sites along Deckers Creek.

Tramps		
	1974	1999-2000
	mean(range)	mean(range)
pH	4.6 (3.7 - 6.3)	5.7 (4.4 - 6.8)
alkalinity	1.2 (0 - 5.4)	9.1 (4.3 - 15.6)
acidity	32.1 (14.2 - 44.2)	25.1 (1.5 - 73.9)
total iron	6.2 (2.6 -8.8)	4.9 (0 - 16.8)

Morgantown		
	1974	1999-2000
	mean(range)	mean(range)
pH	4.8 (4.3 - 6.1)	6.3 (5.8 - 6.8)
alkalinity	2.5 (0 - 11)	14.2 (4.1 - 20.2)
acidity	24.4 (9.4 - 33.8)	12.2 (1.3 - 38.7)
total iron	4.9 (2.5 - 7.3)	2.7 (0 - 12.3)

quality over time. The data indicate that levels of acidity and total iron have significantly decreased ($P < 0.001$) throughout the stream, while alkalinity and pH have significantly increased ($P < 0.001$).

Water pH at all sites was higher during the present study than in 1974 (Figure 3). The present pH levels are in most cases 1 to 2 units greater than in 1974. In 1974, the average pH in Deckers Creek was never above 5.2 (Teti 1974). Prolonged periods of low pH water in a stream are detrimental for several reasons. Metal solubility generally increases as pH declines. When the pH of a sample is below 5.5, aluminum can exist in solution. Dissolved aluminum and free protons interfere with oxygen absorption in benthic macroinvertebrates and fish. Aluminum also binds phosphorous into less available forms and interferes with the uptake, transport, and use of nutrients and water by aquatic plants. When pH is above 5.5, as during the 1999-2000 sampling period, aluminum will bind with hydroxides and precipitate out of solution, causing somewhat less damage to aquatic life.

Alkalinity levels have increased throughout the entire watershed, with the largest average alkalinity levels coming below Greer Limestone (Figure 4). Alkalinity is a measure of the ability to neutralize acidity and dissolved metals. A stream with high alkalinity levels will be able to supply adequate amounts of carbonate, bicarbonate, and hydroxide ions in solution to bind up free protons and metals. Several factors are responsible for the increase from 1974 to 1999-2000. In the late 1970's, an active treatment system was constructed on Kanes Creek. This facility intermittently pumps and treats water from a nearby deep mine using ground calcium carbonate. The treated water

Figure 3. Average pH from February through May (high flow conditions at eight selected sites for 1974 and 1999-2000.

Figure 4. Average alkalinity from February through May (high flow conditions at eight selected sites for 1974 and 1999-2000.

is passed through a series of settling ponds before being discharged into Deckers Creek. When operating, this system adds 3780 to 7560 L/min (1000 to 2000 gpm) of high pH, high alkalinity water to the creek. Tables 5 and 6 show the effects of this treatment on both Kanes Creek and the mainstem of Deckers Creek. Levels of iron, aluminum, manganese, and acidity were all reduced, while pH, alkalinity, and calcium were all increased. In Kanes Creek, acidity was reduced by 97%.

Acidity levels have declined, averaging a 62% decrease across all sites, with the smallest decrease occurring below the Richard Mine discharge (21%) (Figure 5). It is interesting that the worst acidity levels are at two different locations for the two sampling periods. Kanes Creek had the highest acidity during the 1974 study, while Tramps had the highest numbers during 1999-2000. This indicates improvements in the upper half of the watershed, and also the continued inputs of mine water in the lower part of Deckers Creek. Reducing water acidity has multiple benefits, and is consequentially a main goal of all acid mine drainage remediation measures. Acid water irritates the gills and eyes of fish and insects. Elevated acidity levels also lead to accelerated weathering of clay minerals and pyrite. Clay minerals may break down quicker, releasing metals such as aluminum and iron from their crystal lattices, while the weathering of pyrite has been identified by numerous researchers as the source of acid mine drainage.

Figure 6 shows the decrease in total iron concentrations over the past 25 years. Total iron levels dropped as much as 87% at Kanes Creek, with an average decrease of 53% across the eight sites. Elevated pH and reduced acidity are both partially responsible for this decrease. During both studies, Tramps had the highest iron levels, due to inputs of

Table 5. Chemical parameters in Kanes Creek (site 27b) during a period of AMD treatment versus a period of no AMD treatment.

<u>Parameter</u>	With Treatment (August 2000)	Without Treatment (September 2000)
pH	6.2	3.8
Acidity	3.9	143.3
Alkalinity	11.1	0
Total iron	0.1	27.4
Aluminum	0.2	3.7
Calcium	211.4	107.7
Manganese	0.7	1.9

Table 6. Chemical parameters 1500 m downstream (site 26) from Kanes Creek during a period of AMD treatment versus a period of no AMD treatment.

<u>Parameter</u>	With Treatment (August 2000)	Without Treatment (September 2000)
pH	6.4	5.8
Acidity	5.3	30.2
Alkalinity	28.7	20.9
Total iron	0.1	5.8
Aluminum	0.1	0.4
Calcium	142.3	78.1
Manganese	0.5	1.2

Figure 5. Average acidity from February through May (high flow conditions at eight selected sites for 1974 and 1999-2000.

Figure 6. Average total iron from February through May (high flow conditions) at eight selected sites for 1974 and 1999-2000.

untreated mine drainage at Richard. Iron is less toxic than aluminum, but will readily combine with hydroxide ions to form precipitates that coat stream bottoms.

Aluminum and manganese concentrations in water of the Deckers Creek mainstem (Table 7) and its tributaries (Table 8) are provided, but no data for these two metals were collected during the 1974 study. Average aluminum concentrations in the mainstem of Deckers Creek are lower than the state standard (0.75 mg/L) at nearly every sampling point upstream from the Richard mine discharge. At each sampling site below this point, average aluminum concentrations in Deckers Creek vary from 3 to 8 times higher than the state standard. Three of the thirteen sampled tributaries to Deckers Creek also had average aluminum concentrations higher than 0.75 mg/L. Laurel Run (site 24) flows through an unreclaimed surface mine in Preston County. It displayed high levels of dissolved manganese, iron, and iron precipitates. Hartman Run (site 3) flows through a heavily-developed area of the watershed. It receives drainage from abandoned deep mines and landfills, and was rated as “poor” during a benthic macroinvertebrate survey by Mains et al. (1999). It has been traditionally held that Deep Hollow (site 11) contributes largely to the poor quality of the lower section of Deckers Creek. Mains et al. (1999) describe Deep Hollow and the Richard Mine as a “one-two punch” that deliver large amounts of aluminum and acidity to the main stem of Deckers Creek. The data from the current study indicate that Deep Hollow contributes very little aluminum to Deckers Creek, even less than Aaron’s Creek, a relatively clean stream.

Average manganese levels in the mainstem of Deckers Creek are lower than the state standard of 1.0 mg/L at all sites. Only two of the thirteen tributaries, the Richard discharge and Hartman Run, show average values higher than 1.0 mg/L.

Table 7. Aluminum and manganese concentrations (minimum, maximum, and average) at mainstem sampling points (1999-2000) as compared to state water quality standards (aluminum is < 0.75 and manganese is < 1.0). Averages which exceed state standards appear in shaded boxes.

site #	n	Aluminum (mg/L)			Manganese (mg/L)		
		min	max	average	min	max	average
29	19	0.06	3.45	0.5	0.01	0.12	0.05
28	17	0.06	0.3	0.17	0.03	1.30	0.24
27b	19	0.04	0.3	0.18	0.08	0.89	0.35
26	19	0.09	0.4	0.2	0.09	1.17	0.39
25a	19	0.04	2.97	0.54	0.11	0.85	0.52
22	19	0.09	0.31	0.22	0.16	1.22	0.50
21	19	0.07	5.52	0.87	0.22	1.39	0.70
20	18	0.15	1.4	0.53	0.23	1.20	0.68
19	18	0.07	0.8	0.26	0.16	1.29	0.71
17	19	0.1	0.66	0.24	0.17	1.34	0.59
16	13	0.03	0.66	0.22	0.17	0.79	0.43
15	19	0.1	0.69	0.22	0.02	0.66	0.26
12	19	0.08	0.41	0.18	0.01	0.43	0.18
10	7	0.15	19.38	6.62	0.16	1.52	0.66
9	19	0.15	16.79	3.76	0.15	1.90	0.65
8	17	0.04	26.08	3.53	0.16	2.22	0.60
6	19	0.06	21.9	3.43	0.14	2.15	0.56
2	19	0.11	11.84	2.35	0.14	1.48	0.57
1	19	0.11	25.32	3.07	0.19	1.81	0.59

Table 8. Aluminum and manganese concentrations (minimum, maximum, and average) at tributary sampling points (1999-2000) as compared to West Virginia state water quality standards (aluminum is < 0.75 and manganese is < 1.0). Averages which exceed state standards appear in shaded boxes.

site #	n	Aluminum (mg/L)			Manganese (mg/L)		
		min	max	average	min	max	average
27a	19	0.07	3.72	0.68	0.27	1.96	0.64
25a	19	0.05	0.32	0.19	0.15	0.64	0.36
24	19	0.18	13.46	2.64	0.21	3.25	0.89
23	18	0.13	1.59	0.47	0.06	1.74	0.62
18	9	0.02	0.24	0.16	0.00	0.02	0.00
14	9	0.12	0.58	0.34	0.10	0.29	0.13
13	18	0.06	0.35	0.19	0.01	0.10	0.04
11	16	0.06	0.43	0.25	0.01	1.43	0.67
Richard	16	55.47	95.32	67.11	2.70	4.51	3.66
7	14	0.10	0.43	0.21	0.01	0.04	0.01
5	10	0.09	0.48	0.23	0.00	0.15	0.03
4	16	0.09	0.98	0.25	0.00	0.11	0.03
3	19	0.16	12.02	4.17	0.80	2.93	1.55

The limited degree of improvement and overall poor quality of Deckers Creek below the Richard Mine discharge has several negative impacts on the region. Armoring of the creek channel restricts the presence of benthic macroinvertebrates. This affects life throughout the food chain, making larger forms of aquatic life nearly absent. The Monongahela River is also negatively impacted, as Deckers Creek discharges an average of 900 Mg (1,000 tons) of acid per month into the river at Morgantown. In 1991, The Mon River Trails Conservancy began converting an abandoned spur of the Baltimore and Ohio Railroad into a useable bike/hiking trail. The trail follows Deckers Creek from its confluence with the Monongahela River in Morgantown upstream to Kanawha Creek in Preston County. Instead of being an asset, Deckers Creek is a detriment to the trail, due to the unsightly appearance of the creek and its banks. Residents living along the banks of the creek also feel the negative impacts of having a polluted waterway near their homes. In the recently published Environmental Assessment for the Upper Deckers Creek Watershed (Natural Resources Conservation Service 2000), over 150 pages have been taken up by letters of concern from local residents. The Natural Resources Conservation Service has calculated that returning Deckers Creek to a clean, fishable stream will generate over \$970,000 dollars in benefits, with an annual benefit/cost ratio of 1.02. The NRCS has proposed a restoration project with an expected installation time of six years. The Richard Mine discharge is to be addressed in the second year of the project, and is predicted to cost nearly half of the \$9.1 million budget. Treating the discharge will be expensive and complicated for several reasons. First, land area is very limited in the immediate vicinity of the portal, with only 100 to 125 meters between the discharge point and Deckers Creek. Flow from the discharge is extremely high, coupled

with elevated levels of metals and acidity. These factors combine to make passive treatment impractical in the current setting. Grouting is planned to reduce the flow from the mine, and the water flowing from the portal is proposed to be chemically treated with settling ponds to remove metals before discharging into Deckers Creek.

Overall, decreased mining activity, higher additions of alkaline materials to the creek, and reclamation of abandoned mines in the Dillan and Kanawha Creek areas have led to improved chemical quality of Deckers Creek. Possibly the most important factor behind the water quality improvements in Deckers Creek is natural healing that comes with time. Wood et al. (1999) indicate that minewater pollution is most severe in the first few decades after mining and reclamation is completed and that water, even from large mining complexes, improves in quality after 40 years. As oxidizable pyrite supplies diminish, the overall quality of mine drainage improves, contributing to improvements in receiving streams. With less mining activity in the watershed and improved reclamation on the few remaining active mining sites, water quality has improved. Natural reclamation and reclamation projects conducted by the WVDEP on abandoned sites, and better treatment and control of water on active sites also enhances this improvement.

Fecal Coliforms

In contrast to improved water quality for the above conditions, a new water pollution problem is becoming apparent. Fecal coliform bacteria populations are very high in some parts of the watershed due to inadequate sewage treatment. Figure 7 shows the geometric mean fecal coliform counts for the entire 1999-2000 sampling period at eight representative sites. Given the variability of the data at these sites and the sensitivity of arithmetic means to extreme observations (Table 9), the geometric mean was chosen as a

Table 9. Fecal coliform (FC) and fecal streptococcus (FS) levels at five selected sites in Deckers Creek from February through May 2000.

site	date (2000)	FC -----cfu/ 100 mL-----	FS	FC:FS ratio
29	18-Feb	.	.	.
29	20-Mar	6	12	0.5
29	26-Apr	1	1	1
29	31-May	14	34	0.4
26	18-Feb	145	700	0.20
26	20-Mar	100	21	4.8
26	26-Apr	4	3	1.2
26	31-May	980	230	4.3
21	18-Feb	166	130	1.30
21	20-Mar	130	250	0.5
21	26-Apr	5800	63	92.1
21	31-May	1200	740	1.6
12	18-Feb	*	*	*
12	20-Mar	82	110	0.7
12	26-Apr	8	3	2.9
12	31-May	74	98	0.8
1	18-Feb	16	48	0.30
1	20-Mar	140	88	1.6
1	26-Apr	38	7	5.6
1	31-May	68	48	1.4

better measure of centrality (Bissonnette 2000, Hunter et al. 1999). Table 10 lists descriptive statistics for the fecal coliform data collected at the eight selected sites. No data are available from the 1974 study, but it is hypothesized that the harsh chemical conditions in the creek during 1974 would have masked any bacterial problems by limiting survival rates. Of the eight sites shown, two had average fecal coliform counts higher than the West Virginia standard for secondary use waters of 200 colony forming units (cfu) per 100 ml sample (Figure 7, dashed line). Masontown was by far the most heavily impacted site in the watershed. During the summer months of 1999, low stream flow, sustained sewage flow, and elevated temperatures led to fecal coliform levels as high as 9.0×10^6 cfu /100 mL. Coyne and Howell (1994) made similar observations, noting that warm, shallow streams, high in organic carbon, permit fecal coliform regrowth. At the sampling point in Masontown, a large pipe discharges untreated wastewater directly into the stream. An old rock bridge causes the stream to form a shallow lagoon in the creek, similar to the physical parameters necessary for re-growth as set forth by Coyne and Howell (1994).

Statistical analysis indicates that fecal coliform levels are significantly different among sites ($P < 0.01$) and that a significant difference also exists among seasons ($P < 0.01$) at each site. The difference among sites is likely due to the different land uses, population densities, and access to adequate sewage systems throughout the watershed. The worst sanitary water quality was detected near a concentrated human population in Masontown. It appeared that wastewater from a number of homes was collected at a central point and discharged into the creek without undergoing any form of treatment. Seasonal differences

Table 10. Descriptive statistics of fecal coliform concentrations (cfu/100 ml) at eight selected sites in Deckers Creek from May 1999 through October 2000.

Site	Min	Max	Median	Arithmetic Mean	Geometric Mean	St Dev	n
29	1	380	27	82	26	111	13
26	39	5800	900	1535	720	1729	14
23	1	3100	25	337	40	782	16
21	130	970000	23000	137473	16024	268324	18
17	1	820	12.5	127	15	258	12
12	7	590	97	163	82	175	14
9	1	420	6	71	11	137	11
1	4	1280	56	254	68	427	17

have been detected by numerous researchers (Baudart et al. 2000; Davenport et al. 1976; Farrell-Poe et al. 1997; Hunter et al. 1999; Thelin and Gifford 1983; Young and Thackston 1999). During summer months, higher temperatures facilitate the survival of fecal bacteria outside their host. Also, stream flow is normally lower during the hotter and drier summer months, reducing the effect of dilution on point sources of sewage pollution. During winter months, survival times are greatly diminished due to lowered water temperatures, and higher stream flows allow for greater dilution of point source inputs.

Fecal Coliform: Fecal Streptococci ratio

In an attempt to determine the origin of fecal bacteria found in Deckers Creek, fecal streptococcus bacteria were monitored from February 2000 to May 2000, in addition to the regular fecal coliform monitoring. The ratio of fecal coliform bacteria to fecal streptococcus bacteria was determined as previously described. Land use data were initially consulted to develop an idea of what FC : FS ratios could logically be expected at each site. Site #29 (Figure 1) is in an undisturbed section of the creek, where the only fecal input should be from wild animals. Ratios of FC : FS at site #29 should be less than 0.1. Runoff from crop fields and pastureland is collected near site #26, where the creek has cut through a university-owned farm near Reedsville. Levels should indicate domestic animal contributions of fecal bacteria. Masontown (site #21) lacks a municipal sewage treatment system. A large volume discharge of untreated domestic wastewater and several smaller flows are introduced to Deckers Creek here. Site #1 is located in Morgantown, the largest urbanized area in the watershed. High proportions of

impervious ground and long stretches of sewage lines make this area similar to the Young and Thackston (1999) study area. Both of these sites should show ratios indicative of human waste input. The remainder of the sites are comprised of various amounts of rural, residential, and urban land area.

The monthly FC and FS counts, as well as the FC : FS ratios, for February through May are shown in Table 9. It was expected that the FC : FS ratio would be >4 at sites #21 and #1 since these sites are near municipalities. But only two of the possible eight dates showed >4 FC : FS ratios. The only other two dates with >4 FC : FS ratios appeared were at site #26, but these were just slightly over 4. One possible explanation for the low FC : FS ratios at these sites may be that higher creek flows during the February, March, April, and May sampling periods had a dilution effect on the sewage input, which flowed at a steady rate. Increased stream flow is a direct result of increased rainfall, which also causes higher amounts of surface runoff. Surface runoff is likely the chief factor in the introduction of domestic animal waste into the creek. Site #29 should have had the lowest ratio, as it was most likely to contain fecal matter from wild animals. A ratio of 0.5 suggests the presence of domestic animals, which were either absent or present only in very low numbers above the sample collection point. The highest fecal streptococcus levels in the four month study occurred at site #26 in February. This sample site is located under a bridge where numerous raccoon, dog, and bird tracks may often be observed. A high level of animal traffic might account for the elevated levels of fecal bacteria.

A larger data set may give numbers that more closely match the observed land uses and high inputs of observed sewage at specific locations. Sampling for fecal

streptococcus was discontinued after four months due to limited success and wide variability when computing the FC : FS ratio. In the summer, the ratios would likely be higher. During summer months, less rainfall would lead to less runoff from agricultural fields. Also, lower streamflow would mean less dilution of point source sewage discharges.

Sampling frequency was initially proposed to be biweekly. This was not feasible due to set-up time and scheduling conflicts. Howell et al. (1995) explored the difference between monthly and weekly sampling means. No difference was found to exist within sites, nor was the percent of time samples exceeded the primary contact standards for monthly and weekly sampling significantly different. It is doubtful that increased sampling frequency would affect the data interpretation. Differences may have been observed by sampling over a longer time frame. From this study, it appears that the FC : FS ratio is not an absolute means of differentiating between human and animal sources of fecal pollution. Howell et al. (1996) and Jawson et al. (1982) reported similar findings. Problems occurred due to several factors: the varying die-off rates between the two groups, elevated stream flows, and varying degrees of surface runoff.

Conclusions

Water quality in Deckers Creek has significantly improved between 1974 and 2000. Water pH is generally 1 to 2 units higher, and acidity has declined by more than 50% between these two dates across our sampling locations. The present data help highlight some environmental laws and regulations enacted and enforced in the state, which have led to the improvement of water quality in Deckers Creek. In 1970, the first Clean Water Act was passed to aid in cleaning up streams and rivers in the United States. Many municipalities received funds for constructing wastewater treatment plants in the early 1970's. In 1977, the Surface Mining Control and Reclamation Act (SMCRA) was passed by the federal government. This law enhanced already existing state efforts to make coal operators reclaim mine sites and to control the quality of the drainage coming from active mining sites. The present study illustrates the long-term benefits that have been realized by requiring compliance with these laws. Natural reclamation and time passage also have beneficial effects on improving stream quality. With reduced mining and other disturbances, better reclamation and water control techniques on active mines, and treatment of abandoned discharges, water quality has greatly improved. This study also showed that as the chemistry of Deckers Creek returns to pre-mining ranges, sewage input will become an increasingly noticeable problem.

Literature Cited

- Banks, D., P.L. Younger, R. Arnesen, E. R. Iversen, and S.B. Banks. 1997. Mine-water chemistry: the good, the bad, and the ugly. *Environ. Geology* 32(3):161-174.
- Baudart, J., J. Grabulos, J.P. Barusseau, and P. Lebaron. 2000. *Salmonella* spp. and fecal coliform loads in coastal waters from a point vs. nonpoint source of pollution. *J. Environ. Qual.* 29:241-250.
- Bissonnette, G. 1999. Personal communication. West Virginia University. Morgantown, West Virginia.
- Bissonnette, G. 2000. Personal communication. West Virginia University. Morgantown, West Virginia.
- Coyne, M.S., and J.M. Howell. 1994. The fecal coliform/fecal streptococci ratio (FC/FS) and water quality in the bluegrass region of Kentucky. *Soil Science News and Views*. Vol. 15, No. 9.
- Davenport, C.V., E.B. Sparrow, and R.C. Gorden. 1976. Fecal indicator bacteria persistence under natural conditions in an ice covered river. *Appl. Environ. Microbiol.* 32:527-536.
- Donovan, J. 1999. Personal communication. West Virginia University. Morgantown, West Virginia.
- Driscoll, C.T. Jr, J.P. Baker, J.J. Bisogni Jr., and C.L. Schoefield. 1980. Effect of aluminum speciation on fish in dilute acidified waters. *Nature* 284:161-164.
- Edwards, D.R., M. S. Coyne, T. C. Daniel, P. F. Vendrell, J. F. Murdoch, and P.A. Moore Jr. 1997. Indicator bacteria concentrations of two northwest Arkansas streams in relation to flow and season. *American Society of Agricultural Engineers* 40(1):103-109.
- Farrell-Poe, K.L., A.Y. Ranijha, and S. Ramalingam. 1997. Bacterial contributions by rural municipalities in agricultural watersheds. *American Society of Agricultural Engineers* 40(1):97-101.
- Gray, N.F. 1995. Field assessment of acid mine drainage contamination in surface and ground water. *Environ. Geology* 27:358-361.

- Greenberg, A.E., R.R. Trussell, and C.S. Clesceri, eds., *Standard methods for the examination of water and wastewater*. 1985. American Public Health Association /American Water Works Association/American Public Health Association, Washington D.C.
- Havas, M. 1985. Aluminum bioaccumulation and toxicity to *Daphnia magna* in soft water at low pH. *Can. J. Fish. Aquat. Sci.* 42:1741-1748.
- Howell, J.M., M.S. Coyne, and P.L. Cornelius. 1996. Effect of sediment particle size and temperature on fecal bacteria mortality rates and the fecal coliform/fecal streptococci ratio. *J. Environ. Qual.* 25:1216-1220.
- Howell, J.M., M.S. Coyne, and P.L. Cornelius. 1995. Fecal bacteria in agricultural waters of the Bluegrass region of Kentucky. *J. Environ. Qual.* 24:411-419.
- Hunter, C., J. Perkins, J. Tranter, and J. Gunn. 1999. Agricultural land-use effects on the indicator bacterial quality of an upland stream in the Derbyshire Peak district in the U.K. *Wat. Res.* 33(17):3577-3586.
- Jawson, M.D., L.F. Elliott, K.E. Saxton, and D.H. Fortier. 1982. The effect of cattle grazing on indicator bacteria in runoff from a Pacific northwest watershed. *J. Environ. Qual.* 11:621-627.
- Mains, C., B. Williams, and W. Chain-Wen. 1999. Deckers Creek Stream Quality Inventory: Summary Report. Friends of Deckers Creek. Morgantown, West Virginia.
- Moreland, J. 1885. Morgantown District Industrial and Business Survey (1920). West Virginia Collection, West Virginia University. Morgantown, West Virginia.
- National Research Council. 1979. Committee on Medical and Biological Effects of Environmental Pollutants. Subcommittee on Iron. pp. 18-19, 32-33. University Park Press, Baltimore, MD.
- Natural Resources Conservation Service. 2000. Supplemental Watershed Plan No. 1 and Environmental Assessment for the Upper Deckers Creek Watershed: Preston and Monongalia Counties, West Virginia. Report by NRCS, Morgantown, West Virginia.
- Neville, C.M. 1985. Physiological response of juvenile rainbow trout, *Salmon gairdneri*, to acid and aluminum-prediction of field responses from laboratory data. *Can. J. Fish. Aquat. Sci.* 42:2004-2019.

- Neville, C.M. and P.G.C. Campbell. 1988. Possible mechanisms of aluminum toxicity in a dilute, acidic environment to fingerlings and older life stages of salmonids. *Water Air Soil Pollut.* 42:311-327.
- Ormerod, S.J., K.R. Bull, C.P. Cummins, S.J. Tyler, and J.A. Vickery. 1988. Egg mass and shell thickness in dippers *Cinclus cinclus* in relation to stream acidity in Wales and Scotland. *Environ. Pollut.* 55:107-121.
- Paul, J.W. 1904. Bureau of Mines: Annual Report for the year ending 1903. West Virginia Collection. West Virginia University. Morgantown, West Virginia.
- Pegg, W.J. 1984. Physiological effects of sublethal levels of acid water on three species of fishes. Ph. D. Dissertation. Department of Biology, West Virginia University, Morgantown.
- Rosseland, B.O., and O.K. Skogheim. 1986. Neutralization of acidic brook-water using a shell-sand filter or sea water: effects on eggs, alevins and smilts of salmonids. *Aquaculture* 58:99-110.
- Rosseland, B.O., I.A. Blaker, A. Bulgar, F. Kroglund, A. Kvellstad, E. Lydersen, D.H. Oughton, B. Salbu, M. Staurnes, and R. Vogt. 1992. The mixing zone between limed and acidic river waters: complex aluminum chemistry and extreme toxicity for salmonids. *Environ. Pollut.* 78:3-8.
- Sadler, K. and S. Lynam. 1985. The influence of calcium on aluminum induced changes in the growth and mortality of brown trout, *Salmon trutta* L. *J. Fish. Biol.* 33:171-179.
- Skousen, J.G. 2000. Personal communication. West Virginia University. Morgantown, West Virginia.
- Sparling, D.W. and T.P. Rowe. 1996. Environmental hazards of aluminum. *Reviews of Environ. Contamination and Toxicology* 145:1-127.
- Teti, M.J. 1974. Surface water geochemistry of the Deckers Creek drainage basin. M.S. Thesis. Department of Geology and Geography, West Virginia University. Morgantown, West Virginia.
- Thelin, R., and G. F. Gifford. 1983. Fecal coliform release patterns from fecal material of cattle. *J. Environ. Qual.* 12:57-63
- Wiggins, B.A. 1996. Discriminant analysis of antibiotic resistance patterns in fecal streptococci, a method to differentiate human and animal sources of fecal pollution in natural waters. *Appl. Environ. Microbiol.* 62:3997- 4002.

- Wood, S.C., P.L. Younger, and N.S. Robins. 1999. Long-term changes in the quality of polluted minewater discharges from abandoned underground coal workings in Scotland. *Quart. J. of Engineering Geology* 32: 69-79.
- Wren, C.D., and G.L. Stephenson. 1991. The effects of acidification on the accumulation and toxicity of metals to freshwater invertebrates. *Environmental Pollution*. 71:205-241.
- Young, K.D., and E. L. Thackston. 1999. Housing density and bacterial loading in urban streams. *J. Environ. Engineering* 125(12):1177-1180.
- Younger, P.L. 1998. Coalfield abandonment: geochemical processes and hydrochemical products. p. 1-29. In: *Energy and the Environ. Geochemistry of fossil, nuclear, and renewable resources*, MacGregor Science, University of Newcastle. UK.

Appendix A

1999-2000 Chemistry Data

Note: Alkalinity and acidity are expressed as mg/L of calcium carbonate. Decimal points represent instances where no data was collected.

Chemistry Data

Site 29		Headwaters															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
29	3/18	1999	1	4	0.06	5.71	.	5.46	1.71	.	0.00	0.13	0.00	0.04	0.89	0.02	4.78
29	4/15	1999	1	10.1	0.03	4.9	5.77	4.29	0.00	.	0.01	0.35	0.13	0.05	0.88	0.04	3.81
29	5/26	1999	1	13	0.03	5.3	5.74	4.52	3.70	46.1	0.04	0.25	0.16	0.08	1.92	0.03	5.27
29	6/25	1999	2	14.6	0.03	5.4	6.45	3.36	3.81	25.6	0.04	0.20	0.28	0.03	1.26	0.04	4.92
29	7/15	1999	2	16.7	0.07	5.7	6.61	2.34	3.71	19.2	0.07	0.79	0.93	0.07	1.62	0.03	4.70
29	8/17	1999	2	18.9	0.04	5.9	6.81	4.38	7.94	16.4	0.02	0.06	0.28	0.12	1.47	0.04	4.90
29	9/23	1999	2	11.8	0.04	6.3	6.5	8.26	2.61	17.1	0.02	0.39	0.38	0.05	1.35	0.05	5.35
29	10/25	1999	2	6.6	0.04	5.65	6.58	2.78	4.37	47.2	0.03	0.26	0.12	0.03	1.26	0.04	4.95
29	11/20	1999	3	5.4	0.05	5.8	5.95	6.01	5.43	124.0	0.07	0.51	0.39	0.03	1.90	0.05	8.33
29	12/21	1999	3	4.1	0.03	5.51	5.51	9.51	9.28	1478.7	0.04	3.45	2.74	0.08	1.17	0.07	4.98
29	1/31	2000	3	9.7	0.03	5.83	6.08	5.84	19.58	993.8	0.10	0.50	0.30	0.10	1.30	0.03	4.31
29	2/24	2000	1	15.5	0.04	5.18	5.54	4.53	6.24	3850.0	0.04	0.34	0.08	0.10	1.06	0.08	5.96
29	3/31	2000	1	21	0.04	5.17	7.8	8.38	3.11	2571.0	0.08	0.44	0.42	0.05	0.96	0.05	4.28
29	4/25	2000	1	15.5	0.06	5.65	5.5	4.59	3.15	3279.0	0.20	0.24	0.03	0.06	0.95	0.01	3.70
29	5/24	2000	1	19	0.04	5.45	5.35	3.07	3.44	3265.7	0.42	0.76	0.07	0.05	0.51	0.00	1.94
29	6/21	2000	2	22	0.06	5.15	4.78	4.56	6.70	9290.0	0.04	0.12	0.11	0.05	0.84	0.04	3.92
29	7/26	2000	2	22.5	0.04	4.25	6.6	3.16	3.05	.	0.02	0.31	0.29	0.03	1.03	0.04	4.98
29	8/24	2000	2	20.1	0.05	5.11	6.12	2.31	3.07	.	0.03	0.11	0.04	0.01	0.88	0.04	3.97
29	9/20	2000	2	21.6	0.11	5.72	.	4.68	5.20	.	1.48	0.26	0.19	0.03	1.17	0.05	4.47

Chemistry Data

Site 28 Reedsville Farm				Temperature		pH	pH	alkalinity	acidity	flow	zinc	aluminum	iron	manganese	magnesium	barium	calcium
Site	date	year	season	(C)	EC	(field)	(lab)	(mg/L)	(mg/L)	(gpm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
28	3/18	1999	1	4.2	0.06	5.52	.	6.7	3.18	.	0.00	0.18	0.00	0.04	1.06	0.02	5.25
28	4/15	1999	1	14.9	0.04	6	6.73	7.03	0.00	.	0.01	0.24	0.04	0.08	1.02	0.03	5.04
28	5/26	1999	1	16	0.04	6.15	6.95	8.29	2.84	78.0	0.02	0.22	0.11	0.03	1.10	0.02	8.51
28	6/25	1999	2	14.8	0.14	6.3	7.3	51.86	8.44	36.4	0.08	0.13	0.31	0.59	4.49	0.22	27.46
28	7/15	1999	2	17	0.16	6.55	7.14	40.93	6.67	35.0	0.04	0.16	0.48	0.30	4.98	0.19	26.24
28	8/17	1999	2	18.7	0.18	6.51	7.63	49.34	11.84	30.3	0.08	0.13	0.25	0.27	5.84	0.20	30.32
28	9/23	1999	2	10.2	0.16	6.4	7.3	108.57	9.92	14.7	0.00	0.29	0.52	0.29	6.36	0.21	33.20
28	10/25	1999	2	6.2	0.14	6	7.2	51.38	19.51	77.5	0.00	0.13	1.11	1.30	5.66	0.24	31.44
28	11/20	1999	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28	12/21	1999	3	4.7	0.04	5.67	6.23	7.55	5.85	3192.1	0.00	0.15	0.13	0.09	1.22	0.07	6.14
28	1/31	2000	3	6.8	0.04	6.79	5.87	9.29	3.92	1414.5	0.03	0.30	0.07	0.10	1.42	0.08	10.32
28	2/24	2000	1	14.9	0.04	5.74	5.7	6.07	6.91	4250.0	0.01	0.16	0.05	0.11	1.09	0.00	8.95
28	3/31	2000	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28	4/25	2000	1	15.3	0.05	5.93	5.8	6.66	5.13	4459.0	0.09	0.12	0.10	0.07	0.87	0.04	4.65
28	5/24	2000	1	23	0.07	6.4	6.8	15	5.05	4636.4	0.09	0.06	0.08	0.05	0.80	0.02	3.51
28	6/21	2000	2	25.5	0.06	6.56	6.87	7.83	3.67	9604.0	0.05	0.14	0.31	0.04	0.88	0.04	4.52
28	7/26	2000	2	23.5	0.04	5.3	6.82	12.94	3.88	2477.0	0.10	0.19	0.20	0.05	1.19	0.04	7.07
28	8/24	2000	2	20.9	0.08	6.07	6.35	11.41	3.14	310.0	0.17	0.13	0.21	0.14	1.62	0.04	9.53
28	9/20	2000	2	19.1	0.16	6.26	.	64.67	12.54	58.7	0.08	0.13	0.24	0.47	3.20	0.14	17.95

Chemistry Data

Site 27b	Fairfax Pond																
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
27b	3/18	1999	1	5.5	0.27	6.63	.	34.2	2.34	.	0.01	0.21	0.00	0.20	6.80	0.00	26.74
27b	4/15	1999	1	16	0.31	8.34	8.49	42.91	.	.	0.00	0.19	0.11	0.29	11.26	0.00	42.13
27b	5/26	1999	1	17.5	0.36	7.25	7.1	68.58	3.61	624.2	0.07	0.16	1.67	0.85	13.12	0.03	52.19
27b	6/25	1999	2	20.6	0.44	6.7	7.9	78.26	2.06	586.3	0.05	0.25	0.29	0.89	16.47	0.23	63.00
27b	7/15	1999	2	19.7	0.45	7	7.41	67.97	3.25	296.4	0.04	0.24	0.21	0.47	19.17	0.05	63.29
27b	8/17	1999	2	22.7	0.52	6.8	7.7	97.03	15.43	110.4	0.04	0.04	0.20	0.42	21.98	0.08	71.86
27b	9/23	1999	2	13.9	0.48	6.9	7.3	112.32	11.84	132.0	0.01	0.21	0.25	0.20	25.36	0.08	90.60
27b	10/25	1999	2	11	0.33	5.96	8.3	67.27	.	158.1	0.00	0.16	0.11	0.08	16.53	0.04	55.89
27b	11/20	1999	3	7.5	0.29	6.23	6.75	92	9.02	653.0	0.02	0.30	0.48	0.31	14.80	0.02	55.13
27b	12/21	1999	3	4.2	0.26	6.42	6.8	45.29	5.77	2179.0	0.00	0.16	0.13	0.42	11.11	0.04	39.00
27b	1/31	2000	3	6.9	0.21	6.9	6.05	47.96	7.84	1474.0	0.01	0.18	0.14	0.10	12.54	0.04	41.32
27b	2/24	2000	1	14.8	0.17	6.45	6.12	19	7.97	4298.0	0.04	0.09	6.43	0.34	5.98	0.03	50.31
27b	3/31	2000	1	18.2	0.41	7.35	6.49	38.38	.	5223.0	0.02	0.24	0.00	0.24	10.55	0.00	40.85
27b	4/25	2000	1	15.8	0.33	6.2	6.26	36.49	5.13	4258.0	0.05	0.14	0.05	0.34	10.57	0.01	37.94
27b	5/24	2000	1	25	0.46	6.75	7.1	59.35	6.15	7713.0	0.02	0.05	0.14	0.52	13.46	0.02	44.17
27b	6/21	2000	2	26.3	0.40	6.8	7.31	53.35	4.92	5535.0	0.02	0.11	0.41	0.44	10.42	0.03	34.48
27b	7/26	2000	2	25.5	0.30	6.04	7.6	57.89	3.55	3154.0	0.04	0.21	0.39	0.16	10.38	0.04	37.17
27b	8/24	2000	2	21.8	0.36	6.71	6.41	38.08	2.39	266.0	0.04	0.17	0.21	0.27	10.95	0.03	35.55
27b	9/20	2000	2	25.9	0.43	6.55	.	80.78	4.39	177.7	0.03	0.25	0.19	0.18	12.00	0.04	39.27

Chemistry Data

Site 27a		Kanes Creek															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
27a	3/18	1999	1	4.6	0.22	5.89	.	9.83	4.43	.	0.00	0.19	0.21	0.27	3.46	0.00	21.89
27a	4/15	1999	1	13.1	0.18	4.78	5.13	4.29	8.63	.	0.12	0.89	0.59	0.45	4.34	0.02	26.23
27a	5/26	1999	1	14.8	1.01	6.73	6.68	25.73	4.06	666.4	0.14	0.16	0.26	0.54	23.50	0.00	235.18
27a	6/25	1999	2	18.9	1.52	6.05	6.58	10.61	7.78	446.3	0.07	0.13	0.36	0.63	32.98	0.02	327.44
27a	7/15	1999	2	19.7	1.51	4.98	5.18	4.92	13.89	189.3	0.10	1.18	0.21	1.34	28.37	0.03	299.02
27a	8/17	1999	2	21.1	1.86	6.38	5.73	22.9	15.01	10.8	0.02	0.07	0.18	0.44	47.37	0.03	368.63
27a	9/23	1999	2	12.4	1.31	6.75	7.02	30.97	10.17	40.0	0.03	0.33	0.25	0.27	48.84	0.01	420.14
27a	10/25	1999	2	7	0.80	5.78	8.5	9.86	0.00	154.5	0.04	0.21	0.57	0.69	25.82	0.04	225.02
27a	11/20	1999	3	7.5	0.83	5.49	6.12	12.01	12.00	1081.0	0.02	0.30	0.57	0.64	19.92	0.02	251.21
27a	12/21	1999	3	4.6	0.47	5.37	5.32	5.93	11.98	1945.7	0.05	0.91	0.50	0.46	15.46	0.04	118.91
27a	1/31	2000	3	3.4	0.33	6.65	5.87	18.92	8.70	4741.4	0.04	0.27	0.47	0.51	22.74	0.03	115.31
27a	2/24	2000	1	15.6	0.16	4.7	4.6	3.66	21.73	8077.5	0.07	1.75	3.11	0.42	3.33	0.05	141.35
27a	3/31	2000	1	15.5	0.55	5.13	5.21	5.15	9.00	5639.4	0.07	0.64	0.36	0.38	10.01	0.01	84.49
27a	4/25	2000	1	15.5	0.62	5.33	5.27	5.13	10.15	4613.5	0.07	0.65	0.41	0.38	10.08	0.02	96.42
27a	5/24	2000	1	24.6	0.52	6.57	6.15	8.21	7.07	9294.0	0.05	0.22	0.27	0.54	10.41	0.01	84.10
27a	6/21	2000	2	24.5	0.26	6.75	6.21	7.66	7.18	6344.0	0.07	0.17	0.37	0.62	4.05	0.03	26.34
27a	7/26	2000	2	25.4	0.69	4.42	5.08	4.51	25.71	7116.0	0.08	0.98	7.13	0.90	10.06	0.02	110.49
27a	8/24	2000	2	20.8	1.08	6.24	6.01	11.07	3.99	811.0	0.04	0.16	0.13	0.73	18.43	0.02	211.42
27a	9/20	2000	2	25.9	1.06	3.82	3.92	0	143.30	357.1	0.42	3.72	27.40	1.96	18.90	0.04	107.72

Chemistry Data

Site 26		Reedsville															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
26	3/18	1999	1	4.7	0.12	5.96	.	12.08	3.73	.	0.00	0.14	0.00	0.09	2.14	0.01	11.90
26	4/15	1999	1	14.1	0.15	6.44	7.08	15.09	2.92	.	0.09	0.24	0.17	0.23	4.37	0.01	21.33
26	5/26	1999	1	15	0.66	6.85	6.78	0.85	4.15	1343.6	0.10	0.21	0.21	0.39	15.29	0.00	144.13
26	6/25	1999	2	18.1	1.26	6.12	6.99	21.28	6.01	1242.5	0.05	0.19	0.35	0.67	27.21	0.07	265.40
26	7/15	1999	2	19.7	0.79	6.48	6.95	64.85	9.99	815.0	0.03	0.21	0.17	0.29	16.74	0.04	131.93
26	8/17	1999	2	21.5	1.50	6.75	6.06	55.57	13.28	490.6	0.07	0.10	0.32	0.43	32.94	0.03	273.14
26	9/23	1999	2	13.1	1.39	6.88	7.02	52.24	14.45	902.2	0.05	0.28	0.27	0.28	46.38	0.02	380.86
26	10/25	1999	2	9.6	0.69	6.59	7.22	43.95	.	451.1	0.12	0.09	0.09	0.43	18.44	0.05	162.27
26	11/20	1999	3	7.4	0.59	6.31	6.51	37.27	12.53	1515.0	0.02	0.24	0.34	0.49	14.78	0.04	165.66
26	12/21	1999	3	4.3	0.24	6.21	6.5	16.86	6.25	3569.0	0.01	0.18	0.22	0.28	7.82	0.05	55.14
26	1/31	2000	3	3.2	0.29	6.72	5.9	21.32	21.91	7356.3	0.07	0.20	0.61	0.39	13.80	0.07	46.30
26	2/24	2000	1	13.8	0.13	5.95	5.8	8.15	9.04	11997.0	0.03	0.40	0.32	0.25	3.63	0.04	45.36
26	3/31	2000	1	16.6	0.30	6.33	6.09	12.31	46.30	9951.0	0.04	0.16	0.06	0.21	5.79	0.03	38.80
26	4/25	2000	1	15.4	0.33	6.03	6.03	13.12	6.37	8610.0	0.03	0.13	0.16	0.24	6.24	0.03	46.56
26	5/24	2000	1	22.9	0.26	6.75	5.9	19.08	6.03	13121.0	0.01	0.09	0.10	0.28	5.62	0.03	43.78
26	6/21	2000	2	24.3	0.17	6.58	6.81	16.83	4.24	14926.0	0.04	0.15	0.30	0.28	3.01	0.03	14.44
26	7/26	2000	2	24.7	0.40	5.92	6.71	19.26	9.99	11247.0	0.05	0.26	1.97	0.50	7.67	0.03	65.84
26	8/24	2000	2	21.2	0.90	6.43	6.61	28.66	5.32	2121.0	0.05	0.16	0.07	0.54	12.94	0.03	142.28
26	9/20	2000	2	22.8	0.69	5.84	.	20.95	30.17	1409.0	0.11	0.39	5.84	1.17	13.86	0.04	78.13

Chemistry Data

site 25b	Reedsville										0.20	0.61	0.39				
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
25b	3/18	1999	1	4.5	0.16	6.42	.	21.34	2.68	.	0.00	0.15	0.05	0.22	3.59	0.01	14.02
25b	4/15	1999	1	14.2	0.15	6.5	7.04	13.32	2.31	.	0.03	0.21	0.31	0.46	6.16	0.01	18.35
25b	5/26	1999	1	15.9	0.19	6.38	6.82	28.12	4.52	860.8	0.09	0.14	0.34	0.53	7.79	0.00	23.49
25b	6/25	1999	2	20.5	0.22	6.45	7.22	25.31	3.87	860.8	0.04	0.14	0.84	0.39	8.78	0.05	25.92
25b	7/15	1999	2	22.6	0.21	6.75	6.64	29.01	4.59	878.3	0.04	0.16	0.11	0.21	8.81	0.02	22.37
25b	8/17	1999	2	22.8	0.22	6.57	7.83	45.24	13.18	.	0.03	0.05	0.28	0.24	7.75	0.19	31.03
25b	9/23	1999	2	17.5	0.20	7.01	7.05	50.24	10.11	860.8	.	0.32	0.54	0.25	9.18	0.04	36.54
25b	10/25	1999	2	9.3	0.17	6.65	6.85	33.84	.	.	0.02	0.18	0.33	0.15	8.48	0.03	24.09
25b	11/20	1999	3	7	0.17	.	6.46	27.35	7.51	.	0.03	0.23	0.72	0.46	9.92	0.04	30.66
25b	12/21	1999	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25b	1/31	2000	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25b	2/24	2000	1	15.5	0.18	6.35	6.12	12.91	5.64	.	0.04	0.26	0.13	0.35	6.26	0.03	25.31
25b	3/31	2000	1	17.6	0.20	6.21	6.09	10.15	.	.	0.06	0.33	0.09	0.40	6.24	0.01	18.64
25b	4/25	2000	1	14.8	0.20	6.07	6.09	15.17	10.05	.	.	0.22	0.12	0.38	6.55	0.04	19.37
25b	5/24	2000	1	22.8	0.18	6.71	5.92	31.6	7.41	.	0.01	0.13	0.16	0.64	6.82	0.01	20.07

Chemistry Data

site 25a																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
25a	3/18	1999	1	4.9	0.13	5.76	.	11.64	4.68	.	0.02	0.20	0.11	0.11	2.39	0.01	12.35
25a	4/15	1999	1	13.4	0.16	5.32	6.12	8.33	9.53	.	0.09	0.39	0.87	0.32	5.11	0.01	21.80
25a	5/26	1999	1	15.5	0.65	6.25	6.61	22.43	14.03	2189.2	0.06	0.18	1.95	0.51	15.03	0.00	138.16
25a	6/25	1999	2	20.3	1.22	4.8	5.4	6.36	21.01	1843.9	0.13	0.83	3.41	0.84	28.36	0.02	253.77
25a	7/15	1999	2	20	0.49	4.27	4.22	0.24	39.26	1025.0	0.13	2.97	4.84	0.73	13.55	0.03	61.17
25a	8/17	1999	2	22.5	1.19	5.3	5.46	11.5	45.55	618.1	0.09	0.37	4.96	0.57	26.99	0.03	202.55
25a	9/23	1999	2	15.5	1.20	5.7	6.25	19.47	31.95	881.0	0.08	1.19	4.11	0.70	39.93	0.03	292.25
25a	10/25	1999	2	6.3	0.53	5.48	6.63	33.78	33.83	821.4	0.04	0.37	4.08	0.56	17.58	0.04	124.26
25a	11/20	1999	3	6.2	0.65	5.7	6.19	21.37	26.46	9125.2	0.07	0.36	4.68	0.77	17.72	0.03	182.40
25a	12/21	1999	3	4.2	0.40	5.48	5.9	9.11	12.40	6076.0	0.07	1.11	1.33	0.38	2.19	0.08	9.22
25a	1/31	2000	3	6.8	0.59	6.1	5.7	4.26	21.91	11325.0	0.08	0.24	1.34	0.46	13.62	0.04	59.31
25a	2/24	2000	1	13.6	0.14	5.36	5.52	6.42	13.12	14963.0	0.10	0.24	0.61	0.28	4.17	0.04	16.12
25a	3/31	2000	1	15.9	0.33	5.43	5.51	5.8	.	11000.0	0.07	0.53	2.18	0.73	13.95	0.02	102.34
25a	4/25	2000	1	16	0.32	5.63	5.63	6.98	11.03	14977.0	0.08	0.32	0.56	0.30	6.69	0.00	42.39
25a	5/24	2000	1	20.6	0.28	6.3	5.98	9.63	16.28	21103.0	0.03	0.04	0.32	0.35	5.91	0.03	36.74
25a	6/21	2000	2	24.6	0.18	6.25	4.48	2.11	8.82	22000.0	0.05	0.12	0.56	0.29	0.31	0.04	14.44
25a	7/26	2000	2	23.1	0.35	5.21	5.93	9.74	17.71	17554.0	0.08	0.31	1.87	0.54	8.24	0.05	52.94
25a	8/24	2000	2	20.2	0.87	5.53	.	8.62	6.94	2922.0	0.12	0.17	1.18	0.66	12.52	0.04	118.12
25a	9/20	2000	2	23.2	0.58	5.66	.	15.75	24.62	1550.0	0.07	0.24	1.36	0.85	10.87	0.04	62.26

Chemistry Data

site 24																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
24	3/18	1999	1	7	0.08	5.36	.	5.83	4.55	.	0.01	0.18	0.21	0.21	1.58	0.03	7.10
24	4/15	1999	1	16	0.06	4.73	5.32	4.21	7.36	.	0.03	0.36	1.17	0.22	1.41	0.04	5.76
24	5/26	1999	1	16.3	0.07	5	5.38	23.31	8.60	209.2	0.07	0.25	1.43	0.35	1.57	0.02	6.48
24	6/25	1999	2	20.5	0.24	4.1	4.35	0	72.68	28.1	0.07	1.02	13.26	0.83	6.58	0.05	38.77
24	7/15	1999	2	22.9	0.92	3.33	3.25	0	213.99	26.0	0.15	8.26	56.63	3.00	16.51	0.05	58.38
24	8/17	1999	2	27.6	1.19	2.86	3.15	0	494.90	1.7	0.22	13.46	64.07	3.25	19.28	0.05	67.27
24	9/23	1999	2	20.4	0.74	2.9	3.35	0	318.85	1.7	0.21	12.33	36.23	3.00	18.39	0.02	71.07
24	10/25	1999	2	9.2	0.30	3.25	4.07	0	78.77	184.7	0.44	5.82	6.71	2.08	8.18	0.07	34.35
24	11/20	1999	3	6.9	0.19	4.12	4.1	0	44.02	474.0	0.22	3.48	2.92	1.06	5.64	0.05	21.10
24	12/21	1999	3	3.4	0.07	4.75	4.87	5.14	1.23	2430.0	0.03	0.42	0.86	0.36	8.58	0.05	49.64
24	1/31	2000	3	3.2	0.11	4.93	4.9	16.43	18.16	4189.0	0.11	0.65	2.89	0.42	2.12	0.07	25.90
24	2/24	2000	1	14.6	0.09	4.49	4.36	1.7	22.00	5963.0	0.13	1.34	3.20	0.42	3.18	0.01	35.20
24	3/31	2000	1	17.8	0.09	4.82	4.95	4.04	.	3712.0	0.09	0.65	0.54	0.23	1.92	0.05	6.82
24	4/25	2000	1	18.3	0.09	4.61	4.81	3.67	11.18	3997.0	0.12	0.66	0.87	0.25	1.92	0.05	5.88
24	5/24	2000	1	24.2	0.06	4.8	4.96	24.14	7.58	4290.0	0.04	0.24	0.41	0.27	1.40	0.03	4.25
24	6/21	2000	2	25.4	0.06	6.53	4.67	2.85	8.79	1690.0	0.04	0.26	0.66	0.25	1.32	0.04	4.99
24	7/26	2000	2	24.4	0.06	4.3	4.82	3.21	12.07	2114.0	0.11	0.26	1.21	0.24	1.73	0.05	7.04
24	8/24	2000	2	20.5	0.11	6.18	.	15.96	14.03	236.0	0.07	0.23	1.23	0.22	2.21	0.04	10.24
24	9/20	2000	2	23.2	0.16	5.66	.	9.31	18.11	35.1	0.02	0.22	1.66	0.30	2.87	0.05	11.95

Chemistry Data

site 23		Dillan Creek															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
23	3/18	1999	1	4.9	0.08	6.44	.	26.25	7.04	.	0.02	0.15	0.25	0.22	4.75	0.02	23.48
23	4/15	1999	1	13.8	0.16	5.87	6.73	13.51	6.46	.	0.08	0.15	0.40	0.40	5.71	0.02	23.35
23	5/26	1999	1	16.6	0.24	4.78	4.92	4.67	18.12	869.1	0.18	1.13	0.81	1.08	8.94	0.01	31.95
23	6/25	1999	2	20.3	0.41	6.6	7.77	53.96	2.21	164.1	0.04	0.32	1.06	0.66	15.09	0.03	55.96
23	7/15	1999	2	22.5	0.48	7	7.55	50.26	1.47	112.4	0.04	0.73	0.13	0.10	18.75	0.04	66.33
23	8/17	1999	2	22.5	0.46	6.45	6.24	34.21	3.44	23.7	0.01	0.41	0.41	0.06	16.58	0.05	62.72
23	9/23	1999	2	.	.	.	.	.	.	184.3	.	.	.	.	.	.	.
23	10/25	1999	2	4.1	0.30	5.84	5.64	14.54	10.87	577.1	0.07	0.24	0.08	1.74	17.26	0.06	59.39
23	11/20	1999	3	6.1	0.24	.	6.3	21.9	11.05	1944.0	0.09	0.21	0.72	1.45	11.65	0.05	45.41
23	12/21	1999	3	3.9	0.13	5.46	5.6	6.33	.	4220.0	0.05	0.71	0.79	0.46	6.47	0.06	23.68
23	1/31	2000	3	5.2	0.29	6.06	5.78	15.68	16.76	12963.0	0.08	0.23	0.57	0.57	8.26	0.05	38.60
23	2/24	2000	1	14.2	0.22	5.08	4.87	5.25	27.80	20579.2	0.10	1.59	1.75	0.48	6.89	0.06	39.40
23	3/31	2000	1	14.8	0.23	5.13	5.17	5.06	14.85	15527.0	0.12	0.78	0.88	0.42	6.39	0.03	24.87
23	4/25	2000	1	19.5	0.27	5.86	5.95	13.45	8.58	.	.	0.21	0.79	0.43	8.22	0.03	32.33
23	5/24	2000	1	19.6	0.18	5.51	5.04	4.71	18.11	9722.0	0.07	0.94	0.36	0.56	6.35	0.03	21.37
23	6/21	2000	2	25.5	0.29	6.83	7.26	32.76	8.71	12160.0	0.12	0.14	0.35	0.46	7.22	0.05	28.72
23	7/26	2000	2	24	0.22	6.05	6.91	27.53	6.11	5431.0	0.08	0.23	0.29	0.44	7.63	0.04	32.23
23	8/24	2000	2	20.2	0.37	6.29	.	40.36	3.86	1796.0	0.09	0.13	0.09	0.65	11.80	0.04	43.24
23	9/20	2000	2	21.6	0.42	5.93	.	24.02	7.39	1449.0	0.09	0.18	0.07	1.00	14.22	0.05	41.16

Chemistry Data

site 22																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
22	3/18	1999	1	5.3	0.17	6.09	.	19.61	5.51	.	0.02	0.15	0.12	0.16	3.58	0.01	18.05
22	4/15	1999	1	14.9	0.16	5.78	6.82	14.8	5.74	.	0.06	0.27	0.43	0.40	5.12	0.02	22.79
22	5/26	1999	1	17.8	0.46	6	6.93	15.86	9.98	.	0.17	0.19	0.46	0.71	11.78	0.02	82.35
22	6/25	1999	2	23.9	1.17	6.37	6.57	.	5.82	.	0.07	0.06	0.42	0.65	24.46	0.06	196.81
22	7/15	1999	2	22.6	0.47	7.09	7.35	67.1	2.63	.	0.06	0.37	0.45	0.25	18.64	0.03	63.56
22	8/17	1999	2	28	1.62	6.18	7.65	10.84	5.32	.	0.03	0.18	0.19	0.35	28.32	0.04	228.26
22	9/23	1999	2	17.7	1.32	5.6	6.34	13.95	9.48	.	0.07	0.51	0.36	0.53	42.04	0.04	33.51
22	10/25	1999	2	3.9	0.46	5.2	6.51	20.61	13.98	.	0.06	0.18	0.49	0.73	16.34	0.04	109.76
22	11/20	1999	3	12.4	0.51	6.33	6.49	18.8	35.35	.	0.08	0.28	1.21	1.22	15.33	0.04	115.79
22	12/21	1999	3	5.6	0.21	6.21	6.05	14.53	27.50	.	0.03	0.15	0.69	0.44	7.95	0.06	41.87
22	1/31	2000	3	12.7	0.39	6.18	5.84	19.53	16.51	.	0.07	0.25	0.85	0.55	11.06	0.05	70.50
22	2/24	2000	1	14.9	0.16	5.78	5.75	8.18	13.37	.	0.10	0.31	2.21	0.37	5.39	0.05	74.30
22	3/31	2000	1	15.6	0.27	5.82	5.9	10.12	.	.	0.13	0.26	0.58	0.33	6.26	0.03	29.83
22	4/25	2000	1	17.2	0.29	6.07	6.03	15.52	13.83	.	.	0.17	0.65	0.37	7.79	0.03	36.12
22	5/24	2000	1	20.5	0.22	6.41	5.9	11.36	10.98	.	0.05	0.09	0.22	0.47	7.07	0.03	28.16
22	6/21	2000	2	25.5	0.25	6.64	6.82	18.63	5.36	.	0.04	0.15	0.24	0.37	6.18	0.03	25.19
22	7/26	2000	2	25.5	0.29	5.97	6.79	22.24	7.71	.	0.07	0.28	0.72	0.45	7.75	0.03	41.01
22	8/24	2000	2	20.4	0.58	6.24	.	26.36	4.39	.	0.07	0.19	0.36	0.59	11.41	0.04	72.68
22	9/20	2000	2	23.9	0.51	5.89	.	26.66	6.71	.	0.04	0.15	0.07	0.62	12.77	0.05	81.14

Chemistry Data

site 21		Masontown															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
21	3/18	1999	1	4.9	0.16	5.59	.	11.36	7.12	.	0.00	0.07	0.18	0.22	3.47	0.01	16.47
21	4/15	1999	1	12.2	0.15	4.76	5.37	4.78	9.85	.	0.05	0.55	1.20	0.43	4.97	0.02	20.40
21	5/26	1999	1	15.5	0.48	6.09	6.71	14.19	8.70	3203.3	0.13	0.22	0.79	0.62	11.56	0.01	91.66
21	6/25	1999	2	19.9	0.84	4.76	5	5.71	23.29	2111.3	0.52	1.42	1.25	0.99	24.46	0.04	138.01
21	7/15	1999	2	20.4	0.72	4.3	4.41	2.16	39.60	965.1	0.16	5.52	0.45	1.39	19.69	0.05	119.50
21	8/17	1999	2	22.7	1.56	6.11	5.74	20.59	14.26	789.5	0.03	0.16	0.59	0.65	37.05	0.04	294.29
21	9/23	1999	2	15	1.02	6.63	6.48	34.77	27.72	659.9	0.13	0.63	0.93	0.88	28.72	0.06	233.91
21	10/25	1999	2	5.2	0.50	4.96	5.44	7.1	21.40	933.2	0.10	0.92	0.72	1.22	17.17	0.05	113.72
21	11/20	1999	3	7.1	0.48	4.82	5.23	6.08	22.90	3143.4	0.15	1.06	0.90	1.21	16.21	0.04	128.24
21	12/21	1999	3	4.1	0.21	4.93	5.17	5.38	16.62	23101.0	0.04	0.83	1.16	0.47	7.96	0.05	42.78
21	1/31	2000	3	3.6	0.47	4.83	5.23	7.32	25.29	19539.0	0.06	0.85	2.03	0.66	11.19	0.05	89.51
21	2/24	2000	1	13.1	0.17	4.89	4.71	4.45	26.06	25697.0	0.19	1.15	25.19	0.90	4.76	0.05	75.95
21	3/31	2000	1	16.3	0.29	4.88	4.9	4.43	15.83	49479.0	0.11	1.18	0.90	0.36	6.04	0.03	30.27
21	4/25	2000	1	18.1	0.29	5.08	5.06	4.72	13.45	26291.6	0.12	0.99	1.46	0.42	7.09	0.04	35.19
21	5/24	2000	1	20.7	0.23	6.48	5.7	6.27	10.08	30468.0	0.04	0.13	0.38	0.46	6.54	0.02	30.72
21	6/21	2000	2	26.5	0.19	6.41	5.99	7.05	12.92	51780.0	0.05	0.24	0.95	0.44	4.57	0.04	16.53
21	7/26	2000	2	24.7	0.26	5.81	6.18	8.57	10.80	18774.0	0.15	0.26	1.34	0.55	7.35	0.04	35.26
21	8/24	2000	2	22.3	0.61	5.29	.	6.53	14.75	7221.0	0.22	0.35	1.00	0.67	11.05	0.04	74.47
21	9/20	2000	2	21.7	0.73	5.63	.	13.65	11.71	3255.0	0.06	0.09	0.57	0.79	13.32	0.04	85.72

Chemistry Data

site 20		Cascade															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
20	3/18	1999	1	5	0.18	5.99	.	13.02	6.65	.	0.04	0.17	0.18	0.23	3.73	0.01	17.61
20	4/15	1999	1	13	0.15	4.81	5.46	4.86	9.45	.	0.05	0.48	0.97	0.41	5.01	0.02	20.50
20	5/26	1999	1	17.3	0.50	5.73	6.8	15.09	6.35	3385.1	0.07	0.21	0.29	0.63	12.29	0.01	95.46
20	6/25	1999	2	21	0.86	5.83	6.44	9.85	9.39	1421.1	0.12	0.60	0.47	1.08	20.87	0.03	149.53
20	7/15	1999	2	21.8	0.77	5.3	5.33	4.82	9.31	1495.3	0.09	0.83	0.24	1.19	19.19	0.05	125.60
20	8/17	1999	2	24	1.53	5.88	5.53	8.78	8.91	1141.1	0.05	0.00	0.48	0.95	28.91	0.05	288.65
20	9/23	1999	2	17.9	0.97	6.64	6.22	14.39	12.69	899.8	0.10	0.35	0.29	0.94	26.04	0.05	213.68
20	10/25	1999	2	5.1	0.39	4.91	5.78	8.56	15.90	1141.1	0.09	0.43	1.17	1.14	13.32	0.04	86.12
20	11/20	1999	3	11.7	0.48	4.98	5.67	7.58	17.76	3174.0	0.13	0.52	0.60	1.20	15.40	0.05	119.35
20	12/21	1999	3	5	0.25	4.98	5.94	10.24	12.63	30554.0	0.05	0.23	1.00	0.49	7.92	0.05	46.25
20	1/31	2000	3	4.9	0.50	5.38	5.25	7.04	21.95	20599.0	0.05	0.73	1.57	0.64	11.58	0.04	88.95
20	2/24	2000	1	10	0.29	5.08	5.01	6.29	18.84	26993.0	0.09	1.40	1.63	0.50	8.37	0.04	102.31
20	3/31	2000	1	15.4	0.29	4.98	4.92	4.59	14.95	49713.0	0.10	1.24	0.77	0.37	6.39	0.02	30.90
20	4/25	2000	1	18	0.31	5.23	5.05	4.63	8.39	28003.5	0.10	1.31	1.65	0.43	6.96	0.04	36.43
20	5/24	2000	1	22.3	0.24	6.65	5.75	6.61	8.96	30268.0	0.12	0.16	0.34	0.46	6.41	0.03	30.56
20	6/21	2000	2	25.5	0.19	6.63	6.52	6.35	9.66	54023.0	0.39	0.62	0.54	0.18	2.60	0.03	12.82
20	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20	8/24	2000	2	22.8	0.61	5.38	.	7.23	9.42	7213.0	0.07	0.16	0.37	0.69	10.95	0.05	71.00
20	9/20	2000	2	22.3	0.70	5.81	.	12.1	8.24	3975.0	0.06	0.15	0.10	0.77	11.74	0.04	80.89

Chemistry Data

site 19																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
19	3/18	1999	1	5.5	0.17	6.6	.	15.01	1.80	.	0.01	0.17	0.10	0.16	3.41	0.01	16.94
19	4/15	1999	1	13.6	0.15	5.66	6.73	7.13	3.47	.	0.11	0.18	0.72	0.36	4.63	0.01	20.43
19	5/26	1999	1	16.2	0.46	6.31	6.94	16.75	3.17	4853.7	0.11	0.25	0.35	0.53	10.17	0.01	79.36
19	6/25	1999	2	23.7	0.84	6.66	7.06	10.69	2.78	3786.0	0.08	0.20	0.47	1.08	18.38	0.06	138.33
19	7/15	1999	2	24	0.82	2.2	5.53	4.71	3.40	3291.1	0.09	0.26	0.13	1.27	16.99	0.04	111.72
19	8/17	1999	2	24.4	1.38	6.27	5.54	7.17	5.02	1274.6	0.04	0.07	0.14	1.29	26.89	0.08	253.57
19	9/23	1999	2	20.5	0.96	6.7	6.39	11.34	5.51	915.8	0.09	0.41	0.25	1.17	24.08	0.05	186.99
19	10/25	1999	2	4.6	0.38	5.25	6.66	13.75	3.87	1274.3	0.10	0.16	0.17	1.14	12.56	0.06	76.99
19	11/20	1999	3	8.5	0.45	5.1	6.27	10.07	4.47	4490.0	0.07	0.29	0.32	1.12	14.47	0.06	106.88
19	12/21	1999	3	5.2	0.19	5.31	6.66	6.52	6.06	29858.5	0.03	0.14	0.78	0.42	7.13	0.05	37.31
19	1/31	2000	3	3.8	0.41	5.22	5.27	5.98	11.69	19687.0	0.05	0.24	1.17	0.60	9.54	0.04	79.12
19	2/24	2000	1	8.2	0.24	5.37	5.91	5.27	10.63	27142.0	0.03	0.80	1.36	0.44	7.41	0.05	36.79
19	3/31	2000	1	13.7	0.25	5.11	5.04	4.28	8.90	50976.0	0.08	0.51	0.55	0.81	5.65	0.02	27.37
19	4/25	2000	1	18.7	0.29	5.43	5.25	4.55	6.85	28009.1	0.08	0.44	1.03	0.38	6.40	0.05	32.76
19	5/24	2000	1	19.3	0.23	6.74	6.07	7.34	3.27	31789.0	0.05	0.16	0.18	0.40	5.88	0.02	28.43
19	6/21	2000	2	25.1	0.19	6.68	6.74	7.11	2.16	56035.0	0.03	0.09	0.37	0.39	4.16	0.04	16.68
19	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19	8/24	2000	2	22.4	0.53	5.85	.	7.66	2.30	7677.0	0.10	0.18	0.04	0.61	10.47	0.05	60.64
19	9/20	2000	2	.	.	.	.	9.1	10.53	4041.0	0.10	0.13	0.06	0.67	12.88	0.04	81.11

Chemistry Data

site 18		Dry Run															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
18	3/18	1999	1	5.2	0.06	6.23	.	7.74	1.35	.	0.02	0.23	0.00	0.00	1.22	0.01	5.55
18	4/15	1999	1	12.4	0.04	5.7	7.27	9.98	0.43	.	0.02	0.24	0.00	0.00	1.36	0.02	6.50
18	5/26	1999	1	12.5	0.06	5.9	7.41	16.77	.		0.01	0.21	0.08	0.00	1.60	0.03	8.70
18	6/25	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	7/15	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	8/17	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	9/23	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	10/25	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	11/20	1999	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	12/21	1999	3	5.2	0.05	5.99	6.93	11.55	2.59	117.0	0.00	0.02	0.05	0.00	1.72	0.06	8.67
18	1/31	2000	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	2/24	2000	1	9.1	0.04	6.5	6.78	11.21	5.03	855.0	0.02	0.05	0.19	0.02	1.83	0.04	7.72
18	3/31	2000	1	14.7	0.06	6.74	6.18	10.05	.	1109.0	0.05	0.17	0.00	0.00	1.50	0.03	7.35
18	4/25	2000	1	17.3	0.06	6.2	6.1	9.7	4.12	518.0	0.03	0.24	0.12	0.01	1.65	0.04	8.21
18	5/24	2000	1	19.1	0.05	6.77	6.3	11.07	1.06	704.0	0.03	0.17	0.00	0.00	1.41	0.02	6.73
18	6/21	2000	2	22.4	0.06	6.9	7.26	15.89	1.46	275.0	0.01	0.15	0.09	0.00	1.38	0.04	6.62
18	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	8/24	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	9/20	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Chemistry Data

site 17		Greer															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
17	3/18	1999	1	5.3	0.16	6.69	.	14.79	1.30	.	0.00	0.14	0.09	0.17	3.35	0.01	16.18
17	4/15	1999	1	14.1	0.15	5.71	6.92	8.68	2.67	.	0.03	0.18	0.67	0.36	4.83	0.03	20.63
17	5/26	1999	1	16.4	0.47	6.7	7.15	21.14	1.94	5913.2	0.05	0.19	0.05	0.55	11.11	0.02	86.84
17	6/25	1999	2	21.7	0.85	7.15	7.75	30.89	2.11	3906.3	0.07	0.33	0.42	0.93	18.53	0.06	129.32
17	7/15	1999	2	23.7	0.87	6.8	7.01	26.26	1.30	896.1	0.06	0.42	0.53	0.92	19.71	0.06	124.16
17	8/17	1999	2	20.6	1.18	7.22	7.06	5.9	5.00	678.0	0.00	0.00	0.14	0.44	26.41	0.01	28.88
17	9/23	1999	2	19.4	0.90	7.28	7.14	57.18	6.35	616.8	0.04	0.09	0.07	0.83	25.14	0.05	183.34
17	10/25	1999	2	5.9	0.43	6.41	7.18	34.12	3.42	1332.6	0.08	0.17	0.48	1.05	14.13	0.06	91.60
17	11/20	1999	3	9	0.48	6.67	7.78	13.84	4.33	4208.0	0.10	0.24	0.18	1.34	16.41	0.06	115.19
17	12/21	1999	3	3.8	0.15	6.05	5.75	5.92	12.55	26586.0	0.07	0.54	0.88	0.49	5.67	0.06	26.86
17	1/31	2000	3	2.2	0.48	6.01	5.78	8.36	7.77	23447.0	0.05	0.17	1.13	0.60	9.68	0.04	.
17	2/24	2000	1	6.9	0.22	6.7	6.41	5.68	9.63	29333.0	0.05	0.66	1.32	0.44	7.83	0.05	39.43
17	3/31	2000	1	14.4	0.26	5.63	5.39	5.23	8.08	51187.0	0.08	0.44	0.56	0.32	5.71	0.03	29.81
17	4/25	2000	1	16.4	0.27	5.71	5.76	5.6	8.09	28590.0	0.08	0.27	1.02	0.39	6.51	0.05	33.50
17	5/24	2000	1	20.6	0.22	6.82	6.22	11.77	3.01	32729.0	0.03	0.14	0.16	0.39	5.97	0.03	29.57
17	6/21	2000	2	27	0.20	6.99	7.11	12.23	1.62	53900.0	0.04	0.10	0.25	0.35	4.36	0.04	17.33
17	7/26	2000	2	23	0.33	5.4	6.58	10.69	2.96	24997.0	0.05	0.23	0.53	0.55	8.20	0.04	51.56
17	8/24	2000	2	21.9	0.49	6.18	6.95	13.61	1.91	7935.0	0.08	0.11	0.03	0.51	9.60	0.05	55.62
17	9/20	2000	2	17.3	0.63	6.07	6.83	21.87	5.52	4530.0	0.05	0.14	0.02	0.58	12.30	0.05	80.54

Chemistry Data

site 16																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
16	3/18	1999	1	5.4	0.16	6.93	.	16.15	1.32	.	0.03	0.16	0.07	0.17	3.55	0.02	17.08
16	4/15	1999	1	14.7	0.16	5.89	7.07	9.79	1.50	.	0.05	0.24	0.44	0.36	4.73	0.03	21.94
16	5/26	1999	1	16.5	0.46	7.2	7.14	23.81	2.70	2209.5	0.05	0.20	0.09	0.52	11.12	0.03	85.46
16	6/25	1999	2	21.1	0.83	7.57	7.81	36.76	2.12	2208.8	0.03	0.27	0.24	0.66	18.79	0.05	132.87
16	7/15	1999	2	22	0.80	7.36	7.92	28.92	1.59	1879.3	0.04	0.27	0.19	0.63	19.71	0.06	129.58
16	8/17	1999	2	20	1.15	7.52	7.02	5.05	3.49	687.9	0.02	0.03	0.19	0.04	24.91	0.09	215.95
16	9/23	1999	2	17.7	0.88	7.72	7.54	73.65	5.21	810.9	0.07	0.12	0.06	0.04	22.30	0.06	164.30
16	10/25	1999	2	5.2	0.43	6.93	7.44	40.23	2.36	1452.2	0.07	0.66	1.99	0.79	13.28	0.07	86.41
16	11/20	1999	3	10.3	0.34	6.58	6.4	22.4	12.57	4849.0	.	.	.	.	.	.	.
16	12/21	1999	3	3.7	0.15	6.48	6.84	9.16	5.47	30846.0	.	.	.	.	.	.	.
16	1/31	2000	3	5.7	0.98	6.23	6.2	10.72	11.68	23963.0	0.04	0.13	1.04	0.54	10.18	0.04	85.32
16	2/24	2000	1	7	0.25	6.7	6.79	5.83	8.21	30014.0	0.04	0.39	1.29	0.47	8.62	0.05	44.31
16	3/31	2000	1	13.4	0.26	5.99	5.65	6.35	5.55	51118.0	0.11	0.22	0.45	0.30	5.82	0.03	30.85
16	4/25	2000	1	17.7	0.28	5.86	5.89	6.52	5.22	29988.0	0.01	0.13	0.95	0.37	6.71	.	34.62
16	5/24	2000	1	22.1	0.23	6.83	6.23	11.01	1.74	32395.0	0.04	0.11	0.10	0.38	6.15	0.04	30.25

Chemistry Data

site 15																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
15	3/18	1999	1	5.6	0.17	6.85	.	18.79	1.42	.	0.02	0.11	0.00	0.14	3.19	0.00	16.95
15	4/15	1999	1	15.4	0.16	6.13	7.26	11.48	1.24	.	0.04	0.23	0.36	0.30	5.27	0.03	24.94
15	5/26	1999	1	15.8	0.46	7.4	7.9	27.14	2.94		0.07	0.27	0.10	0.41	11.41	0.02	90.62
15	6/25	1999	2	22.7	0.84	7.55	7.82	43.48	2.13	2680.2	0.05	0.22	0.27	0.23	17.88	0.06	133.70
15	7/15	1999	2	19.7	0.80	7.32	7.13	46.37	4.12	1914.6	0.07	0.14	0.02	0.02	18.95	0.08	123.35
15	8/17	1999	2	20	1.06	7.9	7.67	5.7	1.13	737.2	0.05	0.00	0.14	0.00	21.16	0.11	194.46
15	9/23	1999	2	20.7	0.93	8.19	7.94	81.38	3.36	720.1	0.03	0.11	0.03	0.00	19.71	0.09	150.66
15	10/25	1999	2	14.2	0.54	7.69	7.13	52.53	1.02	1571.1	0.04	0.26	0.12	0.02	14.27	0.06	88.82
15	11/20	1999	3	10.8	0.48	6.93	6.58	25.8	6.84	5017.0	0.09	0.20	0.05	0.66	13.65	0.05	95.00
15	12/21	1999	3	3.7	0.15	6.53	6.9	8.58	5.03	31246.0	0.02	0.35	0.40	0.24	10.65	0.05	75.84
15	1/31	2000	3	5.9	0.61	6.5	6.7	12.41	6.71	25777.0	0.05	0.14	1.04	0.54	10.10	0.04	56.30
15	2/24	2000	1	7.5	0.23	5.28	6.3	7.03	6.33	29997.0	0.04	0.15	1.15	0.43	8.00	0.05	42.12
15	3/31	2000	1	12.3	0.26	6.45	5.88	8.99	4.16	51307.0	0.07	0.45	0.01	0.09	1.09	0.03	4.16
15	4/25	2000	1	20.3	0.35	5.91	5.78	23.78	4.01	31559.0	0.10	0.69	1.06	0.38	7.30	0.05	39.10
15	5/24	2000	1	20.4	0.23	6.83	6.3	12.54	2.79	35520.0	0.04	0.11	0.06	0.35	5.28	0.04	31.45
15	6/21	2000	2	26.5	0.21	6.98	7.39	17.65	1.26	58700.0	0.02	0.15	0.06	0.26	4.35	0.03	18.32
15	7/26	2000	2	21.7	0.33	6.11	6.8	15.8	0.15	25331.0	0.06	0.27	0.60	0.44	8.13	0.06	51.46
15	8/24	2000	2	21.9	0.45	6.59	7.41	34.39	1.58	8028.0	0.05	0.16	0.02	0.24	9.16	0.05	52.20
15	9/20	2000	2	17.7	0.62	6.22	7.35	36.69	5.51	4947.0	0.10	0.13	0.02	0.19	11.33	0.05	79.11

Chemistry Data

site 14		Unnamed tributary															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
14	3/18	1999	1	4.7	0.05	4.65	.	4.01	4.43	.	0.02	0.58	0.00	0.12	1.02	0.02	4.14
14	4/15	1999	1	11.4	0.03	5.88	5.9	4.44	1.71	.	0.05	0.25	0.00	0.10	1.18	0.05	4.17
14	5/26	1999	1	11.7	0.05	6.46	7.28	13.34	.	381.7	0.09	0.13	0.03	0.00	1.43	0.04	8.38
14	6/25	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	7/15	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	8/17	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	9/23	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	10/25	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	11/20	1999	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	12/21	1999	3	3.9	0.03	5.46	5.9	4.49	5.02	942.0	0.00	0.54	0.05	0.12	1.17	0.07	4.47
14	1/31	2000	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	2/24	2000	1	7.9	0.02	5.2	5	4.46	3.86	1250.0	0.00	0.45	0.06	0.15	1.48	0.07	7.50
14	3/31	2000	1	10.8	0.03	5.49	5.21	4.3	3.61	1675.0	0.22	0.19	0.36	0.29	5.55	0.06	29.90
14	4/25	2000	1	16.3	0.04	5.5	6.2	8.87	3.88	649.2	0.06	0.39	0.28	0.12	1.33	0.07	4.29
14	5/24	2000	1	18.6	0.03	6.6	7.2	3.82	5.53	913.0	0.04	0.43	0.04	0.13	0.91	0.06	3.03
14	6/21	2000	2	23.7	0.03	6.83	6.68	5.41	1.56	424.0	0.04	0.12	0.05	0.12	1.08	0.05	4.10
14	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	8/24	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	9/20	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Chemistry Data

site 13		Tibbs Run															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
13	3/18	1999	1	6.2	0.08	5.88	.	8.34	1.73	.	0.05	0.35	0.00	0.09	1.42	0.01	6.83
13	4/15	1999	1	12.7	0.07	5.89	7.34	12.7	0.67	.	0.02	0.12	0.00	0.07	2.00	0.04	9.75
13	5/26	1999	1	13.9	0.07	6.56	7.26	17.35	1.60	381.7	0.02	0.26	0.03	0.01	1.80	0.01	10.15
13	6/25	1999	2	21	0.11	7.35	7.77	38.45	1.47	138.1	0.02	0.11	0.22	0.01	2.71	0.05	22.74
13	7/15	1999	2	20.4	0.14	6.55	7.32	63	1.05	96.3	0.07	0.20	0.03	0.00	2.38	0.08	22.70
13	8/17	1999	2	20.5	0.16	7.18	7.44	7.12	1.54	50.5	0.03	0.00	0.16	0.01	3.12	0.08	35.53
13	9/23	1999	2	19.2	0.13	8.01	7.44	56.89	3.69	134.7	0.04	0.06	0.02	0.00	2.18	0.08	28.45
13	10/25	1999	2	14	0.10	7.31	6.7	37.39	0.78	230.1	0.03	0.24	0.07	0.00	1.95	0.04	16.19
13	11/20	1999	3	12.5	0.09	7.1	6.56	43.36	5.42	561.0	0.01	0.23	0.06	0.02	2.92	0.04	18.62
13	12/21	1999	3	4.4	0.06	6.67	6.89	13.18	1.46	3442.0	0.00	0.34	0.05	0.03	1.67	0.06	9.40
13	1/31	2000	3	1.9	0.15	6.81	6.92	15.57	0.00	2498.0	0.01	0.11	0.00	0.03	2.00	0.06	11.31
13	2/24	2000	1	7.2	0.07	6.73	6.83	12.73	2.28	3025.0	0.03	0.16	0.02	0.10	2.06	0.06	10.98
13	3/31	2000	1	11.3	0.09	6.74	6.13	16.01	0.00	4561.0	0.10	0.25	0.00	0.06	2.15	0.05	11.29
13	4/25	2000	1	17.9	0.10	6.08	6.7	13.98	2.99	1129.0	0.04	0.30	0.00	0.08	2.01	0.06	9.89
13	5/24	2000	1	19.5	0.07	7.01	7.58	17.04	2.72	1309.0	0.02	0.35	0.09	0.08	1.80	0.05	10.04
13	6/21	2000	2	26.2	0.09	7.07	7.49	25.77	1.29	1496.0	0.03	0.11	0.06	0.03	2.03	0.04	12.19
13	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	8/24	2000	2	21.4	0.15	6.73	7.53	42.93	1.59	1440.0	0.04	0.10	0.04	0.03	2.68	0.04	19.18
13	9/20	2000	2	18.5	0.14	6.33	6.8	45.68	4.19	164.6	0.04	0.13	0.02	0.02	2.17	0.04	17.91

Chemistry Data

site 12		Dellslow															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
12	3/18	1999	1	6	0.15	6.27	.	16.64	1.22	.	0.05	0.14	0.00	0.13	2.90	0.00	14.97
12	4/15	1999	1	14.1	0.15	5.77	7.34	12.89	0.75	.	0.06	0.11	0.06	0.24	4.31	0.03	19.65
12	5/26	1999	1	13.7	0.39	7.17	7.04	28.3	2.69	5354.2	0.03	0.17	0.06	0.29	9.44	0.01	77.75
12	6/25	1999	2	21	0.72	7.5	7.88	49.52	1.89	3341.3	0.07	0.18	0.26	0.01	14.60	0.08	110.24
12	7/15	1999	2	20.7	0.80	6.41	7.99	57.87	1.68	2565.3	0.04	0.30	0.05	0.01	17.67	0.10	114.06
12	8/17	1999	2	20.4	0.82	7.51	7.62	5.48	1.30	866.9	0.03	0.02	0.21	0.01	16.77	0.10	137.20
12	9/23	1999	2	16.3	0.49	7.86	7.7	61.39	3.61	963.3	0.05	0.22	0.04	0.00	16.04	0.07	125.69
12	10/25	1999	2	12.9	0.43	7.36	7	58.88	1.32	1983.9	0.02	0.13	0.11	0.01	10.75	0.05	71.72
12	11/20	1999	3	10.2	0.43	6.93	6.66	32.47	6.58	5034.0	0.06	0.28	0.04	0.24	14.03	0.05	88.13
12	12/21	1999	3	4.7	0.15	6.46	6.12	13.18	3.36	33708.0	0.00	0.32	0.29	0.36	5.34	0.06	27.90
12	1/31	2000	3	1.5	0.47	6.58	6.32	13.21	5.55	29313.0	0.04	0.08	0.83	0.43	8.67	0.05	65.32
12	2/24	2000	1	7.7	0.21	6.46	6.1	8.5	5.02	37899.0	0.05	0.09	0.77	0.36	7.13	0.05	34.29
12	3/31	2000	1	12.7	0.22	6.44	5.98	9.84	3.02	42843.0	0.07	0.19	0.23	0.24	4.87	0.03	26.47
12	4/25	2000	1	20.4	0.29	5.98	6.6	11.49	8.67	32554.9	0.04	0.20	0.32	0.29	5.95	0.06	32.57
12	5/24	2000	1	19.6	0.18	6.91	6.3	15.58	1.49	35099.0	0.03	0.21	0.21	0.24	4.25	0.04	26.42
12	6/21	2000	2	26	0.19	7.02	7.41	20.22	1.27	53206.0	0.03	0.14	0.09	0.20	4.23	0.03	19.26
12	7/26	2000	2	21.3	0.31	6.41	7	20.95	0.17	25977.0	0.06	0.41	0.30	0.25	7.97	0.04	48.78
12	8/24	2000	2	21.8	0.37	6.72	7.61	39.4	1.55	10888.0	0.04	0.09	0.03	0.05	7.20	0.05	42.46
12	9/20	2000	2	19.8	0.58	6.27	7	42.57	5.32	5481.5	0.07	0.11	0.02	0.00	10.04	0.06	69.10

Chemistry Data

site 11		Deep Hollow															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
11	3/18	1999	1	6.4	0.20	5.88	.	6.54	1.61	.	0.09	0.17	0.00	0.65	5.31	0.00	17.06
11	4/15	1999	1	14.7	0.28	5.03	5.85	4.82	3.68	.	0.18	0.29	0.05	1.43	13.35	0.02	36.64
11	5/26	1999	1	14.2	0.37	6.71	6.97	23.44	3.86	93.4	0.14	0.21	0.03	1.14	16.33	0.01	54.68
11	6/25	1999	2	19.8	0.61	6.8	7.65	54.9	2.95	7.2	0.03	0.15	0.27	0.01	25.27	0.04	98.76
11	7/15	1999	2	19.7	0.68	5.3	7.7	65.1	6.95	17.2	0.05	0.21	0.07	0.03	24.46	0.04	92.21
11	8/17	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	9/23	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	10/25	1999	2	12.4	0.64	7.37	6.78	57.66	3.55	45.9	0.04	0.24	0.08	0.00	29.97	0.04	110.84
11	11/20	1999	3	11.3	0.57	6.55	6.59	34.59	7.15	194.0	0.15	0.21	0.07	0.17	33.74	0.03	104.26
11	12/21	1999	3	4.4	0.26	6.58	6.84	12.3	3.34	628.0	0.08	0.43	0.45	1.03	14.04	0.03	43.02
11	1/31	2000	3	1.6	0.55	6.52	6.3	11.32	3.66	487.0	0.13	0.06	1.29	0.78	15.30	0.02	.
11	2/24	2000	1	7.8	0.27	6.25	6.01	9.97	0.00	795.0	0.09	0.16	0.06	1.10	12.56	0.03	40.44
11	3/31	2000	1	12.7	0.31	6.32	5.92	16	3.18	2415.0	0.15	0.41	0.28	1.11	10.95	0.02	34.16
11	4/25	2000	1	18.2	0.42	5.48	6.1	5.49	0.15	2965.3	0.09	0.38	0.20	1.42	15.39	0.03	43.38
11	5/24	2000	1	19.6	0.31	6.91	6.37	24.93	3.20	3592.0	0.06	0.31	0.66	0.92	10.74	0.02	40.33
11	6/21	2000	2	24.5	0.33	6.95	7.36	32.46	1.64	1796.0	0.05	0.24	0.22	0.75	13.19	0.03	40.66
11	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	8/24	2000	2	21.5	0.51	6.29	7.66	58.65	2.68	449.0	0.07	0.26	0.12	0.19	14.80	0.03	54.84
11	9/20	2000	2	19	0.67	6.57	7.32	74.63	6.42	74.8	0.05	0.22	0.00	0.00	21.16	0.03	77.21

Chemistry Data

Richard																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
Richard	6/25	1999	2	14.2	1.68	3.59	3.7	0	1020.00	135.3	1.92	95.32	113.70	4.26	57.97	0.00	175.84
Richard	7/15	1999	2	13.9	1.72	3.55	3.8	0	1210.00	136.0	1.61	87.60	201.12	4.28	57.26	0.00	160.09
Richard	8/17	1999	2	14	1.71	3.6	3.8	0	1140.00	122.2	1.52	78.35	205.22	4.34	59.69	0.00	174.33
Richard	9/23	1999	2	13.9	1.71	3.63	3.74	0	1250.00	138.2	1.49	60.61	208.57	3.88	63.39	0.02	188.68
Richard	10/25	1999	2	14	1.66	3.95	3.88	0	1145.00	120.4	1.30	62.48	193.05	3.92	61.80	0.01	171.80
Richard	11/20	1999	3	13.7	1.69	3.96	3.7	0	1024.00	101.0	1.28	68.37	218.42	4.51	68.44	0.00	189.05
Richard	12/21	1999	3	13.3	1.72	4.07	3.82	0	997.85	98.2	1.28	59.78	199.58	3.88	69.93	0.01	167.27
Richard	1/31	2000	3	12.3	2.77	4.15	3.94	0	1040.00	134.7	1.19	61.76	181.73	3.63	74.49	0.01	160.32
Richard	2/24	2000	1	13.2	1.67	3.97	3.95	0	618.20	.	1.18	60.23	115.18	3.14	64.22	0.01	137.74
Richard	3/31	2000	1	13.2	2.23	3.89	3.9	0	880.90	121.8	1.13	55.47	95.84	2.70	57.16	0.00	129.30
Richard	4/25	2000	1	18	2.39	3.66	3.95	0	885.30	123.4	1.31	80.13	148.17	3.50	59.90	0.00	155.96
Richard	5/24	2000	1	17.3	2.23	4.2	4.22	3.75	650.00	572.0	1.45	82.47	189.77	4.49	52.29	0.00	182.55
Richard	6/21	2000	2	13.8	1.58	3.48	5.3	0	930.20	233.0	1.31	72.11	176.18	3.70	51.50	0.00	126.77
Richard	7/26	2000	2	16.3	1.93	3.58	4.32	0	917.30	.	1.30	82.10	172.10	3.77	64.90	0.00	142.36
Richard	8/24	2000	2	17	1.95	3.89	4.22	0	1016.60	336.0	1.28	70.76	177.99	3.92	51.35	0.00	137.90
Richard	9/20	2000	2	17.6	1.94	3.97	4.8	0	1296.70	224.0	1.22	63.07	166.61	3.61	59.85	0.01	123.24

Chemistry Data

site 10																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
10	3/18	1999	1	6.1	0.15	6.2	.	15.76	6.20	.	0.03	0.15	0.00	0.16	3.05	0.00	15.68
10	4/15	1999	1	14.6	0.17	5.69	6.74	9.72	6.08	.	0.06	0.16	1.43	0.30	5.26	0.02	22.19
10	5/26	1999	1	14.2	0.43	5.85	6.45	4.71	73.75	.	0.13	0.26	4.54	0.39	11.69	0.03	79.71
10	6/25	1999	2	21	1.00	4.35	6.35	4.9	156.50	.	0.37	10.88	34.09	0.82	26.27	0.07	116.49
10	7/15	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10	8/17	1999	2	20.1	1.24	3.96	4.5	0.75	367.72	.	0.39	15.54	64.39	1.46	38.24	0.08	166.14
10	9/23	1999	2	19.8	1.15	4.2	4.7	10.22	254.32	.		19.38	90.14	1.52	42.03	0.05	149.50
10	10/25	1999	2	14.3	0.67	5.4	5.534	20.24	114.84	.	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	11/20	1999	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Chemistry Data

site 9		Tramps															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
9	3/18	1999	1	6.1	0.16	6.75	.	15.56	1.54	.	0.00	0.11	0.05	0.15	3.04	0.00	15.54
9	4/15	1999	1	15	0.19	5.03	6.52	8.23	9.53	.	0.06	0.24	2.85	0.35	6.24	0.02	24.49
9	5/26	1999	1	14.7	0.46	6.1	6.67	13.8	67.05	3341.8	0.12	0.20	6.11	0.43	12.79	0.02	80.05
9	6/25	1999	2	22	0.99	2.26	5.55	4.37	136.90	3341.3	0.35	9.71	32.08	0.90	28.11	0.07	120.69
9	7/15	1999	2	22.4	1.13	4	5.67	6.71	194.54	2959.3	0.51	16.10	44.20	1.19	36.36	0.08	127.91
9	8/17	1999	2	21.2	1.22	3.93	4.52	0.76	311.54	1156.2	0.39	11.70	52.06	1.38	33.35	0.08	151.72
9	9/23	1999	2	20.7	1.22	4.13	4.53	8.23	211.90	1375.3	0.30	16.59	79.01	1.90	43.59	0.05	159.14
9	10/25	1999	2	15.5	0.69	5.63	5.82	34.69	138.60	2924.0	0.18	0.27	25.19	0.71	22.28	0.04	92.79
9	11/20	1999	3	12.8	0.55	6.03	6.17	24.45	27.12	5263.3	0.13	2.51	19.49	0.60	20.34	0.05	99.55
9	12/21	1999	3	1	0.16	6.45	6.85	6.17	16.86	.	0.02	0.44	2.10	0.41	7.15	0.05	31.78
9	1/31	2000	3	2	0.61	5.59	5.72	5.83	38.82	32156.0	0.09	0.62	6.63	0.59	10.29	0.05	73.65
9	2/24	2000	1	3.2	0.41	5.73	5.86	4.32	8.66	42559.0	0.08	0.40	4.30	0.42	7.20	0.05	39.64
9	3/31	2000	1	12.9	0.26	6.25	5.92	10.19	6.65	.	0.12	0.15	1.73	0.33	6.38	0.04	31.44
9	4/25	2000	1	20.8	0.34	5.77	6.4	7.28	8.39	.	0.18	0.18	2.28	0.41	7.82	0.05	36.88
9	5/24	2000	1	21.1	0.49	4.36	4.71	4.35	73.85	.	0.14	4.20	16.79	0.73	12.04	0.03	47.77
9	6/21	2000	2	21.2	0.24	6.21	6.43	15.49	11.21	.	0.04	0.09	1.70	0.31	5.26	0.04	22.77
9	7/26	2000	2	24.7	0.39	5.48	.	11.72	17.64	26089.0	0.02	1.76	8.20	0.39	10.80	0.05	55.30
9	8/24	2000	2	23.8	0.67	5.4	6.18	14.1	34.98	11557.0	0.23	3.06	17.46	0.49	16.80	0.05	78.26
9	9/20	2000	2	21.9	0.82	5.46	6.23	5.81	88.78	5783.0	0.22	3.10	24.03	0.65	18.63	0.05	83.42

Chemistry Data

site 8																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
8	3/18	1999	1	6.2	0.16	6.53	.	16.04	1.30	.	0.04	0.19	0.02	0.16	2.96	0.00	15.93
8	4/15	1999	1	15.2	0.18	5.13	6.669	7.77	6.92	.	0.08	0.20	2.26	0.33	5.89	0.03	23.76
8	5/26	1999	1	14.8	0.46	6.37	6.77	12.69	58.07	5278.2	0.12	0.16	5.53	0.42	12.97	0.02	78.10
8	6/25	1999	2	21	1.00	4.36	4.85	4.14	129.75	3257.4	0.37	9.84	31.35	0.92	28.55	0.07	125.40
8	7/15	1999	2	20.8	1.14	4.39	4.95	3.9	168.93	2935.2	0.38	14.83	21.94	1.20	36.36	0.08	138.20
8	8/17	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8	9/23	1999	2	18.4	1.24	3.87	5.23	0	98.50	904.8	0.15	26.08	61.36	2.22	50.19	0.05	179.42
8	10/25	1999	2	12.3	1.05	6.13	5.65	13.07	71.65	3304.6	0.17	0.14	22.89	0.77	24.77	0.04	100.61
8	11/20	1999	3	12.5	0.73	5.72	6.125	20.31	29.07	5969.0	0.14	0.21	10.15	0.46	18.46	0.06	93.96
8	12/21	1999	3	2.2	0.16	6.81	6.9	8.24	10.45	38966.0	0.03	0.28	1.95	0.42	7.01	0.04	32.78
8	1/31	2000	3	1.9	0.56	5.81	5.9	8.16	30.20	33312.0	0.06	0.14	5.06	0.15	10.47	0.04	85.32
8	2/24	2000	1	2.3	0.43	5.92	5.96	9.2	15.30	44782.0	0.17	3.54	13.22	0.62	16.33	0.06	75.32
8	3/31	2000	1	13.1	0.26	6.14	5.93	8.91	5.65	71554.0	0.10	0.23	1.52	0.34	6.00	0.03	30.49
8	4/25	2000	1	20.9	0.34	5.79	6.52	7.91	0.11	36948.0	.	0.04	2.26	0.37	7.60		37.34
8	5/24	2000	1	22.3	0.49	4.56	4.66	3.93	64.38	39655.0	0.13	3.73	16.18	0.60	11.56	0.04	46.39
8	6/21	2000	2	21.3	0.23	6.28	6.69	17.11	5.38	71554.0	0.02	0.09	1.22	0.29	5.01	0.04	23.32
8	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8	8/24	2000	2	23.9	0.67	5.46	6.33	10.81	25.50	11939.0	0.13	0.14	7.63	0.34	14.37	0.05	75.21
8	9/20	2000	2	21.9	0.79	5.64	6.22	6.82	75.52	5804.0	0.16	0.24	16.80	0.51	17.37	0.06	80.57

Chemistry Data

site 7		Brookhaven															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
7	3/18	1999	1	8.9	0.24	7.59	.	65.35	0.34	.	0.00	0.14	0.00	0.00	4.48	0.00	29.69
7	4/15	1999	1	16.6	0.25	8.05	8.66	101.77	0.00	.	0.01	0.13	0.00	0.00	6.67	0.01	40.17
7	5/26	1999	1	16.4	0.33	7.83	7.85	143.17	3.96	105.5	0.07	0.17	0.02	0.00	8.54	0.03	57.67
7	6/25	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	7/15	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	8/17	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	9/23	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	10/25	1999	2	14.3	0.25	6.87	7.44	164.26	5.59	113.2	0.04	0.20	0.19	0.00	13.10	0.08	75.83
7	11/20	1999	3	12	0.42	7.3	7.6	153.77	5.89	180.0	0.10	0.27	0.06	0.00	12.77	0.07	78.88
7	12/21	1999	3	2.4	0.25	8.02	8.21	116.92	2.99	180.0	0.00	0.27	0.08	0.00	8.40	0.04	51.90
7	1/31	2000	3	1.6	1.04	7.65	8.1	108.12	19.95	.	0.02	0.10	0.29	0.02	9.86	0.06	53.60
7	2/24	2000	1	2.3	0.45	7.41	7.35	100.3	3.22	.	0.06	0.31	0.15	0.01	8.52	0.04	52.35
7	3/31	2000	1	13.7	0.27	7.45	7.28	99.93	0.92	1398.0	0.19	0.30	0.04	0.00	6.86	0.02	43.34
7	4/25	2000	1	20.4	0.33	8.15	7.95	96.67	.	.	.	0.12	0.18	0.01	7.85	.	44.30
7	5/24	2000	1	24.8	0.35	6.78	6.69	117.29	0.91	662.0	0.04	0.43	0.06	0.04	7.43	0.03	50.43
7	6/21	2000	2	21.1	0.36	7.3	8.16	144.67	1.04	375.0	0.02	0.14	0.12	0.00	7.48	0.04	45.29
7	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7	8/24	2000	2	24.2	0.40	6.87	7.52	140.6	0.89	210.0	0.07	0.16	0.19	0.00	8.29	0.07	47.60
7	9/20	2000	2	23.2	0.39	7.32	8.2	139.3	2.24	.	0.07	0.22	0.12	0.02	8.32	0.04	55.32

Chemistry Data

site 6																	
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
6	3/18	1999	1	6.3	0.16	7.05	.	16.98	1.33	.	0.02	0.17	0.00	0.14	3.26	0.00	16.46
6	4/15	1999	1	16.6	0.19	5.96	6.93	9.83	.	.	0.05	0.20	1.84	0.32	6.05	0.03	24.44
6	5/26	1999	1	16.2	0.47	6.36	6.89	14.75	50.37	11121.7	0.08	0.21	4.14	0.42	12.60	0.02	82.58
6	6/25	1999	2	26.2	1.12	4.25	4.84	3.79	136.92	5653.1	0.37	10.46	30.71	0.97	30.29	0.09	122.25
6	7/15	1999	2	25.2	1.20	4.65	4.64	3.26	120.26	3989.3	0.38	11.48	21.94	0.11	34.03	0.09	140.23
6	8/17	1999	2	23.4	1.23	3.8	4.36	0.41	238.41	969.8	0.37	12.10	34.13	1.30	39.97	0.08	162.77
6	9/23	1999	2	23.4	1.49	3.04	3.38	6.86	112.35	1563.3	.	21.90	19.73	2.15	49.23	0.06	182.94
6	10/25	1999	2	15.6	0.27	6.14	5.72	7.66	52.15	3441.8	0.15	0.25	17.46	0.73	24.32	0.04	99.44
6	11/20	1999	3	12.9	0.54	.	6.13	17.95	18.82	8755.0	0.08	0.25	7.14	0.47	18.63	0.05	97.26
6	12/21	1999	3	1	0.16	6.77	7.2	10.2	9.14	48492.0	0.03	0.30	1.92	0.39	6.91	0.05	34.14
6	1/31	2000	3	1.9	0.62	7.14	7.36	11.11	5.12	40003.0	0.07	0.12	4.14	0.47	9.94	0.05	.
6	2/24	2000	1	4.3	0.58	5.63	6.89	11.28	5.13	46971.0	0.15	0.22	3.23	0.58	8.69	0.05	33.56
6	3/31	2000	1	13.1	0.26	6.35	6.04	11.34	4.10	86208.0	0.20	0.21	1.04	0.28	6.37	0.03	31.76
6	4/25	2000	1	19.5	0.33	5.83	6.4	10.04	.	.	.	0.10	1.86	0.35	7.85	0.05	40.10
6	5/24	2000	1	22	0.47	4.49	4.72	3.92	60.05	52533.0	0.13	3.23	16.26	0.63	11.41	0.04	48.88
6	6/21	2000	2	21.5	0.23	6.9	6.81	20.69	3.46	90518.0	0.03	0.11	0.48	0.30	5.44	0.04	24.15
6	7/26	2000	2	25.1	0.39	5.74	6.4	29.11	9.14	40229.1		0.16	2.75	0.32	9.92	0.04	52.40
6	8/24	2000	2	23.9	0.66	5.59	6.47	11.99	16.02	15086.0	0.11	0.06	3.97	0.32	13.65	0.05	71.81
6	9/20	2000	2	22.3	0.59	5.6	6.35	11.25	59.30	6465.0	0.20	3.59	4.59	0.36	15.23	0.05	79.98

Chemistry Data

site 5		Knocking Run															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
5	3/18	1999	1	8	0.21	7.16	.	40.65	1.22	.	0.00	0.09	0.00	0.06	4.79	0.00	22.33
5	4/15	1999	1	17.1	0.23	7.65	8.76	67.39	0.00	.	0.01	0.48	0.05	0.01	7.00	0.01	35.27
5	5/26	1999	1	14.6	0.33	7.84	7.89	113.27	0.00	.	0.05	0.22	0.01	0.00	10.03	0.01	52.97
5	6/25	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	7/15	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	8/17	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	9/23	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	10/25	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	11/20	1999	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	12/21	1999	3	0.8	0.24	7.8	7.9	100.22	3.15	267.0	0.01	0.20	0.11	0.01	10.50	0.04	53.93
5	1/31	2000	3	1.6	1.19	7.59	8.1	106.32	17.11	.	0.01	0.13	2.76	0.15	11.79	0.05	
5	2/24	2000	1	2.6	0.39	7.32	8	86.2	5.32	.	0.03	0.20	1.35	0.02	8.35	0.02	41.23
5	3/31	2000	1	13.1	0.31	7.25	6.96	71.81	1.24	1947.0	0.03	0.27	0.01	0.00	4.64	0.02	20.63
5	4/25	2000	1	20.1	0.35	7.4	7.42	67.08	0.11	.	0.13	0.43	0.12	0.06	8.26	0.03	42.36
5	5/24	2000	1	22.7	0.34	6.72	6.55	92.98	3.37	102.0	0.00	0.18	0.00	0.01	8.19	0.02	49.63
5	6/21	2000	2	20.5	0.38	6.88	8.07	122.33	1.42	102.0	0.02	0.15	0.06	0.00	8.66	0.03	41.97
5	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	8/24	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5	9/20	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Chemistry Data

site 4		Aarons Creek															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
4	3/18	1999	1	6.7	0.13	7.07	.	13.38	1.23	.	0.03	0.16	0.00	0.01	2.18	0.01	9.88
4	4/15	1999	1	17.3	0.14	6.99	7.85	36.33	0.90	.	0.02	0.15	0.10	0.01	3.93	0.04	17.45
4	5/26	1999	1	17.6	0.20	7.68	7.52	64.6	2.91	215.2	0.04	0.26	0.07	0.01	5.58	0.04	26.62
4	6/25	1999	2	22	0.36	7.58	8.16	135.5	1.33	194.2	0.15	0.98	2.56	0.09	12.04	0.11	48.17
4	7/15	1999	2	21.2	0.42	5.95	7.98	164.29	5.21	185.3	0.05	0.19	0.06	0.11	36.45	0.15	48.50
4	8/17	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4	9/23	1999	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4	10/25	1999	2	15.2	0.20	6.87	4.308	1.32	0.42	172.2	0.03	0.35	0.19	0.01	12.38	0.11	51.02
4	11/20	1999	3	13.3	0.28	.	7.96	98.91	1.55	460.0	0.09	0.20	0.07	0.00	9.52	0.08	38.56
4	12/21	1999	3	0.8	0.11	6.81	.	31.09	1.62	1683.0	0.00	0.35	0.06	0.00	4.33	0.06	18.89
4	1/31	2000	3	1.5	0.23	7.69	.	41.35	4.21	.	0.03	0.09	1.59	0.09	4.86	0.06	.
4	2/24	2000	1	1.94	0.23	6.98	7.32	59.7	1.65	.	0.02	0.26	0.60	0.04	4.99	0.05	28.99
4	3/31	2000	1	13.2	0.20	7.11	6.54	37.29	1.13	10214.0	0.03	0.23	0.01	0.00	4.64	0.04	20.63
4	4/25	2000	1	19.9	0.21	6.55	6.9	36.63	0.08	.	0.05	0.20	0.12	0.03	4.68	0.07	21.12
4	5/24	2000	1	22.5	0.20	6.3	6.31	49.02	0.12	.	0.01	0.16	0.04	0.00	4.57	0.05	22.70
4	6/21	2000	2	20.1	0.10	7.08	7.33	38.84	1.78	14031.0	0.02	0.12	0.06	0.00	3.55	0.04	16.04
4	7/26	2000	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4	8/24	2000	2	23.7	0.29	6.97	8.08	85.26	0.10	1309.0	0.07	0.15	0.08	0.01	5.96	0.07	28.06
4	9/20	2000	2	23.1	0.23	6.88	7.93	61.32	1.89	1122.5	0.04	0.21	0.46	0.02	7.33	0.09	29.36

Chemistry Data

site 3		Hartman Run															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
3	3/18	1999	1	9.1	0.54	6.52	.	10.7	4.05	.	0.08	0.18	1.01	0.80	11.35	0.00	56.58
3	4/15	1999	1	16.5	0.56	3.15	4.77	.	29.56	.	0.15	4.63	0.88	1.41	18.24	0.03	77.26
3	5/26	1999	1	14.2	0.60	4.72	4.89	5.34	46.57	179.6	0.22	4.21	0.55	1.81	22.21	0.01	97.67
3	6/25	1999	2	20.6	0.94	3.45	3.83	.	83.85	179.6	0.27	9.25	1.63	2.23	26.86	0.05	114.16
3	7/15	1999	2	21.5	1.07	3.9	3.92	.	91.83	141.1	0.31	12.02	1.84	2.93	36.45	0.06	142.57
3	8/17	1999	2	20.5	0.99	5.28	5.57	1.61	16.02	112.3	0.28	0.86	0.28	1.67	32.26	0.06	168.54
3	9/23	1999	2	18.3	0.97	5.06	5.32	3.96	40.33	71.8	0.24	2.09	2.34	1.83	31.97	0.07	188.77
3	10/25	1999	2	14.1	0.26	4.64	4.53	3.54	46.59	280.6	0.18	6.60	0.29	1.92	30.39	0.04	149.65
3	11/20	1999	3	12	0.26	4.99	4.82	5.07	30.15	654.0	0.15	3.65	0.22	1.78	28.36	0.03	134.95
3	12/21	1999	3	1.1	0.49	4.87	4.72	6.2	39.35	561.0	0.07	4.55	0.87	1.53	23.52	0.04	103.30
3	1/31	2000	3	1.4	1.59	6.1	6.19	17.51	2.51	.	0.11	0.38	0.69	1.25	21.47	0.05	.
3	2/24	2000	1	1.35	0.77	4.89	4.99	7.3	21.30	.	0.18	3.99	0.87	1.35	24.30	0.03	100.39
3	3/31	2000	1	13.4	0.74	5.01	4.61	4.29	28.29	1571.0	0.11	3.74	0.92	1.17	17.17	0.02	82.23
3	4/25	2000	1	19.5	0.93	3.98	3.94	0	8.60	.	0.23	8.05	2.58	1.57	23.47	0.04	99.77
3	5/24	2000	1	21.2	0.77	5.5	4.81	3.94	18.88	1347.0	0.10	2.55	0.21	1.23	21.43	0.03	110.90
3	6/21	2000	2	20.3	0.64	6.55	6.96	27.17	3.31	1309.0	0.08	0.16	0.06	0.95	14.87	0.03	73.44
3	7/26	2000	2	24.8	0.77	4.37	4.87	4.58	15.50	1115.3	.	3.68	0.29	1.24	25.70	.	115.20
3	8/24	2000	2	22.3	0.90	4.5	5.05	4.35	40.80	523.0	0.17	4.37	0.15	1.25	22.78	0.03	97.86
3	9/20	2000	2	23.4	0.75	4.96	4.89	7.53	32.14	449.0	0.18	4.28	0.89	1.49	24.29	0.05	119.31

Chemistry Data

site 2		Marilla Park															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
2	3/18	1999	1	6.3	0.16	6.76	.	14.88	1.14	.	0.04	0.12	0.01	0.14	3.10	0.01	15.51
2	4/15	1999	1	16.3	0.19	5.29	7.05	13.24	3.94	.	0.07	0.14	1.30	0.30	5.92	0.04	25.28
2	5/26	1999	1	17	0.46	6.48	6.95	18.59	34.99	11807.2	0.10	0.21	2.20	0.40	12.20	0.04	75.14
2	6/25	1999	2	24.6	1.02	4.3	4.7	3.61	97.86	12022.2	0.33	7.55	19.20	1.07	27.91	0.09	118.50
2	7/15	1999	2	24.8	1.15	4.4	4.27	0	86.71	8522.0	0.37	10.25	6.40	1.10	33.04	0.12	131.29
2	8/17	1999	2	22.6	1.23	3.5	3.95	0	167.06	4484.0	0.31	10.31	16.74	1.33	38.06	0.11	172.02
2	9/23	1999	2	21.2	1.18	3.71	3.33	0	142.33	2358.3	0.12	11.84	0.40	1.48	41.64	0.11	165.56
2	10/25	1999	2	14.4	0.64	5.83	5.79	0	27.60	4390.7	0.09	0.32	8.03	0.71	24.49	0.08	101.16
2	11/20	1999	3	12.7	0.52	6.15	6.23	20.09	9.86	13053.0	0.09	0.31	3.48	0.51	18.29	0.07	92.73
2	12/21	1999	3	1.1	0.16	6.51	6.39	11.43	7.82	62939.0	0.02	0.41	1.64	0.40	6.80	0.05	33.19
2	1/31	2000	3	1.4	0.58	6.42	6.55	12.11	12.22	43396.0	0.07	0.11	3.46	0.50	10.76	0.05	.
2	2/24	2000	1	1.23	0.35	6.53	6.99	13.83	11.23	51235.0	0.06	0.21	1.33	0.35	8.65	0.06	48.92
2	3/31	2000	1	13	0.25	6.35	6.08	15.95	3.20	#####	0.06	0.26	0.75	0.30	6.87	0.04	32.85
2	4/25	2000	1	18.6	0.33	6.04	6.08	12.78	2.10	49879.2	0.13	0.44	1.48	0.39	8.43	0.06	40.13
2	5/24	2000	1	20.8	0.43	5.29	4.94	4.16	44.26	51419.0	0.13	1.19	12.30	0.55	10.77	0.05	46.17
2	6/21	2000	2	21.3	0.23	6.9	7.02	23.07	2.33	95253.0	0.04	0.13	0.11	0.30	5.88	0.04	27.01
2	7/26	2000	2	26.6	0.40	5.5	6.58	16.7	3.98	40997.0	.	0.35	1.34	0.32	10.57	0.00	55.52
2	8/24	2000	2	23.7	0.65	5.74	6.7	15.68	4.44	18345.0	0.11	0.20	0.82	0.32	13.79	0.07	70.34
2	9/20	2000	2	21.3	0.59	5.62	5.89	15.44	5.33	9137.0	0.13	0.30	3.89	0.33	15.96	0.06	80.31

Chemistry Data

site 1		Morgantown															
Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
1	3/18	1999	1	6.4	0.16	6.79	.	17.71	1.34	.	0.06	0.21	0.04	0.19	3.08	0.04	15.47
1	4/15	1999	1	16.5	0.19	5.48	7.15	13.88	3.90	.	0.07	0.17	1.04	0.33	6.14	0.07	24.93
1	5/26	1999	1	16.9	0.45	6.75	8.04	20.23	27.92	12003.1	0.09	0.30	1.19	0.45	11.64	0.08	75.71
1	6/25	1999	2	24	1.10	4.09	4.56	2.68	117.25	11875.2	0.40	10.44	20.37	1.12	29.94	0.10	119.49
1	7/15	1999	2	25.2	1.34	4	4.61	0	131.83	8753.3	0.60	25.32	6.55	1.81	45.39	0.11	150.36
1	8/17	1999	2	23.4	1.26	3.36	3.71	0	114.04	5118.6	0.33	8.91	3.58	1.20	33.14	0.14	170.10
1	9/23	1999	2	20.5	1.11	4.18	4.32	0	75.33	2687.3	0.23	10.13	0.27	1.30	35.36	0.11	169.35
1	10/25	1999	2	13.2	0.59	5.76	5.81	5.59	19.55	4721.0	0.12	0.18	6.31	0.72	23.54	0.09	98.82
1	11/20	1999	3	12.1	0.48	6.13	6.25	20.27	7.65	13436.3	0.07	0.29	2.05	0.47	16.66	0.08	88.16
1	12/21	1999	3	0.8	0.15	6.5	6.73	12.01	7.47	63982.0	0.08	0.29	1.63	0.40	6.74	0.07	32.37
1	1/31	2000	3	1.6	0.54	6.5	6.71	13.23	10.28	44593.0	0.04	0.05	3.21	0.45	9.64	0.04	.
1	2/24	2000	1	1.2	0.33	6.51	6.72	14.33	8.32	52850.0	0.08	0.10	2.30	0.39	8.74	0.10	.
1	3/31	2000	1	13	0.26	6.46	6.14	15.99	2.63	#####	0.21	0.22	0.68	0.30	6.47	0.10	32.55
1	4/25	2000	1	18.2	0.32	6.05	6.3	13.03	2.30	52497.3	0.18	0.12	1.27	0.36	7.92	0.08	37.70
1	5/24	2000	1	19.8	0.42	5.8	5.03	4.02	38.74	54385.0	0.14	0.81	12.35	0.55	10.94	0.07	45.63
1	6/21	2000	2	21.4	0.24	6.61	7.09	25.15	2.20	#####	0.07	0.11	0.10	0.27	4.89	0.05	25.88
1	7/26	2000	2	24.8	0.37	6.13	6.55	16.08	3.60	42350.0	0.11	0.26	0.59	0.28	9.86	0.00	54.22
1	8/24	2000	2	22.7	0.63	5.75	6.97	17.21	1.78	19194.8	0.12	0.14	0.06	0.27	13.49	0.07	68.00
1	9/20	2000	2	20.13	0.69	5.65	5.23	15.99	3.65	9597.0	0.18	0.21	0.49	0.30	14.36	0.10	70.23

Appendix B

1974 Chemistry Data from Teti (1974)

Note: Alkalinity and acidity are expressed as mg/L of calcium carbonate. Decimal points represent instances where no data was collected.

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
29	1/6	1974	3	.	0.06	5.15	.	1.2	6.40	.	.	.	0.15	.	.	.	.
29	1/16	1974	3	.	0.07	5	.	0.4	4.20	.	.	.	0.01	.	1.30	.	.
29	2/10	1974	1	.	0.08	5.3	.	0.6	4.40	.	.	.	0.15	.	1.20	.	40.00
29	2/27	1974	1	.	0.10	5	.	1.2	8.20	.	.	.	0.10	.	1.30	.	18.70
29	3/27	1974	1	.	0.09	4.85	.	1.4	5.00	.	.	.	0.35	.	1.30	.	22.20
29	4/28	1974	1	.	0.08	5.05	.	1	7.60	.	.	.	0.27	.	1.50	.	14.80
29	5/26	1974	1	.	0.08	5.1	.	1	7.60	.	.	.	0.10	.	1.35	.	11.60
29	6/5	1974	2	.	0.07	5.2	.	0.8	7.60	.	.	.	0.38	.	1.50	.	2.90
28	1/6	1974	3	.	0.07	6	.	2.8	4.20	.	.	.	0.19	.	.	.	.
28	1/16	1974	3	.	0.10	6.71	.	4	6.00	.	.	.	0.01	.	1.50	.	7.70
28	2/10	1974	1	.	0.10	7.6	.	3.2	4.20	.	.	.	0.35	.	1.70	.	8.10
28	2/27	1974	1	.	0.11	6.67	.	3.6	5.00	.	.	.	0.10	.	1.60	.	8.90
28	3/27	1974	1	.	0.09	6.2	.	3.2	5.20	.	.	.	0.49	.	1.60	.	6.80
28	4/28	1974	1	.	0.10	6.65	.	6	6.00	.	.	.	0.33	.	1.80	.	7.60
28	5/26	1974	1	.	0.08	6.65	.	6.2	6.00	.	.	.	0.33	.	1.43	.	6.60
28	6/5	1974	2	.	0.08	6.5	.	6.4	6.20	.	.	.	0.36	.	1.90	.	8.40
27	1/6	1974	3	.	0.28	3.65	.	0	40.10	.	.	.	3.92	.	.	.	.
27	1/16	1974	3	.	2.28	3.82	.	0	34.00	.	.	.	4.30	.	4.60	.	18.00
27	2/10	1974	1	.	0.37	3.6	.	0	55.20	.	.	.	3.30	.	5.20	.	23.00
27	2/27	1974	1	.	0.39	3.65	.	0	56.00	.	.	.	5.20	.	6.20	.	27.00
27	3/27	1974	1	.	0.76	3.35	.	0	33.60	.	.	.	12.50	.	13.00	.	76.00
27	4/28	1974	1	.	0.51	3.85	.	0	42.00	.	.	.	3.05	.	9.30	.	39.00
27	5/26	1974	1	.	0.31	3.8	.	0	41.60	.	.	.	2.90	.	5.85	.	28.10
27	6/5	1974	2	.	0.60	3.3	.	0	17.20	.	.	.	2.50	.	11.80	.	59.00

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
26	1/6	1974	3	.	0.17	4.6	.	0.6	15.40	.	.	.	1.75	.	.	.	.
26	1/16	1974	3	.	0.20	4.75	.	1	11.00	.	.	.	2.57	.	3.10	.	16.00
26	2/10	1974	1	.	0.20	5.1	.	0.6	15.60	.	.	.	1.00	.	4.70	.	19.00
26	2/27	1974	1	.	0.21	4.75	.	0.4	22.00	.	.	.	2.00	.	4.80	.	20.00
26	3/27	1974	1	.	0.35	4.1	.	0	23.60	.	.	.	4.50	.	8.00	.	38.00
26	4/28	1974	1	.	0.23	5.65	.	3	10.00	.	.	.	1.55	.	6.90	.	29.00
26	5/26	1974	1	.	0.15	5.65	.	4	20.40	.	.	.	0.39	.	3.98	.	17.20
26	6/5	1974	2	.	0.27	5.2	.	2	9.60	.	.	.	1.71	.	7.00	.	31.00
25	1/6	1974	3	.	0.22	3.95	.	0	25.00	.	.	.	3.80	.	.	.	.
25	1/16	1974	3	.	0.28	3.8	.	0	31.00	.	.	.	6.05	.	5.50	.	19.00
25	2/10	1974	1	.	0.18	4.8	.	0.4	16.00	.	.	.	1.40	.	5.20	.	19.00
25	2/27	1974	1	.	0.22	4.75	.	0.4	22.00	.	.	.	2.20	.	5.10	.	20.00
25	3/27	1974	1	.	0.33	4.15	.	0	23.00	.	.	.	4.10	.	8.10	.	35.00
25	4/28	1974	1	.	0.26	5.05	.	2	15.00	.	.	.	2.00	.	7.40	.	26.00
25	5/26	1974	1	.	0.18	5.1	.	2	14.20	.	.	.	0.66	.	4.49	.	17.50
25	6/5	1974	2	.	0.28	4.5	.	0	24.20	.	.	.	1.79	.	7.40	.	29.10
24	1/6	1974	3	.	0.11	4.25	.	0	16.00	.	.	.	0.64	.	.	.	.
24	1/16	1974	3	.	0.07	4.41	.	0	11.00	.	.	.	0.04	.	3.20	.	7.00
24	2/10	1974	1	.	0.07	5.1	.	0.6	9.20	.	.	.	0.70	.	1.80	.	5.50
24	2/27	1974	1	.	0.07	4.5	.	0	12.40	.	.	.	0.70	.	1.80	.	5.60
24	3/27	1974	1	.	0.08	5	.	0.4	4.60	.	.	.	1.35	.	1.90	.	5.40
24	4/28	1974	1	.	0.07	5.35	.	2	13.00	.	.	.	1.01	.	2.10	.	6.00
24	5/26	1974	1	.	0.06	5.35	.	2	13.00	.	.	.	0.16	.	1.38	.	4.40
24	6/5	1974	2	.	0.08	5	.	0.8	13.00	.	.	.	0.64	.	2.40	.	8.00

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
23	1/6	1974	3	.	0.26	4.05	.	0	32.00	.	.	.	4.20	.	.	.	.
23	1/16	1974	3	.	0.37	3.9	.	0	214.00	.	.	.	4.48	.	6.90	.	30.00
23	2/10	1974	1	.	0.26	4.8	.	0.2	23.60	.	.	.	2.40	.	8.00	.	30.00
23	2/27	1974	1	.	0.32	4.19	.	0	36.00	.	.	.	4.30	.	8.60	.	33.00
23	3/27	1974	1	.	0.31	4	.	0	18.00	.	.	.	4.75	.	8.20	.	27.00
23	4/28	1974	1	.	0.36	4.1	.	0	37.00	.	.	.	4.00	.	12.00	.	38.00
23	5/26	1974	1	.	0.27	4.1	.	0	37.40	.	.	.	2.75	.	6.74	.	21.80
23	6/5	1974	2	.	0.23	4.7	.	1.4	18.00	.	.	.	2.05	.	6.60	.	23.50
22	1/6	1974	3	.	0.23	4.45	.	0	23.60	.	.	.	3.80	.	.	.	.
22	1/16	1974	3	.	0.28	4.5	.	0	30.60	.	.	.	4.88	.	6.60	.	28.00
22	2/10	1974	1	.	0.22	4.4	.	0	21.00	.	.	.	3.00	.	4.70	.	17.00
22	2/27	1974	1	.	0.28	4.5	.	0	28.60	.	.	.	2.20	.	7.30	.	29.00
22	3/27	1974	1	.	0.30	4.25	.	0	24.80	.	.	.	4.50	.	9.20	.	28.00
22	4/28	1974	1	.	0.30	4.65	.	0.1	23.00	.	.	.	3.00	.	9.40	.	32.00
22	5/26	1974	1	.	0.22	4.65	.	1	23.04	.	.	.	2.50	.	5.96	.	20.80
22	6/5	1974	2	.	0.23	4.9	.	1.4	18.00	.	.	.	1.32	.	6.80	.	25.70
21	1/6	1974	3	.	0.25	3.85	.	0	36.00	.	.	.	3.60	.	.	.	.
21	1/16	1974	3	.	0.32	3.71	.	0	38.00	.	.	.	5.47	.	5.20	.	22.00
21	2/10	1974	1	.	0.31	3.95	.	0	39.00	.	.	.	6.00	.	5.30	.	24.00
21	2/27	1974	1	.	0.33	3.74	.	0	50.00	.	.	.	6.00	.	5.30	.	22.00
21	3/27	1974	1	.	0.45	3.35	.	0	42.00	.	.	.	4.75	.	7.70	.	29.00
21	4/28	1974	1	.	0.39	3.95	.	0	40.00	.	.	.	4.50	.	7.80	.	27.00
21	5/26	1974	1	.	0.26	3.95	.	0	40.00	.	.	.	3.65	.	6.14	.	23.10
21	6/5	1974	2	.	0.32	3.9	.	0	39.40	.	.	.	5.50	.	7.00	.	28.10

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
20	1/6	1974	3	.	0.28	2.85	.	0	39.00	.	.	.	4.60	.	.	.	.
20	1/16	1974	3	.	0.31	3.9	.	0	38.20	.	.	.	5.37	.	6.00	.	22.00
20	2/10	1974	1	.	0.32	3.85	.	0	41.00	.	.	.	5.50	.	6.00	.	24.00
20	2/27	1974	1	.	0.35	3.89	.	0	53.80	.	.	.	4.50	.	6.50	.	26.00
20	3/27	1974	1	.	0.39	3.6	.	0	45.20	.	.	.	6.00	.	7.60	.	29.00
20	4/28	1974	1	.	0.40	3.95	.	0	40.00	.	.	.	4.60	.	8.00	.	28.00
20	5/26	1974	1	.	0.26	3.9	.	0	40.00	.	.	.	3.05	.	5.42	.	20.40
20	6/5	1974	2	.	0.32	3.85	.	0	41.00	.	.	.	3.50	.	6.80	.	25.80
19	1/6	1974	3	.	0.25	3.81	.	0	36.00	.	.	.	3.24	.	.	.	.
19	1/16	1974	3	.	0.32	3.72	.	0	38.40	.	.	.	6.47	.	5.80	.	18.00
19	2/10	1974	1	.	0.29	3.95	.	0	35.20	.	.	.	1.40	.	5.40	.	22.00
19	2/27	1974	1	.	0.32	3.85	.	0	43.00	.	.	.	3.50	.	6.00	.	25.00
19	3/27	1974	1	.	0.37	3.65	.	0	39.40	.	.	.	4.40	.	7.30	.	28.00
19	4/28	1974	1	.	0.34	4	.	0	32.00	.	.	.	2.50	.	7.10	.	25.00
19	5/26	1974	1	.	0.25	4	.	0	32.00	.	.	.	2.00	.	4.72	.	18.70
19	6/5	1974	2	.	0.30	4	.	0	31.40	.	.	.	1.76	.	6.20	.	25.30
18	1/6	1974	3	.	0.09	6.75	.	3.4	2.00	.	.	.	0.07	.	.	.	.
18	1/16	1974	3	.	0.10	6.25	.	4	3.20	.	.	.	0.04	.	1.90	.	16.00
18	2/10	1974	1	.	0.12	8.1	.	3.8	1.40	.	.	.	0.10	.	2.00	.	9.90
18	2/27	1974	1	.	0.14	7	.	3.2	3.40	.	.	.	0.05	.	1.80	.	10.00
18	3/27	1974	1	.	0.12	5.1	.	1.6	1.80	.	.	.	0.27	.	1.90	.	8.70
18	4/28	1974	1	.	0.13	7.5	.	5	3.00	.	.	.	0.10	.	2.10	.	9.50
18	5/26	1974	1	.	0.12	7.2	.	5	2.40	.	.	.	0.12	.	1.83	.	9.60
18	6/5	1974	2	.	0.12	6.8	.	4.6	2.40	.	.	.	0.16	.	2.20	.	10.20

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
17	1/6	1974	3	.	0.23	4.15	.	0	19.40	.	.	.	3.30	.	.	.	.
17	1/16	1974	3	.	0.27	4.25	.	0	34.20	.	.	.	3.20	.	5.10	.	25.00
17	2/10	1974	1	.	0.27	4.4	.	0	26.00	.	.	.	3.30	.	5.90	.	24.00
17	2/27	1974	1	.	0.30	4.25	.	0	36.00	.	.	.	3.80	.	6.10	.	29.00
17	3/27	1974	1	.	0.32	4	.	0	30.00	.	.	.	4.50	.	7.30	.	31.00
17	4/28	1974	1	.	0.34	4.35	.	0	32.00	.	.	.	2.10	.	7.40	.	28.00
17	5/26	1974	1	.	0.23	4.7	.	1	30.00	.	.	.	3.00	.	4.75	.	22.00
17	6/5	1974	2	.	0.27	5.95	.	6.2	7.20	.	.	.	1.50	.	7.50	.	40.00
16	1/6	1974	3	.	0.22	4.25	.	0	27.20	.	.	.	3.20	.	.	.	.
16	1/16	1974	3	.	0.27	4.35	.	0	25.40	.	.	.	1.45	.	5.30	.	25.00
16	2/10	1974	1	.	0.27	4.3	.	0	26.60	.	.	.	1.35	.	5.70	.	26.00
16	2/27	1974	1	.	0.29	4.35	.	0	33.60	.	.	.	3.00	.	6.00	.	29.00
16	3/27	1974	1	.	0.31	4.5	.	0	29.60	.	.	.	3.50	.	7.30	.	34.00
16	4/28	1974	1	.	0.31	4.31	.	0	33.00	.	.	.	3.50	.	7.40	.	30.00
16	5/26	1974	1	.	0.23	4.9	.	2.4	21.34	.	.	.	1.40	.	4.75	.	22.00
16	6/5	1974	2	.	0.26	5.4	.	2.8	12.00	.	.	.	0.27	.	7.00	.	35.90
15	1/6	1974	3	.	0.22	4.35	.	0	26.00	.	.	.	3.22	.	.	.	.
15	1/16	1974	3	.	0.26	4.45	.	0	23.40	.	.	.	3.10	.	5.00	.	20.00
15	2/10	1974	1	.	0.27	4.3	.	0	36.80	.	.	.	1.60	.	6.20	.	27.00
15	2/27	1974	1	.	0.28	4.41	.	0	31.00	.	.	.	1.85	.	6.00	.	30.00
15	3/27	1974	1	.	0.31	4.5	.	0	27.00	.	.	.	1.59	.	7.40	.	32.00
15	4/28	1974	1	.	0.31	4.4	.	0	30.00	.	.	.	2.50	.	7.30	.	30.00
15	5/26	1974	1	.	0.24	6.9	.	8	4.60	.	.	.	2.00	.	5.24	.	31.60
15	6/5	1974	2	.	0.27	7.05	.	7.8	6.00	.	.	.	2.50	.	6.80	.	36.60

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
14	1/6	1974	3	.	0.07	5.1	.	0.8	5.60	.	.	.	0.04	.	.	.	.
14	1/16	1974	3	.	0.20	5.1	.	1.4	5.80	.	.	.	0.15	.	2.40	.	8.20
14	2/10	1974	1	.	0.14	5.9	.	1.4	4.20	.	.	.	0.15	.	1.70	.	9.00
14	2/27	1974	1	.	0.16	5.8	.	4.6	8.00	.	.	.	0.10	.	1.60	.	9.60
14	3/27	1974	1	.	0.22	4.6	.	2	7.80	.	.	.	0.15	.	2.30	.	13.00
14	4/28	1974	1	.	0.18	6.6	.	1.9	2.00	.	.	.	0.15	.	2.20	.	11.00
14	5/26	1974	1	.	0.07	6.1	.	3.8	5.20	.	.	.	0.04	.	1.33	.	5.40
14	6/5	1974	2	.	0.10	5.65	.	1.4	4.00	.	.	.	0.22	.	2.20	.	11.80
13	1/6	1974	3	.	0.07	6.5	.	4	2.40	.	.	.	0.18	.	.	.	.
13	1/16	1974	3	.	0.11	4.65	.	0	11.40	.	.	.	0.25	.	2.80	.	9.50
13	2/10	1974	1	.	0.08	7.2	.	2	4.00	.	.	.	0.45	.	2.20	.	9.00
13	2/27	1974	1	.	0.08	6.65	.	4	4.00	.	.	.	0.30	.	2.20	.	9.80
13	3/27	1974	1	.	0.11	4.2	.	0	13.60	.	.	.	0.34	.	2.30	.	7.90
13	4/28	1974	1	.	0.07	6.4	.	1.4	3.60	.	.	.	0.35	.	2.30	.	7.80
13	5/26	1974	1	.	0.07	6.9	.	4	4.00	.	.	.	0.30	.	1.76	.	6.60
13	6/5	1974	2	.	0.07	6.9	.	5.4	2.40	.	.	.	0.28	.	2.40	.	9.50
12	1/6	1974	3	.	0.20	6.8	.	4.4	16.00	.	.	.	2.20	.	.	.	.
12	1/16	1974	3	.	0.24	5.11	.	1.8	8.00	.	.	.	3.40	.	9.20	.	15.00
12	2/10	1974	1	.	0.24	4.8	.	0.5	19.00	.	.	.	1.35	.	5.60	.	26.00
12	2/27	1974	1	.	0.26	4.75	.	1	18.20	.	.	.	1.80	.	5.20	.	29.00
12	3/27	1974	1	.	0.27	4.7	.	1.8	15.60	.	.	.	3.00	.	6.40	.	30.00
12	4/28	1974	1	.	0.27	4.7	.	0.4	16.60	.	.	.	1.50	.	6.30	.	29.00
12	5/26	1974	1	.	0.21	6.9	.	6	6.00	.	.	.	0.34	.	4.50	.	24.20
12	6/5	1974	2	.	0.26	7.6	.	15.2	1.80	.	.	.	2.50	.	6.30	.	42.80

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
11	1/6	1974	3	.	0.29	4.5	.	0	32.00	.	.	.	0.59	.	.	.	.
11	1/16	1974	3	.	0.32	4.5	.	0	24.20	.	.	.	1.20	.	11.00	.	26.00
11	2/10	1974	1	.	0.30	4.8	.	0.6	21.00	.	.	.	0.50	.	9.80	.	32.00
11	2/27	1974	1	.	0.31	4.75	.	0.4	18.40	.	.	.	0.50	.	8.60	.	32.00
11	3/27	1974	1	.	0.32	4.65	.	1	24.00	.	.	.	0.60	.	10.00	.	31.00
11	4/28	1974	1	.	0.33	4.65	.	0.8	19.60	.	.	.	0.40	.	12.00	.	37.00
11	5/26	1974	1	.	0.35	4.85	.	2	7.40	.	.	.	0.15	.	10.54	.	36.00
11	6/5	1974	2	.	0.36	4.8	.	2	16.20	.	.	.	0.52	.	10.70	.	36.70
10	1/6	1974	3	.	0.20	4.8	.	1	13.00	.	.	.	2.50	.	.	.	.
10	1/16	1974	3	.	0.24	4.85	.	1	12.40	.	.	.	4.15	.	5.40	.	28.00
10	2/10	1974	1	.	0.24	4.8	.	0.6	15.00	.	.	.	0.70	.	6.20	.	26.00
10	2/27	1974	1	.	0.26	4.9	.	1.6	19.20	.	.	.	1.80	.	5.50	.	30.00
10	3/27	1974	1	.	0.28	4.8	.	1.6	16.00	.	.	.	1.64	.	6.30	.	27.00
10	4/28	1974	1	.	0.27	4.65	.	0.6	16.40	.	.	.	3.55	.	6.60	.	30.00
10	5/26	1974	1	.	0.21	6.2	.	7.4	4.00	.	.	.	2.15	.	4.61	.	24.50
10	6/5	1974	2	.	0.26	7.65	.	13	2.20	.	.	.	1.70	.	5.90	.	35.10
9	1/6	1974	3	.	0.21	4.75	.	1.8	13.00	.	.	.	0.80	.	.	.	.
9	1/16	1974	3	.	0.26	4.45	.	0	22.80	.	.	.	2.42	.	5.60	.	30.00
9	2/10	1974	1	.	0.33	4	.	0	34.20	.	.	.	2.60	.	7.20	.	27.00
9	2/27	1974	1	.	0.32	4.68	.	0.8	36.00	.	.	.	6.00	.	7.00	.	34.00
9	3/27	1974	1	.	0.34	4.15	.	0	32.00	.	.	.	7.50	.	8.30	.	33.00
9	4/28	1974	1	.	0.43	3.7	.	0	44.20	.	.	.	8.75	.	9.50	.	37.00
9	5/26	1974	1	.	0.28	6.3	.	5.4	14.20	.	.	.	6.00	.	5.62	.	28.60
9	6/5	1974	2	.	0.26	6.45	.	6.2	6.90	.	.	.	2.40	.	6.30	.	35.90

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
8	1/6	1974	3	.	0.22	4.7	.	1.6	16.20	.	.	.	0.64	.	.	.	.
8	1/16	1974	3	.	0.28	4.5	.	0	22.20	.	.	.	4.00	.	5.90	.	31.00
8	2/10	1974	1	.	0.33	3.9	.	0	32.00	.	.	.	12.00	.	6.80	.	27.00
8	2/27	1974	1	.	0.32	4.5	.	0	37.20	.	.	.	6.60	.	7.00	.	33.00
8	3/27	1974	1	.	0.35	4.1	.	0	30.00	.	.	.	9.00	.	7.70	.	33.00
8	4/28	1974	1	.	0.42	3.75	.	0	42.00	.	.	.	9.50	.	9.50	.	36.00
8	5/26	1974	1	.	0.27	6.7	.	6	11.00	.	.	.	5.65	.	5.07	.	32.30
8	6/5	1974	2	.	0.30	6.5	.	5.6	6.80	.	.	.	3.90	.	7.30	.	37.50
7	1/6	1974	3	.	0.22	7.25	.	51.4	6.00	.	.	.	0.04	.	.	.	.
7	1/16	1974	3	.	0.26	7.65	.	54	5.60	.	.	.	0.08	.	6.30	.	40.00
7	2/10	1974	1	.	0.27	7.5	.	60	4.00	.	.	.	0.10	.	6.80	.	35.00
7	2/27	1974	1	.	0.27	8.7	.	61	0.00	.	.	.	0.15	.	6.50	.	39.00
7	3/27	1974	1	.	0.25	7.6	.	62.4	1.60	.	.	.	0.24	.	7.00	.	33.00
7	4/28	1974	1	.	0.28	7.8	.	87	3.40	.	.	.	0.22	.	7.10	.	38.00
7	5/26	1974	1	.	0.31	7.6	.	67	2.40	.	.	.	0.06	.	7.02	.	39.10
7	6/5	1974	2	.	0.29	7.8	.	82	2.20	.	.	.	0.29	.	7.70	.	41.40
6	1/6	1974	3	.	0.22	4.7	.	0.4	12.00	.	.	.	5.00	.	.	.	.
6	1/16	1974	3	.	0.29	4.5	.	0	18.00	.	.	.	7.00	.	6.30	.	40.00
6	2/10	1974	1	.	0.30	4	.	0	31.00	.	.	.	2.10	.	7.80	.	31.00
6	2/27	1974	1	.	0.33	4.9	.	1	26.20	.	.	.	6.60	.	6.90	.	36.00
6	3/27	1974	1	.	0.32	4.5	.	0	22.20	.	.	.	6.55	.	7.90	.	35.00
6	4/28	1974	1	.	0.42	3.8	.	0	42.20	.	.	.	8.25	.	9.70	.	38.00
6	5/26	1974	1	.	0.29	6.3	.	11	8.00	.	.	.	8.00	.	6.59	.	38.00
6	6/5	1974	2	.	0.31	7.5	.	6	4.40	.	.	.	4.50	.	7.20	.	39.00

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
5	1/6	1974	3	.	0.21	7.3	.	32	4.20	.	.	.	0.30	.	.	.	.
5	1/16	1974	3	.	0.17	7.5	.	44	4.00	.	.	.	0.05	.	6.10	.	35.00
5	2/10	1974	1	.	0.27	7.6	.	50	4.40	.	.	.	0.35	.	8.00	.	38.00
5	2/27	1974	1	.	0.27	7.45	.	46.2	2.60	.	.	.	0.50	.	6.10	.	43.00
5	3/27	1974	1	.	0.27	7.1	.	58.2	3.60	.	.	.	0.70	.	4.00	.	16.00
5	4/28	1974	1	.	0.30	7.4	.	55.2	3.60	.	.	.	0.30	.	8.40	.	47.00
5	5/26	1974	1	.	0.33	8.1	.	70	2.00	.	.	.	0.16	.	8.51	.	42.90
5	6/5	1974	2	.	0.31	7.65	.	66.8	2.20	.	.	.	0.34	.	8.90	.	46.40
4	1/6	1974	3	.	0.16	7.4	.	12.2	3.00	.	.	.	0.63	.	.	.	.
4	1/16	1974	3	.	0.17	7.2	.	16.2	3.80	.	.	.	0.20	.	4.00	.	20.00
4	2/10	1974	1	.	0.18	7.5	.	16	2.80	.	.	.	0.15	.	4.30	.	18.00
4	2/27	1974	1	.	0.19	7.05	.	18	3.80	.	.	.	0.30	.	3.20	.	16.00
4	3/27	1974	1	.	0.17	7.1	.	20	3.40	.	.	.	0.60	.	21.00	.	75.00
4	4/28	1974	1	.	0.18	7.3	.	22	4.00	.	.	.	0.22	.	4.00	.	17.00
4	5/26	1974	1	.	0.17	6.9	.	16	3.60	.	.	.	0.02	.	2.80	.	12.40
4	6/5	1974	2	.	0.21	7.25	.	25	2.00	.	.	.	0.39	.	4.90	.	24.30
3	1/6	1974	3	.	0.87	3.2	.	0	106.00	.	.	.	18.00	.	.	.	.
3	1/16	1974	3	.	1.07	3	.	0	128.40	.	.	.	13.64	.	14.00	.	80.00
3	2/10	1974	1	.	1.44	2.9	.	0	238.40	.	.	.	50.00	.	25.00	.	90.00
3	2/27	1974	1	.	1.28	3.95	.	0	203.00	.	.	.	34.00	.	20.00	.	90.00
3	3/27	1974	1	.	1.25	2.85	.	0	182.80	.	.	.	32.50	.	7.30	.	34.00
3	4/28	1974	1	.	1.48	2.8	.	0	230.40	.	.	.	33.75	.	26.00	.	84.00
3	5/26	1974	1	.	1.14	3.05	.	0	161.00	.	.	.	22.50	.	20.20	.	88.40
3	6/5	1974	2	.	1.18	3.05	.	0	151.40	.	.	.	18.10	.	20.40	.	91.50

Chemistry Data

Site	date	year	season	Temperature (C)	EC	pH (field)	pH (lab)	alkalinity (mg/L)	acidity (mg/L)	flow (gpm)	zinc (mg/L)	aluminum (mg/L)	iron (mg/L)	manganese (mg/L)	magnesium (mg/L)	barium (mg/L)	calcium (mg/L)
2	1/6	1974	3	.	0.24	4.95	.	0.8	12.00	.	.	.	4.20	.	.	.	.
2	1/16	1974	3	.	0.30	4.5	.	0	19.20	.	.	.	8.13	.	6.40	.	36.00
2	2/10	1974	1	.	0.29	4.5	.	0	25.40	.	.	.	1.65	.	7.20	.	32.00
2	2/27	1974	1	.	0.30	4.7	.	0.4	38.20	.	.	.	0.90	.	6.60	.	32.00
2	3/27	1974	1	.	1.01	2.75	.	0	119.60	.	.	.	6.10	.	7.30	.	34.00
2	4/28	1974	1	.	0.38	4.05	.	0	32.80	.	.	.	7.00	.	8.80	.	36.00
2	5/26	1974	1	.	0.27	6.3	.	7.6	10.00	.	.	.	4.75	.	5.50	.	29.60
2	6/5	1974	2	.	0.31	6.95	.	12.4	4.00	.	.	.	4.35	.	7.00	.	37.20
1	1/6	1974	3	.	0.27	5.05	.	1.8	10.00	.	.	.	1.10	.	.	.	.
1	1/16	1974	3	.	0.29	4.75	.	5	15.00	.	.	.	8.00	.	5.30	.	37.00
1	2/10	1974	1	.	0.32	4.3	.	0	33.80	.	.	.	3.00	.	7.00	.	32.00
1	2/27	1974	1	.	0.32	4.6	.	1	30.00	.	.	.	2.50	.	6.70	.	33.00
1	3/27	1974	1	.	0.32	4.6	.	0.4	15.00	.	.	.	6.30	.	7.40	.	34.00
1	4/28	1974	1	.	0.38	4.25	.	0	33.60	.	.	.	7.25	.	9.00	.	37.00
1	5/26	1974	1	.	0.27	6.06	.	11	9.40	.	.	.	5.25	.	6.13	.	31.40
1	6/5	1974	2	.	0.32	7.25	.	19.2	4.20	.	.	.	3.75	.	7.00	.	42.30

Appendix C

Microbiological Data

Note: Decimal points represent instances where no data was collected.

Site	date	year	season	cfu/100ml
29	20-May	1999	1	11
29	10-Jun	1999	2	.
29	8-Jul	1999	2	.
29	27-Aug	1999	2	.
29	20-Sep	1999	2	.
29	25-Oct	1999	2	104
29	20-Nov	1999	3	120
29	22-Dec	1999	3	6
29	28-Jan	2000	3	2
29	18-Feb	2000	1	
29	20-Mar	2000	1	6
29	26-Apr	2000	1	1
29	31-May	2000	1	14
29	30-Jun	2000	2	220
29	27-Jul	2000	2	102
29	30-Aug	2000	2	27
29	27-Sep	2000	2	380
29	26-Oct	2000	2	70
28	20-May	1999	1	.
28	10-Jun	1999	2	1700
28	8-Jul	1999	2	11300
28	27-Aug	1999	2	4600
28	20-Sep	1999	2	160
28	25-Oct	1999	2	.
28	20-Nov	1999	3	.
28	22-Dec	1999	3	.
28	28-Jan	2000	3	.
28	18-Feb	2000	1	2
28	20-Mar	2000	1	.
28	26-Apr	2000	1	.
28	31-May	2000	1	.
28	30-Jun	2000	2	.
28	27-Jul	2000	2	.
28	30-Aug	2000	2	.
28	27-Sep	2000	2	.
28	26-Oct	2000	2	

Site	date	year	season	cfu/100ml
27b	20-May	1999	1	2800
27b	10-Jun	1999	2	10000
27b	8-Jul	1999	2	1700
27b	27-Aug	1999	2	82
27b	20-Sep	1999	2	.
27b	25-Oct	1999	2	.
27b	20-Nov	1999	3	.
27b	22-Dec	1999	3	.
27b	28-Jan	2000	3	.
27b	18-Feb	2000	1	.
27b	20-Mar	2000	1	.
27b	26-Apr	2000	1	.
27b	31-May	2000	1	.
27b	30-Jun	2000	2	.
27b	27-Jul	2000	2	.
27b	30-Aug	2000	2	.
27b	27-Sep	2000	2	.
27b	26-Oct	2000	2	.
26	20-May	1999	1	2180
26	10-Jun	1999	2	.
26	8-Jul	1999	2	.
26	27-Aug	1999	2	.
26	20-Sep	1999	2	.
26	25-Oct	1999	2	570
26	20-Nov	1999	3	560
26	22-Dec	1999	3	200
26	28-Jan	2000	3	4500
26	18-Feb	2000	1	145
26	20-Mar	2000	1	100
26	26-Apr	2000	1	39
26	31-May	2000	1	980
26	30-Jun	2000	2	5800
26	27-Jul	2000	2	1600
26	30-Aug	2000	2	2400
26	27-Sep	2000	2	1600
26	26-Oct	2000	2	820

Site	date	year	season	cfu/100ml
25b	20-May	1999	1	2800
25b	10-Jun	1999	2	110
25b	8-Jul	1999	2	.
25b	27-Aug	1999	2	.
25b	20-Sep	1999	2	.
25b	25-Oct	1999	2	.
25b	20-Nov	1999	3	.
25b	22-Dec	1999	3	.
25b	28-Jan	2000	3	.
25b	18-Feb	2000	1	.
25b	20-Mar	2000	1	.
25b	26-Apr	2000	1	.
25b	31-May	2000	1	.
25b	30-Jun	2000	2	.
25b	27-Jul	2000	2	.
25b	30-Aug	2000	2	.
25b	27-Sep	2000	2	.
25b	26-Oct	2000	2	.
23	20-May	1999	1	680
23	10-Jun	1999	2	3100
23	8-Jul	1999	2	320
23	27-Aug	1999	2	.
23	20-Sep	1999	2	32
23	25-Oct	1999	2	12
23	20-Nov	1999	3	7
23	22-Dec	1999	3	1
23	28-Jan	2000	3	.
23	18-Feb	2000	1	4
23	20-Mar	2000	1	7
23	26-Apr	2000	1	14
23	31-May	2000	1	860
23	30-Jun	2000	2	51
23	27-Jul	2000	2	250
23	30-Aug	2000	2	8
23	27-Sep	2000	2	18
23	26-Oct	2000	2	33

Site	date	year	season	cfu/100ml
21	20-May	1999	1	61000
21	10-Jun	1999	2	63000
21	8-Jul	1999	2	579000
21	27-Aug	1999	2	510000
21	20-Sep	1999	2	970000
21	25-Oct	1999	2	114000
21	20-Nov	1999	3	64000
21	22-Dec	1999	3	6200
21	28-Jan	2000	3	5100
21	18-Feb	2000	1	166
21	20-Mar	2000	1	130
21	26-Apr	2000	1	5800
21	31-May	2000	1	1200
21	30-Jun	2000	2	44000
21	27-Jul	2000	2	1720
21	30-Aug	2000	2	21000
21	27-Sep	2000	2	3200
21	26-Oct	2000	2	25000
20	20-May	1999	1	61
20	10-Jun	1999	2	26
20	8-Jul	1999	2	.
20	27-Aug	1999	2	500
20	20-Sep	1999	2	1800
20	25-Oct	1999	2	.
20	20-Nov	1999	3	.
20	22-Dec	1999	3	.
20	28-Jan	2000	3	.
20	18-Feb	2000	1	.
20	20-Mar	2000	1	.
20	26-Apr	2000	1	.
20	31-May	2000	1	.
20	30-Jun	2000	2	.
20	27-Jul	2000	2	.
20	30-Aug	2000	2	.
20	27-Sep	2000	2	.
20	26-Oct	2000	2	.

Site	date	year	season	cfu/100ml
19	20-May	1999	1	2
19	10-Jun	1999	2	.
19	8-Jul	1999	2	.
19	27-Aug	1999	2	80
19	20-Sep	1999	2	50
19	25-Oct	1999	2	.
19	20-Nov	1999	3	.
19	22-Dec	1999	3	.
19	28-Jan	2000	3	.
19	18-Feb	2000	1	.
19	20-Mar	2000	1	.
19	26-Apr	2000	1	.
19	31-May	2000	1	.
19	30-Jun	2000	2	.
19	27-Jul	2000	2	.
19	30-Aug	2000	2	.
19	27-Sep	2000	2	.
19	26-Oct	2000	2	.
17	20-May	1999	1	.
17	10-Jun	1999	2	.
17	8-Jul	1999	2	.
17	27-Aug	1999	2	.
17	20-Sep	1999	2	.
17	25-Oct	1999	2	4
17	20-Nov	1999	3	2
17	22-Dec	1999	3	7
17	28-Jan	2000	3	1
17	18-Feb	2000	1	.
17	20-Mar	2000	1	140
17	26-Apr	2000	1	1
17	31-May	2000	1	5
17	30-Jun	2000	2	480
17	27-Jul	2000	2	25
17	30-Aug	2000	2	18
17	27-Sep	2000	2	820
17	26-Oct	2000	2	23

Site	date	year	season	cfu/100ml
15	20-May	1999	1	.
15	10-Jun	1999	2	.
15	8-Jul	1999	2	130
15	27-Aug	1999	2	210
15	20-Sep	1999	2	530
15	25-Oct	1999	2	.
15	20-Nov	1999	3	.
15	22-Dec	1999	3	.
15	28-Jan	2000	3	.
15	18-Feb	2000	1	.
15	20-Mar	2000	1	.
15	26-Apr	2000	1	.
15	31-May	2000	1	.
15	30-Jun	2000	2	.
15	27-Jul	2000	2	.
15	30-Aug	2000	2	.
15	27-Sep	2000	2	.
15	26-Oct	2000	2	.
12	20-May	1999	1	290
12	10-Jun	1999	2	.
12	8-Jul	1999	2	.
12	27-Aug	1999	2	.
12	20-Sep	1999	2	.
12	25-Oct	1999	2	236
12	20-Nov	1999	3	154
12	22-Dec	1999	3	10
12	28-Jan	2000	3	7
12	18-Feb	2000	1	90
12	20-Mar	2000	1	82
12	26-Apr	2000	1	8
12	31-May	2000	1	74
12	30-Jun	2000	2	455
12	27-Jul	2000	2	104
12	30-Aug	2000	2	110
12	27-Sep	2000	2	590
12	26-Oct	2000	2	66

Site	date	year	season	cfu/100ml
9	20-May	1999	1	.
9	10-Jun	1999	2	.
9	8-Jul	1999	2	.
9	27-Aug	1999	2	.
9	20-Sep	1999	2	.
9	25-Oct	1999	2	4
9	20-Nov	1999	3	1
9	22-Dec	1999	3	3
9	28-Jan	2000	3	1
9	18-Feb	2000	1	.
9	20-Mar	2000	1	28
9	26-Apr	2000	1	2
9	31-May	2000	1	6
9	30-Jun	2000	2	250
9	27-Jul	2000	2	33
9	30-Aug	2000	2	.
9	27-Sep	2000	2	420
9	26-Oct	2000	2	31
1	20-May	1999	1	.
1	10-Jun	1999	2	27
1	8-Jul	1999	2	23
1	27-Aug	1999	2	4
1	20-Sep	1999	2	54
1	25-Oct	1999	2	5
1	20-Nov	1999	3	18
1	22-Dec	1999	3	1100
1	28-Jan	2000	3	56
1	18-Feb	2000	1	16
1	20-Mar	2000	1	140
1	26-Apr	2000	1	38
1	31-May	2000	1	68
1	30-Jun	2000	2	1280
1	27-Jul	2000	2	250
1	30-Aug	2000	2	80
1	27-Sep	2000	2	1020
1	26-Oct	2000	2	138

Appendix D

Sample Site Locations and Descriptions

Note: Tributaries appear in bold print.

Sample Site Descriptions

<u>Site number</u>	<u>Description</u>
29	Gravel road off of Born Run near Zinn Chapel
28	Through Reedsville Farm entrance on Zinn Chapel Rd, bridge on back side of the farm
27b	Below Fairfax Ponds discharge on Rt 92
27a	Kanes Creek , where it flows under Rt 92
26	First bridge that crosses Deckers Creek after making a left off of Rt 92 onto Kingwood Pike (toward Morgantown)
25b	Unnamed trib. crossing under Kingwood Pike 500m west from sampling point 26
25a	North on Zinn Chapel Rd to point where Laurel Run intersects Deckers Creek. Sample above confluence
24	Laurel Run , just before it flows into Deckers Creek
23	Dillan Creek , where it crosses secondary road off of Rt 7
22	Bridge where Zinn Chapel Rd crosses Deckers Creek
21	Paved road behind Bridgeway Inn at Masontown. Sample under bridge
20	Cascade, just above first steep drop in Deckers Creek
19	Confluence of Deckers Creek and Dry Run. Sample above confluence
18	Dry Run , below Rt 7
17	Pullout area on left of first Greer Limestone facility
16	Pullout area on left of second Greer Limestone facility (closest to Morgantown)
15	Continuing on Rt 7 west toward Morgantown, past sharp curve to second pull off area on the left

<u>Site number</u>	<u>Description</u>
14	Unnamed tributary crossing Rt 7
13	Tibbs Run. Sample at Tyrone Rd bridge.
12	Rt 7 bridge at Dellslow
11	Deep Hollow , just above the confluence with Deckers Creek
10	Twin bridge pilings in Deckers Creek just below Richard
9	Pull off area below Tramps at the western edge of Dellslow
8	Rt 7 bridge before the I-68 Sabraton Interchange
7	Brookhaven Run , near first sharp curve in Brookhaven Rd
6	Behind Sterling Faucet on Eljadid St. Sample below the Eljadid St Bridge
5	Knocking Run on the north side of Rt 7
4	Aaron's Creek. Near the intersection of Aarons Creek Rd and Rail Trail
3	Hartman Run. Near the point where it emerges from under Rt 7 in Sabraton
2	Deckers Creek directly across from Marilla Park Pool
1	South Park Gauging station, directly under Walnut St Bridge