

TABLE OF CONTENTS

Acknowledgments	1
Section I - Introduction	2
List of Sites	4
Map of Henderson County Sites	5
Section II - Methodology	6
Section III - Results and Discussion	8
Classification Grades Based on Parameters and Ranges	9
A. Acidity and Alkalinity	11
B. Turbidity and Total Suspended Solids	12
C. Conductivity and Heavy Metals	19
D. Nutrients	21
E. Biological Monitoring	25
Section IV - Summary and Conclusions	26
Index Ratings for Stream Monitoring Sites	27
The Green River Watershed	28
The Mud Creek Watershed	29
The Mills River Watershed	30
The Cane Creek Watershed	30
The Streams of Etowah and Horseshoe	31
The French Broad River	32

APPENDICES

A. Sample Data Sheet	A1
B. Laboratory Analysis and Reporting Limits	A2
C. Biological Stream Quality Survey	A3
D. Parameters and Ranges for Stream Quality Classifications	A4
E. Stream Ranking Index for All Sites in the Region	A6
F. Data Summary	A11
G. Trends for Each Site Related to Flow	A17
H. Trends for Each Site Related to Time	A19
I. Number of Sites Exhibiting Seasonal Trends	A21
J. Biological Monitoring Scores and Ratings	A22

Acknowledgments

We wish to thank the Henderson County Board of Commissioners, the Chuck McGrady Family, private donors, and the Town of Lake Lure for their continued support of this work. Their support has enabled Henderson County to develop a comprehensive water quality database that will assist greatly with planning future development in the county. Continued monitoring will provide additional information on changes taking place as the county continues to grow. The Henderson County program also provides essential information to complete the assessment of water quality in the French Broad River and Broad River watersheds. Every county in these watersheds should be clearly aware of the part they play in the overall water quality of the region.

Volunteers continue to be the key to the success of any VWIN program. Without volunteers, a water monitoring program would be prohibitively expensive. Volunteers who have been responsible for collecting samples monthly over the past year include Dave and Betty Bucher, Carl Kalitta, William Tharp, Richard Freudenberger, Sue and Walter Mahnken, Dick Black, Joe Boterf, Jim and Sharon Spicer, Bill Moore, Peter Colburn, Beth and Dave Harris, Denise Sherrill, Marilyn Westphal, Colette Summitt, Betty Shevick, Glenn Musser, Karen and Phil Cutright, Lee Johnson, Richard and Brenda Cross, and Mandy Walline. In 2002 many more volunteers were added to the water testing program in Henderson County to add biological monitoring of many of the VWIN sites to the database. All of the time and effort these volunteers put into this project are greatly appreciated. They are making an important contribution to the preservation of clean water in Henderson County.

Special thanks past to Michelle Skeelee who has graciously allowed the program to use her porch as a kit storage area, and to the county coordinator Jim and Sharon Spicer who have consistently ensured that all samples were collected each month. Thanks also to Mr. Pete's Market VIII, and VanWingerden International for providing cold storage space for water monitoring kits. We also thank Larry and Mary Winn who played a vital role in coordinating the biomonitoring teams and insuring proper training of volunteers and accurate accumulation of data, and to all the biomonitoring volunteers including Melissa Acker, Pat and Roger Bares, Wayne Blackbourn, Frank Blazey, Frank E. Blazey III, Doreen Blue, Virginia and David Craig, Brian Crissy, Brenda Cross, Tom, Davis, Holly Demuth, Judy Deutsch, Will Everhart, Samantha Ford, Lyn and Harry Fozzard, Bill Garrison, Norm Green, Suzanne Haskell, Liz Honnold, Janet and Calvin Koonse, Ramsey Lawson, Arnie Lingle, Barbara and Peter Mackinnow, Lee McCall, Dennis and Deanna McCraw, Lory, Katie, and Patrick McCraw, Bill Moore, Tina Moss, Nan Needs, Mary Jane Pell, Lucy Prim, Lawson Ramsey, Amy Robinson, Cristel Smith, Casey Thurman, David Weintraub, Larry Winn, Ben and Marion Wood, Jim Woolridge, and Bob Youngblood.

Much credit for the continued success of water monitoring also goes to the Environmental and Conservation Organization for their administrative support of the program. ECO continues to be a driving force in the prevention of water quality degradation in Henderson County. As director of ECO, MaryJo Padgett contributed enormously to the preservation of streams, wildlife habitat, and the natural heritage of Henderson County. Her energy and drive have been essential to the success of the organization, and with her recent resignation she will be greatly missed.

I. Introduction

VWIN's History

The Volunteer Water Information Network (VWIN) is a partnership of groups and individuals dedicated to preserving water quality in western North Carolina. Organizations such as the Environmental and Conservation Organization, the Pacolet Area Conservancy, the Lakefront Property Owners of Lake Lure, the Lake James Environmental Association, and many others provide administrative support. The UNC Asheville Environmental Quality Institute (EQI) provides technical assistance through laboratory analysis of water samples, statistical analysis of water quality results, and written interpretation of the data.

An accurate and on-going water quality database, as provided by VWIN, is essential for good environmental planning. The data gathered by the volunteers provides an increasingly accurate picture of water quality conditions and changes in these conditions over time. Communities and governmental agencies can use this data to identify streams of high water quality that need to be preserved, as well as streams which cannot support further development without significant water quality degradation. In addition, the information allows planners to assess the impacts of increased development and measures to control pollution. In other words, this program provides water quality data for evaluation of current management efforts and can help guide decisions affecting future management actions. The VWIN program also encourages involvement of citizens in the awareness, ownership and protection of their water resources.

In February of 1990, volunteers began monthly sampling of 27 stream sites in Buncombe County. The program was expanded to 45 sites by November of 1990. Since that time most of the other counties in Western North Carolina have established sites to bring the total current total number of sites to over 200. Monthly sampling of these sites provides extensive water quality information for the French Broad, Broad, Catawba, Tuckasegee, New, Hiawassee, and Watauga River watersheds in Western North Carolina.

The Henderson County VWIN Program

In July of 1992, members of the Volunteer Water Information Network began monthly sampling of 18 selected streams in Henderson County in order to provide an accurate picture of water quality conditions. Since that time many other sites in the county have been established. Sample sites were chosen to cover a variety of watershed drainage areas. The approximate locations of the monitoring sites in Henderson County are shown in Figure 1. The stream names associated with each site number are listed in Table 1. Some sites were chosen to monitor potential drinking water supplies. Several sites were selected as control sites to provide comparison between undeveloped and developed subwatersheds.

Under the administration of the Environmental and Conservation Organization, this program has gathered over fourteen years of water quality data. This annual report represents statistical analyses and interpretation of fourteen years of data gathered from August 1992 through July 2006 from the current sites in the county.

In 2002, the Environmental and Conservation Organization (ECO) initiated a biological stream monitoring program to augment VWIN testing in Henderson County. Biological monitoring involves collecting, identifying, and counting benthic macroinvertebrates living on the rocks and substrates on the bottoms of streams. Most of these organisms are the larval stages of insects, although they may also include crustaceans, mollusks, and other aquatic animals. Researchers have found that some species are very sensitive to pollutants while others are quite tolerant. Therefore, knowing what organisms are living in a stream is a good indicator of the health of the stream. While chemical analysis provides a snapshot of a stream at the specific time of sampling and can identify specific pollutants, biological monitoring gives a picture of the long-term effects of pollutants on stream life.

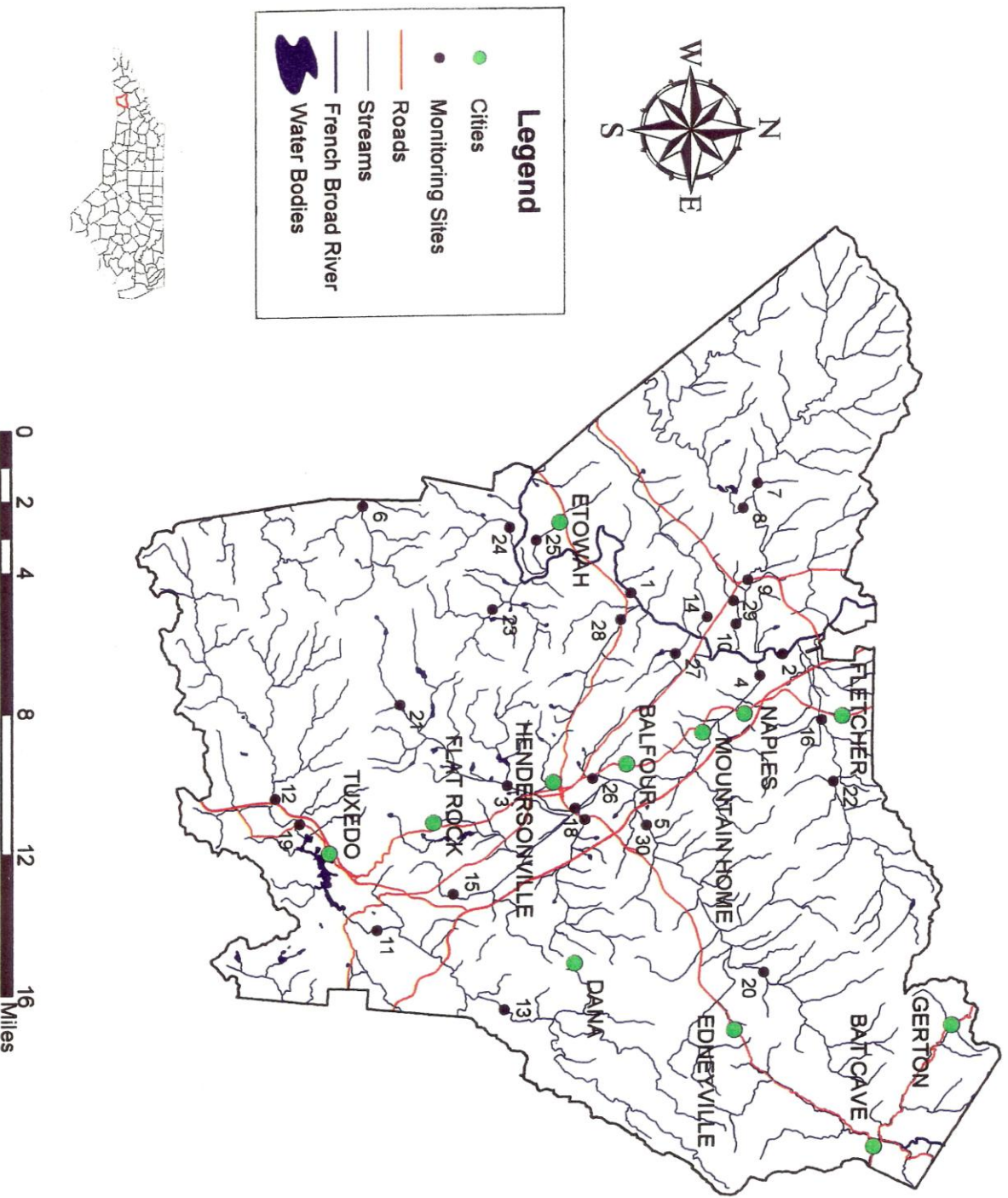
The ECO biological stream monitoring program, funded by the Helen Tarazov Reed Fund, utilizes the Save Our Streams (SOS) program of the Izaak Walton League of America (IWLA). This system provides water quality ratings based on the pollution tolerance levels of the organisms found and the diversity of the organisms in the sample. The original design (scope) of the program was to sample 15 to 20 sites two times per year and to sample at VWIN sites, if possible. In actual practice, several teams of 3-5 volunteers each (or nearly 30 volunteers) sample and analyze most of the VWIN sites in the county in April and October. A few additional biological monitoring sites not located at VWIN sites are also included in the program.

The biological summary information given in this report is the result of five years of sampling twice per year and represents baseline data and some information on changes over time. Several more sets of data will be required to provide a more valid and reliable database from which deviations can be analyzed. However, this report will provide general observations based on experience to date.

Table 1: Location of Henderson Co. VWIN sites

<u>Site#</u>	<u>Approximate Stream Location</u>
1	French Broad River at Banner Farm Road in Horseshoe
2	French Broad River at Butler Bridge Road
3	Mud Creek at Erkwood Road
4	Mud Creek at North Rugby Road
5	Clear Creek at Nix Road
6	Crab Creek at Staton Road (discontinued in 2002)
7	North Fork of Mills River on LL Moore Road
8	South Fork of Mills River on South Mills River Road
9	Mills River at Hwy 191 (Davenport Bridge)
10	Mills River at Hooper Lane
11	Green River below Lake Summit
12	Green River at Terry's Creek Road
13	Big Hungry River below dam
14	Boylston Creek at Ladson Road
15	Bat Fork Creek at Tabor Road
16	Cane Creek at Hoopers Creek/Howard Gap Road
17	Lower Cane Creek at Hwy 25 (discontinued)
18	Mud Creek at 7th Avenue East
19	Green River at Old Hwy 25 S
20	Clear Creek at Apple Valley Road
21	Mud Creek at Berea Church Road
22	Hoopers Creek at Jackson Road
23	Big Willow Creek at Patterson Road
24	Little Willow Creek at River Road (discontinued)
25	Gash Creek at Etowah School Road
26	Brittain Creek at Patton Park
27	Mill Pond Creek at South Rugby Road
28	Shaw Creek at Hunters Glen
29	Brandy Branch at Mills River Village on NC 191
30	Devil's Fork at Dana Road
LL1	Reedypatch Creek at Bat Cave
LL2	Hickory Creek at Bat Cave
LL3	Broad River at Bat Cave

Figure 1: Henderson County WIN Monitoring Sites



II. Methodology

A water monitoring coordinator provides hands-on instruction and experience in sample collection to all volunteers prior to their first day of sample collection. Henderson County samples are collected on the third Saturday of each month. Water samples are collected in six 250 mL polyethylene bottles. In order to assure consistent sampling techniques, each bottle is labeled with the site number and the parameter for which the water from that particular bottle will be analyzed. Each set of samples includes a chain-of-custody form to be completed by the volunteer. This form includes site number and site location, the time and date of sample collection, the name of the person collecting the sample, and the weather conditions prior to sample collection. Appendix A is a copy of the chain-of-custody form used by the volunteers.

After collection, the volunteer takes the samples and data sheet to a designated drop point where the samples are refrigerated. It is the job of the volunteer coordinator to pick up the samples from the drop point and deliver them or ship them to the EQI laboratory for analysis within two days of collection. A description of the laboratory analysis methodology is contained in Appendix B. Following analysis of samples the empty bottles are cleaned in the laboratory and then packed together with blank chain-of-custody forms for use next month.

Various statistical analyses are performed on the data and are intended to:

- 1) Characterize the water quality of each stream site relative to accepted or established water quality standards;
- 2) Identify effects of precipitation, stream water level, seasonality, land use, and temporal trends on water quality, after sufficient data have been collected.

III. Results and Discussion

This discussion is based on fourteen years of data gathered between August 1992 and July 2006. However, monitoring at sites 21 through 30 began in July 1998. With each additional year of continuous stream monitoring, trends in water quality become more evident, and a clearer picture of actual conditions existing in various streams and watersheds is available. Continuing water quality data collection over time provides updated information on changing conditions. With this information, financial resources and policies can be focused on areas of greatest concern.

A discussion of the stream sites relative to specific water quality parameters follows. To better understand the parameters, explanations, standards and sources of contamination, some definitions of units and terms have been provided. The amount of a substance in water is referred to in units of concentration. Parts per million (ppm) is equivalent to mg/L. This means that if a substance is reported to have a concentration of 1 ppm, then there is one milligram of the substance in each liter (1000 grams) of water. The parameter total suspended solids (TSS) illustrates the weight/volume concept of concentration. According to the statistical summary data for Henderson County (Appendix E), site 1 had a median TSS concentration of 9.6 mg/L over the past three years, which is equivalent to 9.6 ppm. Thus if you filter one liter of water from site 1 on average you will collect sediments that weigh 9.6 mg. The same conversion applies for parts per billion (ppb), which is equivalent to micrograms per liter (ug/L). Concentrations of the VWIN parameters in water samples are compared to normal ambient levels. Ambient levels are estimates of the naturally occurring concentration ranges of a substance. For instance, the ambient level of copper in most streams is less than 1 ug/L (1 ppb). Ambient water quality standards, on the other hand, are used to judge acceptable concentrations. The ambient water quality standard for Ammonia-nitrogen to protect trout populations is 1.0 mg/L, but the normal ambient level for most trout waters is about 0.1 mg/L.

A classification grade was assigned to each site based on the results of analysis. This report shows site-specific grades for each parameter for the three-year period from August 2003 through July 2006 (Table 2). Using only the past three years of data allows streams to show the most current water quality status. Thus, streams that may show improved water quality as a result of newly implemented management practices will reflect improvement in their grade. Likewise, streams where water quality has been deteriorating will show lower grades than past years. The grades are designed to characterize the water quality at each site with regard to individual parameters. Water quality standards were used where applicable to assess the possible impacts these levels could have on human health and organisms in the aquatic environment. For example, the 7 ppb water quality standard for copper was used to determine grades for the sites. A grade of "A" would be assigned to a site if, over the last three years, no samples had a concentration that exceeded this standard. In contrast, due to the detrimental effects decreases in pH can have on the organisms that live in streams, a site could receive an "A" if minimum pH value was never lower than 6.0. Appendix D describes the criteria used for the grading system for each parameter.

Appendix E is a list of all VWIN stream sites monitored in Western North Carolina indexed and ranked using the grading system previously discussed and shown in Table 2. This indexing

Table 2: Classification Grades Based on Parameters and Ranges

Site	Description	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho P	Ammonia-N	Nitrate/nitrite-N
1	French Broad River/Banner Farm Rd	A	D	C	C	A	A	A	B	A	A	A
2	French Broad River/Butler Br Rd	A	D	D	D	B	B	B	B	C	A	B
3	Mud Creek/Erkwood Rd	A	C	C	B	B	A	B	A	A	A	B
4	Mud Creek/N Rugby Rd	A	B	C	D	C	A	A	B	D	A	C
5	Clear Creek/Nix Rd	A	B	B	B	C	A	A	B	B	A	C
7	North Fork Mills River	A	D	A	A	A	A	A	A	A	A	B
8	South Fork Mills River	A	D	A	A	A	A	A	A	A	A	A
9	Mills River/Hwy 191	A	D	A	A	A	A	A	A	A	A	A
10	Mills River/Hooper Lane	A	D	A	A	A	A	A	A	A	A	A
11	Green River/down L Summit	A	D	B	A	A	A	A	A	A	A	A
12	Green River/Terry's Ck Rd	A	D	A	A	A	A	B	B	A	B	A
13	Big Hungry River below dam	A	C	A	A	B	B	A	B	A	A	B
14	Boylston Creek/Ladson Rd	A	C	B	B	B	A	A	A	A	A	B
15	Bat Fork Creek/Tabor Rd	A	C	A	A	C	A	A	B	B	A	C
16	Cane Creek/Howard Gap Rd	A	B	C	B	C	A	B	A	B	A	B
18	Mud Creek/7th Ave	A	C	B	B	B	B	A	B	A	A	B
19	Green River/Old 25	A	D	A	A	A	A	A	A	A	A	A
20	Clear Creek/Apple Valley Rd	A	C	B	B	B	B	B	B	B	A	B
21	Mud Creek/Berea Church Rd	A	C	C	C	B	A	A	A	B	A	B
22	Hoopers Creek/Jackson Rd	A	B	C	A	C	A	A	A	B	A	B
23	Big Willow Creek/Patterson Rd	A	C	B	B	B	A	A	A	B	A	A
25	Gash Creek/Etowah School Rd	A	B	D	B	C	A	A	B	C	A	B
26	Brittain Creek/Patton Park	A	B	C	B	C	A	A	B	B	A	B
27	Mill Pond Creek/S Rugby Rd	A	A	B	A	D	A	A	B	B	B	B
28	Shaw Creek/Hunters Glen	A	B	B	A	C	B	A	A	B	A	B
29	Brandy Branch/Mills R Village	B	D	B	A	C	A	A	B	B	B	C
30	Devil's Fork/Dana Rd	A	B	B	B	C	A	A	B	B	A	C
LL1	Reedypatch Creek at Bat Cave	A	B	C	B	B	A	A	A	B	A	B
LL2	Hickory Creek at Bat Cave	A	C	B	B	B	B	A	A	B	A	A
LL3	Broad River at Bat Cave	A	C	B	B	A	A	A	A	B	A	A

system was developed to facilitate comparisons of specific problem areas such as sediment, nutrients, or chemical and heavy metal pollutants. Parameters were grouped into these three categories and number grades were assigned to each parameter (A=100, B=75, C=50, D=25). The numbers were added and the total divided by the number of parameters in the dimension. For example, a site with a B in turbidity and a C in total suspended solids would receive a sediment index of $(75 + 50)/2 = 62.5$ (rounded to 63). Index ratings for each of the three groupings were added and the total divided by 3 to determine the overall index rating for each site. A maximum score of 100 and a minimum of 25 are possible.

It is important and useful to compare sites within the mountain area to understand how water quality from each stream ranks, not only within the county, but also within the region. With this information local governments, organizations, and individuals can compare areas with similar problems or successes and share information or even develop region-wide plans. It will also be helpful to note changes in ranking over time as stream water quality improves or deteriorates relative to the many other mountain streams tested in the VWIN program. Many factors such as population density, industrial development, topography, and land use patterns can affect water quality. All of these factors must be taken into consideration when comparing stream water quality.

Appendix F contains summarized statistical data collected over the course of this study. It is a list of minimum, maximum, and median concentrations or values over the past three years and also includes the median values for each site over the entire period of the study. With this expanded information, changes in median values over time can be seen.

The data from 216 sites throughout Western North Carolina in the VWIN program are used in this report to compare water quality from the stream sites in Henderson County with water quality from the mountain region in general. Some of the graphs in this discussion section include averages of median values for all sites analyzed throughout the region. The averages for sites in mainly forested watersheds are included to show typical water quality in streams that are relatively unaffected by human disturbance. With most parameters, sites that show median values closer to the forested stream median levels exhibit better water quality. In the case of pH and alkalinity, however, the differences may be also related to elevation and rainfall because streams in lower elevation watersheds and those receiving less rainfall naturally exhibit higher pH and alkalinity. Most of the more pristine VWIN sites are currently located in the southern edge of the mountains and/or in relatively high elevation watersheds.

It should be noted that, although there are always some sites in each county that are relatively unaffected by human activities, most VWIN sites are generally chosen to measure the effects of human activities on stream water quality. For this reason, forest streams are under-represented and the averages in all areas are weighted somewhat toward streams that experience various degrees of pollution.

A statistical analysis of the effects of stream water level, temporal changes, and seasonality on the water quality parameters at individual sites has also been included in this discussion. This analysis is used to determine if changes in concentrations or levels of a parameter relate to changes in water levels, (i.e. flow), increases or decreases over time (i.e. temporal change), and changes of the seasons in Western North Carolina (i.e. seasonality). Trends are observed in the data, and interpretations of what might be causing the trends are suggested. Trends are considered significant if the p-value is less than 0.05. The p-value is the probability of obtaining as much trend as observed in the data if, in fact, there was no true underlying trend.

Trends related to flow are determined using flow measurements from nearby US Geological Survey gauging stations. Although this method may also present some problems as gauging stations can only truly represent the streams on which they are located, the method has been found to be the most effective for the least cost. With this method the control for flow allows for more precise examination of the effects of other factors. The USGS gauging stations on the French Broad River at Blantyre (03443000) and on the Mills River (03446000) were utilized to estimate relative flow for the sites in Henderson County. Each site was matched to the gauge station nearest that site. The logarithm of the ratio of the measured flow to the long-term average flow for each date was used as the predictor variable for flow. Corresponding flow data were found for all sample collection dates from the beginning of the Henderson County monitoring program in 1992 to present.

Appendix G is a summary of trends related to flow, Appendix H shows trends related to time and Appendix I shows trends related to season. Appendix J is the biological score and rating for every biological monitoring event in the past five years.

A. Acidity (pH) and Alkalinity: pH is used to measure acidity. The pH is a measure of the concentration of hydrogen ions in a solution. If the value of the measurement is less than 7.0, the solution is acidic. If the value is greater than 7.0, the solution is alkaline (more commonly referred to as basic). The ambient water quality standard is between 6.0 and 9.0. Natural pH in area streams should be in the range of 6.5 - 7.2. Values below 6.5 may indicate the effects of acid rain or other acidic inputs, and values above 7.5 may be indicative of an industrial discharge.

Because organisms in aquatic environments have adapted to the pH conditions of natural waters, even small pH fluctuations can interfere with the reproduction of those organisms or can even kill them outright. The pH is an important water quality parameter because it has the potential to seriously affect aquatic ecosystems. It can also be a useful indicator of specific types of discharges.

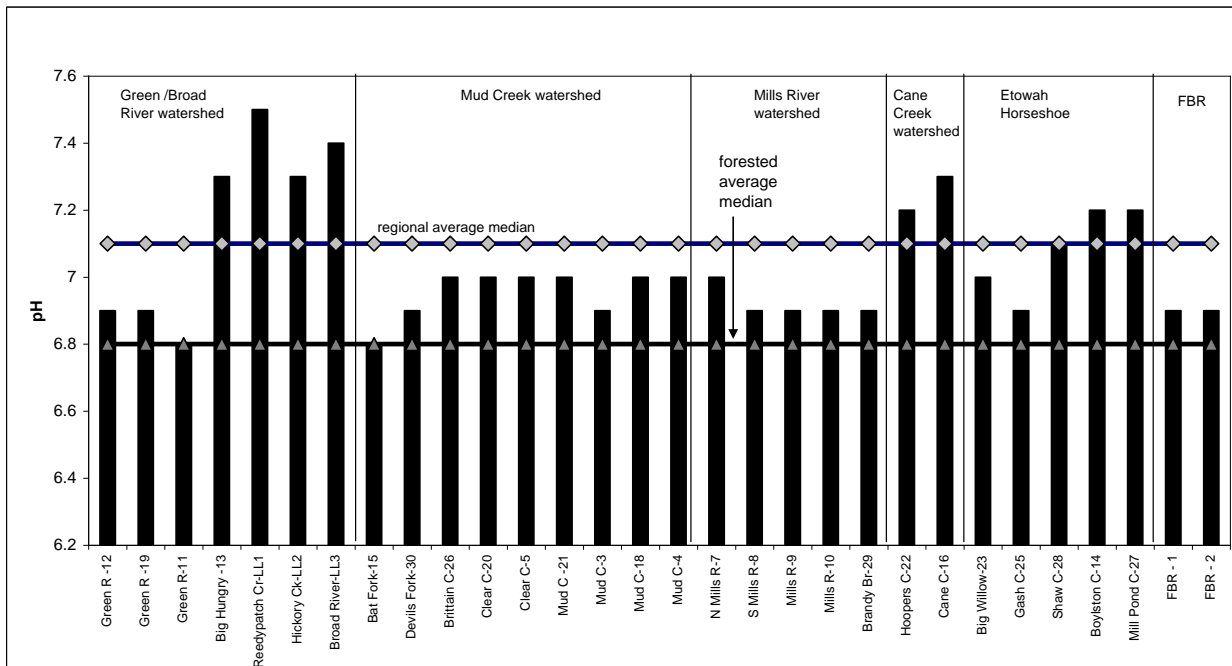
Alkalinity is the measure of the acid neutralizing capacity of a water or soil. Waters with high alkalinity are considered protected (well buffered) against acidic inputs. Streams that are supplied with a buffer are able to absorb and neutralize hydrogen ions introduced by acidic sources such as acid rain, decomposing organic matter and industrial effluent. For example, water can leach calcium carbonate (a natural buffer) from limestone soils or bedrock and then move into a stream, providing that stream with a buffer. As a result, pH levels in the stream are held constant despite acidic inputs. Unfortunately, natural buffering materials can become depleted due to excessive acidic precipitation over time. In that case, further acidic precipitation can cause severe decreases in stream pH. Potential future stream acidification problems can be anticipated by alkalinity measurement. There is no legal standard for alkalinity, but waters with an alkalinity below 30 mg/l are considered to have low alkalinity. Western NC streams tend to have low alkalinity because of generally thin soils and because the underlying granitic bedrock does not contain many acid-neutralizing compounds such as calcium carbonate.

Almost all of the sites in Henderson County continue to exhibit median pH levels lower than the

Western North Carolina regional average (Figure 2). Most of the exceptions are sites in the far northern or eastern parts of the county that may receive less rainfall. None of the sites have exhibited pH levels outside of the acceptable range in the past three years, although Mill Pond Creek exhibited an unusually elevated pH of 9.0 in April 2006 during dry weather and low stream flow. Median alkalinity levels are more influenced by pollutants. Sites with higher median alkalinity levels are generally those that are receiving more point or non-point source pollution (Figure 3).

Most sites show pH and alkalinity levels decreasing as flow increases, but this is much less true in the Mills River watershed, probably because this watershed is less affected by pollutants. With the exception of the sites on the French Broad River, Mud Creek at Erkwood Road, and Brandy Branch, all sites show pH levels increasing over time. There are far fewer sites showing trends related to alkalinity over time, and most sites showing time trends related to alkalinity also show trends for several other pollutants. Fifty-nine percent of sites show seasonal trends related to pH with most showing higher levels in summer and fall and lower levels in winter. Seventy percent of sites show seasonal trends related to alkalinity with almost all showing higher levels in fall and lower levels in spring.

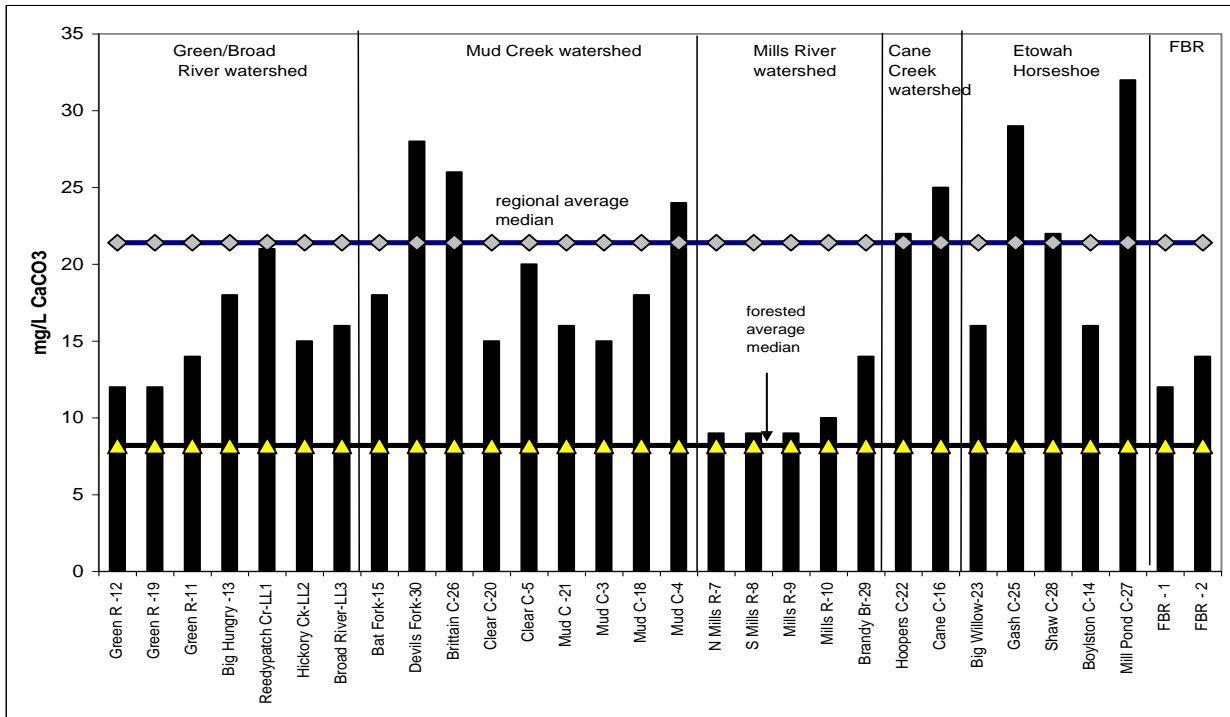
Figure 2: Median pH levels for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



B. Turbidity and Total Suspended Solids (TSS): Turbidity is a measurement of the visual clarity of a water sample and indicates the presence of fine suspended particulate matter. The unit used to measure turbidity is NTU (nephelometric turbidity units), which measures the absorption and reflection of light when it is passed through a sample of water. Because particles can have a wide variety of sizes, shapes and densities, there is only an approximate relationship between the turbidity of a sample and the concentration (i.e. weight) of the particulate matter present. This is why there are separate tests for NTU turbidity and suspended solids.

Turbidity is an important parameter for assessing the viability of a stream for trout propagation. Trout eggs can withstand only small amounts of silt before hatching success is greatly reduced. Fish that are dependent on sight for locating food are also at a great disadvantage when water clarity declines. For this reason, the standard for trout-designated waters is 10 NTU while the standard to protect other aquatic life is 50 NTU.

Figure 3: Median alkalinity levels for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



Mountain streams in undisturbed forested areas remain clear even after a moderately heavy rainfall event, but streams in areas with disturbed soil may become highly turbid after even a relatively light rainfall. Deposition of silt into a stream bottom can bury and destroy the complex bottom habitat. Consequently, the habitat for most species of aquatic insects, snails, and crustaceans is destroyed by stream siltation. The absence of these species reduces the diversity of the ecosystem. In addition, small amounts of bottom-deposited sediment can severely reduce the hatch rate of trout eggs. There is no legal standard for TSS, but values below 30.0 mg/l are generally considered low, and values above 100 mg/l are considered high. TSS quantifies solids by weight and is heavily influenced by the combination stream flow and land disturbing activities. A good measure of the upstream land use conditions is how much TSS rises after a heavy rainfall.

Median turbidity and total suspended solids levels are well below the regional average at the Mills River and Green River watershed sites, and below average for the Cane Creek watershed and most sites in the Broad River watershed (Figures 4 and 5). There are three sites upstream in Buncombe County in the Cane Creek watershed that are also monitored that exhibit

Figure 4: Median turbidity levels for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas

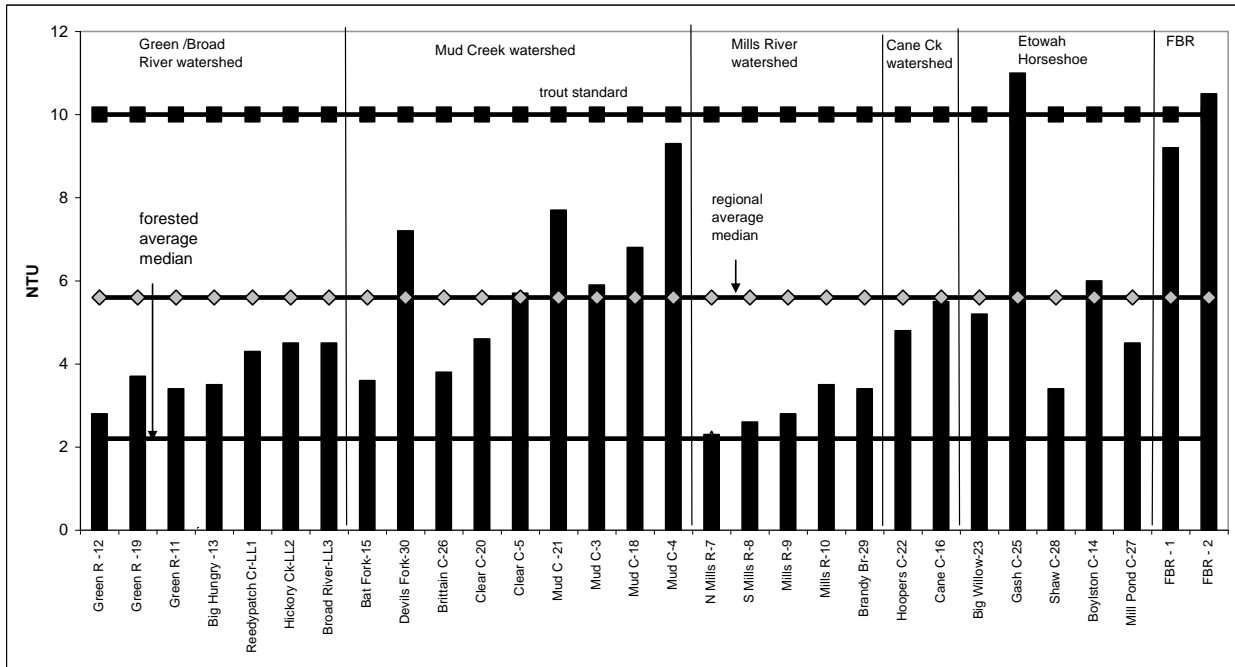
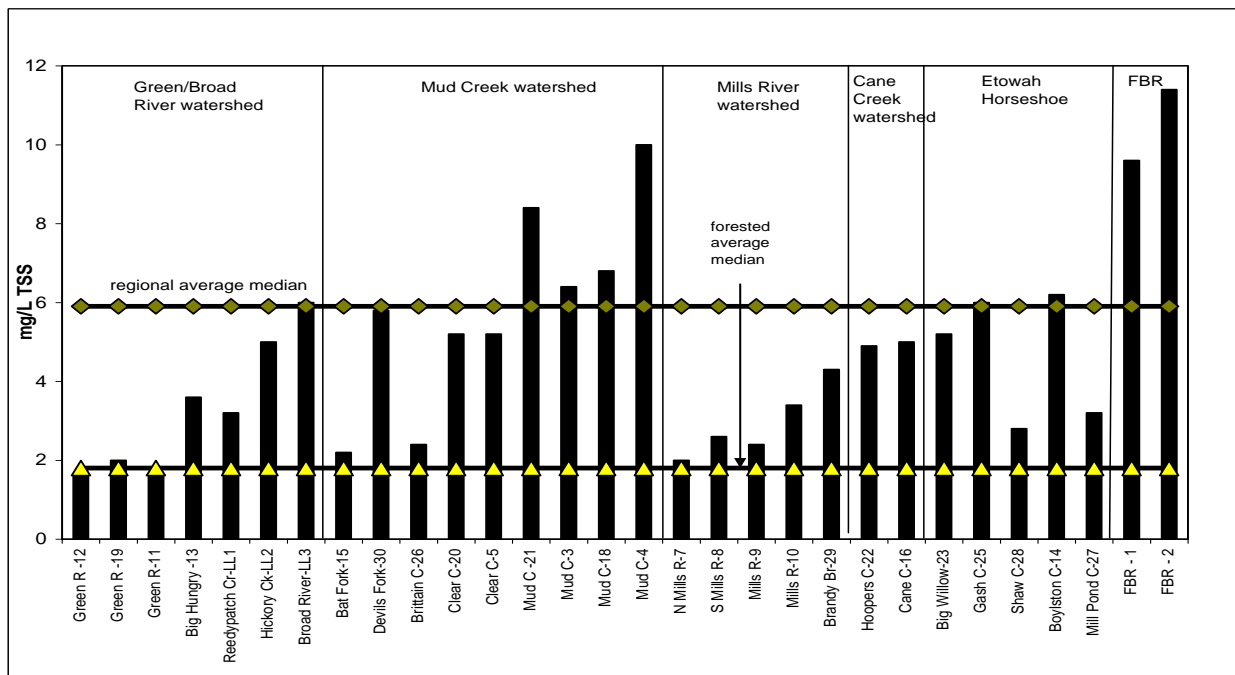


Figure 5: Median total suspended solids concentrations for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



higher than average turbidity and TSS levels, but much of this sediment probably settles in the Cane Creek streambed along the relatively flat section of the river downstream from Fairview. All sections of Cane Creek often exhibit extreme sedimentation during storms.

In the Etowah/Horseshoe area Shaw Creek and Mill Pond Creek exhibit relatively low median turbidity and total suspended solids levels, but storm flow can also cause these creeks to carry greater

loads of sediment. Big Willow Creek and Boylston Creek have median turbidity and TSS levels near average, and median turbidity levels at the Gash Creek site are well above average. In fact, median levels even exceed the trout standard, which is unusual for mountain streams. There is a great deal of sediment build-up in the streambed in the downstream portion of Gash Creek.

In the Mud Creek watershed, Bat Fork and Brittain Creek exhibit relatively low median levels of turbidity and total suspended solids, and median levels at the Clear Creek sites are near average. Median levels at the Devil’s Fork and Mud Creek sites are largely greater than average. The French Broad River sites exhibit relatively elevated turbidity and total suspended solids levels most of the time with the downstream site exhibiting higher levels than the upstream site. Along the length of the French Broad River in North Carolina the turbidity and suspended solids median levels start out very low where the forks of the river form the French Broad, but increase greatly at the next site downstream in Transylvania County. Levels then decline slightly, and then increase again in Henderson County, particularly at the downstream site. After leaving Henderson County levels decline slightly before increasing again downstream from Asheville where the highest levels along the river occur. Past that point levels continuously decline at each site in Buncombe and Madison Counties. The more developed areas show the greatest influence on river sedimentation.

Land use and degree of slope are important factors contributing to potential erosion and runoff. Cleared land on steep slopes will generally produce the greatest erosion rates. Henderson County has lower average slope than most other monitored counties in Western North Carolina, but it also has a high percentage of deforested land. Although the lower slopes result in lower erosion rates, some watersheds experience greater erosion rates because of extensive deforestation. Table 3 shows percent land use upstream from each site in three categories; developed, agricultural, and forested, and shows the mean slope and the total watershed area in square miles upstream from each site. In cases where a watershed has more than one site, the area, slope, and land use categories refer to the drainage area between that specific site and the next site upstream. In some cases total land area does not equal 100% because some areas in the watershed, such as open water, do not fit into the three main categories. ArcGIS 9.0 was used to delineate the catchments, derive slope, and analyze land cover and slope data. Catchments were delineated for each sampling location with ArcHydro 1.1 using one arc second (30-meter resolution) elevation data obtained from the United States Geological Survey (USGS) National Elevation Dataset (NED).

In general the watersheds in Henderson County that are less forested show greater stream sedimentation, but there are exceptions. In the case of the downstream sites on the Mills River, for example, although there is a great deal of agricultural activity, the vast majority of the watershed upstream from these sites flows through heavily forested land. In addition, the agricultural area is on relatively flat land where erosion rates are lower. In the Mud Creek watershed, although most sites show higher median total suspended solids concentrations,

Table 3: Percent land use in three categories, average slope, and watershed area upstream from each site (where more than one site is located in a watershed it includes land use, slope, and area between a site and the next site upstream)

site #	site name				mean	area
	Green River/Broad River Watershed	developed	agricultural	forested	slope	(miles ²)
12	Green River at Terry's Creek Road	4.2%	6.5%	89.3%	26.7%	25.8
19	Green River upstream from Lake Summit	13.6%	7.3%	79.1%	23.8%	7.6
11	Green River downstream from Lake Summit	15.5%	8.4%	72.6%	21.1%	10.2
13	Big Hungry River downstream	7.5%	19.4%	73.1%	24.5%	19.3
LL1	Reedypatch Creek	7.3%	14.9%	77.7%	29.1%	12.4

LL2	Hickory Creek	7.7%	4.8%	87.6%	34.4%	9.7
LL3	Broad River at Bat Cave	3.3%	3.8%	92.9%	31.7%	40.3
Mud Creek Watershed						
21	Mud Creek at Berea Church Road	10.6%	19.6%	69.5%	21.1%	4.3
3	Mud Creek at Erkwood Road	35.3%	10.8%	53.4%	14.6%	16.2
18	Mud Creek at 7th Avenue	88.0%	4.1%	7.9%	7.2%	3.0
15	Bat Fork Creek	46.4%	22.3%	30.9%	9.9%	1.1
30	Devil's Fork	25.9%	51.6%	22.5%	4.8%	8.3
26	Brittain Creek	72.6%	2.0%	25.4%	12.4%	2.0
20	Clear Creek at Bearwallow	5.5%	24.9%	69.6%	20.2%	2.2
5	Clear Creek at Nix Road	12.5%	39.9%	47.6%	12.6%	28.9
4	Mud Creek at N Rugby Rd	43.3%	23.7%	32.8%	9.8%	34.6
Mills River Watershed						
7	North Fork Mills River	2.3%	2.5%	95.2%	33.1%	24.0
8	South Fork Mills River	1.8%	2.5%	95.7%	30.8%	41.3
9	Mills River at Davenport Bridge	8.9%	28.5%	62.6%	16.9%	5.2
29	Brandy Branch	24.1%	65.6%	10.3%	4.5%	0.7
10	Mills River at Hooper Lane	21.2%	67.3%	11.5%	3.5%	1.7
Cane Creek watershed						
22	Hoopers Creek	5.1%	18.8%	76.0%	22.8%	14.5
16	Cane Creek at Howard Gap Rd	32.9%	26.2%	40.8%	12.4%	10.8
Etowah/Horseshoe						
23	Big Willow Creek	22.4%	9.1%	68.4%	18.8%	5.4
25	Gash Creek	45.7%	29.7%	24.6%	7.4%	2.1
28	Shaw Creek	38.5%	10.5%	50.9%	17.4%	5.3
27	Mill Pond Creek	57.3%	12.4%	30.4%	12.6%	2.5
14	Boylston Creek	9.1%	29.6%	61.2%	18.8%	15.4
French Broad River						
1	French Broad River/Horseshoe	11.2%	21.7%	66.9%	16.7%	61.0
2	French Broad River/Mt Home	16.6%	48.9%	34.3%	8.2%	11.4

Brittain Creek has very low median suspended solids concentrations even though it is heavily developed. Maximum suspended solids concentrations are high at this site, however. Urban streams often rise very quickly during storms because of the runoff from large areas of impervious surface, and they fall just as quickly following a rain event. Sediment washed into a creek during the storm quickly washes out with the high energy flow. Thus the sediment is quickly transported, in this case, into Mud Creek. In the case of the Broad River and Hickory Creek median suspended solids concentrations are greater than might be expected considering that they are largely forested watersheds. But they are also very steep, so any exposed land is extremely vulnerable to erosion.

Almost all sites show turbidity and/or suspended solids levels increasing as flow increases. Only one site, Clear Creek at Bearwallow, shows turbidity levels increasing over time, and none of the sites show total suspended solids levels increasing over time. Bat Fork shows both turbidity and suspended solids levels decreasing over time. The sites on the Green River below Lake Summit, Bat Fork Creek, Devil's Fork, South Fork Mills River, Brandy Branch, and Shaw Creek all show turbidity levels decreasing over time. None of the sites show total suspended solids decreasing over time. Over half of the sites show seasonal trends related to turbidity and total suspended solids with almost all showing higher levels in summer when land disturbing activities are at a peak and rains from thunderstorms can cause severe erosion.

In addition to the monthly VWIN monitoring at the sites throughout the county, the

Environmental Quality Institute has been monitoring stormwater sediment concentrations for the past few years in the upper Broad River watershed for the Upper Broad River Watershed Protection Project, and in the Mills River watershed for the Henderson County – Mills River Partnership Program. Samples are collected automatically at different stages as water level rises during storms, and sediment concentrations are analyzed at EQI. The purpose of the monitoring is to locate significant sources of stream sedimentation so that assistance can be provided to landowners to prevent further erosion.

Table 4 shows median total suspended solids concentrations in the upper Broad River watershed at each site for each year since monitoring began in August 1999. The median peak stream flow in cubic feet per second prior to sample collection is also provided (flow data from the USGS gauging station on nearby Cove Creek). The flow data provides comparative average storm flow for each year.

Median total suspended solids concentrations were greater in 2006 than in previous years at many sites in the Broad River watershed, although sample numbers were lower because there were fewer storms that were sufficient to increase stream flow significantly. Two storms during 2006 had a major influence on overall median concentrations because these two storms produced numerous samples. Much of the rest of the year stream levels were so low that minor storms were insufficient to increase stream flow substantially, thus few samples bottles filled. This caused greater weight to be put on the results from major storms.

Sites with substantial increases in sediment over the past year in the Broad River upstream from Bat Cave include Clear Branch, upper middle Broad River, Rock Creek, Sand Branch, and Rush Branch, although Clear Branch, Rock Creek, and Sand Branch have shown significant sedimentation at some other times. Although Hemlock Falls Creek has a higher median concentration than last year, it still shows substantial improvement over the first few years of monitoring. The sites in the Hickory Creek watershed continue to show significant sedimentation, and in the Reedy patch Creek watershed Hominy Mill Branch shows increased sediment compared to last year, but still substantially less than the other previous years. Median concentrations in upper Reedy patch Creek increased greatly.

Table 5 shows median total suspended solids concentrations in the Mills River watershed at each site for each year since monitoring began in May 2003, along with median peak stream flow in the period prior to sample collection (flow data from the USGS gauging station on the Mills River). The sites in the Mills River watershed show no significant increases in median total suspended solids concentrations from previous years, and some show a slight decline. A great deal of work has been done in some parts of the watershed that are probably helping reduce sediment runoff. However, Foster Creek continues to be a significant source of sediment.

Table 4: Comparison of median total suspended solids concentrations from stage samplers in the Broad River watershed

Broad River	med peak		med peak		med peak		med peak		med peak	
	flow prior		flow prior		flow prior		flow prior		flow prior	
	114 CFS		881 CFS		773 CFS		675 CFS		504 CFS	
	8/99-12/02		2003		2004		2005		2006	
site	median	sample	median	sample	median	sample	median	sample	median	sample
upper Broad Rvr wtrshd	mg/L	count	mg/L	count	mg/L	count	mg/L	count	mg/L	count
Upper Broad River	148.9	40	206.7	17	1647.4	14	135.0	19	443.0	7

Clear Branch	1808.0	4	878.8	13	1869.2	18	834.1	13	4750.0	6
Upper Middle Broad River	219.4	24	476.2	13	521.1	11	455.1	25	3079.1	12
Rock Creek	209.0	17	625.7	20	4579.8	11	273.3	18	1987.0	10
Sand Branch	1470.1	6	901.8	13	1333.3	23	482.8	17	2860.0	9
Rush Branch	487.7	15	554.6	15	497.6	11	821.6	11	3371.4	3
Upper Flat Creek	221.0	19	650.0	15	4497.2	8				
Lower Flat Creek	349.1	44	705.4	28	3220.6	19	641.8	25	882.1	9
Lower Middle Broad River	158.3	24	439.5	14	1397.9	20	211.2	27	407.3	3
Hemlock Falls Creek	3750.0	7	3276.9	17	5595.0	17	752.1	21	1708.4	4
Broad River/Chimney Rock	67.6	35	140.0	24	210.4	3				
Hickory Creek watershed										
Bearallow Creek	966.6	16	935.7	5	3383.3	13	2957.7	3	2102.0	4
Upper Hickory Creek	1062.1	12	1286.7	9	3121.7	17	640.9	20	957.7	5
Tom's Fork Creek	1043.8	10	1406.6	6	1922.7	7	1602.3	4	2261.9	6
Middle Fork Creek	322.0	11	837.5	11	352.1	2				
Lower Hickory Creek	460.0	33	1274.3	16	2775.0	9	1855.2	12	1892.1	6
Reedypatch Creek watershed										
Turnbreeches Creek	260.0	11	182.0	6	857.1	10	489.4	6		
Upper Reedypatch Creek	2214.4	8	1287.7	12	1898.1	22	2076.9	6		
Hominy Mill Branch	2345.8	3	855.4	6	2063.6	12	390.2	2	1094.0	6
Little Creek	93.7	17	285.0	19	2246.7	11				
Lower Reedypatch Creek	215.5	27	337.5	13	708.7	12	687.3	20	1895.2	8

Table 5: Comparison of median total suspended solids concentrations from stage samplers in the Mills River watershed

	med peak flow prior	sample	med peak flow prior	sample	med peak flow prior	sample	med peak flow prior	sample
Mills River	499	5/03-12/03	1150	2004	685	2005	530	2006
site	median	count	median	count	median	count	median	count
North Fork Mills River	mg/L		mg/L		mg/L		mg/L	
at campground	172.0	7	754.8	14	83.7	12	78.0	6
at River Loop	479.9	14	207.1	15	319.3	18	318.9	11
South Fork Mills River								
South Fork near Pink Beds	93.6	15	95.8	5	*	*	73.7	13
Slate Rock Creek	88.9	15	320.5	1	*	*	144.6	7
Bradley Creek	66.8	19	55.7	4	*	*	44.9	14
UT near Hall Road	**	**	327.5	20	1066.1	25	354.8	12
South Fork at bridge	138.1	20	253.4	22	152.7	12	121.9	3

Mills River								
Foster Creek in Pisgah Forest	563.5	6	606.8	8	587.4	6	359.6	7
Foster Creek/Humphrey prop	458.9	18	286.0	17	483.6	8	751.1	4
Foster Creek at N Mills R Rd	703.9	20	2805.1	18	1208.2	16	1033.3	11
Foster Creek confl Mills R	489.3	18	1068.9	18	1392.0	15	800.0	11
Mills River at USGS gauge	258.0	15	2290.0	5	242.0	19	194.0	15
Mills River at Davenport Bridge	348.2	18	771.6	6	181.5	23	147.1	19
Brandy Branch at Pres Church	721.6	14	1020.7	14	288.2	24	376.6	15
Brandy Branch/VanWingerden	1322.2	18	858.7	17	1059.1	19	571.2	8
Mills River at Hooper Lane	347.0	27	7087.5	21	3878.4	12	**	**

*No access - road closed 9/2004 due to hurricane damage, re-opened in 2006

**Monitoring began in April 2004

***Sampling device destroyed in June 2005 has not been replaced

C. Conductivity and Heavy Metals (Copper, Lead, and Zinc):

Conductivity is measured in micromhos per centimeter (umho/cm) and is used to measure the ability of a water sample to conduct an electrical current. Pure water will not conduct an electrical current. However, samples containing dissolved solids and salts will form positively and negatively charged ions that will conduct an electrical current. The concentration of dissolved ions in a sample determines conductivity. Inorganic dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron, and aluminum affect conductivity levels. Geology of an area can affect conductivity levels. Streams that run through areas with granitic bedrock tend to have lower conductivity because granitic rock is composed of materials that do not ionize in water. Streams that receive large amounts of runoff containing clay particles generally have higher conductivity because of the presence of materials in clay that ionize more readily in water.

Metals are naturally occurring in surface waters in minute quantities as a result of chemical weathering and soil leaching. However, concentrations greater than those occurring naturally can be toxic to human and aquatic organisms. Elevated levels are often indicative of industrial pollution, wastewater discharge, and urban runoff, especially from areas with high concentrations of automobiles. Airborne contaminants from coal-fired power plants may also contribute metals to the atmosphere, which are then carried to land by precipitation and dry fallout. Because metals sorb readily to many sediment types, they may easily enter streams in areas with high sediment runoff. Another source of heavy metals can be runoff from agricultural fields using sewage sludge as fertilizer, which sometimes is permitted to contain up to 1500 mg metal/1 kg fertilizer.

Copper: The standard of 7.0 ug/l has been established to protect aquatic life. In most areas, ambient levels are usually below 1.0 ug/l. Wear of brake linings has been shown to contribute concentrations of copper, lead, and zinc. Copper has a relatively high content in brake linings. Copper is also present in leaded, unleaded, and diesel fuel emissions.

Lead: A standard of 25.0 ug/l has been established to protect aquatic life, while the normal ambient level is usually below 1.0 ug/l. Lead may be present in industrial wastewater and was once common in road runoff from the use of leaded gasoline. Roadside soils still generally contain high lead levels, resulting in elevated stream concentrations if these soils are subject to erosion.

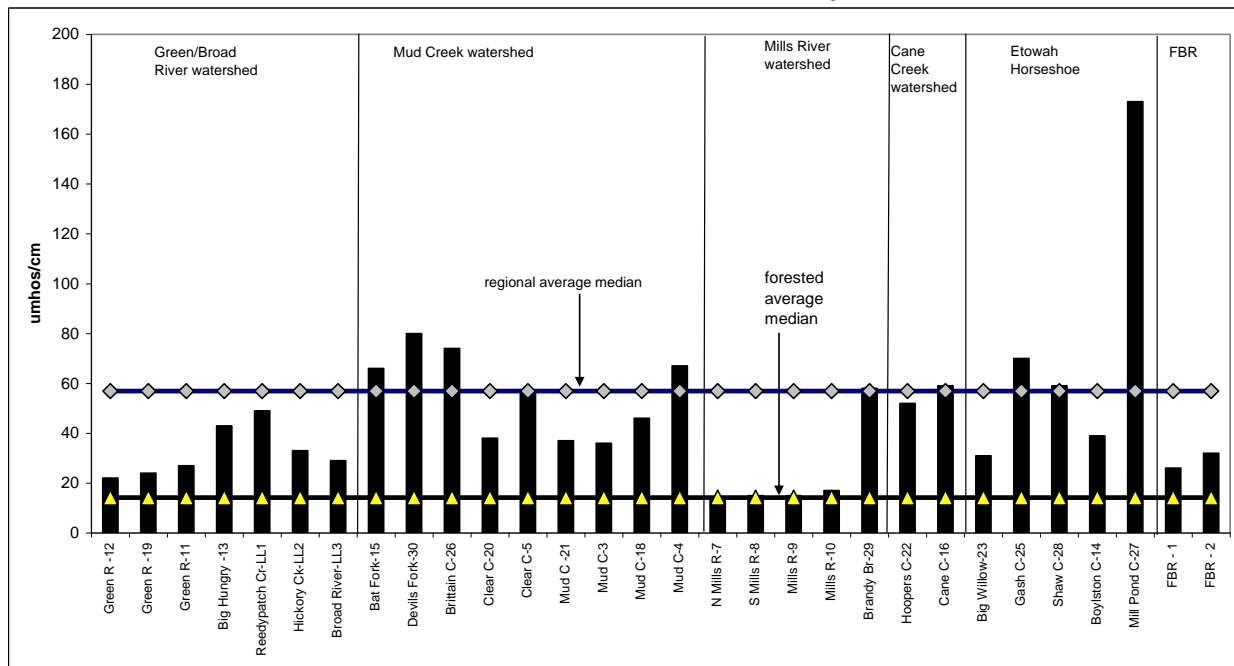
Zinc: The surface water standard is 50.0 ug/l. Typical ambient levels of zinc are approximately 5.0 ug/l. Zinc is a major metal component of tire rubber, brake linings, and galvanized crash barriers. Studies have been conducted linking this to zinc contamination from urban runoff. Because zinc is a by-product of the auto tire vulcanization process as well as the galvanization of iron, its presence in water may also result from industrial or domestic wastewater.

Elevated levels of conductivity and heavy metals are most often seen in streams receiving industrial or domestic wastewater or urban runoff. These substances also occur naturally in soils and may show higher levels in streams where severe erosion and runoff are occurring.

Median conductivity levels at most sites in Henderson County are near or below the regional median for VWIN sites (Figure 6). The exception is Mill Pond Creek where median levels are three times the regional average median. Conductivity at this site has consistently been well above average since monitoring began, and the probable source is landfill leachate. Median conductivity levels at a few other sites are slightly higher than average, particularly Devil’s Fork and Brittain Creek. This could be attributable to urban runoff. The Brittain Creek watershed flows largely through subdivisions in and outside of Hendersonville, and the Devil’s Fork monitoring site is in a very urban area.

Most sites show conductivity levels decreasing as flow increases, but Brandy Branch shows levels increasing as flow increases, which could indicate extensive clay or animal waste runoff during storms. All of the Green River sites, as well as the two sites on Clear Creek and the site on Cane Creek show conductivity levels increasing over time. Sites showing conductivity levels decreasing over time include the two upstream sites on Mud Creek, Bat Fork, Brandy Branch, the Mills River at Hooper Lane, Gash Creek, and the two sites on the French Broad River. Most sites show seasonal trends with higher conductivity levels occurring in fall and lower levels in spring.

Figure 6: Median conductivity levels at each VWIN monitoring sites compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



Heavy metals concentrations have not exceeded standards at most sites in the past three years, but several sites show higher than average median levels especially for zinc. Zinc levels are generally higher in streams receiving urban runoff. Higher than average zinc concentrations occur at the Gash

Creek, Devil's Fork, Mud Creek at North Rugby Road, Brittain Creek, Clear Creek at Nix Road, and French Broad River sites. The sites on the Big Hungry River and on Clear Creek at Bearallow have exceeded both copper and zinc standards once in the past three years. Concentrations of at least two of the heavy metals analyzed increase as flow increases at the sites on Mud Creek, Devil's Fork, Clear Creek at Nix Road, and the downstream site on the French Broad River. This is also often an indication of urban runoff. The sites on Clear Creek and the French Broad River downstream show heavy metals concentrations increasing over time. Two of the Mud Creek sites, as well as the sites on Bat Fork Creek, Brandy Branch, and Gash Creek show at least two of the three metals parameters analyzed decreasing over time. Very few sites show seasonal trends related to heavy metals, but those that do show a seasonal trend largely indicate higher concentrations in summer.

D. Nutrients (Orthophosphate (PO_4^{3-}), Ammonia-Nitrogen ($\text{NH}_4^+/\text{NH}_3$), and Nitrate/Nitrite-Nitrogen ($\text{NO}_3^-/\text{NO}_2^-$): Phosphorus is an essential nutrient for aquatic plants and algae. It occurs naturally in water and is in fact, usually the limiting nutrient in most aquatic systems. In other words, plant growth is restricted by the availability of phosphorus in the system. Excessive phosphorus inputs stimulate the growth of algae and diatoms on rocks in a stream and cause periodic algal blooms in reservoirs downstream. Slippery green mats of algae in a stream, or blooms of algae in a lake are usually the result of an introduction of excessive phosphorus into the system that has caused algae or aquatic plants to grow at abnormally high rates. Eutrophication is the term used to describe this growth of algae due to an over abundance of a limiting nutrient. Sources of phosphorus include soil, disturbed land, wastewater treatment plants, failing septic systems, runoff from fertilized crops and lawns, and livestock waste storage areas. Phosphates have an attraction for soil particles, and phosphorus concentrations can increase greatly during rains where surface runoff is a problem. **In this report orthophosphate is reported in the form of orthophosphate (PO_4^{3-}). To isolate phosphorus (P) from the measurement, divide the reported amount by 3.07.**

Orthophosphate: This is a measure of the dissolved phosphorus that is immediately available to plants or algae. Orthophosphate is also referred to as phosphorus in solution. There is no legal water quality standard, but generally levels must be below 0.05 mg/l to prevent downstream eutrophication.

Ammonia-Nitrogen ($\text{NH}_4^+/\text{NH}_3$) is contained in the remains of decaying wastes of plants and animals. Some species of bacteria and fungi decompose these wastes and NH_3 is formed. The normal ambient level is approximately 0.10 mg/l, and elevated levels of NH_3 can be toxic to fish. Although the actual toxicity depends on the pH of the water, the proposed ambient standard to protect trout waters is 1.0 mg/l in summer and 2.0 mg/l in winter. The most probable sources of ammonia nitrogen are agricultural runoff, livestock farming, septic drainage and sewage treatment plant discharges. In Western North Carolina, streams with extensive trout farming may also show elevated ammonia-nitrogen

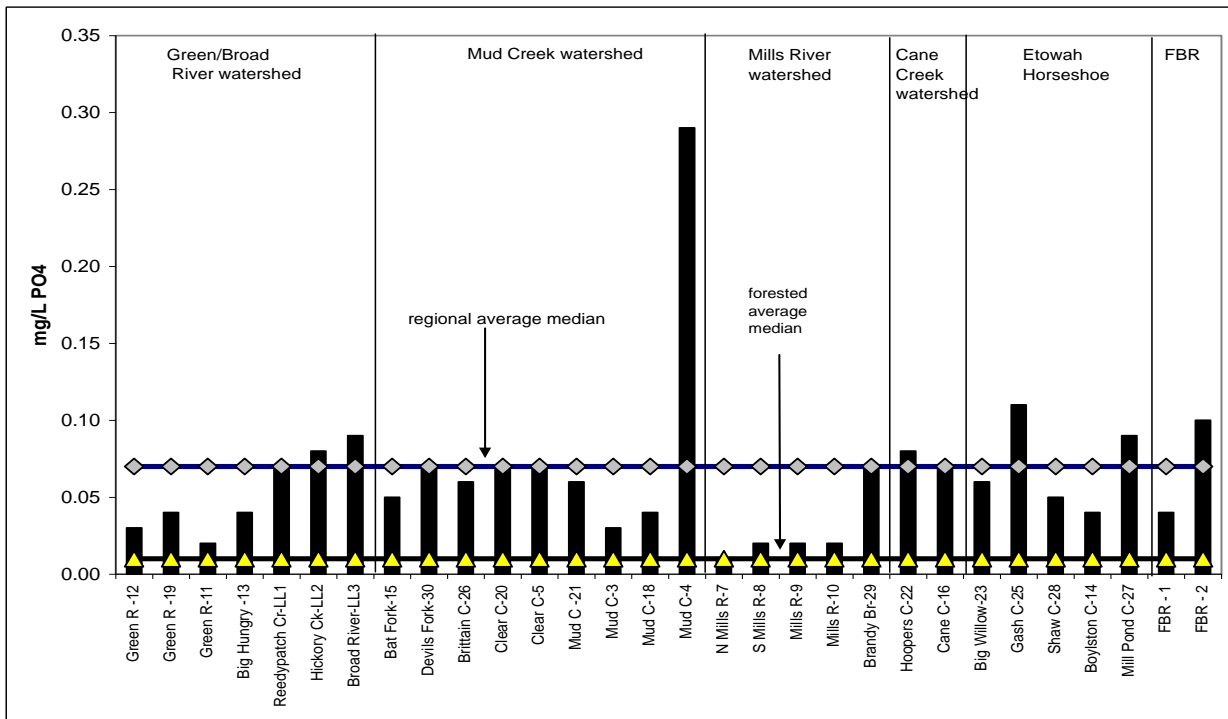
concentrations.

Like phosphorus, **nitrate/nitrite-nitrogen** ($\text{NO}_3^-/\text{NO}_2^-$) serves as an algal nutrient contributing to excessive stream and reservoir algal growth. In addition, nitrate is highly toxic to infants and the unborn causing inhibition of oxygen transfer in the blood stream at high doses. This condition is known as "blue-baby" disease. This is the basis for the 10 mg/L national drinking water standard. The ambient standard to protect aquatic ecosystems is 10 mg/L as well. The most probable sources are septic drainage and fertilizer runoff from agricultural land and domestic lawns. Nitrates from land sources end up in streams more quickly than other nutrients such as phosphorus because they dissolve in water more readily and can travel with ground water into streams. Consequently, nitrates are a good indicator of the possibility of sources of pollution from sewage or animal waste during dry weather.

Median orthophosphate concentrations are near or below the regional average median at most sites, but greatly exceed the average at the downstream site on Mud Creek (Figure 7). Maximum concentrations over the past three years also occurred at this site. Phosphorus concentrations at this site are influenced by effluent from the Hendersonville Wastewater Treatment Plant upstream. Other sites with slightly higher than average median orthophosphate concentrations include Gash Creek, Mill Pond Creek, and the downstream site on the French Broad River. The French Broad River site is influenced by the flow from Mud Creek.

About half of the sites show orthophosphate concentrations decreasing as stream flow increases. Sites showing orthophosphate concentrations increasing over time include the Big Hungry River, the Green River upstream, both sites on Clear Creek, the downstream site on Mud Creek, Cane Creek, and the downstream site on the French Broad River. Sites showing orthophosphate concentrations decreasing over time include the three upstream sites on Mud Creek, Bat Fork Creek, Devil's Fork, Brandy Branch, and Gash Creek. Seven sites show seasonal trends related to orthophosphate with all but one of these sites showing higher levels in summer.

Figure 7: median orthophosphate concentrations for each VWIN monitoring site compared to the average median for all VWIN sites in WNC and to the average median for sites in relatively undisturbed forested areas



Most of the sites in the Mud Creek watershed show higher than average ammonia-nitrogen and nitrate/nitrite nitrogen concentrations (Figures 8 and 9). The Brandy Branch and Gash Creek sites also show higher than average concentrations. Median ammonia-nitrogen concentrations are highest at the Gash Creek, Devil’s Fork, and Mud Creek at North Rugby Road sites. Median nitrate/nitrite-nitrogen concentrations are highest at the Bat Fork, Devil’s Fork, Brandy Branch, Clear Creek downstream, Britain Creek, and Mud Creek at North Rugby Road sites. Median levels are more than double the regional average median at the Bat Fork and Devil’s Fork sites. Animal waste and fertilizer runoff could be significantly influencing nitrogen concentrations at some of these sites, and urban runoff is probably affecting others.

Trend analysis shows concentrations of all three nutrients analyzed decreasing as flow increases at the sites on Clear Creek at Bearwallow and Mud Creek at North Rugby Road. This is often an indication of point-source pollution. In the case of Mud Creek it is almost certainly largely from wastewater effluent inputs from the Hendersonville wastewater treatment plant. Both of these sites also show concentrations of all three nutrients analyzed increasing over time. The sites on Cane Creek at Howard Gap Road and the French Broad River at Butler Bridge Road (the downstream site on the FBR) also show this trend. The sites on Mud Creek at Berea Church

Figure 8: Median ammonia-nitrogen concentrations for each VWIN monitoring site compared to the average median for all VWIN monitoring sites in WNC and to the average median for sites in relatively undisturbed forested areas

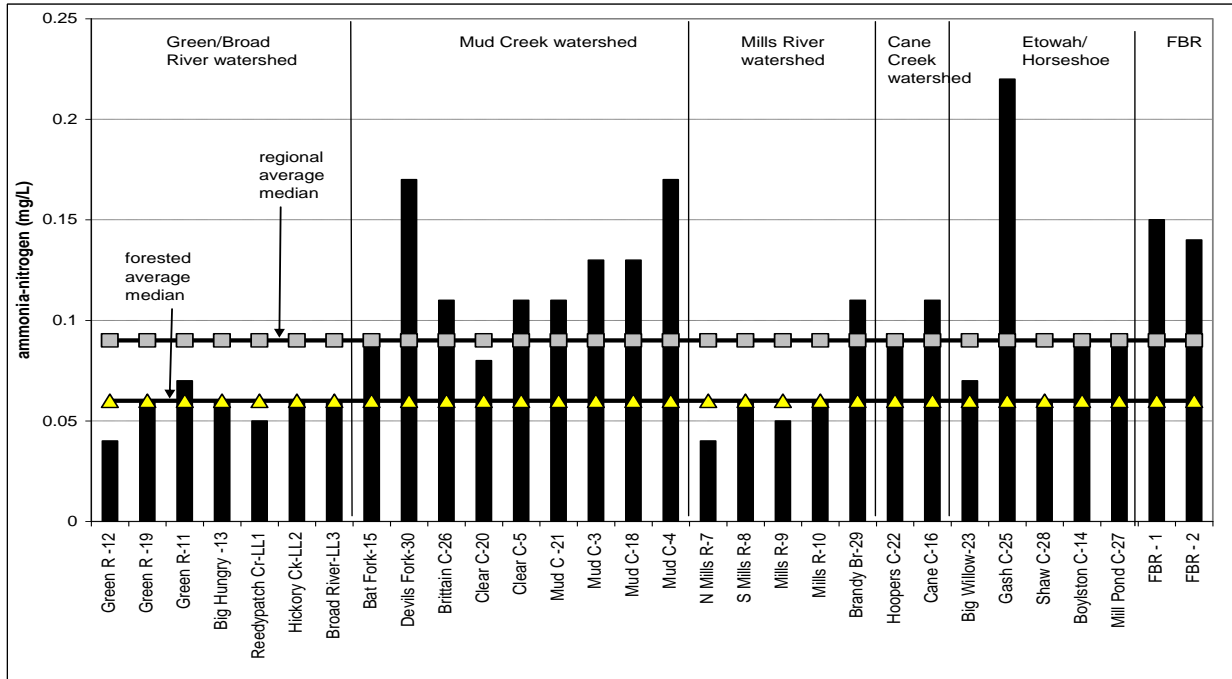
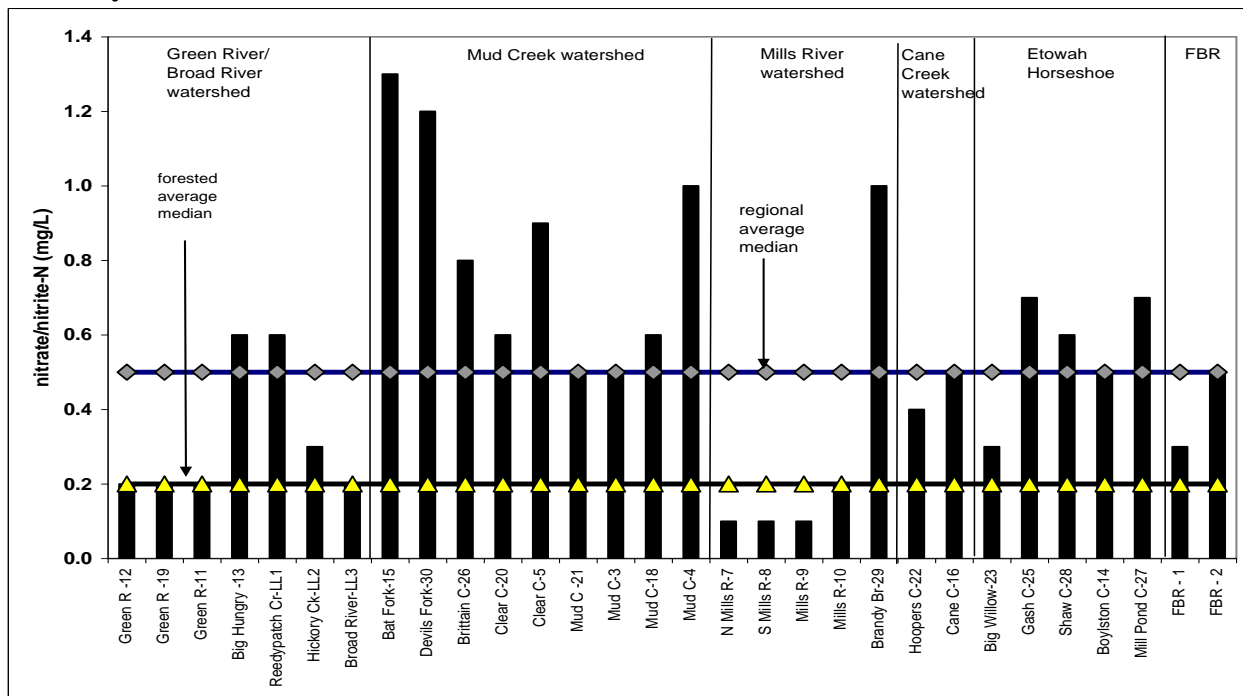


Figure 9: Median nitrate/nitrite-nitrogen concentrations for each VWIN monitoring site compared to the average median for all VWIN sites in WNC and to the average median for sites in relatively undisturbed forested areas



Road, Brandy Branch, and Gash Creek show all three nutrient concentrations decreasing over time. In all three cases this could be from reduced livestock farming in the watersheds, as well as some changes in wastewater effluent flow.

Relatively few sites show seasonal trends related to orthophosphate or ammonia-nitrogen, but those that do show trends indicate higher concentrations in summer. Most sites show seasonal trends related to nitrate/nitrite-nitrogen with almost all showing higher levels in winter when plants are no longer utilizing nitrogen in the soil and the nitrates are carried into streams in groundwater.

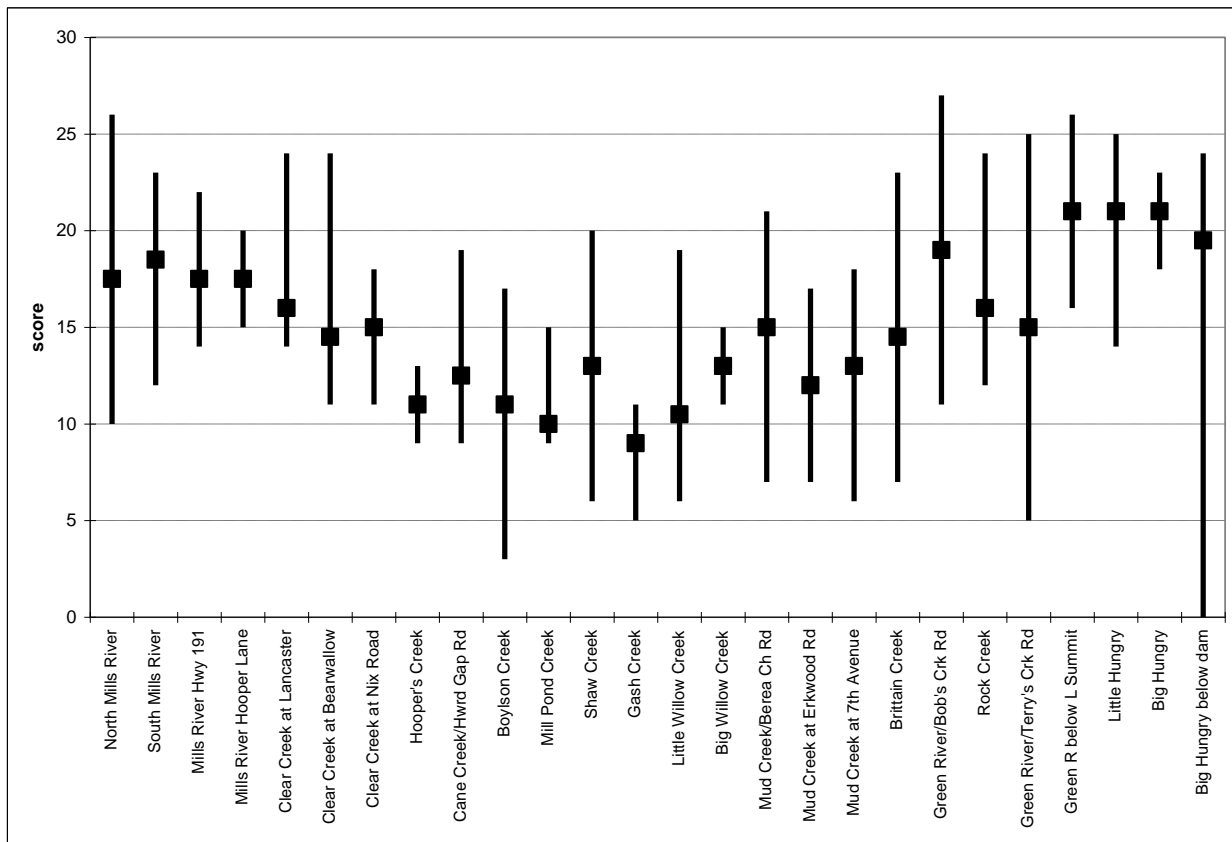
E. Biological Monitoring: This was the fifth year that the Environmental Conservation Organization (ECO) has carried out biological sampling in Henderson County. The results of their findings are included in this section. ECO utilizes the Izaak Walton League method of collection and analysis. Details can be obtained from ECO, and the data sheet is shown in Appendix C. A spreadsheet providing detailed data and observations collected at each of the biological monitoring sites is available in the EQI database and at ECO. Total index values for each site sampled in April and October 2002 - 2006 are shown in Appendix J. Total Index Values have been converted to Water Quality Ratings with >22= Excellent, 17 to 22 = Good, 11 to 16 = Fair, and <11 = Poor. Appendix J shows the ranges of these ratings and is helpful in observing changes over time. As described earlier, the total index value is a measure of the diversity and pollution sensitivity of organisms found at a site and provides a quality “score” for the specific location. These results are grouped according to the sites sampled by each of the monitoring teams, but also correspond to the grouping designated in chemical analysis sections of this report.

Some sites have exhibited a wide variation of scores over the past five years, and others have been very consistent. Figure 10 shows high, median, and low scores for each site over the past five years of monitoring twice each year. Highest overall median ratings occur at most of the sites in the Green River watershed and, only slightly lower, the sites in the Mills River watershed. In the Green River watershed the exceptions are Rock Creek and the Green River at Terry’s Creek Road. Results have varied widely at the Terry’s Creek Road site, although in general the samples analyzed in October are generally better than those in April. Results in 2006 were much lower than average. At the Rock Creek site results were much better during the first three years of monitoring than in the last two years. At the Big Hungry River site downstream from the dam results in 2005 were very poor, but bounced back in 2006. Extreme changes in water flow below a dam can greatly affect macroinvertebrates. Results have been fairly consistent over the years at the Mills River sites, but there has been greater variation at the site on the North Fork of the Mills River, and results were generally better the first two years of monitoring.

Median scores are somewhat lower at the sites in the Mud Creek watershed, and there is only a small difference in median scores from upstream to downstream on Mud Creek. However, monitoring was discontinued at the Mud Creek at Erkwood Road site in 2004 because of heavy sediment build-up in the stream bed.

Median scores in general are lowest at the sites in the Etowah/Horseshoe area of the county, and in the Cane Creek watershed. Most of these sites average ratings are fair and two sites average poor. The two sites with a poor rating, Gash Creek and Mill Pond Creek, also have relatively low chemical ratings. Biological ratings are consistently low at the Gash Creek site, and almost as consistently low at the Mill Pond Creek site. Both of these sites are seriously impacted by both point-source and non-point-source pollution, as well as habitat degradation.

Figure 10: High, median, and low biological monitoring scores at each site over the past five years of monitoring



IV. Summary and Conclusions

Chemical analysis of samples collected at Henderson County sites are intended to characterize the water quality relative to the parameters established by the Volunteer Water Information Network program. Concerned groups and individuals can use the information from the program to help identify problems and evaluate solutions. Characterizing the water quality of the county is a complex task, and interpretation of the data can be difficult due to many factors. With continued long term monitoring, however, various trends become more evident. The VWIN program is currently monitoring over 200 sites throughout Western North Carolina. A comparison of Henderson County stream sites with all other sites in the program is presented in Appendix E. These comparisons are based on the most recent three years of analysis. This ensures that only current water quality is being rated. Summarized observations and trends for Henderson County stream sites are presented below. Summaries of trends are presented in Appendices G, H, and I. Data from all fourteen years of monitoring are used to determine trends.

As discussed in Section 3 of the report, the ranking system allows grouping by parameters into categories. This system permits comparison of specific water quality problems such as stream sedimentation, urban runoff of chemicals and heavy metals, and nutrient loading. Table 6 is a summary of ranking of Henderson County sites by water quality issues and by watershed. With this information it is easier to focus on specific areas with related water quality problems. The addition of biological monitoring carried out twice annually for the past five years allows for comparison of chemical water quality data and biological water quality data.

To obtain a more complete picture of water quality trends, it is useful to group streams geographically and by watershed. In this way problem areas can be more easily illustrated, and it may

help focus limited resources on areas that require the greatest attention.

Table 6: Stream ranking index for Henderson County monitoring sites

site #	site name	sediment	metals	nutrients	overall	chemical rating	biological score	biological rating
	VWIN - WNC Regional Average	71	87	85	81			
	Green River/Broad River Watershed							
	Rock Creek						16	Fair
	Green River at Bob's Creek Road						19	Good
12	Green River at Terry's Creek Road	100	88	92	93	excellent	15	Fair
19	Green River upstream Lake Summit	100	100	100	100	excellent		
11	Green River dwnstrm Lake Summit	88	100	100	96	excellent	21	Good
	Little Hungry River						21	Good
	Big Hungry River upstream						21	Good
13	Big Hungry River downstream	100	81	92	91	excellent	20	Good
LL1	Reedypatch Creek	63	94	83	80	good		
LL2	Hickory Creek	75	88	92	85	good		
LL3	Broad River at Bat Cave	75	100	92	89	good		
	Average for this grouping	86	93	93	91			
	% sites below regional average	14%	14%	14%	14%			

	Mud Creek Watershed							
21	Mud Creek at Berea Church Road	50	94	83	76	average	15	Fair
3	Mud Creek at Erkwod Road	63	88	92	81	good	12	Fair
18	Mud Creek at 7th Avenue	75	81	92	83	good	13	Fair
15	Bat Fork Creek	100	81	75	85	good		
30	Devil's Fork	75	81	75	77	average		
26	Brittain Creek	63	81	83	76	average	15	Fair
	Clear Creek at Lancaster						16	Fair
20	Clear Creek at Bearwallow	75	75	83	78	average	15	Fair
5	Clear Creek at Nix Road	75	81	75	77	average	15	Fair
4	Mud Creek at N Rugby Rd	38	81	58	59	poor		
	Average for this grouping	68	83	80	77			
	% sites below regional average	44%	78%	78%	67%			

Table 6: Stream ranking index for Henderson County monitoring sites-continued

site #	site name	sediment	metals	nutrients	overall	chemical rating		
	VWIN - WNC Regional Average	71	87	85	81			
	Mills River Watershed							
7	North Fork Mills River	100	100	92	97	excellent	18	Good
8	South Fork Mills River	100	100	100	100	excellent	19	Good
9	Mills River at Davenport Bridge	100	100	100	100	excellent	18	Good
29	Brandy Branch	88	81	67	78	average		
10	Mills River at Hooper Lane	100	100	100	100	excellent	18	Good
	Average for this grouping	98	96	92	95			
	% sites below regional average	0%	20%	20%	20%			

	Cane Creek watershed							
22	Hoopers Creek	75	88	83	82	good	11	Fair
16	Cane Creek at Howard Gap Rd	63	81	83	76	average	13	Fair

	Average for this grouping	69	85	83	79			
	% sites below regional average	50%	50%	100%	50%			

	Etowah/Horseshoe							
23	Big Willow Creek	75	94	92	87	good	13	Fair
25	Gash Creek	50	81	75	69	below average	9	Poor
28	Shaw Creek	88	81	83	84	good	13	Fair
27	Mill Pond Creek	88	75	75	79	average	10	Poor
14	Boylston Creek	75	94	92	87	good	11	Fair
	Average for this grouping	75	85	83	81			
	% sites below regional average	20%	60%	60%	40%			

	French Broad River							
1	French Broad River/Horseshoe	50	94	100	81	good		
2	French Broad River/Mt Home	25	75	75	58	poor		
	Average for this grouping	38	85	88	70			
	% sites below regional average	100%	50%	50%	50%			

	Overall County Rating							
	Average for All Sites	76	88	86	83			
	% sites below regional average	27%	47%	47%	37%			

The Green River/Broad River Watershed

Four sites including three sites on the Green River and one site on the Big Hungry River (Three additional sites monitored by the Lake Lure VWIN program include one on The Broad River, one on Hickory Creek, and one on Reedypatch Creek)

All of the sites in the Green River watershed rate **excellent**. No significant chemical water quality problems have been detected in this watershed in the past three years. This is a heavily forested watershed with less potential for surface runoff of sediment and other pollutants than many of the other watersheds analyzed. Biological monitoring also rates most of these sites as **good**, but the site on Rock Creek and the Green River at Terry's Creek Road rate **fair**. The biological rating at the Rock Creek site has declined in recent years, and the biological rating at the Terry's Creek Road site varies greatly from year to year and season to season. Trend analysis shows pH, conductivity, and nutrient levels increasing over time at the Green River watershed sites.

The three sites in the upper Broad River watershed rate good, but stream sedimentation continues to be a problem in this watershed. Special stormwater sediment monitoring shows significant sources of sediment to the Broad River from Clear Branch, Rock Creek, Sand Branch, Rush Branch, and Hemlock Falls Creek, as well as Hickory Creek and its monitored tributaries, Bearwallow Creek and Tom's Fork, the other major tributary to the Broad River, Reedypatch Creek. All of these sites have shown very high sediment concentrations during storms in the past year, and most have shown significant sedimentation during storms over the past several years. Bearwallow Creek, Tom's Fork, and Hemlock Falls Creek

have consistently exhibited the greatest sedimentation, although concentrations have declined somewhat at the Hemlock Falls Creek site in the past couple of years. Median total suspended solids concentrations for each of the monitored sites are shown in Table 4 in section III-B.

The Mud Creek Watershed

Nine sites including four sites on Mud Creek, one site on Bat Fork Creek, one site on Devil's Fork, one site on Brittain Creek, and two sites on Clear Creek

Chemical monitoring ratings range from **good** to **poor** for this group, and biological monitoring ratings are **fair** for all sites in this group. The Mud Creek watershed is the most heavily developed watershed analyzed in the county. The site on Bat Fork Creek and two sites on Mud Creek, at Erkwood Road and at Seventh Avenue, rate **good**. Ratings at the Bat Fork site have been steadily improving over the years. This part of the stream has not received wastewater effluent discharge for many years now, and land use upstream is probably changing. Stream sedimentation has not affected this site as much in recent years. Nitrate/nitrite-nitrogen concentrations are still much higher than average, and higher than any other site monitored in the county, but levels have been declining, as have levels of most other parameters analyzed, especially when compared to the first few years of monitoring at this site. Although the two above-mentioned Mud Creek sites rate **good**, they both have higher than average turbidity and total suspended solids levels, and the site on Erkwood Road shows very elevated sediment concentrations during storms. In fact biological monitoring was discontinued at this site because of the heavy build-up of sediment in the stream bed.

The two sites on Clear Creek, the site on Mud Creek at Berea Church Road, and the sites on Devil's Fork and Brittain Creek all rate **average** for chemical analysis. These watersheds are more heavily agricultural and/or developed and surface runoff is a greater problem. Turbidity, total suspended solids, and nutrient concentrations are generally higher at these sites than at most other monitored sites in the county, particularly compared to those in the more heavily forested Green and Mills River watersheds. At the Clear Creek, Devil's Fork, and Brittain Creek sites median zinc concentrations are also more typical of those in semi-urban areas. Trend analysis shows several parameters improving over time at the Mud Creek and Devil's Fork sites, but water quality at the Clear Creek sites, especially the upstream site, have been declining over time. The Mud Creek at North Rugby Road site is one of the two sites in the county that rate **poor**. This site has rated **poor** every year it has been monitored. The most serious water quality problems are stream sedimentation and elevated nutrient concentrations. Development, construction, and agriculture all contribute to stream sedimentation, and effluent from the wastewater treatment plant greatly increases nutrient concentrations to levels well above average. Trend analysis shows nutrient concentrations increasing over time at this site.

The Mills River Watershed

Five sites including one site on the North Fork of the Mills River, one site on the South Fork of the Mills River, one site on Brandy Branch, and two sites on the Mills River

All of the sites on the Mills River and on the North and South Forks rate **excellent**. All of these sites have exhibited low levels of pollutants during all monitoring events in the past three years. Overall biological monitoring ratings have also been **good**, although ratings declined over the past two years compared to the first three years, especially at the sites on the North and South Forks. The Brandy Branch site still rates **average**, although trend analysis shows levels of most pollutant parameters analyzed declining over time. Although declining, median nitrate/nitrite-nitrogen concentrations are still higher than average at that site.

Although the mean slope is great, the upper portion of the Mills River watershed is heavily forested. Only small sections of the North and South Forks flow through agricultural or developed land, so there is little opportunity for stream degradation in the upper part of the watershed. The lower part of the watershed is much more heavily agricultural or developed, and there is much greater potential for sediment and other pollutant runoff. Stage sediment monitoring in the watershed shows Foster Creek to be a significant contributor of sediment to the lower portion of the Mills River, and Brandy Branch a contributor on a slightly lesser scale (Table 5, section III-B). However, the unpolluted waters from upstream seem to sufficiently dilute pollutant runoff from the lower tributary streams and from the developed areas. Measures taken by the Mills River Partnership Program to control surface runoff along the Mills River have probably also been effective in reducing sediment and other pollutant runoff.

The Cane Creek Watershed

One site on Cane Creek and one site on Hooper's Creek

The site on Hooper's Creek rates **good**, and the site on Cane Creek rates **average**. Biological monitoring rates both sites as **fair**. Median levels of most parameters are about average for the region at both sites. In past years stream sedimentation has been a very serious problem in the Cane Creek watershed, but in the past three years there have been no samples collected with high concentrations of sediment. This could be because there have been fewer samples collected following rain events, but it might also indicate less runoff during storms, or at least during moderate rains. The Hooper's Creek watershed is more heavily forested, but the Cane Creek watershed has a significant amount of developed or agricultural usage. Extensive development in the upper part of the watershed in the Fairview area has resulted in high concentrations of sediment in the stream in Buncombe County. Much of the sediment settles in Cane Creek between Fairview and Fletcher causing the stream bed to be heavily silted in places, but on average monitoring days the silt remains in the stream bed and does not affect turbidity or suspended solids levels.

There are no notable trends related to time at the Hooper's Creek site, but nutrients and conductivity levels are increasing over time at the Cane Creek site. Biological monitoring scores have remained fairly consistent for the past five years at the Hooper's Creek site, but have vacillated between **poor** and **good** at the Cane Creek site. Ratings declined in fall 2004 and spring 2005. Macroinvertebrate populations may have been adversely affected by the hurricanes that passed through the area in

September 2004 causing extensive flooding and stream scour. Other monitoring sites do not show adverse affects by the storms.

The Streams of the Etowah and Horseshoe

Seven sites including one site each on Big Willow Creek, Gash Creek, Shaw Creek, Boylston Creek, and Mill Pond Creek

Like the Mud Creek watershed, Etowah/Horseshoe streams have a much higher percentage of developed and agricultural land than the Mills and Green River watersheds. Because cleared land is more vulnerable to erosion and is more heavily fertilized, most of the sites have higher turbidity and TSS levels and higher nutrient concentrations. Median turbidity and total suspended solids levels are near average or above average at the Gash Creek, Big Willow, and Boylston Creek sites. Turbidity levels are double the average at the Gash Creek site, although suspended solids levels are closer to average. The Gash Creek site also shows higher than average nutrient concentrations. Ammonia-nitrogen concentrations are more than double the regional average. There is probably a great deal of decaying organic matter in this part of the stream, which would also affect turbidity levels. The Gash Creek site rates **below average** and has the lowest rating in this group of streams. However, most of the parameters analyzed show water quality improving over time, and the overall rating improved from **poor** to **below average** in the past year. There is still a great deal of improvement needed in this watershed, though.

The Big Willow Creek, Shaw Creek, and Boylston Creek sites all rate **good** this year. This is a significant improvement for the Boylston Creek site. However, trend analysis only shows zinc concentrations decreasing over time, and nitrogen concentrations are increasing over time, so the improvement may be more related to weather patterns than true trends. Median levels of almost all parameters are near average at the Boylston Creek site. Median levels of most parameters are below the regional average median at the Shaw Creek site, and trend analysis shows turbidity and ammonia-nitrogen levels decreasing over time. Median levels of all parameters are also slightly below the average median at the Big Willow Creek site, and only pH levels are increasing over time.

The Mill Pond Creek site rates **average**. Although median turbidity and total suspended solids levels are relatively low, and maximum levels have not been very high in the past three years, nutrient and heavy metals concentrations are higher than average, and conductivity levels continue to be extremely high for the region. This site is affected by groundwater flow from the county landfill, but urban runoff, and possibly wastewater effluent from package treatment plants could also be affecting water quality.

The sites at Big Willow Creek, Shaw Creek, and Boylston Creek all rate **fair** for biological monitoring, and these ratings have remained fairly consistent throughout the past five years. The sites at Mill Pond Creek and Gash Creek rate **poor** for biological monitoring, and these ratings have also been generally consistent for the past five years. All of the monitored streams in the Etowah/Horseshoe area probably have problems with habitat degradation, but in some cases pollutants are probably also affecting macroinvertebrate populations.

The French Broad River

Includes two sites on the French Broad River

The upstream site on the French Broad River in Henderson County at Banner Farm Road rates **good**, and the downstream site at Butler Bridge rates **poor**. Median levels of turbidity, total suspended solids, conductivity, orthophosphate, and nitrate/nitrite-nitrogen all increase between these two sites. Median ammonia-nitrogen concentrations decrease slightly, and median zinc concentrations reach a peak on the river at the Banner Farm Road site compared to all other sites on the river from Rosman in Transylvania County to Hot Springs in Madison County, although maximum levels have not been greatly elevated at this site in the past three years.

There are a total of twelve VWIN monitoring sites on the French Broad River in North Carolina. Median levels of each parameter at each site are shown in Table 7. As might be expected, with the exception of orthophosphate, median levels of all parameters are lowest at the headwaters site in Transylvania County. Peak levels of most parameters are reached at the site just downstream from Asheville at Ledges Park. Median levels of most parameters start low at the headwaters, increase somewhat through Transylvania County and reach a peak in Henderson County before declining slightly in southern Buncombe County. Median levels increase greatly at the first site downstream from Asheville where most parameters show their highest levels at any site on the river. Levels of most parameters decline through Madison County. The more heavily populated areas of Henderson and Buncombe Counties have the greatest influence on water quality. In Henderson County the downstream site is greatly affected by the pollutant inputs from Mud Creek. Although the Mills River also flows into the French Broad River between the upstream and downstream sites in Henderson County, increased withdrawals from the Mills River for drinking water may be reducing the flow of the cleaner Mills River water into the French Broad River, thus reducing the dilution factor and increasing the influence of Mud Creek.

Although there are a few exceptions, most of the streams in Henderson with **good** or **excellent** chemical and biological ratings are watersheds with high percentages of forested land. Most of those with **average**, **below average**, or **poor** chemical ratings and **fair** or **poor** biological ratings are usually those with higher percentages of developed or agricultural land. Removing trees removes the protective canopy and the spongy layer of leaves and topsoil that are so effective at reducing the impact of stormwater. As land on ever steeper slopes is cleared for development, the impact of stormwater runoff on stream water quality and quantity will increase. Retaining a certain percentage of forest, and limiting development in headwaters areas would help reduce stormwater impact on stream water quality.

Table 7: Median levels of parameters analyzed at each site on the French Broad River from Rosman in Transylvania County to Hot Springs in Madison County

site #	location	Turbidity	TSS	Cond	Zinc	copper	Ortho-P	Ammonia-N	Nitrate-N
		NTU	mg/L	umhos/cm	ug/L	ug/L	mg/L	mg/L	mg/L
T-1	at Mt Lyon Rd	3.9	4.2	17	0.9	0.5	0.06	0.08	0.2
T-15	at Wilson Rd	7.9	10.8	21	5.0	0.9	0.04	0.10	0.3
T-7	at Everett Rd	7.0	9.9	23	3.0	0.5	0.06	0.13	0.3
H-1	at Horseshoe	9.2	9.6	26	7.7	1.4	0.04	0.15	0.3
H-2	at Mountain Home	10.5	11.4	32	5.5	1.4	0.10	0.14	0.5

B-13	at Corcoran Park	7.1	11.6	35	5.9	1.2	0.08	0.12	0.5
B-12B	at Bent Creek	8.0	10.2	34	2.8	0.7	0.09	0.12	0.5
B-23	at Jean Webb Park	8.1	11.8	46	3.9	1.1	0.06	0.11	0.4
B-6A	at Ledges Park at Walnut Island	17.0	18.2	56	7.5	1.7	0.23	0.29	0.7
B-32	Park	15.5	17.6	55	6.3	1.8	0.15	0.21	0.6
M-2	at Barnard Bridge	13.5	14.2	59	5.1	1.5	0.19	0.17	0.7
M-3	at Hot Springs	10.7	9.2	58	3.2	1.2	0.17	0.13	0.7

Patch, S.C., Westphal, M.J., Evans, B.S., Fariss, B., Fariss, B., 2006, Assessment of Water Quality Impacts of Hurricanes in Western North Carolina Through Strategic Monitoring and Statistical Analysis.

Pb ug/L .

pH .

A-1

Appendix B: Laboratory Analysis

Samples are kept refrigerated until they are delivered to the EQI laboratory on the Monday morning following Saturday collections. Methods follow EPA or Standard Methods for the Examination of Water and Wastewater-18TH – 20TH Edition techniques and the EQI laboratory is certified by the State of North Carolina for water and wastewater analysis of orthophosphate, total phosphorus, ammonia-nitrogen, turbidity, total suspended solids, pH, conductivity, copper, lead, and zinc. All samples are kept refrigerated until the time of analysis. Shipped samples are sent on ice. Analysis for nitrogen, phosphorus, pH, turbidity and conductivity are completed within 48 hours of the collection time. As pH cannot be tested on site, the holding time for pH is exceeded. When immediate analysis does not occur, such as for total phosphorus and heavy metals, the samples are preserved by acidification and kept refrigerated.

Explanations about the procedures and instruments used in the EQI lab are quite technical in nature and will be omitted from this report. Detailed information is available on request. The reporting limits for each parameter have been provided.

Approximate Analytical Reporting Limits for VWIN Water Quality Parameters.

<u>PARAMETER</u>	<u>REPORTING LIMIT</u>	<u>UNITS</u>
Ammonia Nitrogen	0.02	mg/L
Nitrate/nitrite Nitrogen	0.1	mg/L
Total Phosphorus (as PO ₄ ³⁻)	0.02	mg/L
Orthophosphate (as PO ₄ ³⁻)	0.02	mg/L
Alkalinity	1.0	mg/L
Total Suspended Solids	4.0	mg/L
Conductivity	10.0	umhos/cm
Turbidity	1.0	NTU
Copper	2.0	ug/L
Zinc	20.0	ug/L
Lead	2.0	ug/L
pH	n/a	n/a

Appendix C: Save Our Streams – Stream Quality Survey



SAVE OUR STREAMS

Stream Quality Survey

The purpose of this form is to aid you in gathering and recording important data about the health of your stream. By keeping accurate and consistent records of your observations and data from your macroinvertebrate count, you can notice and document changes in water quality. Refer to the SOS insect card and instructions to learn how to trap and identify the organisms.

Stream _____ Station _____
 County _____ State _____ Location _____
 Group or individual _____ Number of participants _____
 Weather conditions _____
 Stream width (max.) _____ ft. Stream depth (max.) _____ ft.
 Flow rate: high _____ low _____ normal _____
 You should select a riffle where the water is not running too fast (ideal depth is 3 - 12 inches), and the bed consists of cobble-sized stones or larger.
 Monitored riffle area (should be 3 foot square) _____ Water depth (inches) _____
 Sample number _____ Date _____ Time _____
 Type of test: _____ macroinvertebrate count _____ chemical test _____ other _____

MACROINVERTEBRATE COUNT

Use the stream monitoring instructions to conduct a macroinvertebrate count. Use letter codes (A = 1 - 9, B = 10 - 99, C = 100 or more) to record the numbers of organisms found in a 3 foot by 3 foot area. Then add up the number of letters in each column and multiply by the indicated index value. The following columns are divided based on the organism's sensitivity to pollution.

SENSITIVE	SOMEWHAT-SENSITIVE	TOLERANT
<input type="checkbox"/> caddisfly larvae <input type="checkbox"/> hellgrammite <input type="checkbox"/> mayfly nymphs <input type="checkbox"/> gilled snails <input type="checkbox"/> riffle beetle adult <input type="checkbox"/> stonefly nymphs <input type="checkbox"/> water penny larvae	<input type="checkbox"/> beetle larvae <input type="checkbox"/> clams <input type="checkbox"/> crane fly larvae <input type="checkbox"/> crayfish <input type="checkbox"/> damselfly nymphs <input type="checkbox"/> dragonfly nymphs <input type="checkbox"/> scuds <input type="checkbox"/> sowbugs <input type="checkbox"/> fishfly larvae <input type="checkbox"/> alderfly larvae	<input type="checkbox"/> aquatic worms <input type="checkbox"/> blackfly larvae <input type="checkbox"/> leeches <input type="checkbox"/> midge larvae <input type="checkbox"/> pouch (and other) snails
<input type="checkbox"/> # of letters times 3 = _____ _____ index value +	<input type="checkbox"/> # of letters times 2 = _____ _____ index value +	<input type="checkbox"/> # of letters times 1 = _____ _____ index value

Now add together the three index values = _____ total index value.

Compare this total index value to the following numbers to determine the water quality of your stream. Good water quality is indicated by a variety of different kinds of organisms, with no one kind making up the majority of the sample.

WATER QUALITY RATING

Excellent (> 22) Good (17 - 22)
 Fair (11 - 16) Poor (< 11)

Note: You should test at least 3 different riffles within a 24-foot area to ensure that you have a truly representative sample which includes all key organisms. Record results from the sample which gives the best diversity.



Izaak Walton League of America, SOS Program 1401 Wilson Blvd., Level B, Arlington, Va. 22209 (703)526-1818
 Defenders of Air, Water, Waters and Wildlife

Appendix D: Parameters and Ranges for Stream Quality Classifications

pH -

- Grade A= never less than 6.0
- Grade B= below 6.0 in less than 10% of samples, never below 5.0
- Grade C= never less than 5.0
- Grade D= at least one sample was less 5.0.

Alkalinity -

- Grade A= median greater than 30 mg/L (indicates little vulnerability to acidic inputs)
- Grade B= median 20-30 mg/L (indicates moderate vulnerability to acidic inputs)
- Grade C= median less than 20 mg/L (considered to be vulnerable to acidic inputs).
- Grade D= median less than 15 ppm (very vulnerable to acidic inputs)

Turbidity -

- Grade A= median less than 5 NTU and exceeded the standard for trout waters of 10 NTU in less than 10% of samples, but never exceeded 50 NTU
- Grade B= median less than 7.5 NTU and never exceeded the 50 NTU standard
- Grade C= median less than 10 NTU and exceeded 50 NTU in less than 10% of samples
- Grade D= median greater than 10 NTU or exceeded 50 NTU in more than 10% of samples.

Total Suspended Solids -

- Grade A= median less than 5 mg/L and maximum less than 100 mg/L - not measurably disturbed by human activities
- Grade B= median less than 7.5 mg/L and exceeded 100 mg/L in less than 10% of samples - low to moderate disturbance
- Grade C= median less than 10 mg/L and exceeded 100 mg/L in less than 10% of samples - moderate to high disturbance.
- Grade D= median greater than 10 mg/L or maximum exceeded 100 mg/L in more than 10% of samples - high level of land disturbance

Conductivity -

- Grade A= median less than 30 umhos/cm, never exceeded 100 umhos/cm
- Grade B= median less than 50 umhos/cm, exceeded 100 umhos/cm in less than 10% of samples
- Grade C= median greater than 50 umhos/cm, exceeded 100 umhos/cm in less than 10% of samples
- Grade D= exceeded 100 umhos/cm in more than 10% of samples.

Total Copper -

- Grade A= never exceeded water quality standard of 7 ppb
- Grade B= exceeded 7 ppb in less than 10% of samples
- Grade C= exceeded 7 ppb in 10 to 20% of samples
- Grade D= exceeded 7 ppb in more than 20% of samples

Appendix D (continued)

Total Lead -

- Grade A= never exceeded water quality standard of 10 ppb
- Grade B= exceeded 10 ppb in less than 10% of samples
- Grade C= exceeded 10 ppb in 10 to 20% of samples
- Grade D= exceeded 10 ppb in more than 20% of samples

Total Zinc -

- Grade A= median less than 5 ppb, never exceeded water quality standard of 50 ppb
- Grade B= median less than 10 ppb, exceeded 50 ppb in less than 10% of samples
- Grade C= median less than 10 ppb, exceeded 50 ppb in 10 - 20% of samples.
- Grade D= Median greater than 10 ppb or concentration exceeded 50 ppb in more than 20% of samples

Total Phosphorous -

- Grade A= median not above 0.10 mg/L
- Grade B= median greater than 0.10 mg/L but less than 0.20 mg/L.
- Grade C= median greater than 0.20 mg/L but less than 0.30 mg/L
- Grade D= median greater then 0.30 mg/L

Orthophosphate -

- Grade A= median less than ambient level of 0.05 mg/L
- Grade B= median between 0.05 mg/L but less than 0.10 mg/L
- Grade C= median greater than 0.10 mg/L but less than 0.20 mg/L
- Grade D= median greater then 0.20 mg/L.

Ammonia Nitrogen -

- Grade A= never exceeded 0.50 mg/L
- Grade B= never exceeded the proposed ambient standard for trout waters in the summer of 1 mg/L
- Grade C= exceeded 1 mg/L in less than 10% of samples, but never exceeded 2mg/L
- Grade D= exceeded 1 mg/L in more than 10% of samples, or at least one sample had a concentration greater than the proposed ambient standard for trout waters in the winter of 2.0 mg/L.

Nitrate Nitrogen -

- Grade A= median does not exceed 0.3 mg/L, no sample exceeded 1.0 mg/L
- Grade B= less than 10% of samples exceeded 1.0 mg/L, none exceeded 5 mg/L
- Grade C= no samples exceeded 5 mg/L
- Grade D= at least one sample exceeded 5 mg/L

APPENDIX E

Appendix E: Stream Ranking Index

Excellent	Median and maximum pollutant levels in all parameters show little effect from human disturbances
Good	One or more parameters show minor or only occasional increases in pollutant levels from human disturbances
Average	Exhibits constant low levels of one or more pollutants or sudden significant, but short term increases.
Below Ave	Median pollutant levels are abnormally high in one or more parameters, or exhibits very high pollutant levels during certain weather conditions
Poor	Pollutant levels are consistently higher than average in several parameters and/or show extreme levels during certain weather conditions

B = Buncombe County

H = Henderson County

HW=Hiawasse River Watershed

HY = Haywood County

LG = Lake Glenville

LJ = Lake James

LL = Lake Lure

M = Madison County

N = New River

NOT=Nottely River Watershed

P = Polk County

T = Transylvania County

TU = Tuckasegee River watershed

rank	site #	site description	Excellent
1	H8	South Fork Mills River	100
2	H9	Mills River at SR 191 (Davenport Bridge)	100
3	H10	Mills River at Hooper Lane	100
4	H19	Green River at Old Hwy 25 S	100
5	HW2	Martin's Creek	100
6	HW6	Eagle Fork Creek	100
7	HW7	Upper Shooting Creek	100
8	HW8	Lower Shooting Creek	100
9	HW10	Upper Fodder Creek	100
10	HW11	Hog Creek	100
11	HY2	East Fork Pigeon River/Bethel	100
12	HY3	East Fork Pigeon River/Cruso	100
13	LG5	Cedar Creek at Beetree Rd (Tuckasegee R wtrshd)	100
14	LG7	Norton Creek/up Grassy Cmp (Tuckasegee R wtrshd)	100
15	LL9	Buffalo Creek (Broad River watershed)	100
16	NOT5	Coosa Creek	100
17	NOT9	Conley Creek	100
18	NOT10	Young Cane Creek upstream	100

19	T6	Little River at Dupont Road	100
20	T8	Williamson Creek	100
21	T11	King Creek headwaters	100
22	T19	West Fork French Broad River upstream	100
23	T20	Catheys Creek upstream of water supply	100
24	TU1	East Fork Tuckasegee River	100
25	TU14	Deep Creek (Tuckasegee River watershed)	100
26	HY1	West Fork Pigeon River/Bethel	98
27	NOT1	Nottely River upstream	98
28	T9	Davidson River at entrance to Pisgah National Forest	98
29	T10	King Creek at Brevard College	98
30	T16	Little River at Sherwood Forest	98
31	T18	North Fork French Broad River headwaters	98
32	B12A	Bent Creek at SR 191	97
33	B22	Ivy Creek at Dillingham Road	97
34	H7	North Fork Mills River	97
35	LL6	Pool Creek (Broad River watershed)	97
36	TU15	Oconoluftee River (Tuckasegee River watershed)	97
37	H11	Green River below Lake Summit	96
38	HW5	Geisky Creek	96
39	LG1	Hurricane Creek/Norton Br Rd (Tuckasegee R wtrshd)	96
40	NOT3	Nottely River	96
41	NOT7	Young Cane Creek	96
42	NOT8	Ivy Log Creek	96
43	T5	West Fork French Broad River at 64/215	96
44	T12	Davidson River at confluence with FBR	96
45	T14	Lamb Creek at confluence with FBR	96
46	T4	North Fork French Broad River at 64/215	94
47	H12	Green River at Terry's Creek Rd	93
48	LG2	Norton Creek at Norton Rd br (Tuckasegee R wtrshd)	93
49	LJ5	Linville River at Hwy 126	93
50	T1	French Broad River at Mt Lyon Rd (Rosman)	93
51	T2	East Fork French Broad River at Rosman	93
52	B28	Bent Creek below Lake Powhatan	92
53	HW1	Upper Hiawasse River	92
54	HW3	Hightower Creek	92
55	HW9	Upper Bell Creek	92
56	LG4	Pine Creek/Pine Creek Rd br (Tuckasegee R wtrshd)	92
57	T13	Lamb Creek headwaters	92
58	TU3	Caney Fork (Tuckasegee River watershed)	92
59	H13	Big Hungry River below dam (Green River watershed)	91
60	HY12	Jonathan Creek near confluence with Pigeon River	91
61	LG3	Mill Creek/dnstrm Norton br (Tuckasegee R wtrshd)	91
62	B38	Swannanoa River at Bull Creek	90
63	P13	Green River at Hwy 9	90

			Good
64	LL3	Broad River at Bat Cave	89
65	LL10	Fairfield Mts Creek (Broad River watershed)	89
66	P8	Demannu Creek at SR 1140 and Hwy 9 (Green River wtrshd)	89
67	B24	Swannanoa River at confluence with North Fork	88
68	LL7	Public Golf Course Creek at Hwy 64/74 (Broad Rvr wtrshd)	88
69	M8	Little Laurel Creek (Laurel River watershed)	88
70	NOT6	Anderson Creek	88
71	P6	Horse Creek at SR 1516 (River Rd) (N Pacolet River wtrshd)	88
72	T3	Middle Fork French Broad River at Rosman	88
73	TU5	Tuckasegee River upstream from Scott's Creek	88
74	TU9	Tuckasegee River at Barker's Creek	88
75	H14	Boylston Creek at Ladson Road	87
76	H23	Big Willow Creek at Patterson Rd	87
77	HY11	Richland Creek at Lake Junaluska	87
78	HY13	Allens Creek (Richland Creek watershed)	87
79	LG6	Glenville Creek at Tator Knob Rd (Tuckasegee R)	87
80	LL8	Cane Creek upstream from Tryon Bay (Broad Rvr wtrshd)	87
81	M9	Shelton Laurel Creek (Laurel River watershed)	87
82	N5	North Fork (New River watershed)	87
83	P16	North Pacolet River at Rte 108	87
84	P14	White Oak Creek at Briar Hill Farm	86
85	TU4	Cullowhee Creek (Tuckasegee River watershed)	86
86	B20	Ivy Creek at Buckner Branch Road	85
87	B43	Ross Creek at Swannanoa River (Swannanoa R wtrshd)	85
88	H15	Bat Fork Creek at Tabor Road (Mud Creek watershed)	85
89	HY10	Richland Creek at West Waynesville	85
90	HW4	Scataway Creek	85
91	HW12	Woods Creek	85
92	LJ1	Catawba River at SR 1501	85
93	LL2	Hickory Creek at Bat Cave (Broad River watershed)	85
94	TU2	West Fork Tuckasegee River	85
95	TU11	Connelley Creek (Tuckasegee River watershed)	85
96	H28	Shaw Creek at Hunters Glen	84
97	NOT2	Arkaqua Creek	84
98	H18	Mud Creek at 7th Avenue	83
99	LJ2	Catawba River at US 221A	83
100	LJ4	Catawba River at Resistoflex	83
101	LL4	Broad River at Chimney Rock	83
102	LL5	Broad River at Lake Lure	83
103	P2	White Oak Creek at SR 1531 (Fox Mt Rd)	83
104	P5	Horse Creek at SR 1516 (River Road) N Pacolet R wtrshd)	83
105	P15	North Pacolet River at Melrose	83

106	TU12	Tuckasegee River downstream from Bryson City	83
107	H22	Hoopers Creek at Jackson Rd (Cane Creek watershed)	82
108	NOT4	Butternut Creek	82
109	P4	White Oak Creek at SR 1322 (Moore Road)	82
110	P17	White Oak Creek at Weidman's	82
111	B9A	Beetree Creek (Swannanoa River watershed)	81
112	B31	Swannanoa River at Grassy Branch confluence	81
113	B33	North Fork Swannanoa River at Grovestone Quarry	81
114	H1	French Broad River at Banner Farm Road in Horseshoe	81
115	H3	Mud Creek at Erkwood Road	81
116	HY9	Plott Creek in Hazelwood (Richland Crk watershed)	81
117	P1	White Oak Creek at SR 1137/Houston Road	81
118	T7	French Broad River at Everett Road	81
119	B10	Bull Creek at Swannanoa River (Swannanoa R wtrshd)	80
120	LL1	Reedypatch Creek at Bat Cave (Broad River watershed)	80
121	M7	Spring Creek	80

Average

122	B8	Beaverdam Creek at Beaver Lake	79
123	B17A	Swannanoa River at NC 81	79
124	H27	Mill Pond Creek at South Rugby Road	79
125	T15	French Broad River at Wilson Road	79
126	TU8	Green's Creek (Tuckasegee River watershed)	79
127	B1A	Big Ivy Creek at Forks of Ivy	78
128	B5B	Reems Creek at Ox Creek	78
129	H20	Clear Creek at Apple Valley Rd (Mud Crk watershed)	78
130	H29	Brandy Branch at Mills River Village (Mills River watershed)	78
131	HY27	Jonathan Creek at Maggie Valley	78
132	M10	Laurel River	78
133	M14	Middle Fork at Beech Glen (Ivy River watershed)	78
134	N1	Helton Creek (New River watershed)	78
135	N2	Big Horse Creek (New River watershed)	78
136	P7	North Pacolet River at SR 1516 (S River Rd)	78
137	B27	Flat Creek at NC 19/23	77
138	H5	Clear Creek at Nix Road (Mud Creek watershed)	77
139	H30	Devils Fork at Dana Road (Mud Creek watershed)	77
140	HY5	Pigeon River at Hepco Bridge	77
141	TU7	Savannah Creek (Tuckasegee River watershed)	77
142	TU10	Barker's Creek (Tuckasegee River watershed)	77
143	B9B	Swannanoa River at Beetree Creek	76
144	H16	Cane Creek at Howard Gap Road	76
145	H21	Mud Creek at Berea Church Road	76
146	H26	Brittain Creek at Patton Park (Mud Creek watershed)	76
147	T17	North Fork French Broad River at Macedonia Bridge	76
148	HY26	Crabtree Creek at Crabtree Rd	75
149	TU6	Scott's Creek (Tuckasegee River watershed)	75
150	TU13	Kirkland Creek (Tuckasegee River watershed)	75
151	B40	Ross Creek at Lower Chunns Cove Rd(Swannanoa R wtrshd)	74

152	HY8	Eaglenest Creek in Hazelwood (Richland Creek watershed)	74
153	M13	California Creek at Beech Glen (Ivy River watershed)	74
154	N3	Buffalo Creek (New River watershed)	73
155	B7A	Reed Creek at UNCA Botanical Gardens	72
156	HY4	Pigeon River downstream from Canton	72
157	B14	Lower Flat Creek	71
158	HY25	Raccoon Creek downstream (Richland Creek watershed)	71
159	LJ3	North Fork of the Catawba River at SR 1552	71
160	LJ12	North Fork of the Catawba River below Limekiln Creek	71
161	P18	Camp Creek (Green River watershed)	70

**Below
Average**

162	B6B	Reems Creek at French Broad River	69
163	H25	Gash Creek at Etowah School Road	69
164	HY6	Rush Fork at Crabtree (Crabtree Creek watershed)	69
165	N4	Big Laurel Creek (New River watershed)	69
166	B5A	Ox Creek at Reems Creek (Reems Creek watershed)	67
167	B12B	French Broad River at Bent Creek	67
168	B13	French Broad River at Corcoran Park (Hend/Bunc line)	67
169	B17B	Haw Creek at NC 81 (Swannanoa River watershed)	67
170	B41	Ross Creek at Tunnel Road (Swannanoa River watershed)	67
171	HY23	Ratcliff Cove Branch (Raccoon Creek watershed)	67
172	HY7	Fines Creek downstream	66
173	LJ13	North Fork of the Catawba River at Old Linville Rd	66
174	M6	Big Pine Creek	66
175	M11	Bull Creek (Ivy River watershed)	66
176	M15	Paint Fork at Beech Glen (Ivy River watershed)	66
177	B7B	Glenn Creek at UNCA Bot Gardens (Reed Ck wtrshd)	65
178	B21	Paint Fork at Barnardsville (Ivy River watershed)	65
179	B23	French Broad River at Jean Webb Park - Asheville	65
180	B35	Smith Mill Creek at Louisiana Blvd.	65
181	B47	Reed Creek at entrance to UNCA	65
182	HY19	Fines Creek upstream	65
183	M3	French Broad River at Hot Springs	65
184	P10	Joels Creek downstream (N Pacolet River watershed)	65
185	B15A	Cane Creek at Hwy 74 (FBR watershed)	64
186	B26	North Turkey Creek (Sandymush Creek watershed)	64
189	M12	Grapevine Creek (Ivy River watershed)	64
188	B16A	Cane Creek at Mills Gap Road	63
189	B30	Grassy Branch (Swannanoa River watershed)	63
190	B2	Lower Sandymush Creek	61
191	B34	Lower Hominy Creek at NC 191	61
192	B37	Newfound Creek at Leicester Hwy	60
193	HY14	Rush Fork upstream (Crabtree Crk watershed)	60
194	HY24	Raccoon Creek upstream (Richland Creek watershed)	60
195	M4	East Fork Bull Creek (Ivy River watershed)	60
196	P9	Joels Creek upstream (N. Pacolet Rvr watershed)	60

			Poor
197	B42	Ross Creek at Upper Chunns Cove (Swannanoa R wtrshd)	59
198	H4	Mud Creek at North Rugby Road	59
199	B3B	Sandymush Creek at Willow Creek	58
200	B6A	French Broad River at the Ledges Park	58
201	B32	French Broad River at Walnut Island Park	58
202	H2	French Broad River at Butler Bridge Road	58
203	HY20	Cove Creek at NC 209 (Fines Creek watershed)	58
204	M1	Ivy River at NC 25/70	58
205	M17	Gabriel's Creek at Ivy River	57
206	B25	South Turkey Creek (Sandymush Creek watershed)	56
207	HY15	Fines Creek midstream	55
208	B4	Lower Newfound Creek	53
209	B36	Newfound Creek at Dark Cove Road	53
210	M2	French Broad River at Barnard Bridge	53
211	HY22	Hyatt Creek downstream (Richland Creek watershed)	52
212	B1B	Little Ivy Creek (Ivy River watershed)	51
213	HY21	Hyatt Creek upstream (Richland Creek watershed)	51
214	B15B	Ashworth Creek at Hwy 74 & Cane Crk Rd (Cane Ck wtrshd)	49
215	B48	South Creek Pond/Beaver Lake (Beaverdam Crk wtrshd)	45
216	B39	South Creek at Beaver Lake (Beaverdam Crk watershed)	44

	Percent -	Excellent	Good	Average	Below Average	
						Poor
Buncombe		8	14	18	37	23
Henderson		30	30	29	4	7
Haywood		17	17	25	24	17
Hiwassee		83	17	0	0	0
Lake Glenville		86	14	0	0	0
Lake James		14	43	29	14	0
Lake Lure		20	80	0	0	0
Madison		0	20	20	40	20
New River		0	20	60	20	0
Nottely		70	30	0	0	0
Polk		7	67	13	13	0
Transylvania		80	10	10	0	0
Tuckasegee River		27	40	33	0	0
TOTAL		29	27	19	16	9

APPENDIX F: DATA SUMMARY

Site the number assigned to the VWIN site
 Sample # the number of samples collected for each parameter
 Low minimum value of any sample(s)
 Median median value for each site for last 3 years and then for all years monitored
 High maximum value of any sample(s)

<u>pH - Last 3 Years</u>			<u>All Results</u>		<u>Alkalinity - Last 3 Years/rept. limit 1 mg/L</u>					<u>All Results</u>			
site	sample #	low	median	high	sample #	median	site	sample #	low	median	high	sample #	median
1	34	6.4	6.9	7.2	150	6.8	1	34	2	12	18	152	16
2	36	6.5	6.9	7.2	159	6.8	2	36	4	14	19	160	16
3	34	6.3	6.9	7.1	161	6.7	3	35	6	15	22	164	17
4	36	6.6	7.0	7.3	154	6.9	4	36	12	24	34	155	24
5	34	6.6	7.0	7.2	152	6.9	5	34	8	20	70	153	20
7	36	6.5	7.0	7.5	161	6.8	7	36	5	9	16	162	10
8	36	6.2	6.9	7.2	159	6.6	8	36	4	9	13	160	10
9	35	6.4	6.9	7.2	163	6.7	9	36	5	9	14	164	10
10	36	6.5	6.9	7.7	166	6.7	10	36	4	10	31	166	10
11	34	6.4	6.8	7.3	138	6.7	11	34	8	14	24	139	13
12	35	6.7	6.9	7.2	154	6.8	12	35	6	12	22	154	12
13	35	7.0	7.3	7.8	155	7.1	13	35	12	18	31	155	18
14	36	6.6	7.2	7.5	151	7.0	14	36	8	16	26	151	17
15	36	6.5	6.8	7.4	147	6.7	15	36	13	18	26	148	20
16	34	6.9	7.3	7.6	145	7.1	16	34	18	25	33	144	25
18	35	6.7	7.0	7.3	141	6.9	18	35	14	18	26	144	19
19	36	6.6	6.9	7.2	102	6.8	19	36	7	12	17	103	12
20	35	6.5	7.0	7.5	121	6.9	20	35	12	15	28	122	16
21	35	6.5	7.0	7.2	90	6.9	21	35	12	16	26	90	18
22	36	6.7	7.2	7.3	97	7.0	22	36	13	22	30	97	23
23	35	6.7	7.0	7.4	90	6.9	23	35	12	16	39	90	16
25	36	6.5	6.9	7.2	94	6.8	25	36	12	29	39	94	31
26	36	6.7	7.0	7.4	90	7.0	26	36	8	26	33	90	27
27	36	6.8	7.2	9.0	96	7.1	27	36	12	32	45	96	33
28	36	6.8	7.1	7.4	93	7.0	28	36	16	22	31	94	24
29	36	5.5	6.9	7.3	93	6.8	29	36	9	14	44	94	14

30	36	6.5	6.9	7.1	95	6.8	30	36	13	28	36	96	28
LL1	36	7.0	7.5	8.2	120	7.3	LL1	36	7	21	33	120	21
LL2	35	7.0	7.3	7.9	119	7.2	LL2	35	10	15	23	119	16
LL3	35	7.1	7.4	7.7	119	7.3	LL3	35	9	16	30	119	16

APPENDIX F: DATA SUMMARY (continued)

site	sample #	Turbidity (NTU) - Last 3 Years/rept. limit 1 NTU			All Results		site	sample #	TSS (mg/L) - Last 3 Years/rept. limit 4 mg/L			All Results	
		low	median	high	sample #	median			low	median	high	sample #	median
1	34	3.1	9.2	35	152	9.0	1	34	<4	9.6	57.6	151	10.4
2	36	3.1	10.5	34	160	9.0	2	36	<4	11.4	35.6	159	10.8
3	35	2.7	5.9	70	164	7.4	3	35	<4	6.4	152.0	163	6.4
4	36	2.6	9.3	120	155	12.0	4	36	<4	10.0	128.4	154	10.6
5	34	2.3	5.7	23	152	7.6	5	34	<4	5.2	50.6	151	6.0
7	36	0.9	2.3	28	162	2.7	7	36	<4	2.0	30.0	159	2.0
8	36	0.6	2.6	15	160	3.2	8	36	<4	2.6	20.8	157	2.4
9	36	1.1	2.8	27	165	3.0	9	36	<4	2.4	40.4	163	2.0
10	36	0.9	3.5	14	167	3.6	10	36	<4	3.4	16.0	163	3.2
11	34	1.5	3.4	31	139	3.7	11	34	<4	1.6	34.4	138	1.6
12	35	0.9	2.8	21	155	3.0	12	35	<4	1.6	17.2	153	1.6
13	35	0.9	3.5	13	156	4.0	13	35	<4	3.6	37.6	154	3.6
14	36	2.4	6.0	32	152	7.3	14	36	<4	6.2	38.4	152	6.4
15	36	1.6	3.6	23	148	5.5	15	36	<4	2.2	16.0	146	3.2
16	34	1.7	5.5	90	145	7.0	16	34	<4	5.0	85.2	144	6.2
18	35	3.1	6.8	32	144	7.5	18	35	<4	6.8	51.6	143	6.8
19	36	1.3	3.7	21	103	3.9	19	36	<4	2.0	44.0	99	3.2
20	35	2.2	4.6	20	122	5.1	20	35	<4	5.2	24.0	120	4.4
21	35	3.5	7.7	35	90	6.6	21	35	<4	8.4	134.4	90	7.8
22	36	1.4	4.8	71	97	5.4	22	36	<4	4.9	69.6	97	5.2
23	35	1.6	5.2	29	90	4.8	23	35	<4	5.2	29.2	90	4.8
25	36	5.9	11.0	34	94	10.5	25	36	<4	6.0	32.4	94	6.2
26	36	1.3	3.8	210	90	3.6	26	36	<4	2.4	155.6	90	2.4
27	36	1.9	4.5	45	96	4.9	27	36	<4	3.2	42.4	96	3.0

28	36	1.2	3.4	18	94	4.6	28	36	<4	2.8	53.6	94	3.2
29	36	2.1	3.4	25	95	5.2	29	36	<4	4.3	55.2	95	5.6
30	36	2.9	7.2	34	96	7.3	30	36	<4	5.8	18.0	96	4.8
LL1	36	1.4	4.3	160	120	4.1	LL1	36	<4	3.2	125.3	121	3.6
LL2	35	2.0	4.5	21	119	5.2	LL2	35	<4	5.0	25.2	120	7.6
LL3	35	1.9	4.5	45	119	4.9	LL3	35	<4	6.0	49.6	120	5.6

APPENDIX F: DATA SUMMARY (continued)

site	sample #	Conductivity - Last 3 Years/rept. limit 10 umhos/cm			All Results		site	sample #	Copper (ppb) - Last 3 Years/rept. limit 2 ppb			All Results	
		low	median	high	sample #	median			low	median	high	sample #	median
1	34	20	26	34	152	38	1	34	<2	1.4	4.8	151	1.6
2	36	23	32	42	160	40	2	36	<2	1.4	8.2	160	1.5
3	35	32	36	55	164	40	3	35	<2	0.9	4.4	162	1.1
4	36	34	67	91	155	71	4	36	<2	1.6	6.7	155	1.6
5	34	14	56	65	153	55	5	34	<2	0.9	2.6	152	0.9
7	36	13	14	18	162	15	7	36	<2	0.4	<2	161	0.6
8	36	12	15	19	160	15	8	36	<2	0.2	<2	159	0.2
9	36	13	15	19	164	16	9	36	<2	0.1	<2	164	0.3
10	36	15	17	21	166	18	10	36	<2	0.7	3.5	166	0.7
11	34	22	27	35	139	26	11	34	<2	0.3	<2	138	0.4
12	35	20	22	54	154	22	12	35	<2	0.1	2.2	154	0.3
13	35	37	43	52	155	43	13	35	<2	0.4	11.0	155	0.5
14	36	26	39	49	151	40	14	36	<2	0.5	3.4	152	0.7
15	36	44	66	82	147	73	15	36	<2	0.6	2.7	147	1.1
16	34	49	59	72	144	61	16	34	<2	0.6	6.6	144	0.7
18	35	40	46	60	144	48	18	35	<2	1.3	8.9	142	1.4
19	36	19	24	30	103	24	19	36	<2	0.4	<2	101	0.4
20	35	31	38	43	122	39	20	35	<2	0.7	16.0	121	0.6
21	35	33	37	51	90	42	21	35	<2	0.6	4.2	89	0.7
22	36	44	52	65	97	57	22	36	<2	0.9	2.5	96	1.1
23	35	28	31	42	90	32	23	35	<2	0.2	<2	89	0.4

25	36	58	70	94	94	78	25	36	<2	0.8	3.5	93	1.4
26	36	62	74	316	90	74	26	36	<2	0.8	2.8	89	0.9
27	36	105	173	256	96	172	27	36	<2	0.5	<2	96	0.7
28	36	52	59	68	94	61	28	36	<2	0.3	8.2	93	0.5
29	36	41	58	81	95	62	29	36	<2	0.6	2.3	94	0.9
30	36	66	80	91	96	81	30	36	<2	1.5	4.0	94	1.7
LL1	36	43	49	61	120	50	LL1	36	<2	0.4	6.0	118	0.5
LL2	35	29	33	59	119	33	LL2	35	<2	0.4	23.2	117	0.5
LL3	35	27	29	38	119	30	LL3	35	<2	0.4	2.1	117	0.5

APPENDIX F: DATA SUMMARY (continued)

site	sample #	Lead (ppb) - Last 3 Years/rept. limit 1 ppb			All Results		site	sample #	Zinc - Last 3 Years/rept. limit 20 ppb			All Results	
		low	median	high	sample #	median			low	median	high	sample #	median
1	34	<2	1.4	4.3	151	1.2	1	34	<20	7.7	28.7	150	8.6
2	35	<2	1.1	12.2	159	1.0	2	36	<20	5.5	49.5	160	7.7
3	35	<2	0.4	10.5	163	0.4	3	35	<20	1.8	<20	163	3.4
4	36	<2	1.0	5.1	155	0.9	4	36	<20	7.5	31.3	155	8.5
5	34	<2	0.8	3.0	153	0.5	5	34	<20	6.5	<20	152	5.7
7	36	<2	0.2	3.2	162	0.2	7	36	<20	1.0	<20	162	1.5
8	36	<2	0.2	<2	160	0.2	8	36	<20	0.0	<20	160	1.4
9	36	<2	0.2	<2	165	0.2	9	36	<20	0.5	<20	165	1.6
10	36	<2	0.3	<2	167	0.3	10	36	<20	2.8	<20	167	2.9
11	34	<2	0.2	<2	139	0.2	11	34	<20	0.6	<20	139	0.9
12	35	<2	0.2	21.2	155	0.2	12	35	<20	2.6	60.5	155	2.1
13	35	<2	0.4	2.5	156	0.3	13	35	<20	1.4	86.9	156	1.9
14	36	<2	0.4	3.1	152	0.5	14	36	<20	2.4	<20	152	4.2
15	36	<2	0.4	<2	148	0.4	15	36	<20	4.7	124.9	148	9.2
16	34	<2	0.3	27.8	145	0.4	16	34	<20	2.8	39.2	145	3.7
18	35	<2	0.9	3.0	143	0.7	18	35	<20	6.1	21.2	143	6.9
19	36	<2	0.4	2.3	102	0.5	19	36	<20	2.2	23.6	102	3.2
20	35	<2	0.5	18.2	122	0.4	20	35	<20	5.3	130.4	122	2.4

21	35	<2	0.6	3.0	90	0.4	21	35	<20	3.4	<20	90	2.4
22	36	<2	0.7	3.4	97	0.6	22	36	<20	4.0	<20	97	3.5
23	35	<2	0.2	<2	90	0.2	23	35	<20	2.1	<20	90	1.8
25	36	<2	0.6	3.5	94	0.8	25	36	<20	9.1	36.8	94	16.2
26	36	<2	0.4	5.6	90	0.4	26	36	<20	6.7	32.9	90	5.5
27	36	<2	0.3	5.0	96	0.3	27	36	<20	5.1	21.9	96	6.3
28	36	<2	0.2	2.0	94	0.2	28	36	<20	2.9	39.3	94	2.3
29	36	<2	0.3	<2	94	0.3	29	36	<20	4.8	53.1	94	6.7
30	36	<2	0.9	7.9	96	0.8	30	36	<20	7.5	<20	96	7.0
LL1	36	<2	0.2	6.5	120	0.2	LL1	36	<20	0.7	20.3	119	0.6
LL2	35	<2	0.3	<2	119	0.3	LL2	35	<20	0.2	44.8	118	0.8
LL3	35	<2	0.2	<2	119	0.2	LL3	35	<20	0.0	<20	118	0.0

A-17

Appendix G: Trends for Each Site Related to Flow

		increases as flow increases										decreases as flow increases												
site #	site name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	
Green/Broad River watershed																								
12	Green River upstream			X	X				X								X				X			
19	Green River above L Summit			X	X								X			X				X		X		
11	Green River below L Summit			X	X		X		X			X	X			X					X			
13	Big Hungry River			X	X							X	X			X						X		
LL1	Reedypatch Creek			X	X							X	X			X					X			
LL2	Hickory Creek			X	X			X				X	X	X		X					X			
LL3	Broad River			X	X				X			X	X	X		X								
Mud Creek watershed																								
21	Mud Creek at Berea Ch Rd			X	X		X	X	X		X	X	X	X										
3	Mud Creek at Erkwood Road			X	X			X	X			X	X	X		X								
18	Mud Creek at 7th Ave/H'ville			X	X			X	X				X	X		X					X			
15	Bat Fork Creek			X	X			X					X			X								X
30	Devil's Fork			X	X		X		X		X	X	X	X										
26	Brittain Creek			X							X		X	X										
20	Clear Creek upstream				X								X	X		X					X	X	X	
5	Clear Creak downstream			X	X			X	X				X	X		X					X			
4	Mud Creek at N Rugby Rd			X	X			X					X	X		X					X	X	X	
Mills River watershed																								
7	North Fork Mills River				X								X			X	X				X	X		
8	South Fork Mills River			X	X								X									X		
9	Mills River at 191/280				X								X			X						X		
29	Brandy Branch					X			X			X	X											

10	Mills River at Hooper Ln			X	X								
----	--------------------------	--	--	---	---	--	--	--	--	--	--	--	--

X				X					X				
---	--	--	--	---	--	--	--	--	---	--	--	--	--

A17

Appendix G: Trends for Each Site Related to Flow - continued

site #	site name	increases as flow increases											
		pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-n	Nitrate-n	
	Cane Creek watershed												
22	Hooper's Creek				X								
16	Cane Creek/Howard Gap Rd			X	X			X					X
	Etowah/Horseshoe												
23	Big Willow Creek												
25	Gash Creek			X									
28	Shaw Creek						X		X				
27	Mill Pond Creek			X	X				X		X		
14	Boylston Creek			X	X				X				
	French Broad River												
1	French Broad River/Horseshoe			X	X								
2	French Broad River/Mt Home			X	X			X	X				

decreases as flow increases												
pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-n	Nitrate-n		
X	X			X								
	X			X								
X	X			X					X			
X	X								X			
X	X											
X	X			X					X	X		
X	X			X					X			

A-19

Appendix H: Trends for Each Site Related to Time

		increasing over time										decreasing over time												
site		pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	
Green/Broad River watershed																								
12	Green River upstream	X				X				X	X	X												
19	Green River above L Summit	X				X					X	X												
11	Green River below L Summit	X				X					X	X									X			
13	Big Hungry River	X	X			X				X	X	X												
LL1	Reedypatch Creek	X	X			X					X	X												
LL2	Hickory Creek	X									X	X												
LL3	Broad River	X									X	X												
Mud Creek watershed																								
21	Mud Creek at Berea Ch Rd	X															X				X	X	X	
3	Mud Creek at Erkwood Road							X						X			X	X		X	X			
18	Mud Creek at 7th Ave/H'ville	X																X		X	X			
15	Bat Fork Creek	X												X	X	X	X	X		X	X			X
30	Devil's Fork	X													X			X			X	X		
26	Brittain Creek	X																X						
20	Clear Creek upstream	X	X	X		X	X	X	X	X	X	X												
5	Clear Creak downstream	X				X	X	X		X	X													
4	Mud Creek at N Rugby Rd	X								X	X	X												
Mills River watershed																								
7	North Fork Mills River	X					X				X	X								X				
8	South Fork Mills River	X									X	X												
9	Mills River at 191/280	X									X	X		X	X									

29	Brandy Branch																			
10	Mills River at Hooper Ln	X						X											X	

			X					X	X				X	X	X	X				
													X							

Appendix H: Trends for Each Site Related to Time-continued

site #	site name	increasing over time																		
		pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N								
	Cane Creek watershed																			
22	Hooper's Creek	X																		
16	Cane Creek/Howard Gap Rd	X				X				X	X	X								
	Etowah/Horseshoe																			
23	Big Willow Creek	X																		
25	Gash Creek	X																		
28	Shaw Creek	X																		
27	Mill Pond Creek	X																		
14	Boylston Creek	X											X	X						
	French Broad River																			
1	French Broad River/Horseshoe												X	X						
2	French Broad River/Mt Home							X	X		X	X	X	X						

		decreasing over time										
		pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N
							X				X	
						X	X	X	X	X	X	X
				X							X	
									X		X	
									X			
		X				X	X					
		X				X						

APPENDIX I: Number of Sites Exhibiting Seasonal Trends

Seasons include the following months:
 winter = December, January, February
 spring = March, April, May
 summer = June, July, August
 fall = September, October,
 November

Totals for Henderson County Sites

number of sites examined for trends = 27

parameter	hi winter	hi spring	hi summer	hi fall	lo winter	lo spring	lo summer	lo fall	trend sites	% sites showing trend
pH		3	7	6	16				16	59.3%
alkalinity			4	15	3	16			19	70.4%
turbidity	2	1	13		3	1		12	16	59.3%
total susp sol		1	15		4			12	16	59.3%
conductivity	5		3	9	1	14	2		17	63.0%
copper			3	1	2	2			4	14.8%
lead			4	1	3			2	5	18.5%
zinc	4		2				4	2	6	22.2%
orthophos.	1		6		2	5			7	25.9%
ammonia-N			5		3	1		1	5	18.5%
nitrate-N	16		2			3	4	11	18	66.7%

Totals for All VWIN Sites Examined for Trends

number of sites examined for trends = 174

parameter	hi winter	hi spring	hi summer	hi fall	lo winter	lo spring	lo summer	lo fall	trend sites	% sites showing trend
pH		5	46	45	84	11		1	96	55.2%
alkalinity			35	79	21	92	1		114	65.5%
turbidity	4	32	82		61	14		53	128	73.6%
total susp sol	1	32	97	1	79	1		51	131	75.3%
conductivity	12	3	36	79	22	101	4	3	130	74.7%
copper		3	22	2	21	4		2	27	15.5%
lead	1	9	26	1	23	2		12	37	21.3%
zinc	5	7	25		12	9	6	10	37	21.3%
orthophos.	1		54	4	33	23		3	59	33.9%
ammonia-N	6	3	51	5	40	9	5	11	65	37.4%
nitrate-N	83	12	36	1	14	12	17	89	132	75.9%

APPENDIX J: Biological Monitoring Score for Each Monitoring Period Since 2002 and Overall Rating

Appendix J: Biological Monitoring Score for Each Monitoring Period Since 2002 and Overall Rating

VWIN SITE NUMBER	SITE NAME	Apr-02	Oct-02	Apr-03	Oct-03	Apr-04	Oct-04	Apr-05	Oct-05	Apr-06	Oct-06	WQ # MEDIAN	WQ LETTER RATING
		WQ # RATING	WQ # RATING	WQ # RATING	WQ # RATING	WQ # RATING	WQ # RATING	WQ # RATING	WQ # RATING	WQ # RATING			
Mills River Watershed													
7	North Mills River	26	22	19	19	24	14	14	16	14	10	18	Good
8	South Mills River	21	22	13	23	21	15	19	15	18	12	19	Good
9	Mills River Hwy 191	22	17	21	19	18	20	15	15	14	17	18	Good
10	Mills River Hooper Lane	16	16	17	19	17	15	19	19	18	20	18	Good
Clear Creek Watershed													
	Clear Creek at Lancaster	17	24	16	17	16	14	15	15	15	16	16	Fair
20	Clear Creek at Bearallow	24	23	22	18	14	12	11	14	12	15	15	Fair
5	Clear Creek at Nix Road	17	15	18	15	15	18	14	14	11	16	15	Fair
Cane Creek Watershed													
22	Hooper's Creek	10	13	9	12	10	11	11	12	11	11	11	Fair
16	Cane Creek at Howard Gap Rd	9	14	15	14	19	9	9	12	12	13	13	Fair
Etowah-Horseshoe													
14	Boylson Creek	17	15	3	11	6		12	10	17	9	11	Fair
27	Mill Pond Creek	10	12	10	19	9	9	6	10	14	15	10	Poor
28	Shaw Creek	20	18	16	16	11	9	12	6	7	14	13	Fair
25	Gash Creek	8	10	7	11	11	5	5		9	10	9	Poor
24	Little Willow Creek	19	9	6	16	17	8	9		12		11	Fair
23	Big Willow Creek	14	13	15	15	12	11	12		14	13	13	Fair
Mud Creek Watershed													
21	Mud Creek at Berea Church Rd	21	7	12	15	14	17	15	17	11	21	15	Fair
3	Mud Creek at Erkwod Rd	17	16	11	11	7	13					12	Fair
18	Mud Creek at 7th Avenue	18	18	12	15	14	6	11	10	16	12	13	Fair
26	Brittain Creek	15	23	17	14	15	14	7	13	18	9	15	Fair
Green River Watershed													
	Green River at Bob's Crk Rd	15	20	27	20	18		11		16	20	19	Good
	Rock Creek	24	23	16	24	22	15	15		13	12	16	Fair
12	Green River at Terry's Crk Rd	9	17	15	19	16		14	25	5	10	15	Fair
11	Green River below Lake Summit	22	21	16	17	21		17	26	22	20	21	Good

	Little Hungry	25	25	23	16	19	14	21	Good
	Big Hungry	21	21	19	18	23	22	21	Good
13	Big Hungry below dam	21	21	9	0	24	18	20	Good

A-24