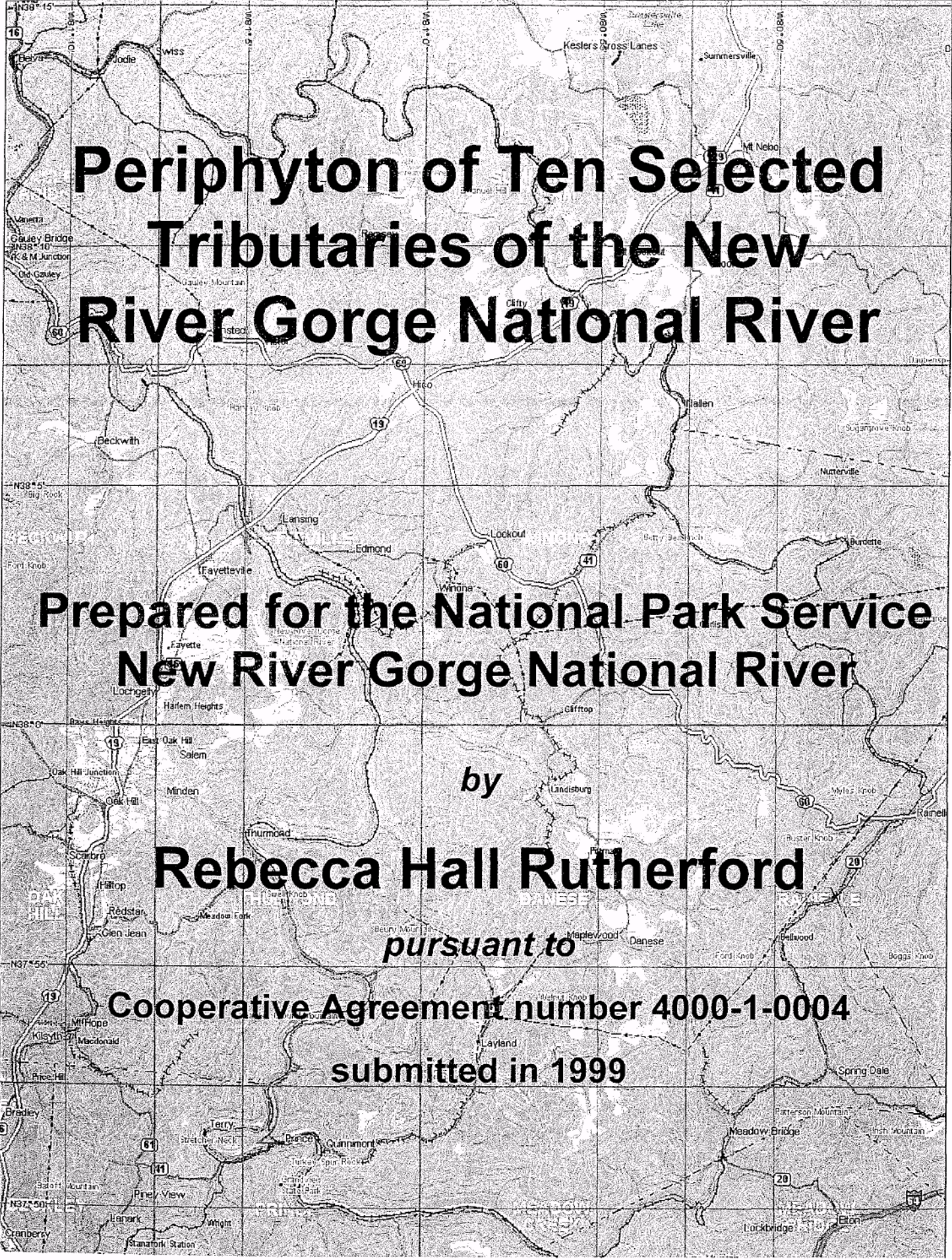




Periphyton of Ten Selected Tributaries of the New River Gorge National River

**Prepared for the National Park Service
New River Gorge National River**

by

Rebecca Hall Rutherford

pursuant to

Cooperative Agreement number 4000-1-0004

submitted in 1999

Table of Contents

Chapter	page
ABSTRACT	i
ACKNOWLEDGEMENTS	iii
LIST OF TABLES	iv
LIST OF FIGURES	v
I. INTRODUCTION	1
New River	3
Objectives	3
Literature Review	4
Study Area	10
II. MATERIALS AND METHODS	28
III. RESULTS AND DISCUSSION	31
Algae present	31
Community Structure - by Stream and Season	34
Community Structure by Season	43
Environmental Problems	50
Possible Pollution Sources	62
IV. CONCLUSIONS	68
Future Study	69
LITERATURE CITED	70
A. Location of study sites on sections of topographical maps...	80
B. Species identified in each stream and cell counts	86
C. Species list with pollution indicators by stream	102
D. Morisita's Index, Jaccard Coefficient, and Horn's	
Index of Similarity by season	133
E. Community Similarity by Stream	137

Acknowledgments

Dr. Tom Weaks provided guidance and encouragement that I was fortunate to receive. I appreciate the time and personal sacrifice he willingly gave to me and his students. He was very easy to work with and was always willing to try and accommodate me. Dr. Weaks was always pleasant and positive. I appreciate all his advice and I am grateful for the times I was able to work with him. Dr. Weaks was very flexible and tried to make it easier for me to complete this research while maintaining my full-time career as a biologist at the Army Corps of Engineers.

Drs. Dan Evans and Don Tarter also provided important advice and encouragement for this research. I have enjoyed learning from each of them. Dr. Evans gave me the direction to pursue the grant with the National Park Service. It has been a pleasure to learn from all the professors I have studied under at Marshall.

Mr. Ken Stephens, National Park Service, New River Gorge National River (NPS, NERI) coordinated funding for this research under Cooperative Agreement Number 4000-1-0004. He has been most helpful. I appreciate his flexibility and the extra time he gave me to work on this research. It has been difficult to complete this research while maintaining my full-time career, but he has been very understanding and supportive.

I also want to thank the U. S. Army Corps of Engineers, Huntington District, Water Quality Lab staff for allowing me to use the equipment to take the water quality measurements. This equipment provided greater flexibility and higher accuracy.

My mother and grandmother (Carlene Hall and Sylvia Booten) have been wonderful, not only while I was a student, but during my career as a biologist at the Corps of Engineers. Both have made sacrifices for me and my education and have been most supportive.

Rick, my husband, always accompanied me when I sampled the streams. I truly believe I couldn't have made it without him! He has been supportive the entire time and has helped me whenever he could. I truly appreciate the sacrifices he made for me.

My friends and co-workers provided support and encouragement in many ways: Jean Lehigh, Julie Bush, Joe Boggs, Mindy Hogan, Wallace Dean, Dale Suiter, and many more.

The staff at the NPS, NERI were very helpful and supplied valuable information, especially Lisa Wilson, John Perez and Jesse Purvis.

Thank-you all very much!

List of Tables

Table	Subject	Page
1.1	Soils of the Tributaries of the NERI	13
1.2	Climatological and Precipitation Data	14
3.1	Algal species identified in study area	30
3.2	Species richness of tributaries sampled within NERI ...	34
3.3	Similarity indices between the summer of 1995 and winter of 1996 communities in Dunloup Creek	35
3.4	Percent Similarity for Arbuckle Creek	36
3.5	Quotient of Similarity for Arbuckle Creek	36
3.6	Coefficient of Community for Arbuckle Creek	36
3.7	Percent Similarity for Wolf Creek	37
3.8	Quotient of Similarity for Wolf Creek	37
3.9	Coefficient of Community for Wolf Creek	37
3.10	Percent Similarity for Marr Branch	38
3.11	Quotient of Similarity for Marr Branch	38
3.12	Coefficient of Community for Marr Branch	38
3.13	Percent Similarity for Keeney Creek	38
3.14	Quotient of Similarity for Keeney Creek	39
3.15	Coefficient of Community for Keeney Creek	39
3.16	Percent Similarity for Laurel Creek	40
3.17	Quotient of Similarity for Laurel Creek	40
3.18	Coefficient of Community for Laurel Creek	40
3.19	Similarity indices between fall of 1995 and spring of 1996 communities in Dowdy Creek	41
3.20	Percent Similarity for Lick Creek	41
3.21	Quotient of Similarity for Lick Creek	42
3.22	Coefficient of Community for Lick Creek	42
3.23	Percent Similarity for Meadow Creek	42
3.24	Quotient of Similarity for Meadow Creek	42
3.25	Coefficient of Community for Meadow Creek	43
3.26	Percent Similarity for Summer Communities	43
3.27	Quotient of Similarity for Summer Communities	44
3.28	Coefficient of Community for Summer Communities	44
3.29	Percent Similarity for Fall Communities	45
3.30	Quotient of Similarity for Fall Communities	46
3.31	Coefficient of Community for Fall Communities	46
3.32	Percent Similarity for Winter Communities	47
3.33	Quotient of Similarity for Winter Communities	47
3.34	Coefficient of Community for Winter Communities	48
3.35	Percent Similarity for Spring Communities	48
3.36	Quotient of Similarity for Spring Communities	49
3.37	Coefficient of Community for Spring Communities	49
3.38	Dominant species found in the study area and their indicator status	51
3.39	Water Quality Data Summer	55
3.40	Water Quality Data Fall	56
3.41	Water Quality Data Winter	57
3.42	Water Quality Data Spring	58

List of Figures

Figure	Title	Page
1.1	Study area within NERI	12
1.2	Photograph of Glade Creek site	16
1.3	Photograph of Laurel Creek site	17
1.4	Photograph of Dowdy Creek site	18
1.5	Photograph of Dunloup Creek site	19
1.6	Photograph of Arbuckle Creek site	22
1.7	Photograph of Wolf Creek site	23
1.8	Photograph of Marr Branch site	24
1.9	Photograph of Keeney Creek site	25
1.10	Photograph of Lick Creek site	26
1.11	Photograph of Meadow Creek site	27

Introduction

Human activities and development contribute to pollution in streams. West Virginia, like many states, has many sources of pollution including, but not limited to, agricultural activities, industrial and chemical plants, household and animal waste, fertilizers, pesticides, and others. Pollution finds its way into streams and creates many problems for the environment by affecting our drinking water and the aquatic life. Therefore, it is very important to protect and maintain the aquatic resources of our waterways. In order to do this, the water quality of a stream must first be determined. One method of establishing water quality data is through studies of periphyton community structure. Periphyton consist of attached algae. Not only is it an integral part of the food chain, but it is also recognized as a good measure of water quality (Palmer, 1959 and 1969 and Patrick, 1971). The New River Gorge National River (NERI) and its tributaries represent a waterway of importance and pollution is a concern on this waterway.

The New River

In 1978, Congress passed legislation (Public Law 95-625) creating the NERI for the purpose of: (1) conserving and interpreting natural, scenic and historic values and objects in and around the New River Gorge and (2) preserving the New River as a free-flowing stream. This area is under the management of the National Park Service (NPS), United States Department of the Interior. The New River is approximately 250 miles in length and drains approximately 6920 square miles (National Park Service,

1982). Public Law 95-625 set aside a 62,000 acre corridor along 53 miles of the NERI (Sullivan, 1993).

In some parts of Raleigh and Fayette counties and Sandstone Falls just north of Hinton, WV, resistant sandstones of Pottsville and Mauch Chunk Series remain, which are responsible for the nearly perpendicular sandstone walls and benches along the New River (National Park Service, 1982). Typically there is a 1000 feet change in elevation, within the NERI, between the river bottom and the adjacent plateau. The elevation near the southern end of the NERI at Hinton, WV, is 1360 feet, while Sewell Mountain is over 3200 feet in elevation. Within the NERI the New River falls an average of 10.6 feet/mile while the gradient of the New River over its entire length is 12.6 feet/mile (National Park Service, 1982).

The New River is thought to be one of the oldest rivers in North America (WV DNR, 1989). The most accepted estimates date it at least 65 million years in its present course; however, the age of the river is a subject of uncertainty. Age estimates range from 3 to 320 million years old.

The major period of European settlement began in 1873 (National Park Service, 1982). The Chesapeake and Ohio Railroad opened the gorge to coal and timber industries. The riverside communities of Quinnimont and Thurmond were early centers of shipping for locally mined coal. Coal mining, logging and railroading supported the economy and dominated in the towns between Sandstone and Fayetteville between 1900 and 1935. These

communities experienced rapid economic decline between 1930 and 1950 (National Park Service, 1982).

Today this area is popular among fishermen, Whitewater rafters, rock climbers, and tourists. The rugged beauty of the park attracts thousands of visitors a year. The increased use of the area and its resources can influence water quality. Humans can impact resources by disposing of trash/debris and human waste into the watercourses. Much of this area is rural, and some locations lack appropriate septic systems.

Objectives

Purposes of this study were to: (1) compare periphyton community structure of selected tributaries within the NERI; (2) identify changes in periphyton community structure within the selected tributaries over a one-year period; (3) suggest environmental problems within the streams using indicator species of periphyton; and (4) identify possible pollution sources of the tributaries to the NERI.

Literature Review

Water quality and environmental indicators

Algae have long been recognized as a measure of water quality (Palmer, 1959 and 1969; Patrick, 1971; Thomas, 1972; Lowe, 1974; United States Environmental Protection Agency, 1979; Laws, 1981; Shubert, 1984). Palmer (1959) demonstrated that algal assemblages could be used as indicators of water quality. In addition, Palmer (1969) published a rating of organisms which indicate their tolerance level to water pollution. In studies of water pollution, Patrick (1971) stated that it was also important to study community structure. She reported that clean water supports a wide variety of organisms, while polluted water supports only a few species, with one or two being dominant. In 1984, Shubert presented a series of proposals indicating that one or more algae can be used as indicators of water quality.

These studies led to many algae being designated as indicators of polluted or clean water. For example, Schizothrix calcicola (Ag.) Gomont is usually present in waters containing heavy organic pollution (Thomas, 1972). Blue-green algae can be used as indicators of pollution in rivers (Fogg et al., 1973). Venkataraman et al. (1974) reported that blue-green algal abundance is closely correlated with dissolved organic matter.

States et al. (1978) reported that periphyton should be considered in baseline studies (especially in streams) because of this component's importance in primary production. These researchers suggested that periphyton indicates environmental

conditions. Furthermore, changes in species present, or species abundance, may function as early indicators of shifts in environmental conditions.

Palmer (1980) presented an extensive list of indicator species of algae. Commonly occurring algae were listed as indicators of water quality. The indicator species described are still used today and are referenced throughout this report.

In more recent studies, Pederson et al. (1992) found that some metals were more highly concentrated in periphyton than in associated sediments.

In 1994, Vaultonburg et al. reported that much attention had been given to macroinvertebrate and fish communities but algal communities had been ignored. They noted that algae were potentially more sensitive as monitors of environmental change.

Nutrients

Richardson et al. (1994) studied streams impacted by agricultural activities and identified several species of algae that were present in the majority of streams known to be impacted by agriculture.

In somewhat related studies, Watson (1988) found that periphyton accumulation rates on artificial substrates were significantly lower upstream from major point sources of nutrients.

Lewis (1986) found different dominant periphyton species when comparing areas above and below a municipal wastewater outfall. Amphora perpusilla comprised 80% of the community

Abstract

Periphyton communities of ten selected tributaries of the New River Gorge National River, West Virginia, were sampled from the summer of 1995 through the spring of 1996. Artificial substrates (diatometers) were placed in the streams for a period of three weeks to collect periphyton during each of the four seasons. During the study, 106 species of algae were identified and densities determined. The majority of the species were of the orders Naviculales and Fragilariales, comprising 35% and 22% of the species, respectively. Community structure and seasonal variation were evaluated using percent similarity, quotient of similarity and coefficient of community. Based on the indices used in the analysis, Arbuckle and Dunloup Creeks had the highest similarity of the ten communities studied. The winter communities of Dunloup and Arbuckle Creeks had the highest percent similarity observed (94.8%). The summer community also showed high percent similarity (65.4%). Indicator species were used to identify possible environmental problems within each watershed. The presence of Schizothrix calcicola in over 71% of the samples indicated that human waste was the major contributor to pollution in these streams.

downstream of the outfall, but only 30% above the outfall. Knorr and Fairchild (1987) found periphyton to be more responsive to physical variables (discharge and stream size) than to nutrient chemistry in Pennsylvania streams. Brown and Olive (1994) found a shift in dominant periphytic diatoms, and an increase in the number of taxa present, following renovation of a wastewater treatment plant.

Other factors affecting algal growth

Power and Stewart (1987) found that prior to flooding, 81% of their study sites had macroscopically detectable algae. However, four days after flooding only 26% of the sites had macroscopically detectable algae. They concluded that scouring and redistribution of sediment could drastically affect attached algae.

In a more recent study, Stevenson et al. (1996) reported that light deprivation, suspension and redeposition of sediment, as a result of wave action in lentic systems, type and extent of grazing, and seasonal drying affected algal communities.

In a somewhat related study, DeNicola et al. (1992) discussed the effects of canopy cover in small streams. They found that substrates play an important role in the algal community.

Stream chemistry also plays a role in algal growth. Meegan et al. (1994) evaluated the influence of pH on periphyton communities of headwater streams in Monongahela National Forest. Alkaline streams had the highest biomass of species richness and evenness, while acidic streams had the lowest.

Stream velocity is also important according to Lamb and Lowe (1987). They found that diatom cells were more than three times as dense in slow currents. Greater community diversity and more rapid development also occurred among communities in slow current.

Borchardt et al. (1994) reported that water motion enhanced productivity by reducing the unstirred water layer around the algae, therefore, increasing the diffusive flux of nutrients to the uptake points within the cell membrane. They found that the low velocities that provide for physiologically optimum conditions were different among lotic algae. It was suggested that this could help explain patterns of algal abundance and distribution in running water. In addition, Lindstrom and Traaen (1984) noted flow velocities vary widely over the length and width of a stream. Some algae grow in a narrow range of flow velocities while other taxa are found at any flow velocity as long as scouring does not occur.

Grazing

Dickman (1968) and Elwood and Nelson (1972) reported that algal communities decrease in abundance and/or diversity of taxa with grazing. Lamberti et al. (1995) found that algal turnover rate increased with grazer abundance. Algal standing crop, export, and gross primary production declined logarithmically with increasing grazer density. Lamberti et al. (1987) found that the key mechanisms by which herbivores modified periphyton communities were consumption and dislodgment.

In 1990, Hill and Harvey studied the effects of grazers and light on periphyton. They found that the response of periphyton to grazers and light was layer-specific. Snail grazing primarily controlled chlorophyll and productivity in the loosely attached layer. In the tightly attached layer, chlorophyll and productivity were significantly related to ambient light.

Colonization

Hoagland et al. (1982) found that the rate of algal colonization was slow for the first two weeks in the spring, fall and winter but rapid during the summer. They found a fairly consistent colonization sequence: a presumably organic coating and a variety of bacteria, next came low profile diatoms, and finally an upper story of long-stalked and large rosette diatoms and filamentous green algae. They reported that diatom mucilage also contributed to community structure by binding particles and entrapping other algae and serve as a mechanism for substrate attachment.

Seasonal variation

Rosowski et al. (1986) discussed spring-summer and fall-winter diatom dominants. They also briefly discussed the environmental indicators suggested by Lowe (1974).

Jones et al. (1992) found that phytoplankton densities were higher in embayment areas of the Potomac River than in the main channel. They believed flushing to be more important than growth processes in explaining seasonal variation. Diatoms dominated in the spring and blue-green algal dominated in the summer.

Local studies

Warner (1971) found Ulothrix tenerrima Kutzing, and Eunotia exigua Breb. ex Kutz, to be tolerant to acid mine drainage. Rose et al. (1979) discussed the water quality changes that have occurred as a result of surface coal mining in the New River basin.

Moll and Keller (1980) examined periphyton of streams that receive sewage effluent, steel mill effluent, mine drainage, and no effluent. The study revealed unique and different growth patterns, seasonal variation, and changes in community structure as a function of the type of effluent or lack of effluent.

Water quality monitoring programs have been conducted within the NERI since 1980. The West Virginia Department of Natural Resources (WV DNR) was contracted to assist in this research. Many of the studies were concentrated on fecal coliform (WV DNR, 1989; Wood, 1990; Wood, 1990; Hebner, 1991; Sullivan, 1993).

Weeks et al. (1997) identified the algae present in various tributaries of the NERI, including Glade Creek, Marr Branch, Arbuckle Creek and Wolf Creek.

WVDNR (1976) prepared a comprehensive survey of the New River basin. They described the area's soils, tributaries, etc. They found that mine drainage affected approximately 66 miles of tributaries to NERI in Fayette and Raleigh Counties. Acid mine drainage occurred in Wolf, Arbuckle, Dunloup, Laurel, and Glade Creeks. Industrial pollution was noted in Arbuckle Creek, and Dunloup Creek contained domestic pollution. At the time this

study was completed, only about one-third of the area was served by wastewater treatment facilities.

Study area

Ten tributaries to the NERI, WV, were selected for study (Figure 1.1). This selection was based on historical water quality data, local knowledge of the area and assistance from the NPS. Five of the streams (Arbuckle Creek, Dunloup Creek, Keeney Creek, Marr Branch and Wolf Creek) were believed to be polluted. The other five (Laurel Creek at Quinnimont, Glade Creek, Dowdy Creek, Lick Creek and Meadow Creek) were believed to be relatively unpolluted.

Soils

Soils (Table 1.1) of the study streams are dominated by Calvin, Gilpin, Dekalb and Berks soils (Soil Conservation Service, 1975). Calvin soils are found along the ridgetops, benches and hillsides and were formed from red shale, siltstone and some sandstone. Gilpin soils, found on ridgetops, benches and side slopes, were formed from siltstone, shale and some soft sandstone. Dekalb soils are of sandstone origin and also found on ridgetops, benches and side slopes. Berks soils are similar to the Calvin series in origin and location (Soil Conservation Service, 1975). Climate

Climatic data summarized in Table 1.2 was recorded by the National Weather Service at the Raleigh County Memorial Airport near the edge of the New River Gorge, 2.5 miles east of Beckley

at 2,504 feet elevation. May through September is generally warm, with November through March moderately cold. April and October are months of fairly rapid transition. Cold waves occur two or three times during the winter on average, but severe cold spells longer than two or three days duration are uncommon. Below-zero (°F) temperatures, as well as temperatures around 70°F, have been recorded during the winter. Summer highs may be near 90°F, while summer lows may be near 30°F (National Oceanic and Atmospheric Administration, 1995 and 1996).

Precipitation is relatively evenly distributed throughout the year. July has the highest monthly average, while October has the lowest average. Snowfall occurs mostly from November through March. Precipitation for the study period is summarized in table 1.2 (National Oceanic and Atmospheric Administration, 1995 and 1996).

Vegetation

Most of NERI is forested (Suiter, 1995). Disturbed areas are scattered throughout the region, but are concentrated around the towns.

Tributaries studied

Glade Creek is a large tributary entering the New River near Hamlet in Raleigh County, WV. The (63.3 square mile) Glade Creek watershed contains the largest tract of relatively undeveloped land within the New River Gorge National River and is the largest stream in the study area. Glade Creek flows 18.1 miles from its source before it enters the New River (U.S. Department of Interior, 1990) . Approximately six miles of Glade Creek are

Figure 1.1 New River Gorge National River Site Map, West Virginia. Site 1 - Glade Creek, Site 2 - Laurel Creek, Site 3 - Dowdy Creek, Site 4 - Dunloup Creek, Site 5 - Arbuckle Creek, Site 6 - Wolf Creek, Site 7 - Marr Branch, Site 8 - Keeney Creek, Site

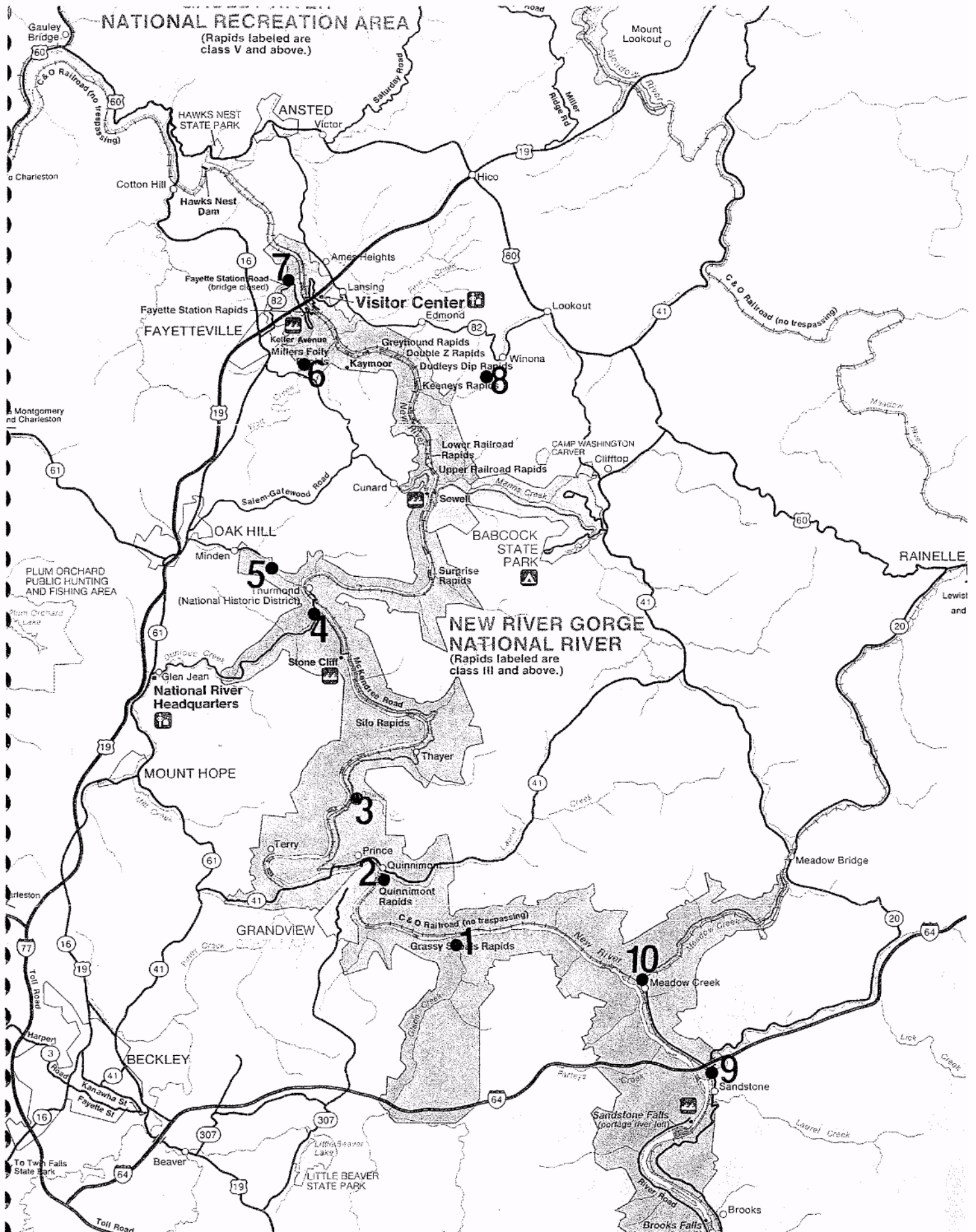


Table 1.1 Soils of the Tributaries of the NERI

Site No.	Site Name	Soil Phase
1	Glade Creek	Gravelly Alluvial & Steep Rock land
2	Laurel Creek	Made land & Meckesville very stony
3	Dowdy Creek	Dekalb and Gilpin very stony
4	Dunloup Creek	Philo silt loam
5	Arbuckle Creek	Dekalb and Gilpin, very stony & Philo silt loam
6	Wolf Creek	Dekalb and Gilpin very stony
7	Marr Branch	Ernest and Shelocta very stony silt loams
8	Keeney Creek	Ernest and Shelocta very stony silt loams
9	Lick Creek	Shouns stony silt loam Chagrin Loam
10	Meadow Creek	Shouns stony silt loam

Service (1975) and Soil Conservation

Service (1984).

Table 1.2. Climatological Data for the New River Gorge National River (National Oceanic and Atmospheric Administration, 1995 and 1996)

Month	Precipitation Inches	Departure*	Temperature (°F)	Departure*
May 95	5.62	1.64	58.2	-1.0
June 95	5.57	1.73	67.2	.1
July 95	2.67	-2.03	71.8	1.1
August 95	2.67	-.71	74.1	4.2
September 95	2.92	-.41	62.1	-1.9
October 95	3.29	0.40	54.8	1.9
November 95	3.84	0.85	37.5	-6.4
December 95	2.43	-.80	29.6	-4.5
January 96	5.53	2.61	30.3	1.1
February 96	2.84	-.10	31.8	-.3
March 96	4.11	0.71	36.6	-5.4
April 96	3.15	-.28	50.6	-0.6
May 96	7.52	3.54	62.8	3.3
June 96	3.97	0.13	69.2	3.0
	*Departure is from the average precipitation or temperature			

within the NERI boundary. The stream was sampled approximately 0.4 mile above its confluence with the New River (Figure 1.2).

Laurel Creek flows approximately 11.0 miles before it enters the New River at Quinnimont, in Fayette County, WV. The drainage area for this stream is approximately 27.6 square miles (Adkins, 1976). The stream originates north of the small town of Crickner, flows west through a strip mine, and continues west through the small communities of Lawton and Laurel Creek. Laurel Creek was sampled approximately 0.15 mile above its confluence with the New River (Figure 1.3).

Dowdy Creek begins in Highland Mountains and enters the New River near McKendree in Fayette County, WV. The stream is very shaded and has a rocky substrate. The stream length is approximately 3.1 miles. Its watershed is approximately 3.2 square miles. The stream was sampled approximately 0.25 mile above its confluence with the New River (Figure 1.4).

Dunloup Creek flows approximately 14.9 miles before it enters the New River in Fayette County, WV. The drainage area is approximately 48.5 square miles (Adkins, 1976). The stream receives drainage and run-off from numerous communities, including Glen Jean, Mount Hope and Kilsyth. The stream was sampled approximately 0.05 mile above its confluence with the New River (Figure 1.5).

The total length of Arbuckle Creek is approximately 6.2 miles. The stream originates in the town of Summerlee at a mine dump, runs south through Oak Hill, continues east through the small communities of Minden and Rocklick, then enters the New

Figure 1.2 Glade Creek (Site 1). Photographs taken looking upstream.



Figure 1.3 Laurel Creek (Site 2). Photograph taken looking
upstream.

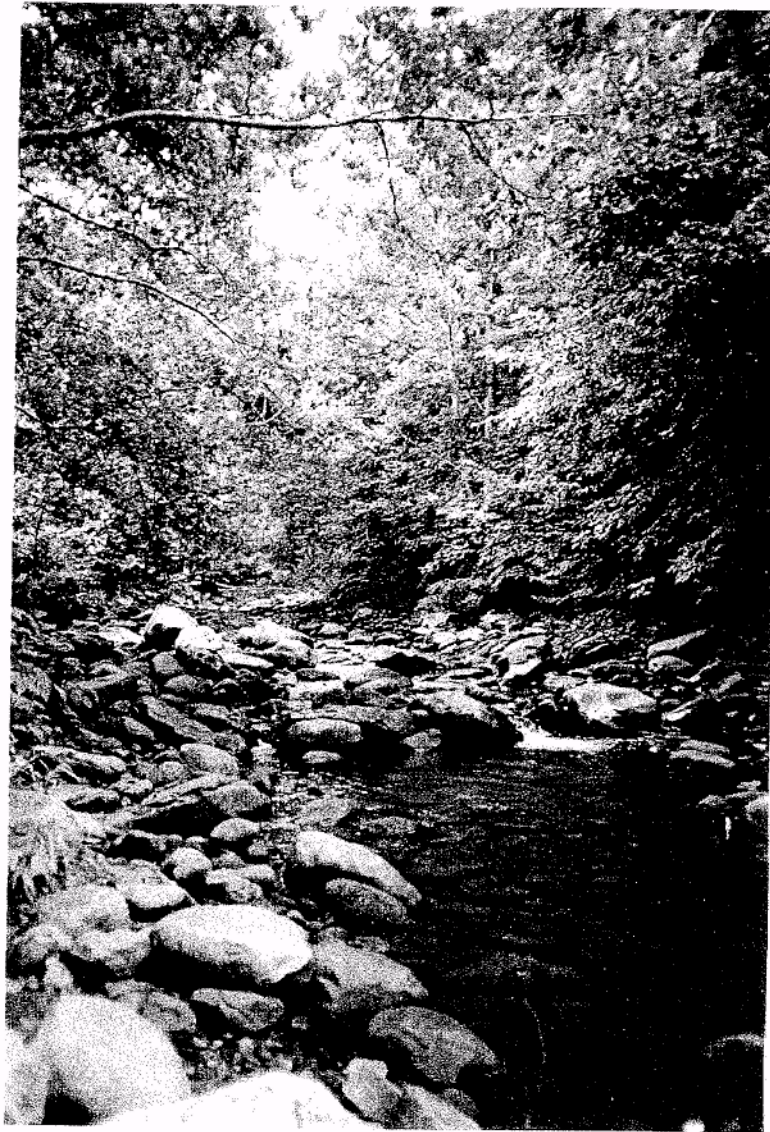
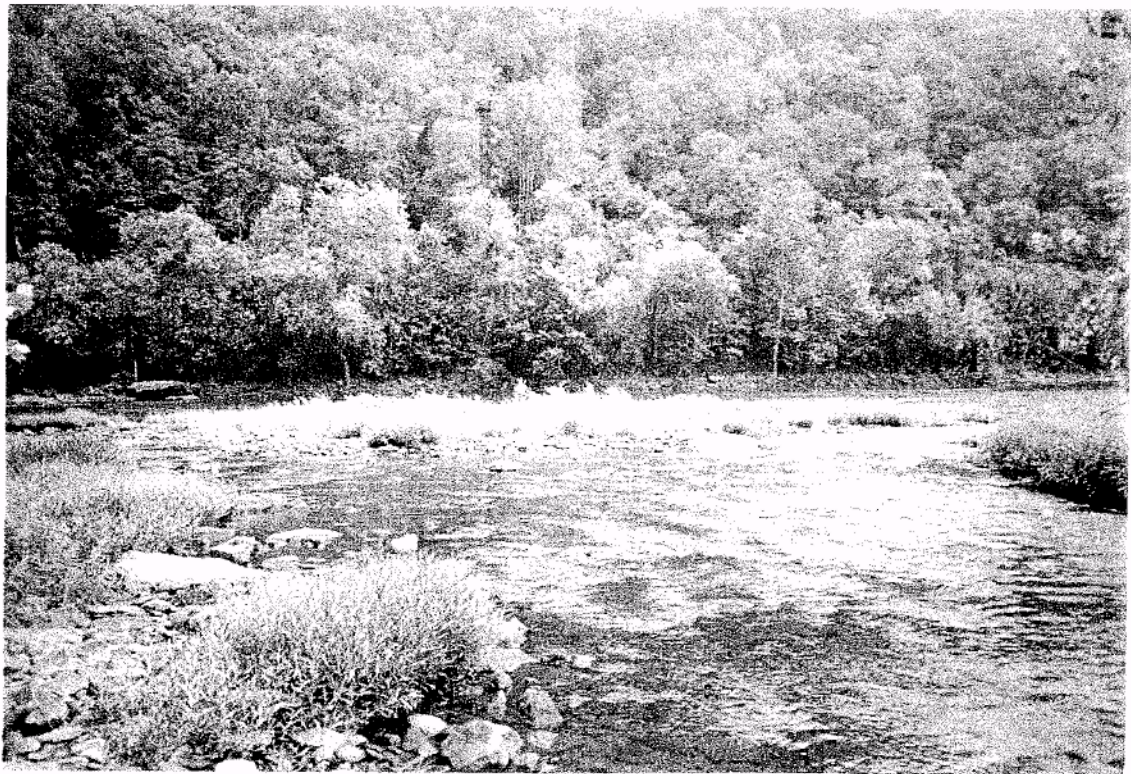
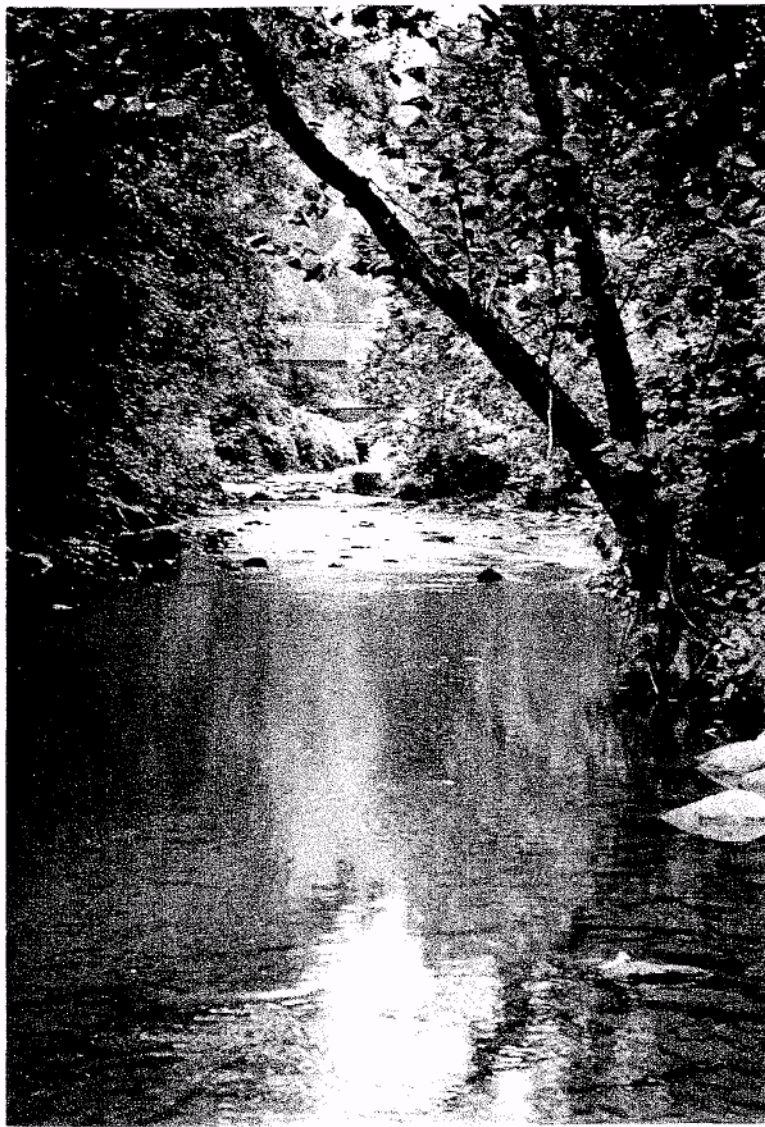


Figure 1.4 Dowdy Creek (Site 3). Photograph taken looking
upstream.



Figure 1.5 Dunloup Creek (Site 4). Photograph (above) looking upstream, photograph (below) looking downstream to the New River Gorge National River.



River across the river from Thurmond, in Fayette County, WV. The drainage area is approximately 8.7 square miles (Adkins, 1976). Arbuckle Creek was sampled approximately 1.4 miles above its confluence with the New River (Figure 1.6).

The length of Wolf Creek is approximately 5.2 miles and its drainage area is approximately 17.4 square miles (Adkins, 1976). The stream originates in the town of Summerlee, flows east along State Route 16 through Harlem Heights and continues north-east; just east of Fayetteville. Wolf Creek enters the New River near Fayette Station in Fayette County, WV. The stream was sampled approximately 1.9 miles above its confluence with the New River (Figure 1.7).

Marr Branch has its origin just west of the small community of Oak Ridge and flows eastward. The main branch of Marr Branch is approximately 3.1 miles in length and drains approximately 2.8 square miles. It receives drainage from the town of Fayetteville before it enters the New River in Fayette County, WV. The stream was sampled approximately 0.45 mile above its confluence with the New River (Figure 1.8).

Keeney Creek flows approximately 6.9 miles and drains 8.9 square miles before it enters the New River (Adkins, 1976). The stream begins south east of Lookout, flows west along State Route 82 to the community of Winona then flows south where it enters the New River at the community of Keeneys Creek, Fayette County, WV. The stream was sampled approximately 1.1 miles above its confluence with the New River (Figure 1.9).

Lick Creek flows approximately 11.2 miles and drains approximately 39.1 square miles before it enters the New River just north of Sandstone, Summers County, WV. The stream begins in Keeney Mountains and runs west through Green Sulphur Springs, The stream continues west along State Route 20 before it enters the New River. The stream was sampled approximately 0.1 mile above its confluence with the New River (Figure 1.10).

Meadow Creek flows approximately 8.9 miles and drains approximately 28.8 square miles before it enters the New River in the small community of Meadow Creek, Summers County, WV. Meadow Creek begins north of Meadow Bridge in Fayette County, winds along State Route 20, and flows south-west along the railroad tracks through Summers County before entering the river. The stream was sampled approximately 0.1 mile above its confluence with the New River (Figure 1.11).

Figure 1.6 Arbuckle Creek (Site 5). Photograph taken looking downstream.



Figure 1.7 Wolf Creek (Site 6). Photograph taken looking
 downstream.



Figure 1.8 Marr Branch (Site 7). Photograph taken looking
 downstream.



Figure 1.9 Keeney Creek (Site 8). Photograph taken looking
 downstream.



Figure 1.10 Lick Creek (Site 9). Photograph taken looking
downstream toward the New River Gorge National River.



Figure 1.11 Meadow Creek (Site 10). Photographs taken looking upstream.



Methods and Materials

Each tributary was sampled four times over one year (summer of 1995, fall of 1995, winter of 1996 and spring of 1996). Artificial substrates, diatometers, (Patrick and Reimer, 1966) were placed in each stream for a period of 21 days. Each diatometer contained eight standard microscope slides. The floating diatometers were concealed in the stream, under trees and away from heavy recreational areas, and secured by nylon string to large rocks or tree roots. Some diatometers were lost due to storm events or human intervention.

Water quality measures were taken at each location using the Hydrolab Model H20/SCOUT Water Quality Monitoring System. Water temperature ($^{\circ}\text{C}$), dissolved oxygen (D.O.) in parts per million (ppm), pH, specific conductance ($\mu\text{S}/\text{cm}$), and turbidity in (NTUs) were evaluated. Alkalinity (ml/l) was measured using a HACK Model AL-36DT Test Kit. Air temperature ($^{\circ}\text{C}$) was also determined.

Identification of algal communities was accomplished with a Baush and Lomb phase contrast microscope. Living samples were examined for preliminary identification. Diatom slides were prepared for examination under oil immersion according to the methods of Patrick et al. (1966). Identifications were made using Prescott (1978), Patrick and Reimer (1966, 1975), and Whitford and Schumacher (1984). After the algae were identified, the sample was counted under 40x using a Whipple eyepiece, Finn timer 250 μL and a Palmer counting cell according to the

methods of Choi, et al. (1992). After the periphyton was counted the cell density per week (cells/cm²/week) was calculated.

Percent similarity, quotient of similarity and the coefficient of community were selected to evaluate community similarity for this study.

Percent similarity was calculated within each community. Taxa abundance was calculated as a percentage using E[lowest percentage for each taxa]. For each taxa, the lowest percentage between any two communities was summed to calculate percent similarity. The closer the value was to 100, the higher the similarity was considered to be for the two communities.

Quotient of similarity was calculated as $2c/(s_1 + s_2)$, where s_1 and s_2 equal the number of taxa present in community 1 and 2, respectively, and c equals the number common to both communities. This analysis addressed the presence or absence of taxa within the communities that were being compared. The closer the values were to 1.0, the higher the similarity was considered to be for the communities.

Coefficient of community was calculated as $2w/(A + B)$, where w equals the sum of the lower of the two quantitative values for taxa present in both communities. A equals the sum of all values for first community, and B equals the sum of all values for second community. Coefficient of community addressed the abundance of the species present in the community. The closer the values were to 1.0, the higher the similarity was considered to be for the individuals present.

A computer program (Eckblad, 1989) was used to determine the values for the percent similarity, quotient of similarity and coefficient of community.

Results & Discussion

Algae Present

A total of 106 species, representing ten orders (Table 3.1), were identified. The majority of the species present were of the orders Naviculales and Fragilariales (33% and 21%, respectively). Diatoms comprised 79% of the algal community. Wolf Creek had the highest species richness and Dowdy Creek had the lowest (Table 3.2).

Table 3.1 Algal Species identified in the study area

Division Chlorophyta

Class Chlorophyceae

Order Ulotrichales

Ulothrix aequalis Kutzing
Ulothrix tenerima Kutzing
Ulothrix subtilissima Rabenhorst
Stigeoclonium stagnatile Hazen
Stigeoclonium tenue (Ag.) Kutz.

Order Oedogoniales

Oedogonium suecicum var. *australe* G. S. West

Order Chlorococcales

Pediastrum boryanum (Turp.) Meneghini

Order Zygnematales

Closterium moniliferum Ehrenb.
Closterium sp. Nitzsch
Cosmarium sp. Corda
Mougeotia sphaerocarpa Wolie
Staurastrum botrophilum Wolle

Division Chrysophyta

Class Bacillariophyceae

Order Eupodiscales

Cyclotella comta (Her.) Kutzing
Cyclotella meneghiniana Kutzing
Cyclotella stelligera Cleve & Grunow
Melosira varians C. A. Grdth.

Class Bacillariophyceae**Order Fragilariales**

Diatoma hiemale var. mesodon (Her.) Grun.
Diatoma vulgare Boyr
Diatoma vulgare Boyr var. vulgare
Fragilaria construens (Her.) Grun.
Fragilaria crotonensis Kitton
Fragilaria pinnata Ehr. var. pinnata
Fragilaria vaucheria (Kutz.) Boye Petersen
Meridion circulare (Grev.) Agardh
Synedra acus Kutz.
Synedra acus var. radians (Kutz.) Hust.
Synedra amphicephala Kutz.
Synedra amphi c ephala var. austriaca (Grun.) Hust.
Synedra capitata Ehr. var. capitata
Synedra fasciculata var. fasciculata (Ag.) Kutz
Synedra nana Meister
Synedra pulchella var. lanceolata O'Meara
Synedra rumpens Kutz.
Synedra tabulata (Ag.) Kutz.
Synedra ulna (Nitzsch.) Ehrenberg
Synedra ulna var. contracta Oestrup
Tabellaria fenestrata (Lyng.) Kuntzing
Tabellaria flocculosa (Roth.) Kut.

Class Bacillariophyceae**Order Eunotiales**

Eunotia elegans Oestrup
Eunotia glacialis Meister
Eunotia incisa W. Smith
Eunotia trianacria Krasske
Eunotia valida Hustedt

Order Achnanthales

Achnanthes conspicua A. Meyer
Achnanthes lanceolata (Breb.) Grunow
Achnanthes microcephala Kutzling
Cocconeis disculus (Schum.) Cleve
Cocconeis placentula Ehrenberg
Cocconeis placentula var. euglypta (Ehr.) Cleve
Rhoicosphenia curvata (Kutz.) Grun.

Order Naviculales

Amphora pediculus var. minor Grunow
Cymbella affinis Kutz.
Cymbella aspersa (Ehr.) Cleve
Cymbella cesati Kutz.
Cymbella tumida (Breb.) van Huerck
Cymbella turgida (Greg.) Cleve
Gomphonema acuminatum Ehr.
Gomphonema angustatum var. producta Grunow
Gomphonema augur Ehr.
Gomphonema constrictum Ehr.
Gomphonema parvulum Kutz.

Class Bacillariophyceae

Order Naviculales

Gomphonema subclavatum Grunow
Gyrosigma obtusatum (Sulliv.) Boyer
Navicula accomoda Hust.
Navicula angusta Grunow
Navicula capitata Ehrenberg.
Navicula cryptocephala Kutz.
Navicula exigua (Greg.) O. Muller
Navicula exigua var. capitata Patr.
Navicula gottlandica Grun. var. gottlandica
Navicula graciloides A. Mayer
Navicula inflexa Greg.
Navicula placenta Ehr.
Navicula protracta Grun.
Navicula radiosa var. tenella (Breb.) Cleve
Navicula rhynchocophala var. amphiceros (Kutz.) Grun
Navicula salinarum var. intermedia (Grun.) Cl.
Navicula tripunctata (O.F. Mull) Bory
Navicula viridula (Kutz.) Kutz.
Navicula viridula (Kutz.) Kutz. emend. V.H. var. viridula
Pinnularia biceps Gregory
Pinnularia legumen Ehr.
Pinnularia mesolepta (Ehr.) W. Smith
Pinnularia sudetica Hilse
Pinnularia viridis (Nitz.) Hustedt

Class Bacillariophyceae

Order Nitzschiales

Nitzschia acicularis W. Smith
Nitzschia fonticola Grun.
Nitzschia ignorata Krasske
Nitzschia linearis W. Smith
Nitzschia palea (Kutz.) W. Sm.
Nitzschia vermicularis (Kutz.) Grun.

Order Bacillariales

Bacillaria paradoxa Gmelin

Order Surirellales

Surirella biseriata var. bifrons f. amphioxys (W. Smith)
Hust.
Surirella brightwellii (Ehr.)
Surirella lanicostata Oestrup
Surirella patella var. neupaueri (Pant.) Cleve-Euler

Division Cyanophyta

Class Cyanophyceae

Order Oscillatoriales

Lyngbya aestuarii (Mert.) Liebman
Lyngbya birgei G. M. Smith
Lyngbya digueti Com.

Lyngbya lagerheimii (Mobius) Gomont.
 Lyngbya ochracea (Kutz.) Thuret
 Lyngbya penicillata Kutz
 Lyngbya putealis Motaigue
 Schizothrix calcicola (Ag.) Gomont
Spirulina major Kutzing

Table 3.2 Species Richness of tributaries sampled in the NERI, WV

Stream	Season/year	Number of Species
Glade Creek	Fall 1995	14
Laurel Creek	Summer 1995	2
	Fall 1995	9
	Winter 1996	11
	Spring 1996	8
Dowdy Creek	Fall 1995	2
	Spring 1996	7
Dunloup Creek	Summer 1995	12
	Winter 1996	12
Arbuckle Creek	Summer 1995	16
	Fall 1995	16
	Winter 1996	13
	Spring 1996	19
Wolf Creek	Summer 1995	24
	Fall 1995	15
	Spring 1996	14
Marr Branch	Summer 1995	16
	Fall 1995	9
	Winter 1996	7
Keeney Creek	Fall 1995	12
	Winter 1996	8
	Spring 1996	18
Lick Creek	Summer 1995	18
	Fall 1995	18
	Spring 1996	11
Meadow Creek	Summer 1995	15
	Fall 1995	4
	Spring 1996	6

Community structure - seasonally

Each of the streams was compared to determine the similarity between the seasons. This was accomplished by looking at the dominants from each season according to the methods of Weeks, et

al. (1997). In addition the percent similarity, coefficient of community and quotient of similarity were used.

Dunloup Creek

The percent similarity between the summer and winter samples was 56.5%. The quotient of similarity and coefficient of community were low (Table 3.3). Species richness was the same for both summer and winter communities (Table 3.2). S. calcicola was the dominant species in both seasons. Weaks et al. (1997) found that M. varians was one of the dominants in both the summer and winter communities. Twenty percent of the species identified by Weaks et al. (1997) was present in this sample.

Table 3.3 Similarity indices between summer 1995 and winter 1996 communities of Dunloup Creek

Percent Similarity	Quotient of Similarity	Coefficient of Community
56.5	.364	0.66

Arbuckle Creek

Based on percent similarity, quotient of similarity and coefficient of community, summer and fall communities had the highest similarity (Tables 3.4-3.6). S. calcicola was dominant in all four seasons. M. varians accounted for the second highest cell density in both the summer and fall communities. Species richness remained similar throughout the seasons (Table 3.2). Seventy-five percent of the species observed by Weaks et al. (1997) were present in Arbuckle Creek.

Table 3.4 Percent Similarity for
Arbuckle Creek

Season/year	Winter 1996	Summer 1995	Fall 1995
Spring 1996	5.8	19.2	10.4
Fall 1995	46.7	81.4	
Summer 1995	48.8		

Table 3.5 Quotient of Similarity for
Arbuckle Creek

Season/year	Winter 1996	Summer 1995	Fall 1995
Spring 1996	.483	.471	.313
Fall 1995	.400	.600	
Summer 1995	.444		

Table 3.6 Coefficient of Community for
Arbuckle Creek

Season/year	Winter 1996	Summer 1995	Fall 1995
Spring 1996	.050	.187	.099
Fall 1995	.326	.464	
Summer 1995	.181		

Wolf Creek

Percent similarity and coefficient of community indicated that the spring and fall communities had the highest similarity. Quotient of similarity was low for all communities (Tables 3.7-3.9). S. calcicola was dominant in the fall and spring seasons. The summer season had no obvious dominant. In the fall and spring community there were two or three obvious dominants. The cell count for the summer sample showed that the taxa were evenly distributed with no obvious dominant. Forty percent of the species identified by Weeks et al. (1997) were present in this study. Species richness for the fall and spring seasons was very similar but the summer sample contained a higher number of species (Table 3.2).

Table 3.7 Percent Similarity for
Wolf Creek

Season/year	Spring 1996	Fall 1995
Summer 1995	4.5	15.3
Fall 1995	47.5	

Table 3.8 Quotient of Similarity
for Wolf Creek

Season/year	Spring 1996	Fall 1995
Summer 1995	.378	.316
Fall 1995	.276	

Table 3.9 Coefficient of Community
for Wolf Creek

Season/year	Spring 1996	Fall 1995
Summer 1995	.057	.096
Fall 1995	.433	

Marr Branch

Percent similarity and coefficient of community demonstrated that the summer and fall periphyton communities were moderately similar (Tables 3.10-3.12). The similarity indices also indicated that the winter community showed little to no similarity for the other two seasons. S. calcicola was the dominant species in the summer and fall communities, but was absent in the winter community. N. viridula, which was absent in the other communities, was a dominant in the winter sample. Species richness was lowest in the winter and highest in the summer season. Approximately 25% of the species observed by Weeks et al. (1997) in the three branches of Marr were identified in these communities.

Table 3.10 Percent Similarity
for Marr Branch

Season/year	Winter 1996	Fall 1995
Summer 1995	0.7	47.8
Fall 1995	0.3	

Table 3.11 Quotient of Similarity
for Marr Branch

Season/year	Winter 1996	Fall 1995
Summer 1995	.190	.300
Fall 1995	.182	

Table 3.12 Coefficient of Community
for Marr Branch

Season/year	Winter 1996	Fall 1995
Summer 1995	.003	.547
Fall 1995	.001	

Keeney Creek

Percent similarity indicated that the fall and winter communities were most similar (Table 3.13). The coefficient of community for the spring and winter had a higher value than the other communities (Table 3.15). S. calcicola was the obvious dominant in the spring, fall and winter seasons. Species richness was highest in the spring season community, and lowest during the winter.

Table 3.13 Percent Similarity
for Keeney Creek

Season/year	Winter 1996	Fall 1995
Spring 1996	67.4	69.1
Fall 1995	80.2	

Table 3.14 Quotient of Similarity
for Keeney Creek

Season/year	Winter 1996	Fall 1995
Spring 1996	.348	.467
Fall 1995	.471	

Table 3.15 Coefficient of Community
for Keeney Creek

Season/year	Winter 1996	Fall 1995
Spring 1996	.123	.491
Fall 1995	.292	

Glade Creek

The only community represented in this study was the fall community. Samples were lost from flooding during the other seasons. The community was dominated by F. crotonensis. Weeks et al. (1997) observed eight species in this community, while 14 were present in this study. Twenty-five percent of the species identified by Weeks et al. (1997) were present in this community.

Laurel Creek

Percent similarity, coefficient of community and quotient of similarity showed moderate similarity between the spring and winter communities, and the summer and fall communities (Tables 3.16-3.18). Spring community had no (zero) similarity with summer or fall communities. The spring community was unique in that S. calcicola was very abundant, but absent in the fall and summer. It was present in the winter community. The taxa and density of the species varied significantly from season to season. The dominant in both summer and fall was C. placentula var. euglypta. The abundance of this species was substantially

lower in the fall community and completely absent in the spring community. The winter dominant was M. circulare, but this species was present only during the winter. Species richness was similar in the fall, winter, and spring, but the summer community had only two species.

Table 3.16 Percent Similarity for
Laurel Creek

Season/year	Spring 1996	Fall 1995	Summer 1995
Winter 1996	24.1	7.7	1.8
Summer 1995	0.0	23.5	
Fall 1995	0.0		

Table 3.17 Quotient of Similarity for
Laurel Creek

Season/year	Spring 1996	Fall 1995	Summer 1995
Winter 1996	.267	.222	.364
Summer 1995	.000	.182	
Fall 1995	.000		

Table 3.18 Coefficient of Community for
Laurel Creek

Season/year	Spring 1996	Fall 1995	Summer 1995
Winter 1996	.192	.095	.013
Summer 1995	.000	.038	
Fall 1995	.000		

Dowdy Creek

Percent similarity and coefficient of community indicated that the spring and fall seasons were similar (Table 3.19). S. calcicola was the dominant species in both communities. U. tenerrima was also dominant in the spring community. Species richness was low in both seasons (Table 3.2).

Table 3.19 Similarity indices between the fall 1995 and spring 1996 communities of Dowdy Creek

Percent Similarity	Quotient of Similarity	Coefficient of Community
58.7	.333	0.700

Lick Creek

Lick Creek demonstrated low similarity between seasons (Tables 3.20-3.22), with highest similarity occurring between the summer and fall seasons. The dominant in the fall season was F. crotonensis, which had an extremely high cell density (10,000 cells/cm²/wk). The other species present in the sample contained fewer than 505 cells. The obvious dominant in the spring was S. calcicola. C. placentula and C. turgida were the obvious dominants in the summer sample. These dominants were very abundant in the samples. Species richness was similar in the fall and summer communities but the number of species was approximately half that of the spring community. The spring community had a low number of species compared to the fall and summer communities.

Table 3.20 Percent Similarity for Lick Creek

Season/year	Spring 1996	Summer 1995
Fall 1995	4.3	21.9
Summer 1995	10.0	

Table 3.21 Quotient of Similarity
for Lick Creek

Season/year	Spring 1996	Summer 1995
Fall 1995	.222	.389
Summer 1995	.222	

Table 3.22 Coefficient of Community
for Lick Creek

Season/year	Spring 1996	Summer 1995
Fall 1995	.052	.198
Summer 1995	.101	

Meadow Creek

Similarity indices showed little to no similarity between the three seasons (Tables 3.23-3.25). The fall community was comprised of only four species, dominated by S. calcicola. The spring community was dominated by L. putealis. The summer community had the highest species richness, with no obvious dominant. Blue-green algae dominated the fall and spring communities. Only diatoms were present during the summer.

Table 3.23 Percent Similarity for
Meadow Creek

Season/year	Fall 1995	Spring 1996
Summer 1995	10.5	1.9
Spring 1996	18.9	

Table 3.24 Quotient of Similarity
for Meadow Creek

Season/year	Fall 1995	Spring 1996
Summer 1995	.222	.111
Spring 1996	.250	

Table 3.25 Coefficient of Community
for Meadow Creek

Season/year	Fall 1995	Spring 1996	
Summer 1995	.089	.014	I
Spring 1996	.171		

Slimmer Community Similarity

Table 3.26 gives percent similarity for the summer 1995 samples. Laurel Creek had the most unique flora among the streams sampled. C. placentula var. euglypta was dominant in such abundance (20,012 cells/cm²/week) , that only one other species was observed in this season. Arbuckle Creek and Marr Branch had the highest similarity, (71.4%). Dunloup Creek had high percent similarity with the other communities. Arbuckle Creek, Dunloup Creek and Marr Branch were dissimilar (0 - 21.4%) with the streams thought to be relatively unpolluted (Lick, Meadow and Laurel Creeks). However, Wolf Creek, also thought to be polluted, had high similarity (70.2) with Meadow Creek.

Table 3.26. Percent Similarity for the Summer 1995 Communities

Stream	Laurel	Dunloup	Meadow	Arbuckle	Marr	Lick
Wolf	0.6	14.0	70.2	18.9	9.0	20.5
Lick	0.6	21.4	7.0	7.8	5.4	
Marr	2.7	59.9	17.4	71.4		
Arbuckle	1.6	65.4	15.4			
Meadow	5.7	13.0				
Dunloup	0.0					

Table 3.27 shows the Quotient of similarity for summer samples. Arbuckle Creek and Marr Branch had the highest value,

while Dunloup Creek and Laurel Creek had no similarity. Again the data show that Arbuckle, Dunloup and Marr were the most similar during the summer.

Table 3.27 Quotient of Similarity for the Summer 1995 Communities

Stream	Laurel	Dunloup	Meadow	Arbuckle	Marr	Lick
Wolf	.080	.229	.108	.359	.158	.250
Lick	.105	.276	.129	.364	.250	
Marr	.235	.296	.207	.516		
Arbuckle	.222	.429	.267			
Meadow	.125	.154				
Dunloup	.000					

Coefficient of Community is shown in Table 3.28. Laurel Creek and Meadow Creek had very low similarity with the other communities. Dunloup and Marr had the highest similarity value. Arbuckle and Dunloup showed the second highest value. Arbuckle and Marr had the highest values for percent similarity and quotient of similarity (Table 3.27). In this analysis the values were low, 0.252. Therefore, the number of individuals was dissimilar within the communities, but the taxa were similar within the communities.

Table 3.28. Coefficient of Community for the Summer 1995 Communities

Stream	Laurel	Dunloup	Meadow	Arbuckle	Marr	Lick
Wolf	.008	.135	.107	.098	.092	.207
Lick	.008	.243	.070	.052	.053	
Marr	.013	.473	.165	.252		
Arbuckle	.017	.410	.081			
Meadow	.022	.081				
Dunloup	.000					

Fall Community Similarity

Percent similarity is illustrated in Table 3.29. The highest value (91.7%) was between Marr Branch and Dowdy Creek. The lowest values (0.0%) occurred between Marr Branch and Glade Creek, and Marr Branch and Laurel Creek. Overall, Lick Creek had very low percent similarity (0.6% to 7.1%) with the other communities. Likewise, Glade and Laurel Creeks had low percent similarities compared to other communities. Dowdy Creek, Marr Branch, Meadow Creek and Keeney Creek had high percent similarities.

Table 3.29. Percent Similarity for the Fall 1995 Communities

Stream	Meadow	Marr	Dowdy	Laurel	Keeney	Glade	Arbuckle	Wolf
Lick	1.2	5.5	0.6	1.7	2.0	4.4	1.7	7.1
Wolf	47.1	48.4	42.9	2.5	47.5	4.6	47.1	
Arbuckle	54.6	46.5	45.2	6.4	59.2	5.5		
Glade	5.3	0.0	0.7	20.9	6.7			
Keeney	90.6	81.4	81.2	4.5				
Laurel	2.3	0.9	0.0					
Dowdy	88.2	91.7						
Marr	88.2							

The highest value observed for quotient of similarity was between Keeney Creek and Arbuckle Creek (Table 3.30). The lowest values were between Laurel Creek and Dowdy Creek, and Glade Creek and Marr Branch at 0.0.

Table 3.30. Quotient of Similarity for the Fall 1995 Communities

Stream	Meadow	Marr	Dowdy	Laurel	Keeney	Glade	Arbuckle	Wolf
Lick	.091	.087	.100	.148	.267	.258	.125	.182
Wolf	.316	.200	.118	.167	.296	.143	.207	
Arbuckle	.222	.316	.125	.348	.462	.148		
Glade	.118	.000	.133	.182	.400			
Keeney	.250	.235	.143	.286				
Laurel	.154	.143	.000					
Dowdy	.333	.286						
Marr	.222							

The algal communities of Marr Branch and Dowdy Creek had the highest coefficient of community (Table 3.31). Laurel Creek and Dowdy Creek showed no similarity. Lick Creek and Glade Creek showed low similarity with all other communities. Dowdy Creek, Marr Branch and Meadow Creek had relatively high community similarity. Arbuckle Creek showed little to no community similarity with streams that are believed to be relatively free of pollutants. Wolf Creek and Keeney Creek also showed low similarity with the relatively unpolluted streams. However, Marr Branch showed high similarity with Dowdy Creek and Meadow Creek.

Table 3.31. Coefficient of Community for the Fall 1995 Communities

Stream	Meadow	Marr	Dowdy	Laurel	Keeney	Glade	Arbuckle	Wolf
Lick	.019	.026	.004	.015	.018	.039	.005	.092
Wolf	.175	.216	.253	.005	.537	.027	.282	
Arbuckle	.078	.094	.117	.015	.468	.011		
Glade	.056	.000	.006	.073	.043			
Keeney	.220	.259	.318	.018				
Laurel	.016	.013	.000					
Dowdy	.704	.844						
Marr	.773							

Winter Community Similarity

Dunloup and Arbuckle Creeks had the highest percent similarity (94.8%) (Table 3.32). The lowest percent similarity occurred between Marr Branch and Dunloup Creek (0.2%). Marr Branch had very low percent similarity when compared to all the streams. Dunloup Creek, Arbuckle Creek and Keeney Creek showed high percent similarity.

Table 3.32 Percent Similarity for the Winter 1996 communities

Stream	Laurel	Marr	Keeney	Dunloup
Arbuckle	24.8	1.6	80.2	94.8
Dunloup	22.0	0.2	79.5	
Keeney	28.2	12.7		
Marr	2.2			

Keeney Creek and Marr Branch showed the highest quotient of similarity at 0.545 (Table 3.9). The lowest value of 0.267 was between Dunloup Creek and Marr Branch.

Table 3.33 Quotient of Similarity for the Winter 1996 communities

Stream	Laurel	Marr	Keeney	Dunloup
Arbuckle	.400	.471	.375	.500
Dunloup	.333	.267	.286	
Keeney	.429	.545		
Marr	.400			

According to the Coefficient of Community, only Arbuckle and Dunloup Creeks exhibited similar communities (0.822) (Table 3.34). The values for the other streams were very low.

Table 3.34. Coefficient of Community for the Winter 1996 Communities

Stream	Laurel	Marr	Keeney	Dunloup
Arbuckle	.029	.018	.059	.822
Dunloup	.009	.002	.043	
Keeney	.185	.025		
Marr	.104			

Spring Community Similarity

The highest value calculated for percent similarity was 68.4% for the communities of Keeney and Laurel Creeks (Table 3.35). Arbuckle and Dowdy Creeks had the lowest percent similarity (4.1%) between their communities. When Arbuckle Creek was compared to the other streams the percent similarity between all the communities and Arbuckle Creek was very low.

Table 3.35 Percent Similarity for the Spring 1996 Communities

Stream	Dowdy	Laurel	Meadow	Lick	Wolf	Keeney
Arbuckle	4.1	6.2	10.7	4.3	8.8	10.8
Keeney	59.9	68.4	19.1	62.1	59.2	
Wolf	57.7	59.1	18.9	56.9		
Lick	56.3	61.0	24.5			
Meadow	20.3	20.4				
Laurel	59.6					

Laurel and Lick Creeks have the highest value for the quotient of similarity (0.533) (Table 3.36). The lowest value was between the communities of Meadow and Wolf Creeks.

Table 3.36. Quotient of Similarity for the Spring 1996 Communities

Stream	Dowdy	Laurel	Meadow	Lick	Wolf	Keeney
Arbuckle	.182	.250	.182	.222	.500	.389
Keeney	.273	.333	.182	.296	.313	
Wolf	.222	.400	.111	.174		
Lick	.154	.533	.308			
Meadow	.500	.400				
Laurel	.400					

Laurel and Dowdy Creeks have the highest similarity for coefficient of community (0.709) (Table 3.37). Likewise, the communities of Lick and Laurel Creeks have a high similarity value (0.706). Comparison of Arbuckle Creek with the other communities illustrated that Arbuckle had very low similarity to the other communities. Keeney and Wolf Creeks also showed low similarity values when compared to the other communities. In this analysis the streams that are believed to be free of contaminants showed higher values for the coefficient of community to each other.

Table 3.37 Coefficient of Community for the Spring 1996 Communities

Stream	Dowdy	Laurel	Meadow	Lick	Wolf	Keeney
Arbuckle	.055	.063	.040	.061	.081	.107
Keeney	.111	.113	.015	.108	.236	
Wolf	.341	.380	.049	.300		
Lick	.526	.706	.192			
Meadow	.113	.162				
Laurel	.709					

Environmental Problems

The identification of potential environmental problems within the streams using indicator species of periphyton was accomplished using Palmer (1980), Bahls et al. (1984), and Whitford and Schumacher (1984). The results are shown in a summary table that includes all the species that were dominant in samples within the study area and their indicator status (Table 3.38). The streams that were thought to be polluted will be discussed first.

Dunloup Creek

The blue-green algae S. calcicola, an indicator of sewage pollution (Palmer, 1980), was the dominant species during the winter and summer seasons (Table 3.38). M. varians had a high cell density. Whitford and Schumacker (1984) indicated that this diatom preferred high nutrients. It occurs in fresh, slightly brackish water, and prefers a pH 8.0 - 8.3 (Bahls et al., 1989). The pH value for the winter and summer seasons were 7.93 and 8.48, respectively (Tables 3.41 and 3.39). Other species present (N. cryptocephala, N. viridula, S. acus, C. placentula, D. vulgare var. vulgare, G. parvulum and S. ulna) have been designated as indicators of pollution (Bahls et al., 1984, Palmer, 1980). Two species (R. curvata, and S. fasciculata) tolerate hard, somewhat brackish water. Conductivity in Dunloup Creek (Tables 3.39, 3.41) was higher than that for all other streams sampled in the summer and winter seasons. High conductivity values may reflect dissolved solids, metal ions and organic compounds in a stream (Sullivan, 1993).

Table 3.38. Dominant species of the study area and the conditions they indicate

Dominant Species	Stream/Season/year	Conditions Indicated
<u>Cocconeis placentula</u>	Dunloup summer 1995 Lick fall 1995	pH > 7; C; prefers low turbidity, summer and fall dominant, pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa
<u>Cocconeis placentula</u> var. <u>euglypta</u>	Laurel summer 1995 Laurel fall 1995	Can tolerate a slight salt content, even found in estuaries; Prefers low turbidity, Pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa; summer and fall dominant
<u>Cymbella turgida</u>	Lick summer 1995	PI
<u>Fragillaria crotonensis</u>	Glade fall 1995 Wolf summer 1995 Lick fall 1995	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high concentrations of suspended sediment and turbidity
<u>Gomphonema parvulum</u>	Arbuckle winter 1996 Arbuckle spring 1996 Arbuckle winter 1996	I, PE, PF
<u>Lyngbya digueti</u>	Arbuckle fall 1995 Wolf summer 1995 Keeney spring 1996	PF
<u>Lyngbya ochracea</u>	Marr summer 1995	---

<u>Lyngbya putealis</u>	Glade fall 1995	Affects operation of canals
<u>Melosira varians</u>	Dunloup summer 1995 Dunloup winter 1996 Arbuckle summer 1995 Arbuckle fall 1995 Marr summer 1995 Keeney fall 1995 Keeney spring 1996	High nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Meridion circulare</u>	Arbuckle winter 1996 Laurel winter 1996	C
<u>Navicula accomoda</u>	Arbuckle fall 1995	---
<u>Navicula cryptocephala</u>	Arbuckle summer 1995 Arbuckle spring 1996	PF
<u>Navicula inflexa</u>	Arbuckle fall 1995	---
<u>Navicula radiosa</u> var. <u>tenella</u>	Dunloup winter 1996	Sensitive to low concentrations of chloride; cool, fresh very hard waters with relatively low concentrations of sodium sulfate; tolerates some suspended sediment and turbidity, summer dominant

<u>Navicula viridula</u>	Marr winter 1996 Keeney winter 1996	PF	
Schizothrix calcicola	Dunloup summer 1995 Dunloup winter 1996 Arbuckle summer 1995 Arbuckle fall 1995 Arbuckle winter 1996 Arbuckle spring 1996 Wolf spring 1996 Marr summer 1995 Marr fall 1995 Keeney fall 1995 Keeney winter 1996 Keeney spring 1996 Laurel winter 1996 Laurel spring 1996 Dowdy fall 1995 Dowdy spring 1996 Lick fall 1995 Meadow fall 1995	SP	
Stigeoclonium stagnatile	Keeney spring 1996	---	
Synedra pulchella var. lanceolata	Arbuckle spring 1996	---	
Synedra tabulata	Arbuckle winter 1996 Keeney spring 1996	PE, PI	

Synedra ulna	Marr winter 1996 Lick fall 1995	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4
Tabellaria fenestrata	Wolf summer 1995	F, T
Ulothrix subtilissima	Wolf spring 1996	---
Ulothrix tenerima	Dowdy spring 1996	---

C, clean; E, eutrophication; F, filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; St, stream; and T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Table 3.39. Physiochemical data for the Summer 1995 Sample

Stream	Air Temperature °C	Water Temperature °C	Dissolved Oxygen Ppm	pH stand- ard units	Conductivity µS/cm	Turbidity NTUs	Alkalinity mL/L
Glade Creek	22.0	20.1	7.16	7.54	155	5.0	24
Laurel Creek	23.0	19.5	8.05	7.90	174	30.1	60
Dowdy Creek	23.0	18.11	7.57	6.18	52	0	14
Dunloup Creek	24.0	19.74	8.07	8.48	588	0	58
Arbuckle Creek	39.0	15.74	9.15	8.04	368	0	72
Wolf Creek	36.0	17.75	7.46	7.53	526	4.8	178
Marr Branch	31.0	21.05	7.42	7.75	357	5.8	60
Keeney Creek	37.0	20.72	7.56	7.37	204	0	48
Lick Creek	31.0	25.80	9.55	8.55	340	9.8	108
Meadow Creek	28.0	24.66	7.68	8.36	176	7.9	44

Table 3.40. Physiochemical Data for the Fall 1995 Sample

Stream	Air Temperature °C	Water Temperature °C	Dissolved Oxygen Ppm	pH stand- ard units	Conductivity µS/cm	Turbidity NTUs	Alkalinity mL/L
Glade Creek	15.0	16.11	7.90	7.61	184	10.2	24
Laurel Creek	16.0	15.86	9.46	7.93	188	24.5	46
Dowdy Creek	17.0	15.30	7.98	6.24	60	17.2	12
Dunloup Creek	19.0	19.70	8.10	7.96	242	44.7	62
Arbuckle Creek	22.0	16.45	9.72	8.00	588	4.1	64
Wolf Creek	21.0	16.72	7.0	7.57	582	7.0	264
Marr Branch	20.0	17.08	9.03	8.0	546	4.5	172
Keeney Creek	23.0	16.61	8.5	7.39	263	3.5	56
Lick Creek	20.0	19.33	9.31	8.38	357	1.2	108
Meadow Creek	19.0	17.22	10.5	8.11	204	6.8	62

Table 3.41. Physiochemical Data for the Winter 1996 Sample

Stream	Air Temperature °C	Water Temperature °C	Dissolved Oxygen Ppm	pH Stand-ard Units	Conductivity µS/cm	Turbidity NTUs	Alkalinity mL/L
Glade Creek	1.0	2.55	13.88	7.24	125	17.4	16
Laurel Creek	4.0	3.17	20.76	7.51	80	47.2	30
Dowdy Creek	6.0	3.88	17.40	6.88	25	79.0	22
Dunloup Creek	13.0	5.28	15.9	7.93	291	59.0	48
Arbuckle Creek	14.0	9.14	13.2	7.67	260	70.2	38
Wolf Creek	15.0	3.55	13.32	7.37	116	2.0	14
Marr Branch	14.0	5.64	14.42	7.55	126	150	24
Keeney Creek	17.0	5.36	15.24	7.57	117	15.8	16
Lick Creek	16.0	5.95	12.53	7.96	118	32.5	28
Meadow Creek	15.0	5.25	21.22	7.69	81	33.4	24

Table 3.42. Physiochemical Data for the Spring 1996 Sample

Stream	Air Temperature °C	Water Temperature °C	Dissolved Oxygen Ppm	pH Stand- ard Units	Conductivity µS/cm	Alkalinity mL/L
Glade Creek	17.0	13.7	11.2	6.99	115	20
Laurel Creek	18.0	12.4	10.08	7.21	79	24
Dowdy Creek	19.0	11.82	9.840	5.45	21	16
Dunloup Creek	22.0	13.97	9.48	7.70	372	60
Arbuckle Creek	24.0	11.8	10.2	7.30	288	64
Wolf Creek	24.0	13.16	8.54	6.66	153	16
Marr Branch	25.0	14.0	8.93	7.08	142	52
Keeney Creek	27.0	12.5	9.26	7.07	108	22
Lick Creek	30.0	16.4	7.94	7.58	128	56
Meadow Creek	29.0	16.2	8.63	7.48	88	32

Arbuckle Creek

Samples were collected for all four seasons at Arbuckle Creek. S. calcicola, an indicator of sewage pollution, was a dominant in all samples (Table 3.38) . M. varians, an indicator of pollution, was also present at high cell densities during the fall and summer. N. cryptocephala was an obvious dominant in the summer and spring communities. According to Palmer (1980) N. cryptocephala is also an indicator of pollution. In addition, G. parvulum was a dominant in the spring community and an indicator of pollution (Palmer, 1980). Other algal species present (C. meneghiniana, N. palea, S. acus, S. ulna, L. digueti, N. viridula, N. cryptocephala, S. tenue) suggest that this stream receives pollution. Some of the species found prefers hard, somewhat brackish water (C. placentula var. euglypta, C. menegheniana, N. palea, R. curvata, F. vaucheria, and M. varians) (Palmer, 1980, Bahls et al., 1984). Conductivity at this site was higher than that for all other streams during the fall and spring (Tables 3.40 and 3.42).

Wolf Creek

S. calcicola was the obvious dominant in the spring and fall communities, but was absent in the summer community. The fall community also contained high cell densities of F. crotonensis, an indicator of eutrophication and problems associated with filters. M. sphaerocarpa and T. flocculosa, were also common. Other species were present that indicated pollution, high nutrients, and taste and odor problems. No clean water indicator species were observed in the spring and fall communities (Table 3.38). The summer community (Table 3.38) was dominated by F. crotonensis, L. digueti (pollution

indicators) and T. fenestrata. One indicator species of clean water (N. exigua var. capitata) was observed at a very low cell density in the summer community.

Marr Branch

S. calcicola was a dominant in the summer and fall communities (Table 3.38). The summer community was also dominated by M. varians, while N. viridula was the obvious dominant in the winter community. These indicator species showed that the stream is receiving pollution. Furthermore, some species present were associated with taste and odor problems (T. fenestrata, S. ulna, C. compta, and N. graciloides).

Keeney Creek

S. calcicola was the obvious dominant for all the three seasons collected (Table 3.38). The fall and spring communities were also dominated by M. varians. Other indicators of pollution present in the three communities include G. parvulum, N. viridula, L. digueti, and S. tabulata. Two taste and odor indicator species were observed (N. graciloides and S. ulna).

Glade Creek

The obvious dominant in this stream was F. crotonensis. This diatom was an indicator of eutrophication and may cause problems with filters (Table 3.38). On the other hand, C. placentula was present and indicates clean water. Furthermore, Glade Creek was one of the few streams in the study that did not contain S. calcicola.

Laurel Creek

Laurel Creek contained species that indicated both clean and polluted water. S. calcicola was present in the spring and winter indicating sewage pollution, but not present in the summer and fall (Table 3.38). This suggested that the stream received sewage pollution during periods of high flow, but not during base flow. M. circulare, the obvious dominant in the winter, was an indicator of clean water. Likewise, C. cesati, another indicator of clean water, was observed in the fall. G. parvulum, S. ulna, and N. cryptocephala, indicators of pollution, were present in relatively low densities.

Dowdy Creek

S. calcicola, an indicator of sewage pollution, was dominant in the fall and spring seasons (Table 3.38). U. tenerrima, one of only a few green algae observed in the study, was co-dominant during the spring with S. calcicola. U. tenerrima has not been demonstrated to be an indicator of either polluted or clean water.

Lick Creek

C. placentula, an indicator of clean water, was dominant in the summer and fall communities (Table 3.38). The spring community was dominated by S. calcicola. This species was not observed during other seasons. Two clean water indicator species, U. aequalis and M. circulare, were also present in the spring community. Other indicators of pollution present in the spring community occurred at very low cell densities. The fall community was dominated by F. crotonensis, an indicator of eutrophication. S. ulna, an indicator of pollution, was also present. Likewise, other indicators of

pollution were present in relatively low concentrations. On the other hand, clean water indicators present included N. linearis and C. placentula.

Meadow Creek

Although Meadow Creek was believed to be relatively free of pollutants, no clean water indicator species were observed during the study (Table 3.38). Meadow Creek was dominated by S. calcicola in the fall community. This species was also present in the spring but was not dominant. L. putealis, not known to be an indicator species, was the obvious dominant in the spring community.

Possible Pollution Sources

This study indicated that the majority of the streams studied contained species associated with sewage pollution. These findings are in agreement with the study conducted by Wood (1990), who reported that sewage and/or animal waste were the major cause of water quality problems within the NERI. Sullivan (1993) reported that Meadow Creek, Dunloup Creek, Arbuckle Creek, Keeney Creek, Wolf Creek and Marr Branch showed probable violations (greater than 200 fecal coliform colonies per 100 milliliters of sample) regarding the presence of fecal coliform bacteria. In the present study, S. calcicola was a dominant in the above streams for most seasons. S. calcicola was present in 71% of the samples.

Fecal coliform counts have been high in Dunloup Creek and have often exceeded the standard since 1980 (Wood, 1990). Very high concentrations of S. calcicola were observed in this stream, with the highest concentration observed during the winter season. This may have resulted from high precipitation resulting in overflow of sewage

treatment plants. The sampling site was approximately one mile downstream of a sewage treatment facility. This and other sewage treatment facilities and numerous communities are likely sources of pollution. A river access that was heavily used by recreationists at the mouth of the stream where the sampling was conducted represented an additional potential source of pollution. Furthermore, mining has occurred in the upper region of the watershed (Sullivan, 1993) which may have contributed to the stream pollution. Almost the entire watershed above the town of Kilsyth has been strip mined. However, it seemed unlikely that mining made a substantial contribution to the domestic pollution load of this stream.

Arbuckle Creek had exhibited high fecal coliform counts since 1980 (Wood, 1990) . Arbuckle Creek received drainage from the city of Oak Hill, a relatively large community, and a likely source of pollution for this stream. Arbuckle Public Service District had a sewage treatment plant at Minden. Small communities along the stream (i.e., Minden and Rocklick) included dwellings with questionable methods of sewage disposal. Mine dumps were also present in and around Minden.

Wolf Creek flowed through numerous small communities and received drainage from the town of Fayetteville. Wolf Creek had probable fecal coliform violations (Sullivan, 1990). The small communities around the stream have inadequate sewage disposal, which has probably contributed to domestic pollution in the stream. Based on the abundance of S. calcicola, the greatest sewage problems were in the spring and fall. This species was absent in the summer community. This may have been due to higher precipitation during

these seasons. There were fairly large tracts of pastureland around Fayetteville (Sullivan, 1993). Agriculture runoff from this land probably contributed fecal coliform bacteria. This could conceivably cause the lift station on House Branch of Wolf Creek to become overloaded and release untreated sewage.

Marr Branch also received drainage from the town of Fayetteville. The greatest potential problem associated with this stream is that of domestic waste. The sewage disposal system is located downstream from Fayetteville. Fayetteville and the sewage treatment plant are likely contributors of domestic waste to Marr Branch. Sullivan (1993) reported that the main contributor of the wasteload is the Fayetteville STP, which discharges into an unnamed tributary of Marr Branch. Frequently the STP receives flow estimated to be as much as three times the amount of inflow that the facility was originally designed to accommodate. This stream follows along State Route 82, a road heavily used by area recreationists. A large campsite (Rivers, Inc.) located along Marr Branch, and visited by hundreds of people each summer, may contribute pollution to the stream. Marr Branch also receives drainage from the small community of Oak Ridge.

All of the Keeney Creek samples indicated a sewage pollution problem. Keeney Creek flows through the communities of Winona and Divide. Strip mining was active along some of the tributaries of this stream for several years. The major contributor to sewage in the stream was likely Winona. Sullivan (1993) stated that the fecal coliform counts exceeded the standard on every sample. The lowest

bacterial counts were in the spring, and the highest occurred in the periods when rainfall decreased. He concluded that a continual source of wastewater was being introduced into the stream. This source was likely failing septic systems or straight household discharge. Keeney Creek did not have a sewage treatment plant within the watershed.

Due to weather related problems, only one sample was available for study on Glade Creek. For this reason, it was difficult to accurately evaluate water quality on this stream. However, this one sample suggested that Glade Creek was not polluted like many of the other streams. The Glade Creek drainage area was one of the largest tracts of undeveloped land of the region. Any future attempt to evaluate Glade Creek should incorporate data from mining activities on Cooper Creek, a tributary of Glade Creek. In addition, a small community and golf course were located at Glade Springs Resort that should be studied. The single sample from Glade Creek, suggested that sewage pollution was not a problem for this stream during that season.

Laurel Creek at Quinnimont was, for the most part, found to be a clean stream. However, a relatively high quantity of S. calcicola, which indicates sewage pollution, was present during the spring sample. Mining in the vicinity of the community of Hemlock may have contributed to the occurrence of this and other pollution indicator species. However, these species did not dominate the algal communities. For example, the winter sample was dominated by clean water indicator species. No large towns or communities were present in this watershed.

An evaluation of Dowdy Creek suggested that sewage pollution was possibly a problem along this stream. However, this is not in agreement with the results of prior studies. The area upstream of the sampling site appeared devoid of recent human disturbance, and no structures were shown on the USGS topographical map. Only old mining roads and jeep trails were located within the watershed. Periphyton species richness for this stream was rather low. As only algal species indicating sewage were present in the samples, it seemed likely that animal waste may have represented the source of pollution. S. calcicola was present in rather small quantities. Prior sampling of fecal coliform in this stream indicated that sewage has not been a problem in this stream (Sullivan, 1993). Wood (1990) believed this stream to be one of the cleanest streams within the NERI.

Like Dowdy Creek, Lick Creek was also thought to be relatively clean. Based upon the indicator species present, Lick Creek appeared to be a relatively clean. However, the spring community showed signs of sewage pollution. On the other hand, clean water indicator species were also present. There was no mining in this watershed. As the stream paralleled State Route 20, there may be run-off from the roadway. That could possibly account for the low number of pollution indicator species present in the samples. Sullivan (1993) indicated that fecal coliform bacteria were not a problem in this stream. While low amounts of human and/or animal waste probably entered the stream, this did not appear to present a water quality problem. On the other hand, Meadow Creek showed water quality problems.

Meadow Creek was one of the five streams believed to be relatively free of contaminants. However, no clean water indicator species were identified. The fall community suggested that sewage pollution and high nutrient levels were present. Sewage pollution would most likely come from the community of Meadow Bridge. The community of Meadow Creek may also contribute to the pollution of this stream. Meadow Creek fecal coliform counts exceeded the standard in 1993 (Sullivan). In recent years, the sewage treatment plant located at Meadow Bridge has had inflow problems and operational deficiencies which have contributed to partially treated wastewater being discharged into Meadow Creek during high precipitation events (Sullivan, 1993). The stream did not show evidence of degradation comparable with some of the streams that were heavily polluted like Arbuckle Creek, Dunloup Creek and Marr Branch, but Meadow Creek did not demonstrate the high water quality expected.

Conclusions

The dominant algal types observed in this study were diatoms and blue-green algae. High populations of blue-green algae were present in many of the streams indicating the presence of sewage pollution.

The main contributor to pollution within the study area appeared to be human waste. This was evidenced by the indicator species S. calcicola that appeared in over 71% of the communities analyzed. Mining may also have contributed to pollution in the streams.

Of all streams sampled, Arbuckle Creek and Dunloup Creek appeared to be most similar, especially during the summer and winter seasons. Algal communities of Marr Branch and Keeney Creek showed similarity with those of Arbuckle and Dunloup Creeks. During most seasons, Lick Creek, Laurel Creek and Glade Creek showed low similarity with the other streams. The streams that were thought to be most heavily polluted were found to be most similar. Streams that were thought to be relatively unpolluted showed little similarity to other communities.

Future Studies

Some of the streams studied had relatively large watersheds. For more definitive results, more stations should be established on each of these streams. Ideally, stations should be located both upstream and downstream of potential sources of pollution.

Other methods of sampling should be tested to determine which would best withstand high flows during times of floods. Some of the samples were lost during high flow events. Vandalism was also a problem that requires a solution. Scrapping of natural substrates instead of samplers may be a more convenient and more rapid way to collect a sample. However, the researcher would have no way to measure the accumulation period.

It would be advisable to conduct in-depth sampling on one large watershed, such as Glade or Arbuckle Creeks. This would provide a source of information for that watershed and may initiate water quality improvements in areas that reveal pollution sources. Follow-up studies should be conducted in subsequent years at prior sampling stations and used for comparison.

Literature Cited

Adkins, James R. 1976. New River basin plan. Department of Natural Resources, Division of Water Resources, Charleston, West Virginia, 232pp.

Bahls, L. L., I. I. Weber and J. O. Jarvie. 1984. Ecology and distribution of major diatom ecotypes in Southern Fort Union Coal Region of Montana. Geological Survey professional paper 1289. U. S. Department of Interior, 151pp.

Borchardt, Mark A. 1994. Effects of flowing water on Nitrogen and Phosphorous - limited photosynthesis and optimum N:P ratios by Spirogyra fluviatilis. Journal of Phycology 30:418-430.

Brown, B. J. and J. H. Olive. 1994. Diatom communities in the Cuyahoga River (U.S.A): changes in the species composition between 1974 and 1992 following renovation in wastewater management. The Ohio Journal of Science 94:20.

Choi, M. Y., C. K. Gulp, T. E. Weeks and D. J. Webb. 1992. Artificial aeration as a factor influencing the periphytic algal community of Beech Fork Lake. Arch. Hydrobiologia. 123:497-511.

DeNicola, K. H., S. Raemer, 1992. Influences of canopy cover on spectral irradiance and periphyton assemblages in a prairie system. Journal of North American Benthological Society 11(4):391-404.

Dickman, M. 1968. The effect of grazing by tadpoles on the structure of a periphyton community. Ecology 49:1188-1190.

Eckblad, J. 1986 - 1989. Ecological Analysis PC V1.5 Oakleaf System, Decorah, Iowa.

Elwood, J. W. and D. J. Nelson. 1972. Periphyton production of grazing rates in a stream measured with a P balance method. Oikos 23:295-303.

Fogg, G. E., W. D. P. Stewart, P. Fay and W. E. Walsby. 1973. The blue-green algae. New York, NY, 459pp.

Hebner, Scott W. 1991. New River Gorge National River Fecal Coliform Study April - September 1991. West Virginia Department of Natural Resources, 46pp.

Hill, W. R. and B.C. Harvey. 1990. Periphyton responses to higher trophic levels and light in a shaded stream. Canadian Journal of Fisheries and Aquatic Sciences 47 (12):2307-2314.

Hoagland, K. D., S. Roemer and J. Rosowskii. 1982. Colonization and community structure of two periphyton assemblages with emphasis on the diatom (Bacillariophyceae). American Journal of Botany 69:188-213.

Jones, R. C., C. Buchanan, V. Andrie. 1992. Spatial, seasonal, and interannual patterns in the phytoplankton community of a tidal freshwater ecosystem. *Virginia Journal of Science* 43(1A):25-40.

Knorr, D. F. and G. W. Fairchild. 1987. Periphyton, benthic invertebrates and fishes as biological indicators of water quality in the East Branch of Brandywine Creek. *Proceedings of the Pennsylvania Academy of Science* 61(1):61-66.

Lamb, M. A. and R. L. Lowe. 1987. Effects of current velocity on the physical structuring of diatom (Bacillariophyceae) communities. *The Ohio Journal of Science* 87 (3):72-78.

Lamberti, G., L. Ashkenas, S. Gregory and A. Steinman. 1987. Effects of three herbivores on periphyton communities in laboratory streams. *Journal of North American Benthological Society* 6(2):92-104.

Lamberti, G., S. Gregory, L. Ashkenas, J. Li, A. Stienman and D. McIntire. 1995. Influence of grazer type and abundance on plant herbivore interactions in streams. *Hydrobiologia* 306:179-188.

Laws, Edward A. 1981. *Aquatic pollution*. New York: Wiley, 482 pp.

Lewis, M. A. 1986. Impact of municipal wastewater effluent on water quality, periphyton and invertebrates in the Little Miami near Xenia, Ohio. The Ohio Journal of Science 86(1):2-8.

Lindstrom, E. A. and T. S. Traaen. 1984. Influence of current velocity on periphyton distribution and succession in a Norwegian soft water river. Limnology 22:1965-1972. In Borchardt, Mark. 1994. Journal of Phycology 30:418-430.

Lowe, R. L. 1974. Environmental requirements and pollution tolerance of freshwater diatoms. Cincinnati, Ohio. EPA-670/4-74-005, 334pp.

Meegan, S. K. and S. A. Perry. 1994. Periphyton community dynamics in headwater streams of contrasting pH. Proceedings of the West Virginia Academy of Science 66(1):2.

Moll, M. B. and E. C. Keller, Jr. 1980. An examination of periphyton in perturbed aquatic environments in West Virginia. Proceedings of the West Virginia Academy of Science 52(2):31-40.

National Oceanic and Atmospheric Administration. 1995. Climatological Data Annual Summary West Virginia for 1995. Beckley, West Virginia WSO AP. National Oceanic and Atmospheric Administration, National Climatic Data Center Asheville, NC. 17pp.

National Oceanic and Atmospheric Administration. 1996. Climatological Data Annual Summary West Virginia for 1996. Beckley,

West Virginia WSO AP. National Oceanic and Atmospheric Administration, National Climatic Data Center Asheville, NC. 21pp.

National Park Service. 1982. Draft General Management Plan/Environmental Assessment. Denver Service Center, United States Department of the Interior. 187pp.

Palmer, C.M. 1959. Algae in water supplies. US Department of Health, Education and Welfare, Public Health Service, Cincinnati, Ohio. 123pp.

Palmer, C.M 1969. Journal of Phycology 5:78-82.

Palmer, C. Mervin, 1980. Algae and water pollution. Castle House Publications, LTD. Cincinnati, Ohio. 124pp.

Patrick, R. and C. Reimer. 1966. The Diatoms of the United States. Livingston, Wynnewood, Pennsylvania. 688pp.

Patrick, R. and C. Reimer. 1975. The Diatoms of the United States Vol II, Part I. The Academy of Natural Sciences of Philadelphia. 189pp.

Patrick, R. 1971. The effects of increasing light and temperature on the structure of diatom communities. *Limnology and Oceanography* 16:405-421.

Patrick, R. 1971. Diatom communities. Virginia Polytechnic Institute and State University Press, Blacksburg. pp151-164. In, *Algae as ecological indicators* (Shubert, 1984).

Pederson, C.L. and D. L. Vaultonburg, 1992. Attached Algae as Biological Monitors of Metals in Streams. *Proceedings of the Illinois State Academy of Science. Supplement* 85:38.

Power, M. E. and A. J. Stewart 1987. Disturbance and recovery of an algal assemblage following flooding in an Oklahoma stream. *American National* 117:333-345.

Prescott, G. W. 1978. *How to know the freshwater algae* 3rd edition. W. C. Brown Company Publishers, Dubuque, Iowa. 348pp.

Richardson, N. Mody and M. Stacey, 1994. Summer diatom floras of agriculturally impacted streams in Lancaster, Pennsylvania. *Journal of the Pennsylvania Academy of Science* 67:195.

Rose, R. R., G. E. Valentine, Jr., R. A. Minear. 1979. Water quality changes resulting from coal surface mining in the New

River basin of Tennessee. Proceedings of the West Virginia Academy of Science 51(3):146-167.

Rosowski, F. R., K. D. Hoagland, and J. E. Aloï. 1986. Structural morphology of diatom - dominated stream biofilm communities under the impact of soil erosion. pp 247 - 299. In, L. Evans and K. Hoagland Algal Biofouling. 1986. Studies in Environmental Science 28.

Shubert, L. E. 1984. Algae as ecological indicators. Amsterdam. Academic Press, Grand Forks, ND. 434pp.

Soil Conservation Service. 1975. Soil Survey of Fayette and Raleigh Counties West Virginia. United States Department of Agriculture. 76pp.

Soil Conservation Service. 1984. Soil Survey of Mercer and Summers Counties West Virginia. United States Department of Agriculture. 173pp.

States, J. B., P. T. Haug, T. G. Shoemaker, L. W. Reed and E. B. Reed. 1978. A systems approach to ecological baseline studies. U. S. Department of Interior, U. S. Fish and Wildlife Service. FWS/OBS-78/21.

Stevenson, R., M. L. Bothwell and R. L. Lowe. 1996. Algal ecology, freshwater benthic ecosystems. Academic Press, Inc. pp 375-402.

Suiter, D. W. 1995. The vascular flora, rare species and plant migrations of New River Gorge National River, West Virginia. Masters Thesis, Marshall University, Huntington, West Virginia. 175pp.

Sullivan, Robert J. 1993. New River Gorge National River Bluestone National Scenic River Gauley National Recreation Area, Water Quality Monitoring Program 1993 Revised. New River Gorge National River Resource Management and Visitor Protection Resource Management Branch. 67pp.

Thomas, W. A. 1972. Indicators of environmental quality, Plenum Press, New York. 275pp.

United States Department of Interior, National Park Service, New River Gorge National River, West Virginia 1990. Development Concept Plan / Interpretive Prospectus Glade Creek. 21pp.

United States Environmental Protection Agency. 1979. Phytoplankton water quality relationships in the U. S. Lakes, Part VI. EPA-600/3-79-051. 138pp.

Vaultonburg, D. L. and C. L. Pederson. 1994. Spatial and temporal variations of diatom community structure in two East-Central Illinois streams. Transactions of the Illinois State Academy of Science 87(1-2) :9-28.

Venkataraman, G.S., S. K. Goyal, B.D. Kaushik, and Paromita Roychoudhury. 1974. Algae: form and function. Menai Bridge, Anglesey, U.K, 562pp.

Warner, R. W., 1971. Distribution of biota in a stream polluted by acid mine-drainage. Ohio Journal of Science 71(3): 202-215.

Watson, V. 1988. Accumulation rates of periphyton in the Middle Clark Fork River, Northwestern Montana, U.S.A. Montana Academy of Sciences 48:113-117.

Weeks, T. E., D. Nash, and M. Nowland. 1997, Biological surveys in proposed development sites in the New River Gorge National River. Volume II: Non-Vascular Flora. Cooperative Agreement CA4000-1-0004. Marshall University, Huntington West Virginia. February 1997. 822pp.

West Virginia Department of Natural Resources. 1976. Comprehensive Survey of the New River Basin Volume 1 Inventory. 1976, Charleston, West Virginia. 239pp.

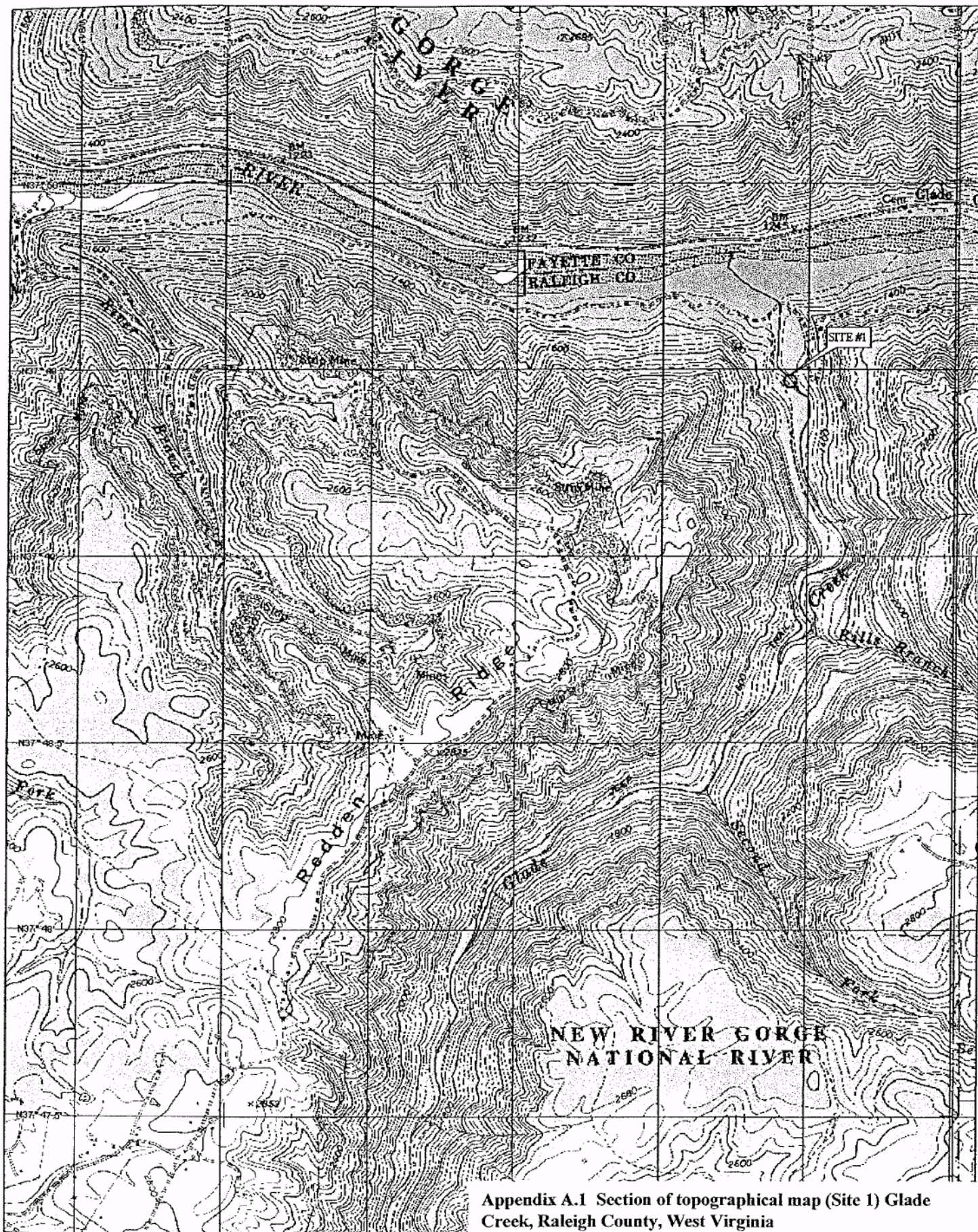
West Virginia Department of Natural Resources. 1989. New River Gorge National River Fecal Coliform Bacteria Survey Report. Charleston, West Virginia. 41pp.

Whitford, L.A. and G. J. Schumacher. 1984. A manual of fresh-water algae. Raleigh, NC. 337pp.

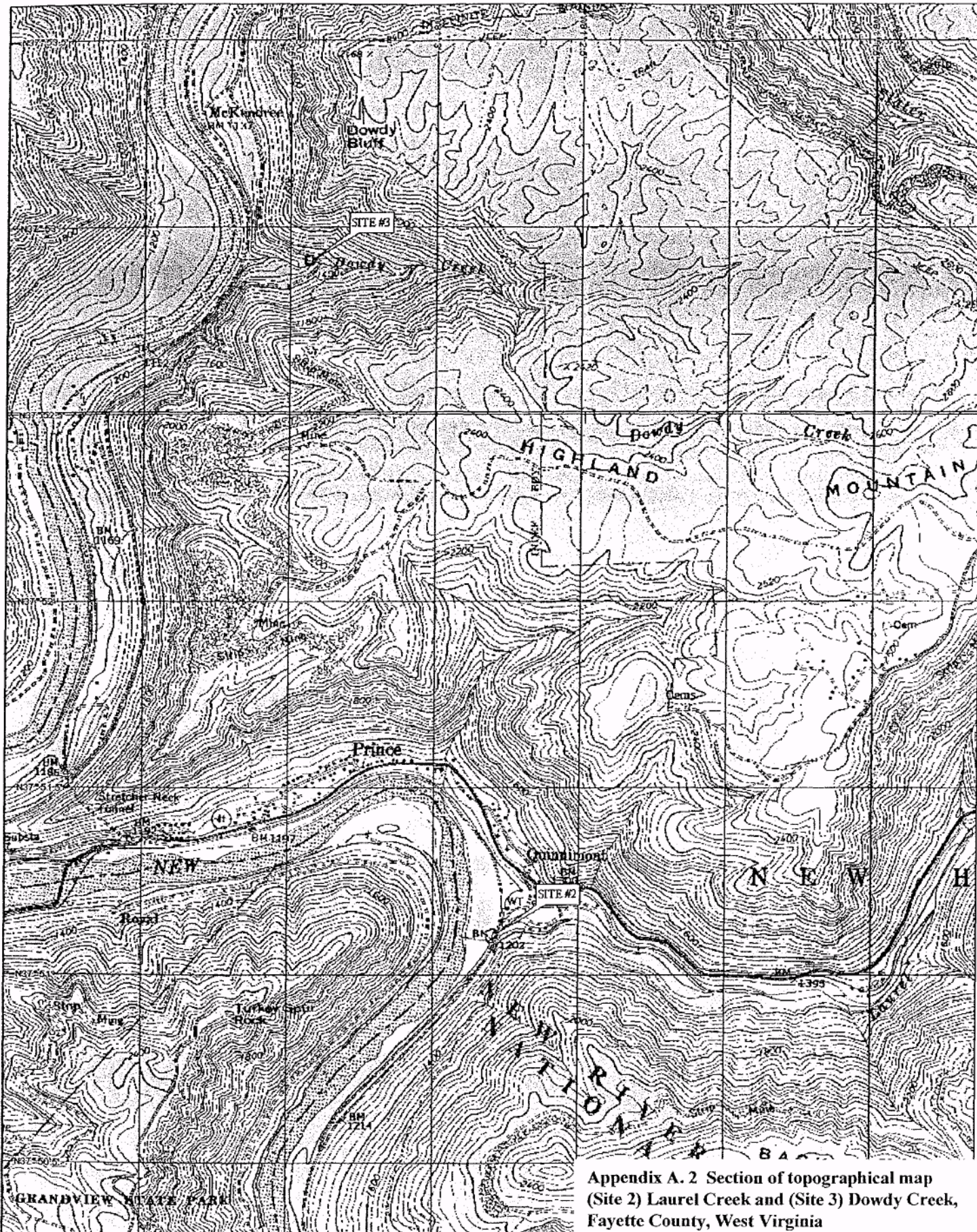
Wood, D. 1990. New River Gorge National River Water Studies Summary. West Virginia Division of Natural Resources, Charleston, West Virginia. 93pp.

Wood, D. 1990. New River Gorge National River Water Quality Study 1989. West Virginia Division of Natural Resources, Water Resources Section, Charleston, West Virginia. 38pp

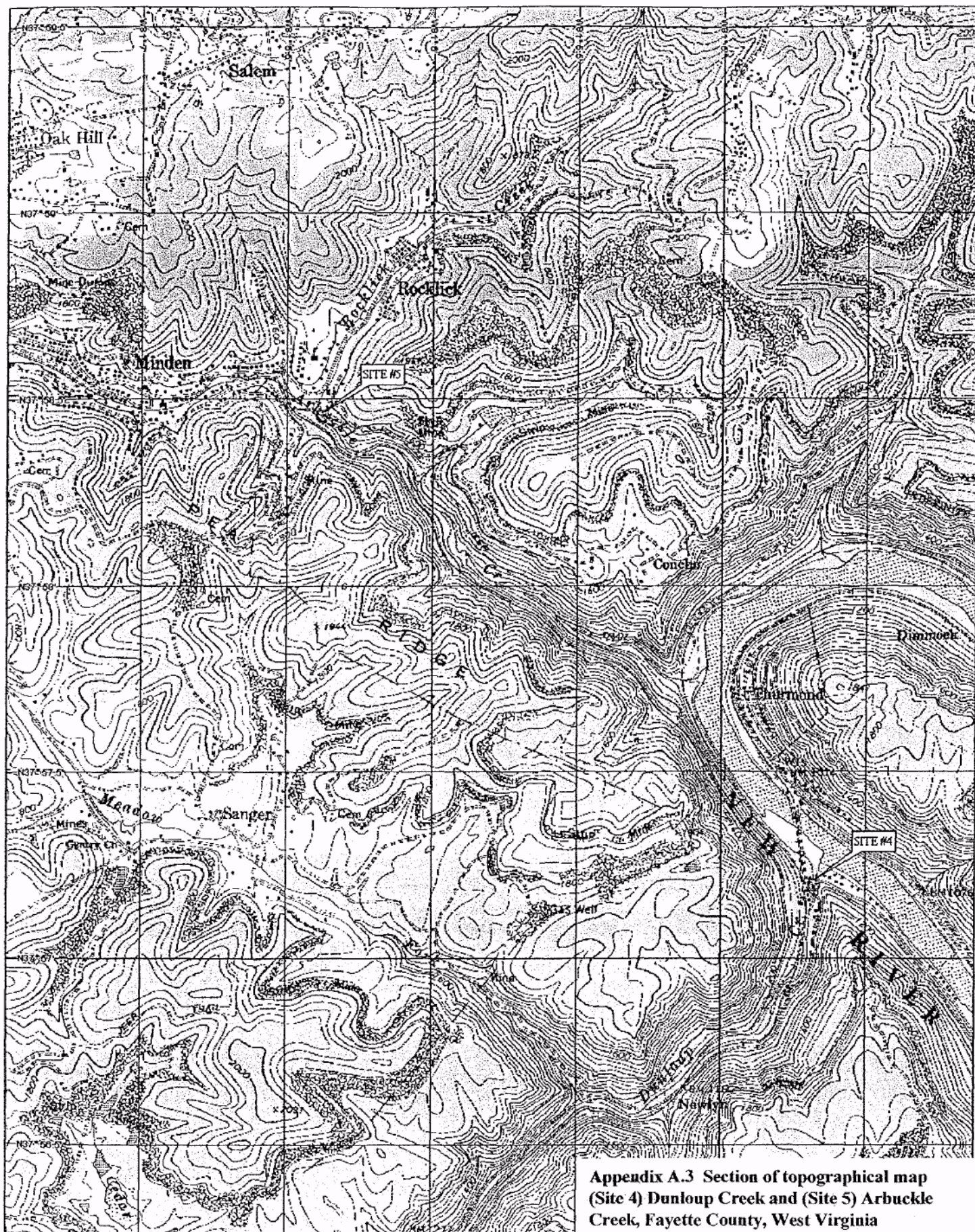
Wood, D. 1990. New River Gorge National River Water Quality Study 1990. West Virginia Division of Natural Resources, Water Resources Section, Charleston, West Virginia. 29pp.



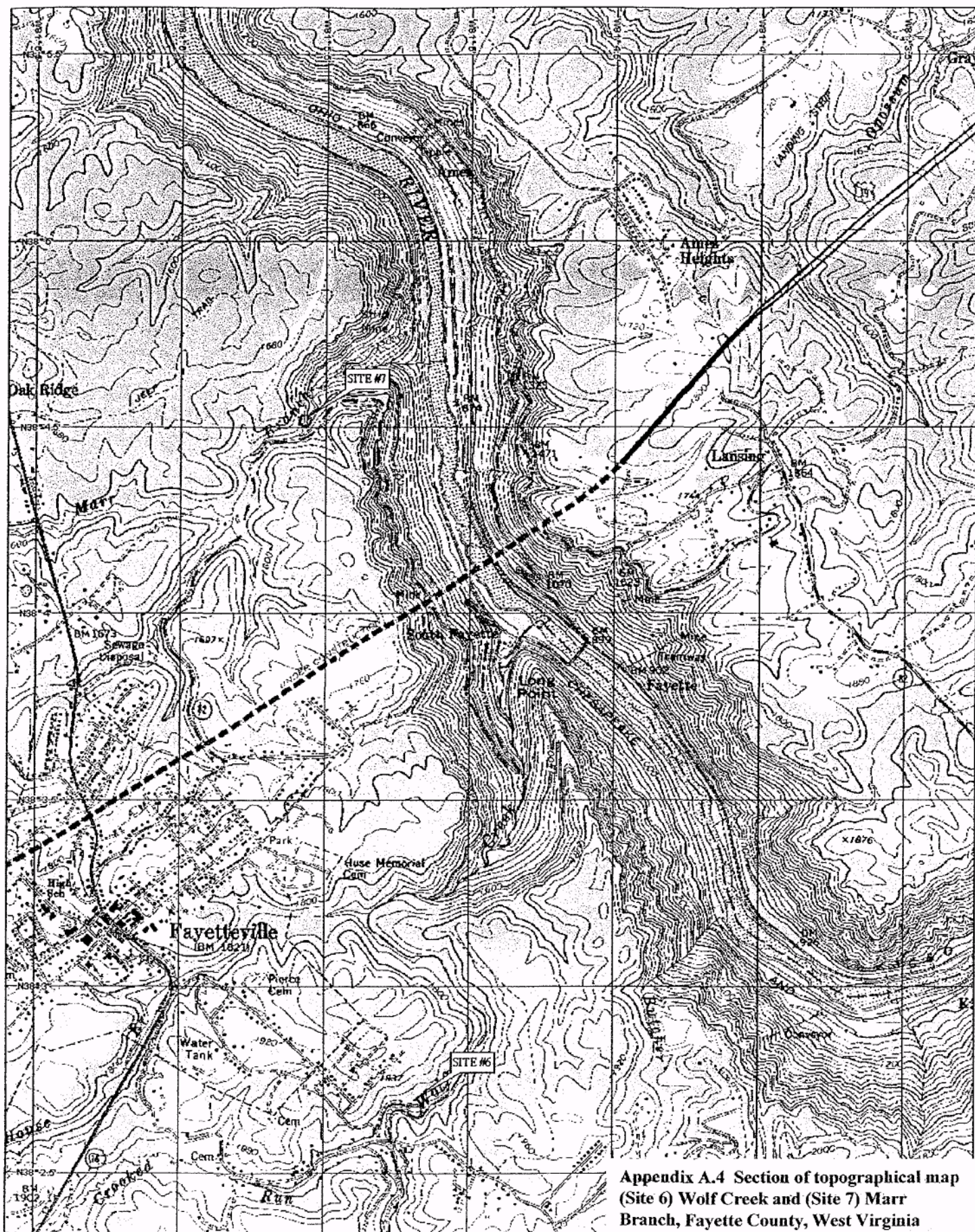
Appendix A.1 Section of topographical map (Site 1) Glade Creek, Raleigh County, West Virginia

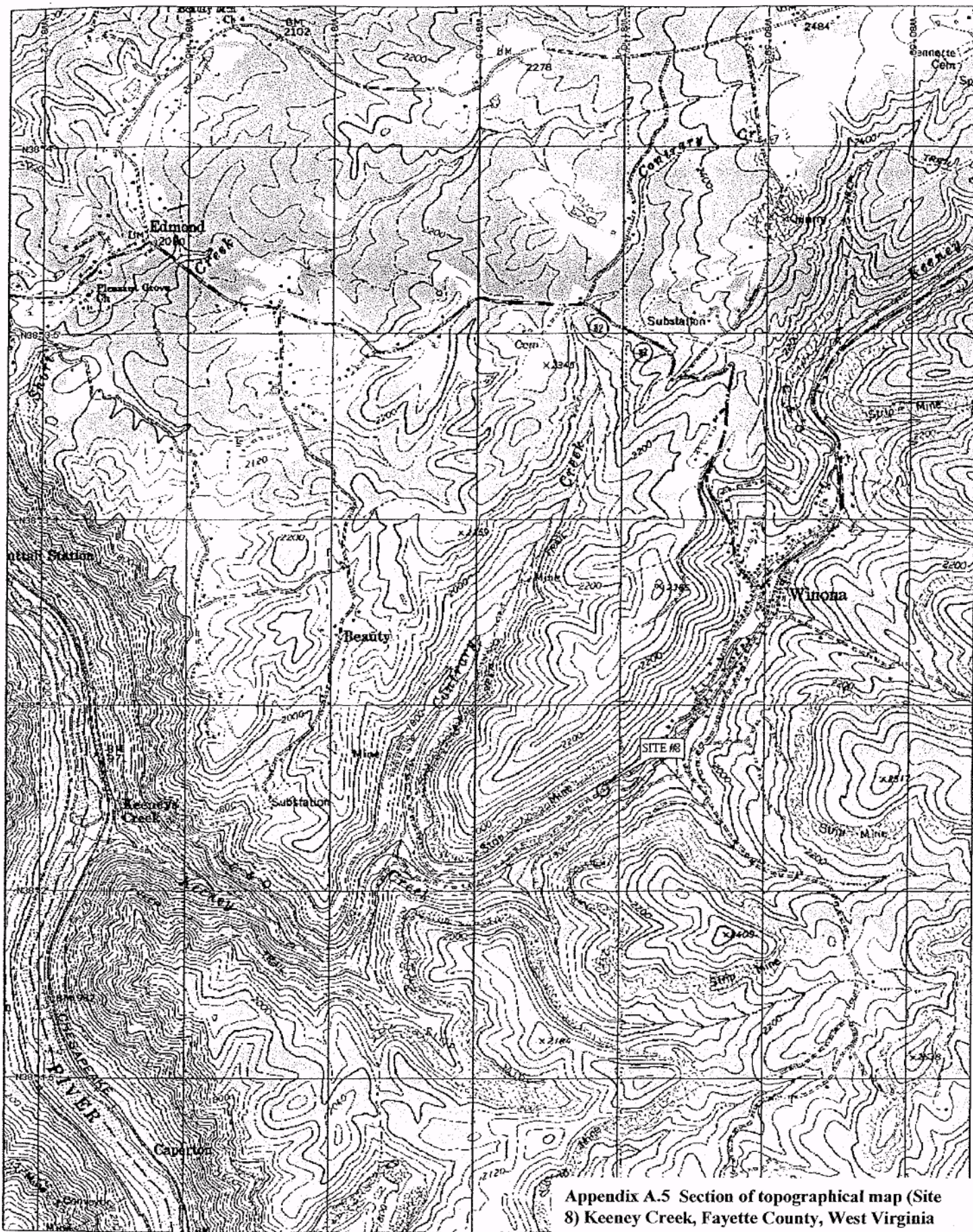


Appendix A. 2 Section of topographical map
(Site 2) Laurel Creek and (Site 3) Dowdy Creek,
Fayette County, West Virginia

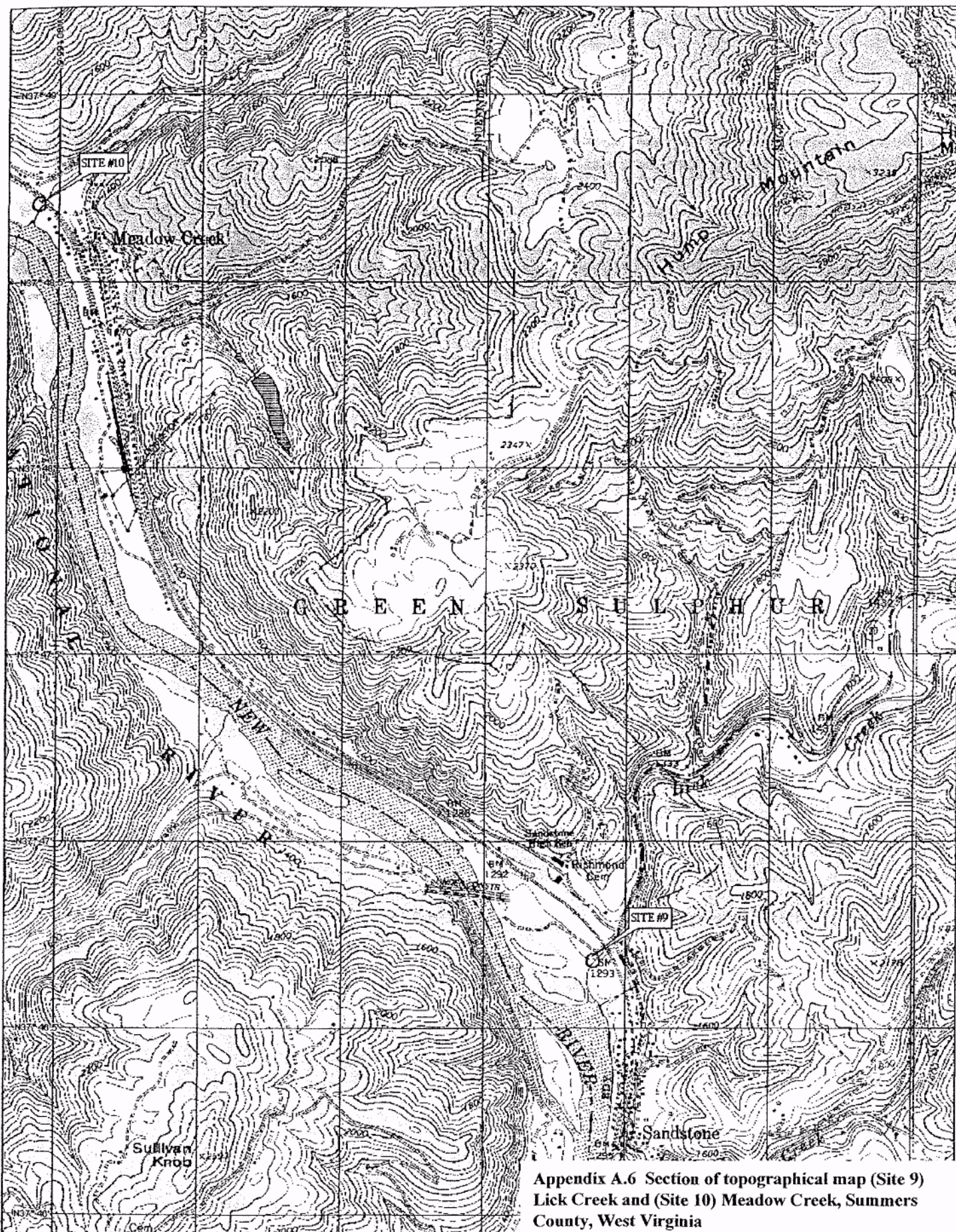


Appendix A.3 Section of topographical map
(Site 4) Dunloup Creek and (Site 5) Arbuckle
Creek, Fayette County, West Virginia





Appendix A.5 Section of topographical map (Site 8) Keeney Creek, Fayette County, West Virginia



Appendix A.6 Section of topographical map (Site 9) Lick Creek and (Site 10) Meadow Creek, Summers County, West Virginia

Appendix B.1 Arbuckle Creek Winter 1996

Species List	Number cells /cm² /week
<u>Gomphonema parvulum</u>	1229.8
<u>Melosira varians</u>	559
<u>Meridion circulare</u>	3242.2
<u>Navicula accomoda</u>	111.8
<u>Navicula capitata</u>	* 0
<u>Navicula cryptocephala</u>	1453.4
<u>Schizothrix calcicola</u>	157,638
<u>Spirulina major</u>	782.6
<u>Surirella brightwellii</u>	559
<u>Synedra capitata var. capitata</u>	111.8
<u>Synedra nana</u>	* 0
<u>Synedra tabulata</u>	1229.8
<u>Synedra ulna</u>	559

*Noted during identification

Appendix B.2 Dunloup Creek Winter 1996

Species List	Number cells /cm² /week
<u>Achnanthes conspicua</u>	111.8
<u>Cymbella turgida</u>	* 0
<u>Diatoma vulgare var. vulgare</u>	111.8
<u>Gomphonema parvulum</u>	111.8
<u>Melosira varians</u>	670.8
<u>Navicula cryptocephala</u>	447.2
<u>Navicula radiosa</u>	1173.9
<u>Nitzschia ignorata</u>	* 0
<u>Schizothrix calcicola</u>	216,333
<u>Spirulina major</u>	559
<u>Synedra fasciculata</u>	335.4
<u>Synedra ulna</u>	223.6

*Noted during identification

Appendix B.3 Keeney Creek Winter 1996

Species List	Number cells /cm² /week
<u>Cymbella turgida</u>	111.8
<u>Gomphonema parvulum</u>	335.4
<u>Melosira varians</u>	* 0
<u>Navicula cryptocephala</u>	* 0
<u>Navicula viridula</u>	726.7
<u>Schizothrix calcicola</u>	4751.5
<u>Synedra capitata var. capitata</u>	55.9
<u>Synedra tabulata</u>	* 0

*Noted during identification

Appendix B.4 Marr Branch Winter 1996

Species List	Number cells /cm² /week
<u>Gomphonema parvulum</u>	223.6
<u>Navicula cryptocephala</u>	1565.2
<u>Navicula viridula</u>	72,222.8
<u>Surirella brightwellii</u>	* 0
<u>Synedra capitata var. capitata</u>	223.6
<u>Synedra tabulata</u>	223.6
<u>Synedra ulna</u>	447.2

*Noted during identification

Appendix B.5 Laurel Creek Winter 1996

Species List	Number cells/cm² /week
<u>Achnanthes microcephala</u>	37.27
<u>Cocconeis placentula var. euglypta</u>	37.27
<u>Cyclotella stelligera</u>	149.08
<u>Fragillaria crotonensis</u>	186.35
<u>Gomphonema angustatum var. producta</u>	37.27
<u>Gomphonema parvulum</u>	149.08
<u>Meridion circulare</u>	1304.45
<u>Pinnularia biceps</u>	* 0
<u>Schizothrix calcicola</u>	633.59
<u>Synedra capitata var. capitata</u>	* 0
<u>Synedra ulna</u>	372.7

*Noted during identification

Appendix B.6 Lick Creek Fall 1995

Species List	Number cells /cm² /week
<u>Cocconeis placentula</u>	503.16
<u>Cyclotella stelligera</u>	125.79
<u>Cymbella affinis</u>	335.44
<u>Cymbella turrida</u>	419.3
<u>Diatoma vulgare var. vulgare</u>	83.86
<u>Eunotia incisa</u>	83.86
<u>Fragillaria construens</u>	83.86
<u>Fragillaria crotonensis</u>	10,734.1
<u>Melosira varians</u>	167.72
<u>Navicula rhynchocephala var.</u> <u>amphiceros</u>	335.44
<u>Nitzschia acicularis</u>	83.86
<u>Nitzschia fonticola</u>	83.86
<u>Nitzschia linearis</u>	83.86
<u>Nitzschia palea</u>	83.86
<u>Oegonium suecicum var. australe</u>	251.58
<u>Rhoicosphenia curvata</u>	83.86
<u>Synedra capitata var. capitata</u>	419.3
<u>Synedra ulna</u>	503.16

Appendix B.7 Wolf Creek Fall 1995

Species List	Number cells/cm² /week
<u>Cymbella tumida</u>	55.9
<u>Diatoma vulgare</u>	55.9
<u>Eunotia valida</u>	112
<u>Fragillaria crotonensis</u>	2124.2
<u>Gomphonema acuminatum</u>	55.9
<u>Gomphonema constrictum</u>	55.9
<u>Melosira varians</u>	1509.3

<u>Mougeotia sphaerocarpa</u>	4695.6
<u>Navicula placenta</u>	55.9
<u>Rhoicosphenia curvata</u>	55.9
<u>Schizothrix calcicola</u>	15,707.9
<u>Synedra tabulata</u>	167.7
<u>Synedra ulna var. contracta</u>	140
<u>Tabellaria fenestrata</u>	1788.8
<u>Tabellaria flocculosa</u>	10,062

Appendix B.8 Arbuckle Creek Fall 1995

Species List	Number cells/cm² /week
<u>Closterium sp.</u>	* 0
<u>Cocconeis placentula var. euglypta</u>	335.4
<u>Cyclotella meneghiniana</u>	335.4
<u>Gomphonema parvulum</u>	1677
<u>Lyngbya digue ti</u>	3018.6
<u>Melosira varians</u>	29,347.5
<u>Navicula accomoda</u>	3354
<u>Navicula inflexa</u>	3018.6
<u>Navicula viridula</u>	251.55
<u>Nitzschia ignorata</u>	167.7
<u>Rhoicosphenia curvata</u>	1173.9
<u>Schizothrix calcicola</u>	38,906.4
<u>Surirella brightwellii</u>	1173.9
<u>Synedra acus</u>	1257.75
<u>Synedra capitata var. capitata</u>	* 0
<u>Synedra pulchella var. lanceolata</u>	2021.4

*Noted during identification

Appendix B.9 Glade Creek Fall 1995

Species List	Number cells /cm² /week
<u>Closteriura moniliferura</u>	33.5
<u>Cocconeis placentula</u>	55.9
<u>Cymbella turgida</u>	167.7
<u>Eunotia incisa</u>	55.9
<u>Fragillaria crotonensis</u>	4416.1
<u>Gyrosigma obtusatum</u>	* 0
<u>Lyngbya penicillata</u>	559
<u>Lyngbya putealis</u>	2124.2
<u>Melosira varians</u>	447.2
<u>Navicula cryptocephala</u>	167.7
<u>Navicula tripunctata</u>	167.7
<u>Nitzschia ignorata</u>	55.9
<u>Synedra capitata var. capitata</u>	55.9
<u>Synedra tabulata</u>	167.7

*Noted during identification

Appendix B.10 Keeney Creek Fall 1995

Species List	Number cells/cm² /week
<u>Cocconeis placentula</u>	111.8
<u>Cyclotella meneghiniana</u>	55.9
<u>Cymbella turgida</u>	111.8
<u>Gomphonema parvulum</u>	55.9
<u>Melosira varians</u>	3186.3
<u>Navicula exigua</u>	838.5
<u>Pinnularia sudetica</u>	111.8
<u>Rhoicosphenia curvata</u>	55.9
<u>Schizothrix calcicola</u>	22,807.2
<u>Synedra capitata var. capitata</u>	55.9
<u>Synedra pulchella var. lanceolata</u>	559
<u>Synedra tabulata</u>	111.8

Appendix B.11 Laurel Creek Fall 1995

Species List	Number cells /cm² /week
<u>Achnanthes lanceolata</u>	125.72
<u>Cocconeis placentula var. euglypta</u>	419.2
<u>Cymbella cesati</u>	146.72
<u>Fragillaria crotonensis</u>	335.36
<u>Gomphonema augur</u>	356.32
<u>Melosira varians</u>	41.92
<u>Rhoicosphenia curvata</u>	125.72
<u>Synedra acus var. radians</u>	83.84
<u>Synedra lanceolata</u>	167.68

Appendix B.12 Marr Branch Fall 1995

Species List	Number cells/cm² /week
<u>Cocconeis disculus</u>	41.92
<u>Cocconeis placentula var. euglypta</u>	41.92
<u>Cymbella tumida</u>	* 0
<u>Fragillaria crotonensis</u>	251.52
<u>Gomphonema constrieturn</u>	* 0
<u>Gomphonema parvulum</u>	41.92
<u>Melosira varians</u>	* 0
<u>Schizothrix calcicola</u>	4192
<u>Tabellaria fenestrata</u>	* 0

*Noted during identification

Appendix B.13 Meadow Creek Fall 1995

Species List	Number cells/cm² /week
Cymbella tumida	41.92
Gomphonema subclavatum	41.92
Melosira varians	335.36
Schizothrix calcicola	3144

Appendix B.14 Dowdy Creek Fall 1995

Species List	Number cells /cm² /week
<u>Eunotia incisa</u>	41.92
<u>Schizothrix calcicola</u>	5323.8

Appendix B.15 Laurel Creek Summer 1995

Species List	Number cells/cm /week
<u>Cocconeis placentula</u> var. <u>euglypta</u>	20,012.2
<u>Synedra ulna</u>	111.8

Appendix B.16 Wolf Creek Summer 1995

Species List	Number cells/cm²/week
<u>Coloneis lewisii</u> var. <u>inflata</u>	* 0
<u>Cymbella aspersa</u>	167.7
<u>Cymbella tumida</u>	111.8
<u>Cymbella turqida</u>	223.6
<u>Eunotia elegans</u>	559
<u>Fragillaria crotonensis</u>	670.8
<u>Gomphonema acuminatum</u>	391.3
<u>Gomphonema parvulum</u>	503.1
<u>Lyngbya digueti</u>	838.5
<u>Melosira varians</u>	447.2
<u>Navicula cryptocephala</u>	391.3
<u>Navicula exigua</u> var. <u>capitata</u>	55.9
<u>Navicula gottlandica</u> var. <u>gottlandica</u>	55.9
<u>Navicula viridula</u> var. <u>viridula</u>	111.8
<u>Nitzschia ignorata</u>	55.9
<u>Nitzschia palea</u>	55.9
<u>Oedogonium suecicum</u> var. <u>australe</u>	223.6
<u>Pinnularia legumen</u>	167.7
<u>Staurostrum botrophilura</u>	55.9
<u>Surirella lanicostata</u>	111.8

<u>Synedra capitata</u> var. <u>capitata</u>	27.95
<u>Synedra nana</u>	223.6
<u>Synedra ulna</u>	335.4
<u>Tabellaria fenestrata</u>	782.6

Appendix B.17 Lick Creek Summer 1995

Species List	Number cells/cm²/week
<u>Bacillaria paradoxa</u>	409.97
<u>Cocconeis placentula</u>	1639.88
<u>Cyclotella meneghiniana</u>	37.27
<u>Cymbella turgida</u>	1378.99
<u>Fragillaria crotonensis</u>	670.86
<u>Fragillaria pinnata</u> var. <u>pinnata</u>	633.59
<u>Gomphonema augur</u>	279.5
<u>Gomphonema parvulum</u>	186.35
<u>Gyrosigma obtusatum</u>	37 .27
<u>Melosira varians</u>	447.2
<u>Navicula exigua</u>	223.62
<u>Navicula radiosa</u> var. <u>tenella</u>	37.27
<u>Pinnularia mesolepta</u>	74.54
<u>Rhoicosphenia curvata</u>	149.08
<u>Surirella biseriata</u> var. <u>bifrons</u> f .	37 .27
Amphyoxys	
<u>SSynedra capitata</u> var. <u>capitata</u>	37.27
<u>Synedra pulchella</u> var. <u>lanceolata</u>	260.89
<u>Synedra ulna</u>	223.62

Appendix B.18 Marr Branch Summer 1995

Species List	Number cells /cm² /week
<u>Amphora pediculus</u> var. <u>minor</u>	27.95
<u>Cocconeis placentula</u> var. <u>euglypta</u>	139.75
<u>Cyclotella comta</u>	27.95
<u>Cymbella affinis</u>	* 0
<u>Gomphonema parvulum</u>	111.8
<u>Lyngbya ochracea</u>	1145.95
<u>Melosira varians</u>	1257.75
<u>Navicula exigua</u>	167.7
<u>Navicula graciloides</u>	55.9
<u>Navicula protracta</u>	55.9
<u>Pinnularia viridis</u>	83.85
<u>Rhoicosphenia curvata</u>	27.95
<u>Schizothrix calcicola</u>	2878.85
<u>Surirella brightwellii</u>	55.9
<u>Synedra acus</u>	195.65
<u>Synedra ulna</u>	27.95

*Noted during identification

Appendix B.19 Arbuckle Creek Summer 1995

Species List	Number cells /cm² /week
<u>Achnanthes conspicua</u>	447.2
<u>Achnanthes lanceolata</u>	111.8
<u>Cocconeis placentula</u> var. <u>euglypta</u>	335.4
<u>Cyclotella meneghiniana</u>	* 0
<u>Cymbella turgida</u>	111.8
<u>Gomphonema parvulum</u>	894.4
<u>Melosira varians</u>	8944
<u>Navicula cryptocephala</u>	2012.4
<u>Navicula viridula</u> var. <u>viridula</u>	447.2
<u>Nitzschia palea</u>	* 0
<u>Rhoicosphenia curvata</u>	670.8
<u>Schizothrix calcicola</u>	14,310.4
<u>Surirella brightwellii</u>	1453.4
<u>Synedra acus</u>	223.6
<u>Synedra pulchella</u> var. <u>lanceolata</u>	335.4
<u>Synedra ulna</u>	223.6

*Noted during identification

Appendix B.20 Meadow Creek Summer 1995

Species List	Number cells /cm² /week
<u>Achnanthes conspicua</u>	614.9
<u>Cocconeis disculus</u>	224
<u>Cocconeis placentula</u> var. <u>euglypta</u>	279.5
<u>Cymbella turgida</u>	167.7
<u>Eunotia trianacria</u>	55.9
<u>Gomphonema subclavatum</u>	55.9
<u>Melosira varians</u>	* 0
<u>Navicula angusta</u>	838.5
<u>Navicula exigua</u>	279.5
<u>Navicula salinarum</u> var. <u>intermedia</u>	167.7

Surirella patella var. neupaueri	* 0
Synedra amphicephala	224
Synedra nana	55.9
Synedra rumpens	447.2
Synedra tabulata	894

*Noted during identification

Appendix B.21 Dunloup Creek Summer 1995

Species List	Number cells /cm² /week
<u>Cocconeis placentula</u>	1928.5
<u>Cymbella turgida</u>	55.9
<u>Diatoma vulgare</u> var. <u>vulgare</u>	55.9
<u>Eunotia incisa</u>	55.9
<u>Fragillaria crotonensis</u>	335.4
<u>Melosira varians</u>	1509.3
<u>Navicula cryptocephala</u>	447.2
<u>Navicula viridula</u>	279.5
<u>Rhoicosphenia curvata</u>	167.7
<u>Schizothrix calcicola</u>	6484.4
<u>Synedra acus</u>	55.9
<u>Synedra amphicephala</u> var. <u>austriaca</u>	223 .6

Appendix 33.22 Arbuckle Creek Spring 1996

Species List	Number cells /cm² /week
<u>Cocconeis placentula</u>	55.9
<u>Fragillaria crotonensis</u>	1565.2
<u>Fragillaria pinnata</u> var. <u>pinnata</u>	894.4
<u>Fragillaria vaucheria</u>	3577.6
<u>Gomphonema parvulum</u>	7714.2
<u>Lyngbya lagerheimii</u>	894.4
<u>Melosira varians</u>	559
<u>Meridion ciculare</u>	111.8
<u>Navicula cryptocephala</u>	4360.2
<u>Navicula viridula</u> var. <u>viridula</u>	3354
<u>Rhoicosphenia curvata</u>	670.8
<u>Schizothrix calcicola</u>	127,340.2
<u>Spirulina major</u>	* 0
<u>Stigeoclonium tenue</u>	1341.6
<u>Surirella patella</u> var. <u>neupaueri</u>	894.4
<u>Synedra capitata</u> var. <u>capitata</u>	1034.15
<u>Synedra nana</u>	111.8
<u>Synedra pulchella</u> var. <u>lanceolata</u>	6484.4
<u>Synedra ulna</u>	503.1

*Noted during identification

Appendix B.23 Keeney Creek Spring 1996

Species List	Number cells/cm²/week
<u>Closterium sp.</u>	111.8
<u>Cyclotella meneghiniana</u>	111.8
<u>Cymbella turgida</u>	3018.6
<u>Fragillaria crotonensis</u>	1677
<u>Gomphonema augur</u>	447.2
<u>Gomphonema parvulum</u>	1006.2
<u>Lyngbya birgei</u>	2012.4
<u>Lyngbya digueti</u>	5590
<u>Melosira varians</u>	3577.6
<u>Navicula graciloides</u>	223.6
<u>Nitzschia vermicularis</u>	111.8
<u>Pediastrum boryanum</u>	894.4
<u>Schizothrix calcicola</u>	50,310
<u>Stigeoclonium stagnatile</u>	4248.4
<u>Surirella patella</u> var. <u>neupaueri</u>	559
<u>Synedra capitata</u> var. <u>capitata</u>	1341.6
<u>Synedra tabulata</u>	3940.95
<u>Synedra ulna</u>	297.39

Appendix B.24 Wolf Creek Spring 1996

Species List	Number cells /cm² /week
<u>Cymbella turgida</u>	111.8
<u>Eunotia glacialis</u>	167.7
<u>Gomphonema parvulum</u>	167.7
<u>Lyngbya aestuarii</u>	279.5
<u>Melosira varians</u>	111.8
<u>Navicula cryptocephala</u>	223.6
<u>Nitzschia ignorata</u>	167.7
<u>Rhoicosphenia curvata</u>	55.9

<u>Schizothrix calcicola</u>	11,291.8
<u>Synedra capitata</u> var. <u>capitata</u>	55.9
<u>Synedra nana</u>	55.9
<u>Synedra pulchella</u> var. <u>lanceolata</u>	447.2
<u>Tabellaria flocculosa</u>	782.6
<u>Ulothrix subtilissima</u>	5925.4

Appendix B.25 Lick Creek Spring 1996

Species List	Number cells/cm /week
<u>Achnanthes conspicua</u>	391.3
<u>Cocconeis placentula</u> var. <u>euglypta</u>	419.25
<u>Cymbella turgida</u>	600.93
<u>Diatoma vulgare</u> var. <u>vulgare</u>	* 0
<u>Eunotia incisa</u>	838.5
<u>Melosira varians</u>	* 0
<u>Meridion circulare</u>	223.6
<u>Schizothrix calcicola</u>	3913
<u>Synedra tabulata</u>	111.8
<u>Synedra ulna</u>	55.9
<u>Ulothrix aequalis</u>	391.3

*Noted during identification

Appendix B.26 Laurel Creek Spring 1996

Species List	Number cells /cm² /week
<u>Achnanthes conspicua</u>	74.54
<u>Cymbella turgida</u>	74.54
<u>Gomphonema parvulum</u>	111.8
<u>Navicula cryptocephala</u>	37.27
<u>Rhoicosphenia curvata</u>	* 0
<u>Schizothrix calcicola</u>	4472.4
<u>Synedra tabulata</u>	111.8

*Noted during identification

Appendix B.27 Dowdy Creek Spring 1996

Species List	Number cells/cm² /week
<u>Achnanthes conspicua</u>	* 0
<u>Cosmarium</u> sp.	* 0
<u>Diatoma hiemale</u> var. <u>mesodon</u>	* 0
<u>Gomphonema parvulum</u>	74.54
<u>Navicula graciloides</u>	111.81
<u>Schizothrix calcicola</u>	4658.75
<u>Ulothrix tenerrima</u>	3093.41

*Noted during identification

Appendix B.28 Meadow Creek Spring 1996

Species List	Number cells /cm² /week
<u>Gomphonema parvulum</u>	* 0
<u>Lyngbya putealis</u>	2124.2
<u>Melosira varians</u>	* 0
<u>Navicula viridula</u> var. <u>viridula</u>	223.6
<u>Schizothrix calcicola</u>	559
<u>Synedra tabulata</u>	55.9

*Noted during identification

Appendix C.1 Indicator Species of Periphyton for Dunloup Creek Summer 1995 community

** obvious dominant; * a dominant; A, attached; E, Eutrophication; F, Filter; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; St, stream (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Cocconeis placentula</u> *	PF; Prefers low turbidity, Pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa; summer and fall dominant
<u>Cymbella turgida</u>	PI
<u>Diatoma vulgare</u> var. <u>vulgare</u>	---
<u>Eunotia incisa</u>	genera indicates PI
<u>Fragillaria crotonensis</u>	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high amounts of suspended sediment and turbidity
<u>Melosira varians</u> *	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula cryptocephala</u>	PF
<u>Navicula viridula</u>	PF
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Schizothrix calcicola</u> **	SP
<u>Synedra acus</u>	F, PF
<u>Synedra amphicephala</u> var. <u>austriaca</u>	---

Appendix C.2 Indicator Species of periphyton for Dunloup Creek Winter 1996 community

**Obvious dominant; *a dominant; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Achnanthes conspicua</u>	---
<u>Cymbella turgida</u>	PI
<u>Diatoma vulgare</u> var. <u>vulgare</u>	F, PF, PI, St; prefers cool fresh water with relatively low concentrations of sodium and sulfate, late summer to fall dominant, found pH around 8
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Melosira varians</u> *	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula cryptocephala</u>	PF
<u>Navicula radiosa</u> var. <u>tenella</u> *	Sensitive to low concentrations of chloride; cool, Fresh very hard waters with relatively low concentrations of sodium sulfate; tolerates some suspended sediment and turbidity, summer dominant
<u>Nitzschia ignorata</u>	---
<u>Schizothrix calcicola</u> **	SP
<u>Spirulina major</u>	PE
<u>Synedra fasciculata</u>	Cool, brackish extremely hard sodium sulfate waters, Sensitive to suspended sediment and turbidity, summer and fall dominant, pH 7.8 - 8.2
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, Relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4

Appendix C.3 Indicator Species of Periphyton for Arbuckle Creek Summer 1995 community
 ** obvious dominant; A, attached; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Achnanthes conspicua</u>	---
<u>Achnanthes lanceolata</u>	Inhibited by high light, found in shady areas; Cool water, low turbidity; summer dominant; low concentrations of chloride
<u>Cocconeis placentula</u> var. <u>euglypta</u>	Can tolerate a slight salt content, even found in estuaries; Prefers low turbidity, Pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa; summer and fall dominant
<u>Cyclotella meneghiniana</u>	F, PF; prefers hard somewhat brackish water; high sulfate but low chloride content, summer and fall dominant
<u>Cymbella turgida</u>	PI
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Melosira varians</u> **	High nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula cryptocephala</u> **	PF
<u>Navicula viridula</u> var. <u>viridula</u>	---
<u>Nitzschia palea</u>	A, I, PF, F; Very broad ecological amplitude; prefers fresh to brackish water; very hard to extremely hard waters; indifferent to moderate amounts of suspended sediment, turbidity and chloride
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6

<u>Schizothrix calcicola</u> **	SP
<u>Surirella brightwellii</u>	---
<u>Synedra acus</u>	F, PF
<u>Synedra pulchella</u> var. <u>lanceolata</u>	---
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4

Appendix C.4 Indicator Species of Periphyton for Arbuckle Creek Fall 1995 community

**Obvious dominant; *a dominant; A, attached; C, clean; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; SP sewage pond (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Closterium</u> sp.	---
<u>Cocconeis placentula</u> var. <u>euglypta</u>	pH > 7; C; prefers low turbidity, summer and fall dominant, pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa
<u>Cyclotella meneghiniana</u>	F, PF; Prefers hard somewhat brackish water, high sulfate but low chloride content; summer and fall dominant
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Lyngbya digueti</u> *	PF
<u>Melosira varians</u> **	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula accomoda</u> *	---

<u>Navicula inflexa</u> *	---
<u>Navicula viridula</u>	PF
<u>Nitzschia ignorata</u>	---
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Schizothrix calcicola</u> **	SP
<u>Surirella brightwellii</u>	---
<u>Synedra acus</u>	F, PF
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra pulchella</u> var. <u>lanceolata</u>	---

Appendix C.5 Indicator Species of periphyton for Arbuckle Creek Winter 1996 sample

**Obvious dominant; *a dominant; C, clean; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Gomphonema parvulum</u> *	I, PE, PF
<u>Melosira varians</u>	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Meridion circulare</u> *	C
<u>Navicula accomoda</u>	--
<u>Navicula capitata</u>	---
<u>Navicula cryptocephala</u>	PF
<u>Schizothrix calcicola</u> **	SP
<u>Spirulina major</u>	PE
<u>Surirella brightwellii</u>	---
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra nana</u>	PI
<u>Synedra tabulata</u> *	PE, PI
<u>Synedra ulna</u>	PF, T; Cool fresh water with high mineral content, relatively high concentrations of inorganic nitrogen, sensitive to suspended sediment and turbidity, spring and fall dominant

Appendix C.6 Indicator Species of Periphyton for Arbuckle Creek Spring 1996 community

** obvious dominant; A, attached; C, clean; E, eutrophication; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; St, stream; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Cocconeis placentula</u>	PF; Prefers low turbidity, Pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa; summer and fall dominant
<u>Fragillaria crotonensis</u>	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high amounts of suspended sediment and turbidity
<u>Fragillaria pinnata</u> var. <u>pinnata</u>	---
<u>Fragillaria vaucheria</u>	Prefers cool, fresh to slightly brackish, water; tolerates some suspended sediment and turbidity; spring and fall dominant
<u>Gomphonema parvulum</u> **	I, PE, PF
<u>Lynceba lagerheimii</u>	A
<u>Melosira varians</u>	High nutrients, prefers pH>7; F, PF; Fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Meridion circular</u>	C
<u>Navicula cryptocephala</u> **	PF
<u>Navicula viridula</u> var. <u>viridula</u>	---
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Schizothrix calcicola</u> **	SP
<u>Spirulina major</u>	PE

<u>Stigeoclonium tenue</u>	I, PF	
<u>Surirella patella</u> var. <u>neupaueri</u>	---	
<u>Synedra capitata</u> var. <u>capitata</u>	---	
<u>Synedra nana</u>	PI	
<u>Synedra pulchella</u> var. <u>lanceolata</u> **	---	
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4	

Appendix C.7 Indicator Species of Periphyton for Wolf Creek Spring 1996 community

** obvious dominant; * a dominant; A, attached; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Cymbella turgida</u>	PI
<u>Eunotia glacialis</u>	---
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Lyngbya aestuarii</u>	Affects the operation of canals
<u>Melosira varians</u>	High nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula cryptocephala</u>	PF
<u>Nitzschia ignorata</u>	----
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Schizothrix calcicola</u> **	SP
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra nana</u>	PI
<u>Synedra pulchella</u> var. <u>lanceolata</u>	---
<u>Tabellaria flocculosa</u>	F
<u>Ulothrix subtilissima</u> *	---

Appendix C.8 Indicator Species of Periphyton for Wolf Creek Fall 1995 community

*Obvious dominant; *a dominant; A, attached; C, clean; E, eutrophication; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; St, stream; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Cymbella tumida</u>	PI
<u>Diatoma vulgare</u>	F, PF, PI, St; prefers cool fresh water with relatively low concentrations of sodium and sulfate, late summer to fall dominant, prefers pH of 8.0 - 8.5
<u>Eunotia valida</u>	---
<u>Fragillaria crotonensis</u>	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high amounts of suspended sediment and turbidity
<u>Gomphonema acuminatum</u>	---
<u>Gomphonema constrictum</u>	---
<u>Melosira varians</u>	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Mougeotia sphaerocarpa</u>	F
<u>Navicula placenta</u>	---
<u>Rhoicosphenia curvata</u>	A ; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Schizothrix calcicola</u>	SP
<u>Synedra tabulata</u>	PE, PI

<u>Synedra ulna</u> var. <u>contracta</u>	Cool fresh water of large mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4
<u>Tabellaria fenestrata</u>	F, T
<u>Tabellaria flocculosa</u>	F

Appendix C.9 Indicator Species of Periphyton for Wolf Creek Summer 1995 community

*a dominant; A, attached; C, Clean; E, Eutrophication; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; St, Stream; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Colonies lewisii</u> var. <u>inflata</u>	---
<u>Cymbella aspersa</u>	---
<u>Cymbella tumida</u>	PI
<u>Cymbella turgida</u>	PI
<u>Eunotia elegans</u>	Genera <u>Eunotia</u> indicates PI
<u>Fragillaria crotonensis</u> *	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water; sensitive to high amounts of suspended sediment and turbidity
<u>Gomphonema acuminatum</u>	---
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Lyngbya digueti</u> *	PF
<u>Melosira varians</u>	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula cryptocephala</u>	PF

<u>Navicula exigua</u> var. <u>capitata</u>	C
<u>Navicula gottlandica</u> var. <u>gottlandica</u>	---
<u>Navicula viridula</u> var. <u>viridula</u>	---
<u>Nitzschia ignorata</u>	---
<u>Nitzschia palea</u>	A, I, PF, F; Very broad ecological amplitude; prefers fresh to brackish water; very hard to extremely hard waters; indifferent to moderate amounts of suspended sediment, turbidity and chloride
<u>Oedogonium suecicum</u> var. <u>australe</u>	---
<u>Pinnularia legumen</u>	---
<u>Staurastrum botrophilum</u>	---
<u>Surirella lanicostata</u>	---
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra nana</u>	PI
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4
<u>Tabellaria fenestrata</u> *	F, T

Appendix C.10 Indicator Species of Periphyton for Marr Branch Summer 1995 community

** obvious dominant; *a dominant; A, attached; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Amphora pediculus</u> var. <u>minor</u>	---
<u>Cocconeis placentula</u> var. <u>euglypta</u>	Can tolerate a low salt content, even found in estuaries; Prefers low turbidity, Pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa; summer and fall dominant
<u>Cyclotella comta</u>	PI, T
<u>Cymbella affinis</u>	Broad ecological amplitude, prefers fresh calcium bicarbonate water; tolerates some turbidity and suspended sediment; no clear seasonal preference
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Lyngbya ochracea</u> *	---
<u>Melosira varians</u> *	High nutrients, prefers pH>7; F, PF; Fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula exigua</u>	---
<u>Navicula graciloides</u>	T
<u>Navicula protracta</u>	---
<u>Pinnularia viridis</u>	---
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Schizothrix calcicola</u> **	SP
<u>Surirella brightwellii</u>	---

<u>Synedra acus</u>	F, PF
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4

Appendix C.11 Indicator Species of Periphyton for Marr Branch Fall 1995 community

**Obvious dominant; E, Eutrophication; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP, sewage pond; St, Stream; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Cocconeis disculus</u>	---
<u>Cocconeis placentula</u> var. <u>euglypta</u>	Prefers low turbidity summer and fall dominant; pioneer species colonized artificial substrates at some site almost to the exclusion of other taxa
<u>Cymbella tumida</u>	PI
<u>Fragillaria crotonensis</u>	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high amounts of suspended sediment and turbidity
<u>Gomphonema constrictum</u>	---
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Melosira varians</u>	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Schizothrix calcicola</u> **	SP
<u>Tabellaria fenestrata</u>	F, T

Appendix C.12 Indicator species of periphyton for Marr Branch Winter 1996 community

**Obvious dominant; *a dominant; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; T, Taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Navicula cryptocephala</u> *	PF
<u>Navicula viridula</u> **	PF
<u>Surirella brightwellii</u>	---
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra tabulata</u>	PE, PI
<u>Synedra ulna</u> *	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4

Appendix C.13 Indicator Species of Periphyton for Keeney Creek Fall 1995 community
 **Obvious dominant; *a dominant; A, attached; C, clean; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP, sewage pond (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Cocconeis placentula</u>	Water with pH > 7.0; C and PF; Prefers low turbidity summer and fall dominant; pioneer species colonized artificial substrates at some site almost to the exclusion of other taxa
<u>Cyclotella meneghiniana</u>	F, PF; prefers hard somewhat brackish water, high sulfate but low chloride content, summer and fall dominant
<u>Cymbella turgida</u>	PI
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Melosira varians</u> *	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula exigua</u>	---
<u>Pinnularia sudetica</u>	---
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Schizothrix calcicola</u> **	SP
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra pulchella</u> var. <u>lanceolata</u>	---
<u>Synedra tabulata</u>	PE, PI

Appendix C.14 Indicator Species of periphyton for Keeney Creek Winter 1996 community

**Obvious dominant; *a dominant; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Cymbella turgida</u>	PI
<u>Gomphonema parvulum</u> *	I, PE, PF
<u>Melosira varians</u>	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula cryptocephala</u>	PF
<u>Navicula viridula</u> *	PF
<u>Schizothrix calcicola</u> **	SP
<u>Synedra capitata</u> var. <u>capitata</u>	--
<u>Synedra tabulata</u>	PE, PI

Appendix C.15 Indicator Species of Periphyton for Keeney Creek Spring 1996 community
 **obvious dominant; * a dominant; E, eutrophication; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; St, stream; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Closterium</u> sp.	---
<u>Cyclotella meneghiniana</u>	F, PF; prefers hard somewhat brackish water; high sulfate but low chloride content, summer and fall dominant
<u>Cymbella turgida</u>	PI
<u>Fragillaria crotonensis</u>	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high amounts of suspended sediment and turbidity
<u>Gomphonema augur</u>	---
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Lyngbya birgei</u>	---
<u>Lyngbya digueti</u> *	PF
<u>Melosira varians</u> *	High nutrients, prefers pH>7; F, PF; Fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula graciloides</u>	T
<u>Nitzschia vermicularis</u>	---
<u>Pediastrum boryanum</u>	PF, PI; organically enriched areas
<u>Schizothrix calcicola</u> **	SP
<u>Stigeoclonium stagnatile</u> *	---
<u>Surirella patella</u> var. <u>neupaueri</u>	---
<u>Synedra capitata</u> var. <u>capitata</u>	---

<u>Synedra tabulata</u> *	PE, PI
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4

Appendix C.16 Species Indicator of Periphyton for Glade Creek Fall 1995 community

**Obvious dominant; *a dominant; C, clean; E, eutrophication; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; St, stream (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Closterium moniliferum</u>	F
<u>Cocconeis placentula</u>	Water with pH > 7.0; C; Prefers low turbidity summer and fall dominant; pioneer species colonized artificial substrates at some site almost to the exclusion of other taxa
<u>Cymbella turgida</u>	PI
<u>Eunotia incisa</u>	---
<u>Fragillaria crotonensis</u> **	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high amounts of suspended sediment and turbidity
<u>Gyrosigma obtusatum</u>	---
<u>Lyngbya penicillata</u>	---
<u>Lyngbya putealis</u> *	Affects the operation of canals
<u>Melosira varians</u>	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula cryptocephala</u>	PF

<u>Navicula tripunctata</u>	PI; Cool fresh Calcium Magnesium bicarbonate waters; relatively low concentrations of Sodium, sulfate, chloride and suspended sediment, pH 8.2 - 8.4
<u>Nitzschia ignorata</u>	---
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra tabulata</u>	PE, PI

Appendix C.17 Indicator Species of Periphyton for Laurel Creek Summer 1995 community
****Obvious dominant; PF, pollution; T, taste and odor (Palmer, 1980; Bahls, et al., 1984)**

Species List	Indicator
<u>Cocconeis placentula</u> var. <u>euglypta</u> **	Prefers low turbidity summer and fall dominant; pioneer species colonized artificial substrates at some site almost to the exclusion of other taxa
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4

Appendix C. 18 Indicator Species of Periphyton for Laurel Creek Fall 1995 community

*a dominant; A, attached; C, clean; E, Eutrophication; F, Filter; PF, pollution, fresh; PI plankton of lakes; St, stream (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Achnanthes lanceolata</u>	inhibited by high light, found in shady areas; Cool water low turbidity, summer dominant, small concentrations of chloride
<u>Cocconeis placentula</u> var. <u>euglypta</u> *	Prefers low turbidity summer and fall dominant; pioneer species colonized artificial substrates at some site almost to the exclusion of other taxa
<u>Cymbella cesati</u>	C
<u>Fragillaria crotonensis</u>	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high amounts of suspended sediment and turbidity
<u>Gomphonema augur</u>	---
<u>Melosira varians</u>	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Synedra acus</u> var. <u>radians</u>	F
<u>Synedra pulchella</u> var. <u>lanceolata</u>	---

Appendix C. 19 Indicator Species of Periphyton for Laurel Creek Winter 1996 community

**Obvious dominant; *a dominant; C, clean; E, eutrophication; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; St, stream; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Achnanthes microcephala</u>	---
<u>Cocconeis placentula</u> var. <u>euglypta</u>	pH > 7; C; prefers low turbidity, summer and fall dominant, pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa
<u>Cyclotella stelligera</u>	PI
<u>Fragillaria crotonensis</u>	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high amounts of suspended sediment and turbidity
<u>Gomphonema angustatum</u> var. <u>producta</u>	---
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Meridion circulare</u> **	C
<u>Pinnularia biceps</u>	---
<u>Schizothrix calcicola</u> *	SP
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4

Appendix C.20 Indicator Species of Periphyton for Laurel Creek Spring 1996 community
 ** obvious dominant; A, attached; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond (Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Achnanthes conspicua</u>	---
<u>Cymbella turgida</u>	PI
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Navicula cryptocephala</u>	PF
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Schizothrix calcicola</u> **	SP
<u>Synedra tabulata</u>	PE, PI

Appendix C.21 Indicator Species of Periphyton for Dowdy Creek Fall 1995 community
 **Obvious dominant; SP, sewage pond (Palmer, 1980;)

Species List	Indicator
<u>Eunotia incisa</u>	---
<u>Schizothrix calcicola</u> **	SP

Appendix C.22 Indicator Species of Periphyton for Dowdy Creek Spring 1996 community

** obvious dominant; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; T, taste and odor (Palmer, 1980;)

Species List	Indicator
<u>Achnanthes conspicua</u>	---
<u>Cosmarium</u> sp.	---
<u>Diatoma hiemale</u> var. <u>mesodon</u>	---
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Navicula graciloides</u>	T
<u>Schizothrix calcicola</u> **	SP)
<u>Ulothrix tenerima</u> **	PI

Appendix C.23 Indicator Species of Periphyton for Lick Creek Summer 1995 community

** obvious dominant; A, attached; C, Clean; E, Eutrophication; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; St, Stream; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Bacillaria paradoxa</u>	Can tolerate brackish water
<u>Cocconeis placentula</u> **	Water pH > 7.0; C, PF; prefers low turbidity summer and fall dominant; pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa
<u>Cyclotella meneghiniana</u>	F, PF; prefers hard somewhat brackish water; high sulfate but low chloride content, summer and fall dominant
<u>Cymbella turgida</u> **	PI
<u>Fragillaria crotonensis</u>	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high amounts of suspended sediment and turbidity
<u>Fragillaria pinnata</u> var. <u>pinnata</u>	---
<u>Gomphonema augur</u>	---
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Gyrosigma obtusatum</u>	---
<u>Melosira varians</u>	High nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula exigua</u>	---
<u>Navicula radiosa</u> var. <u>tenella</u>	Sensitive to low concentrations of chloride; cool, fresh very hard waters with relatively low concentrations of sodium sulfate; tolerates some suspended sediment and turbidity, summer dominant
<u>Pinnularia mesolepta</u>	---

<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Surirella biseriata</u> var. <u>bifrons</u> f. <u>Amphyoxyis</u>	---
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra pulchella</u> var. <u>lanceolata</u>	---
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4

Appendix C.24 Indicator Species of Periphyton for Lick Creek Fall 1995 community

**Obvious dominant; *a dominant; C, clean; E, eutrophication; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; St, stream; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Cocconeis placentula</u> *	pH > 7; C; prefers low turbidity, summer and fall dominant, pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa
<u>Cyclotella stelligera</u>	PI
<u>Cymbella affinis</u>	Prefers pH of 7.6 - 8.8, Broad ecological amplitude, prefers fresh calcium bicarbonate water, tolerates some turbidity and suspended sediment, no clear seasonal preference
<u>Cymbella turgida</u>	PI (2)
<u>Diatoma vulgare</u> var. <u>vulgare</u>	F, PF, PI, St; prefers cool fresh water with relatively low concentrations of sodium and sulfate, late summer to fall dominant, prefers pH of 8.0 - 8.5
<u>Eunotia incisa</u>	---
<u>Fragillaria construens</u>	T; Cold calcium Magnesium bicarbonate waters; sensitive to high concentrations of suspended sediment and turbidity, spring and fall dominant, prefers pH of 8.4
<u>Fragillaria crotonensis</u> **	E, PI, St, F; Fresh Calcium Magnesium bicarbonate water, sensitive to high concentrations of suspended sediment and turbidity
<u>Melosira varians</u>	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate

<u>Navicula rhynchocephala</u> var. <u>amphiceros</u>	Very hard slightly brackish water, sensitive to low amounts of suspended sediment, turbidity and chloride; summer dominant
<u>Nitzschia acicularis</u>	PF; fresh to somewhat brackish water pH > 8.0, fall dominant, tolerates considerable amounts of suspended sediment and turbidity but does best with low concentrations
<u>Nitzschia fonticola</u>	PI
<u>Nitzschia linearis</u>	C; Cool, slightly brackish water, relatively low amounts of suspended sediment and chloride; spring dominant
<u>Nitzschia palea</u>	A, I, PF, F; Very broad ecological amplitude; prefers fresh to brackish very hard to extremely hard waters; indifferent to moderate amounts of suspended sediment, turbidity and chloride; spring to fall dominant
<u>Oegonium suecicum</u> var. <u>australe</u>	---
<u>Rhoicosphenia curvata</u>	A; Prefers fresh to brackish waters, tolerates some suspended sediment and turbidity; indifferent to season and stream size; requires stable attachment sites; prefers pH of 8.0 - 8.6
<u>Synedra capitata</u> var. <u>capitata</u>	---
<u>Synedra ulna</u> *	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4

Appendix C.25 Indicator Species of Periphyton for Lick Creek Spring 1996 community

** obvious dominant; C, clean; F, Filter; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond; T, taste and odor (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Achnanthes conspicua</u>	---
<u>Cocconeis placentula</u> var. <u>euglypta</u>	Can tolerate a slight salt content, even found in estuaries; Prefers low turbidity, Pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa; summer and fall dominant
<u>Cymbella turgida</u>	---
<u>Diatoma vulgare</u> var. <u>vulgare</u>	---
<u>Eunotia incisa</u>	---
<u>Melosira varians</u>	High nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Meridion circulare</u>	C
<u>Schizothrix calcicola</u> **	SP
<u>Synedra tabulata</u>	PE, PI
<u>Synedra ulna</u>	PF, T; Cool fresh water of high mineral content, relatively high concentrations of inorganic nitrogen, Sensitive to suspended sediment and turbidity, spring and fall dominant, prefers pH 8.2 - 8.4
<u>Ulothrix aequalis</u>	C

Appendix C.26 Indicator Species of Periphyton for Meadow Creek Summer 1995 community
no obvious dominants; F, Filter; PE, pollution, estuarine; PF, pollution, fresh; PI
plankton of lakes (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Achnanthes conspicua</u>	---
<u>Cocconeis disculus</u>	---
<u>Cocconeis placentula</u> var. <u>euglypta</u>	Can tolerate a slight salt content, even found in estuaries; Prefers low turbidity, Pioneer species colonized artificial substrates at some sites almost to the exclusion of other taxa; summer and fall dominant
<u>Cymbella turgida</u>	PI
<u>Eunotia trianacria</u>	---
<u>Gomphonema subclavatum</u>	---
<u>Melosira varians</u>	high nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula angusta</u>	---
<u>Navicula exigua</u>	---
<u>Navicula salinarum</u> var. <u>intermedia</u>	Cool fresh to slightly brackish water; relatively rich in Magnesium and bicarbonate ions; tolerates some suspended sediment turbidity and chloride; summer dominant
<u>Surirella patella</u> var. <u>neupaueri</u>	---
<u>Synedra amphicephala</u>	---
<u>Synedra nana</u>	PI
<u>Synedra rumpens</u>	---
<u>Synedra tabulata</u>	PE, PI

Appendix C.27 Indicator Species of Periphyton for Meadow Creek Fall 1995 community
 **Obvious dominant; F, Filter; PE, pollution, estuarine; PI plankton of lakes; SP, sewage pond (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Cymbella tumida</u>	PI
<u>Gomphonema subclavatum</u>	---
<u>Melosira varians</u>	High nutrients, prefers pH>7; F, PF; Fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Schizothrix calcicola</u> **	SP

Appendix C.28 Indicator Species of Periphyton for Meadow Creek Spring 1996 community
 ** obvious dominant; F, Filter; I, indicator; PE, pollution, estuarine; PF, pollution, fresh; PI plankton of lakes; SP sewage pond (Whitford and Schumacher, 1984; Palmer, 1980; Bahls, et al., 1984)

Species List	Indicator
<u>Gomphonema parvulum</u>	I, PE, PF
<u>Lyngbya putealis</u> **	Affects operation of canals
<u>Melosira varians</u>	High nutrients, prefers pH>7; F, PF; fresh, slightly brackish water, Magnesium sulfate bicarbonate water, pH 8-8.3, sensitive to low amounts of suspended sediment and chloride, summer dominate
<u>Navicula viridula</u> var. <u>viridula</u>	---
<u>Schizothrix calcicola</u>	SP
<u>Synedra tabulata</u>	PE, PI

Appendix D.1 Morisita Index for the Winter 1996 Communities

Stream	Laurel	Marr	Keeney	Dunloup
Arbuckle	.370	.000	.974	.999
Dunloup	.345	.000	.966	
Keeney	.384	.149		
Marr	.022			

Appendix D.2 Jaccard Coefficient for the Winter 1996 Communities

Stream	Laurel	Marr	Keeney	Dunloup
Arbuckle	.250	.308	.231	.333
Dunloup	.200	.154	.167	
Keeney	.273	.375		
Marr	.250			

Appendix D.3 Horn's Index for the Winter 1996 Communities

Stream	Laurel	Marr	Keeney	Dunloup
Arbuckle	.540	.024	.859	.971
Dunloup	.316	.004	.840	
Keeney	.427	.215		
Marr	.091			

Appendix D.4 Morisita Index for the Summer 1995 Communities

Stream	Laurel	Dunloup	Meadow	Arbuckle	Marr	Lick
Wolf	.001	.066	.102	.140	.084	.201
Lick	.000	.187	.072	.013	.008	
Marr	.035	.874	.139	.916		
Arbuckle	.017	.897	.184			
Meadow	.013	.069				
Dunloup	.000					

Appendix D.5 Jaccard Coefficient for the Summer 1995 Communities

Stream	Laurel	Dunloup	Meadow	Arbuckle	Marr	Lick
Wolf	.042	.129	.057	.219	.086	.143
Lick	.056	.160	.069	.222	.143	
Marr	.133	.174	.115	.348		
Arbuckle	.125	.273	.154			
Meadow	.067	.083				
Dunloup	.000					

Appendix D.6 Horn's Index for the Summer 1995 Communities

Stream	Laurel	Dunloup	Meadow	Arbuckle	Marr	Lick
Wolf	.017	.203	.126	.275	.154	.269
Lick	.015	.306	.114	.124	.072	
Marr	.063	.682	.228	.768		
Arbuckle	.056	.764	.252			
Meadow	.119	.139				
Dunloup	-.00					

Appendix D.7 Morisita Index for the Spring 1996 Communities

Stream	Dowdy	Laurel	Meadow	Lick	Wolf	Keeney
Arbuckle	.067	.072	.038	.076	.095	.093
Keeney	.814	.926	.246	.941	.868	
Wolf	.732	.830	.221	.838		
Lick	.781	.871	.324			
Meadow	.221	.263				
Laurel	.804					

Appendix D.8 Jaccard Coefficient for the Spring 1996 Communities

Stream	Dowdy	Laurel	Meadow	Lick	Wolf	Kenney
Arbuckle	.100	.143	.100	.125	.333	.241
Keeney	.158	.200	.100	.174	.185	
Wolf	.125	.250	.059	.095		
Lick	.083	.364	.182			
Meadow	.333	.250				
Laurel	.250					

Appendix D.9 Horn's Index for the Spring 1996 Communities

Stream	Dowdy	Laurel	Meadow	Lick	Wolf	Keeney
Arbuckle	.159	.243	.182	.162	.220	.217
Keeney	.617	.896	.252	.676	.625	
Wolf	.589	.799	.256	.586		
Lick	.575	.797	.459			
Meadow	.295	.400				
Laurel	.757					

Appendix D.10 Morisita Index for the Fall 1995 Communities

Stream	Meadow	Marr	Dowdy	Laurel	Keeney	Glade	Arbuckle	Wolf
Lick	.002	.058	.000	.002	.002	.003	.009	.104
Wolf	.714	.703	.671	.005	.737	.007	.682	
Arbuckle	.774	.709	.684	.050	.813	.054		
Glade	.009	.000	.000	.394	.012			
Keeney	.995	.981	.394	.011				
Laurel	.005	.004	.011					
Dowdy	.988	.995						
Marr	.992							

Appendix D.11 Jaccard Coefficient for the Fall 1995 Communities

Stream	Meadow	Marr	Dowdy	Laurel	Keeney	Glade	Arbuckle	Wolf
Lick	.048	.045	.053	.080	.154	.148	.067	.100
Wolf	.188	.111	.063	.091	.174	.077	.155	
Arbuckle	.125	.188	.067	.211	.300	.080		
Glade	.063	.000	.071	.100	.250			
Keeney	.143	.133	.077	.167				
Laurel	.083	.077	.000					
Dowdy	.200	.167						
Marr	.125							

Appendix D.12 Horn's Index for the Fall 1995 Communities

Stream	Meadow	Marr	Dowdy	Laurel	Keeney	Glade	Arbuckle	Wolf
Lick	.036	.114	.007	.044	.044	.065	.032	.210
Wolf	.784	.770	.741	.042	.660	.059	.522	
Arbuckle	.869	.778	.796	.209	.833	.086		
Glade	.073	.000	.007	.284	.097			
Keeney	.960	.887	.927	.107				
Laurel	.038	.037	.000					
Dowdy	.930	.952						
Marr	.899							

Appendix E.1 Morisita Index for
Arbuckle Creek

Season/year	Winter 1996	Summer 1995	Fall 1995
Spring 1996	.065	.173	.126
Fall 1995	.704	.979	
Summer 1995	.733		

Appendix E.2 Jaccard Coefficient of
Community for Arbuckle Creek

Season/year	Winter 1996	Summer 1995	Fall 1995
Spring 1996	.318	.308	.185
Fall 1995	.250	.429	
Summer 1995	.286		

Appendix E.3 Horn's Index for
Arbuckle Creek

Season/year	Winter 1996	Summer 1995	Fall 1995
Spring 1996	.168	.370	.246
Fall 1995	.641	.871	
Summer 1995	.661		

Appendix E.4 Morisita Index for
Wolf Creek

Season/year	Spring 1996	Fall 1995
Summer 1995		.083
Fall 1995	.008	
	.730	

Appendix E.5 Jaccard Coefficient of
Community for Wolf Creek

Season/year	Spring 1996	Fall 1995
Summer 1995		.188
Fall 1995	.233	
	.160	

Appendix E.6 Horn's Index for
Wolf Creek

Season/year	Spring 1996	Fall 1995
Summer 1995	.108	.252
Fall 1995	.591	

Appendix E.7 Morisita Index for
Lick Creek

Season/year	Spring 1996	Summer 1995
Fall 1995	.008	.261
Summer 1995	.074	

Appendix E.8 Jaccard Coefficient of
Community for Lick Creek

Season/year	Spring 1996	Summer 1995
Fall 1995	.125	.241
Summer 1995	.125	

Appendix E.9 Horn's Index for
Lick Creek

Season/year	Spring 1996	Summer 1995
Fall 1995	.086	.436
Summer 1995	.151	

Appendix E.10 Morisita Index for
Laurel Creek

Season/year	Spring 1996	Fall 1995	Summer 1995
Winter 1996	.360	.069	.021
Summer 1995	.000	.404	
Fall 1995	.000		

Jaccard Coefficient of
community f Laurel C ek

Season/year	Spring 1996	Fall 1995	Summer 1995
Winter 1996	.154	.125	.222
Summer 1995	.000	.100	
Fall 1995	.000		

Appendix E.12 Horn's Index for
 Laurel Creek

Season/year	Spring 1996	Fall 1995	Summer 1995
Winter 1996	.407	.149	.061
Summer 1995	.000	.328	
Fall 1995	.000		

Appendix E. 13 Similarities for Dowdy Creek
 Fall 1995 and Spring 1996

	Jaccard C	Horn's Index
	.786	.200
		0.769

Appendix E.14 Similarities for Dunloup Creek
 Summer 1995 and Winter 1996

	Jaccard C	Horn's Index
	.8.29	.222
		0.682

Appendix E.I5 Morisita Index for
 Marr Branch

Season/year	Winter 1996	Fall 1995
Summer 1995	.000	.745
Fall 1995	.000	

Appendix E.16 Jaccard Coefficient
of Community for Marr Branch

Season/year	Winter 1996	Fall 1995
Summer 1995	.105	.176
Fall 1995	.100	

Appendix E.17 Horn's Index for
Marr Branch

Season/year	Winter 1996	Fall 1995
Summer 1995	.014	.673
Fall 1995	.007	

Appendix E.18 Morisita's Index for
Keeney Creek

Season/year	Winter 1996	Fall 1995
Spring 1996	.946	.953
Fall 1995	.975	

Appendix E.19 Jaccard Coefficient of
Community for Keeney Creek

Season/year	Winter 1996	Fall 1995
Spring 1996	.211	.304
Fall 1995	.308	

Appendix E.20 Horn's Index for
Keeney Creek

Season/year	Winter 1996	Fall 1995
Spring 1996	.815	.836
Fall 1995	.826	

Appendix E.21 Morisita's Index for
Meadow Creek

Season/year	Fall 1995	Spring 1996
Summer 1995	.026	.010
Spring 1996	.248	

Jaccard Coefficient of
Community for Meadow Creek

Season/year	Fall 1995	Spring 1996
Summer 1995	.125	.059
Spring 1996	.143	

Appendix E.23 Horn's Index for
Meadow Creek

Season/year	Fall 1995	Spring 1996
Summer 1995	.118	.041
Spring 1996	.350	