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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 Dick Black, Joe Boterf, Dave and Betty Bucher, Peter Colburn, Richard and Brenda Cross, Karen and Phil Cutright, Richard Freudenberger, Beth and Dave Harris, Lee Johnson, Sue and Walter Mahnken, Bill Moore, Glenn Musser, Bill Rylands, Denise Sherrill, Betty Shevick, Jim and Sharon Spicer, Colette Summitt, William Tharp, Mandy Walline, and Marilyn Westphal. 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 also go to Michelle Skeele who has graciously allowed the program to use her porch as a kit storage area, and to the county coordinators 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 Doreen Blue and Lucy Butler for their passionate and dedicated administration of the biological monitoring program, and to all the biomonitoring volunteers including Melissa Acker, Ron Baird, Wayne Blackbourn, Frank Blazey, Doreen Blue (Green River team captain), Kristina Bowers, Anthony Brancato, Patrick Brennan, Bob Brown, Lucy Butler (Mills River team captain), Andy Cambron, Alan Cameron, Tom Cameron, Lia Campbell, Thomas Clyde, Brian and Pam Crissy, Sims Crownover, Sheila Davis, Tom Davis (Mills River team captain), Holly Demuth, Judy Deutsch, Anne Elks, Michael Fitzpatrick, Harry and Lynn Fozzard, Bill Garrison (Mud Creek team captain), Louisa and Paul Goebel, Don Goodman, Norm Green, Katie Greenberg, Kendra Hammond, Sue Haskel, Liz Honnold, Jessica Houston, Fran Hudelson, Mike Judd, Amy Kobos, Mark and Eric Lauer, Ramsay Lawson, Betty and Jim Liebzeit, Arnie Lingle, Peter and Barbara Mackinnon (Hungry River team captains), David Mangum (Etowah II team captain), Lee McCall, Scott McDermott, Don Miller, Jim Mitchel, Bill Moore, Joe Morrow, Tina Moss, Pat Norwood, Monica Owen, Bob and Maryjane Pell, Jon Popowski, Lucy Prim, Amy Robinson, Kay Shurtleff, Christel and David Smith, Linda Sokalski, Tara Taylor, Casey Thurman, Paul Weinberg, David Weintraub (Green River team captain), Lori Williams, Jim Woolrich, and Bob Youngblood (Cane Creek team captain).

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.

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 Town 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 number of sites to over 200. Monthly sampling of these sites provides extensive water quality information for the French Broad, Broad, Catawba, Tuckasegee, 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 fifteen years of water quality data. This annual report represents statistical analyses and interpretation of fifteen years of data gathered from August 1992 through July 2007 for the currently monitored 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.

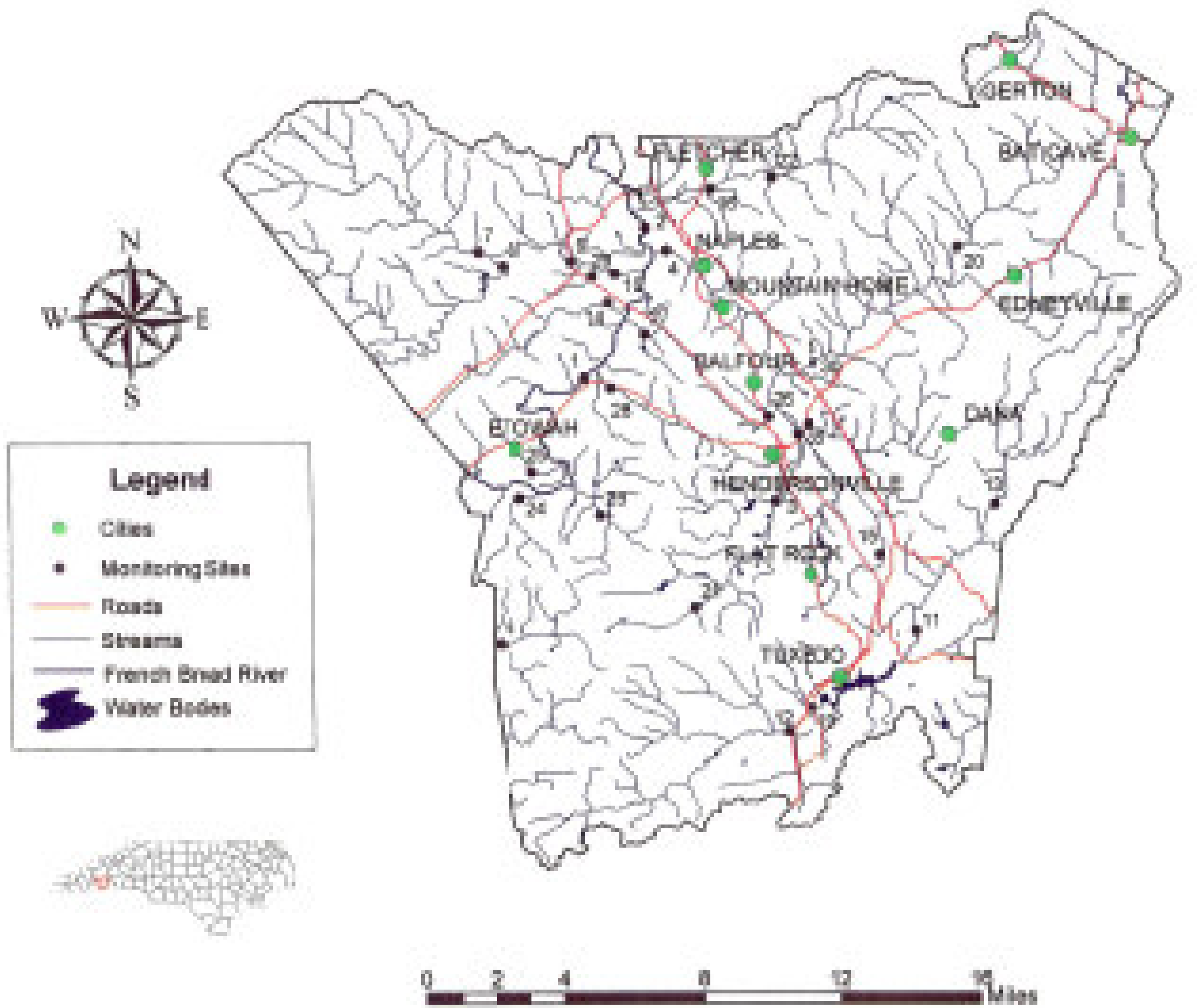
The ECO biological stream monitoring program, funded by the Helen Tarazov Reed Fund, utilizes the Save Our Streams (SOS) program of the Izaak Walton League of America (IWLA). This system provides water quality ratings based on the pollution tolerance levels of the organisms found and the diversity of 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 six years of sampling twice per year and represents baseline data and some information on changes over time.

Table 1: Location of Henderson Co. VWIN sites

Site#	Approximate Stream Location
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 VWIN Monitoring S tes



II. Methodology

Chemical Monitoring

Volunteers are provided with instructions about sample collection procedures prior to their first sample collection day. Instruction is provided through hands-on experience by a VWIN coordinator, and a training manual is given to each volunteer to read.

Henderson County stream samples are collected on the third Saturday of each month. Collecting coincident samples from all the sites in the monitoring area greatly reduces meteorological variability between sites. Therefore, the volunteers are asked to collect samples from the assigned site as close to noon as possible. 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. Information recorded by the volunteer (chain-of-custody form) can be found in Appendix A.

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 to the EQI laboratory for analysis Monday morning. A description of the laboratory analysis methodology is contained in Appendix B. After analysis, the empty bottles are cleaned in the laboratory and then packed together with a blank data sheet 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) Compare water quality of each stream site relative to all other sites in the VWIN program;

3) Identify effects of precipitation, stream water level, and seasonality and temporal trends on water quality, after sufficient data has been collected.

Biological Monitoring

Prior to the initial sampling, volunteers attend a training workshop conducted by David Dudek, Haywood Community College instructor and certified biologist. Additional training is provided through hands-on instruction by the coordinator at the stream sites. New volunteers are trained in review sessions available to all volunteers before each sampling campaign and trained individually at the sites. The coordinator works with each team during the sampling period to insure consistency in procedures, identification, and analysis.

Each of the volunteer teams sample 2 to 4 sites during the April and October sampling campaigns. The specific sampling times during the designated months are left at the discretion of individual teams although the teams are asked to avoid severe weather events. At each site, three separate samples are taken. Each sample is taken at a riffle (a shallow fast-moving area with a depth of 3-12 inches and cobble-sized stone or larger) where the water is highly oxygenated. Only the sample with the highest score and, therefore, the best diversity (greatest number of different kinds of organisms) is recorded. This is to ensure that the sample is truly representative of the organisms present in the stream.

Volunteers use a 3-foot wide kick-seine (a 1/32- inch mesh net with a supporting pole on each side) to collect the benthic macroinvertebrate samples in selected riffle areas. The stream bed, including rocks, sand, and sediment, is disturbed (by rubbing rock surfaces and kicking the substrate) for a distance of 3 feet upstream of the kick-seine to dislodge any attached or burrowing organisms. All detached macroinvertebrates are carried into the net. The net is then carefully removed from the water, taken to shore, and placed in a well-lit area on a light background (i.e. white plastic trash bag). All living organisms are picked out of the net and roughly sorted based on distinguishing features (i.e.numbers of legs, gill location, tail structure, etc.). Plastic ice cube trays or other small containers are helpful in this segregation process. Once all the macroinvertebrates have been removed from the seine and separated into look-alike groups, the organisms are identified, counted, and recorded on a worksheet. The described procedure is then used to collect and analyze two additional samples at the site. These are taken from an upstream or an adjacent riffle to make sure organisms caught are new and not those disturbed from previous tests.

The sample with the highest score or "total index value" is recorded on the Save Our Streams Stream Quality Survey (Appendix C) and used to determine the Water Quality Rating of the site. The total index value for a sample is based on the number of different organisms in each of three pollution-sensitivity categories and a weighted factor for each category: (I) sensitive –3X (II) somewhat sensitive- 2X and (III) tolerant-1X. It should be noted that this result depends primarily on the number of <u>different</u> organisms found (i.e. diversity) and not on the number of individual organisms, as designated by letters, A, B, and C. However, the letters are valuable because they document changes in population over time. The Water Quality Rating for a particular site is related to total index value as follows: Excellent - >22, Good- 17 to 22, Fair - 11 to 16, and Poor - < 11.

III. Results and Discussion

This discussion is based on fifteen years of data gathered between August 1992 and July 2007. 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 2004 through July 2007 (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	C	D	D	B	B	B	B	B	A	B
3	Mud Creek/Erkwood Rd	A	C	C	B	B	A	B	B	A	A	B
4	Mud Creek/N Rugby Rd	A	B	C	C	C	A	A	B	D	A	C
5	Clear Creek/Nix Rd	A	B	B	A	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	B	A	A	A	A	D	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	A	B	A	B	A
13	Big Hungry River below dam	A	B	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	B	A	A	C	A	A	A	A	A	C
16	Cane Creek/Howard Gap Rd	A	B	C	B	C	B	B	B	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	B	A	A	A	A	A	A	A	A
20	Clear Creek/Apple Valley Rd	A	C	B	A	B	B	B	B	A	A	B
21	Mud Creek/Berea Church Rd	A	C	B	B	B	A	A	A	A	A	B
22	Hoopers Creek/Jackson Rd	A	B	C	B	C	A	A	A	B	A	B
23	Big Willow Creek/Patterson Rd	A	C	B	B	B	A	A	B	A	A	A
25	Gash Creek/Etowah School Rd	A	A	D	B	C	A	A	B	C	C	B
26	Brittain Creek/Patton Park	A	B	C	B	C	A	A	B	A	A	B
27	Mill Pond Creek/S Rugby Rd	A	A	B	A	D	A	A	A	B	B	B
28	Shaw Creek/Hunters Glen	A	B	B	A	C	B	A	A	A	A	B
29	Brandy Branch/Mills R Village	B	C	B	A	C	A	A	B	B	A	C
30	Devil's Fork/Dana Rd	A	B	C	A	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	A	A	B	B	A	A	B	A	A
LL3	Broad River at Bat Cave	A	C	B	A	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 regional 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 over 200 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. Appendices J and K are the biological scores and ratings for each biological monitoring event from 2002 - 2004 and 2005 - 2007.

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.

Figures 2 and 3 show median pH and alkalinity levels for each monitoring site compared to median levels for all sites in Western North Carolina and to sites in relatively undisturbed areas.

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

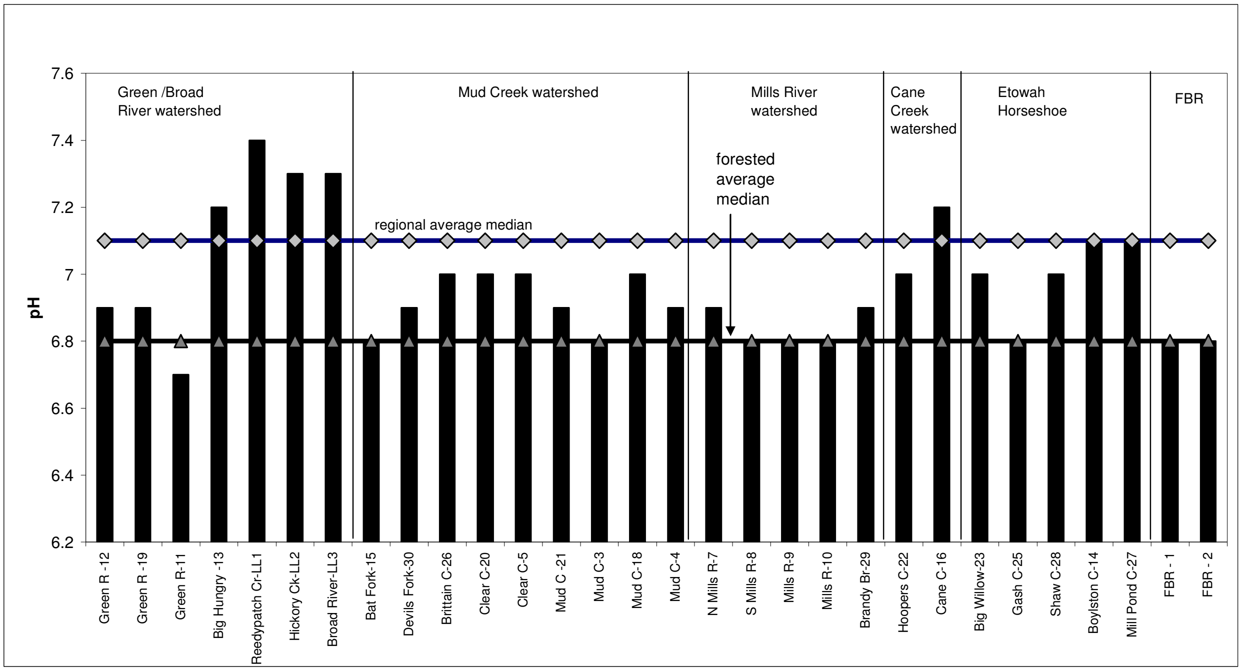
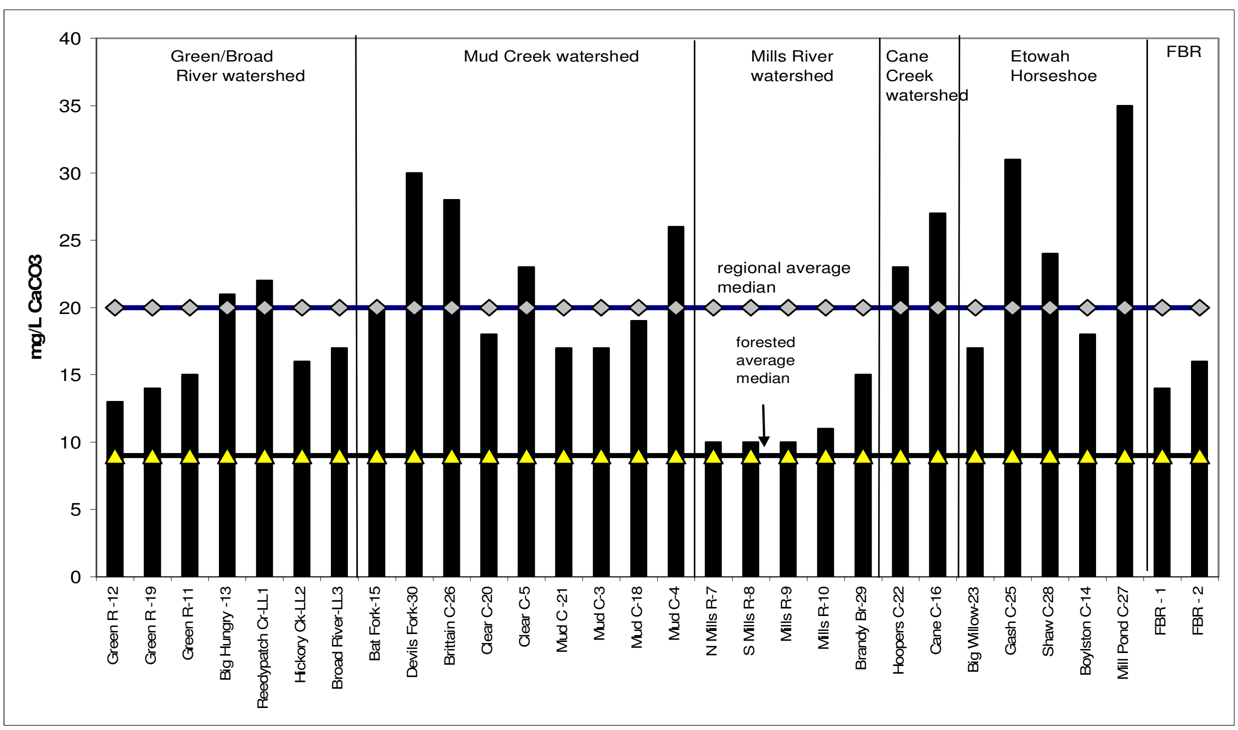


Figure 3: Median alkalinity levels for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



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.

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.

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).

Figures 4 and 5 show median turbidity levels and total suspended solids concentrations for each monitoring site compared to median levels for all sites in Western North Carolina and to sites in relatively undisturbed areas.

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

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

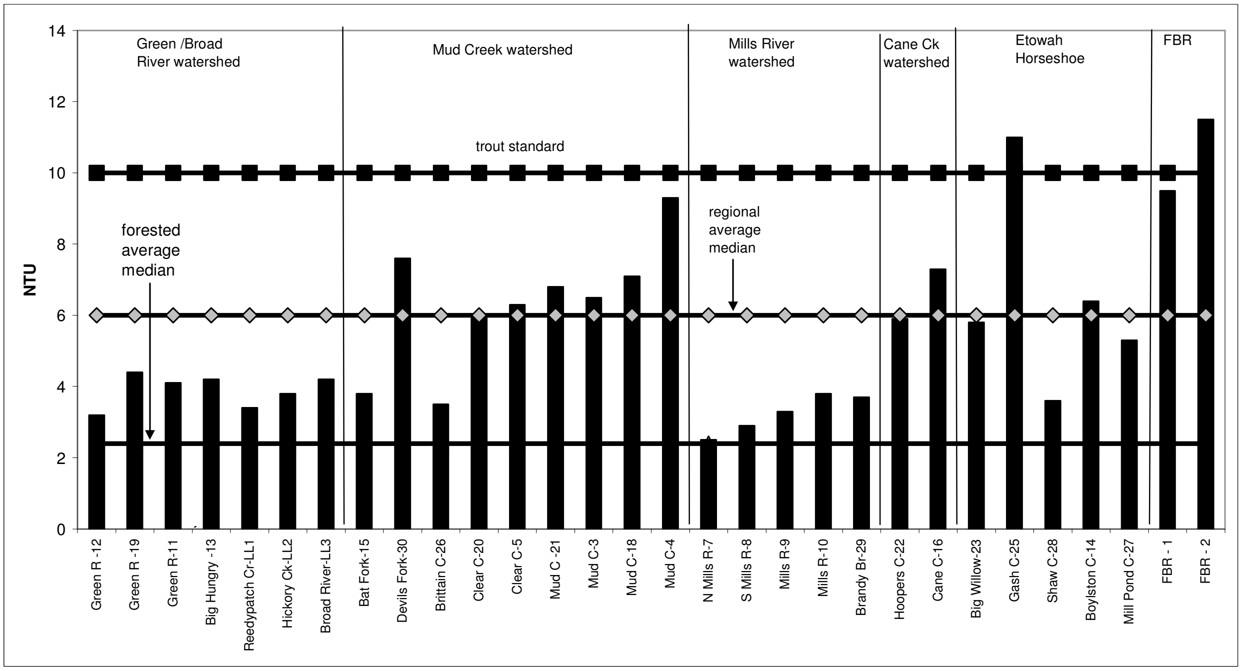
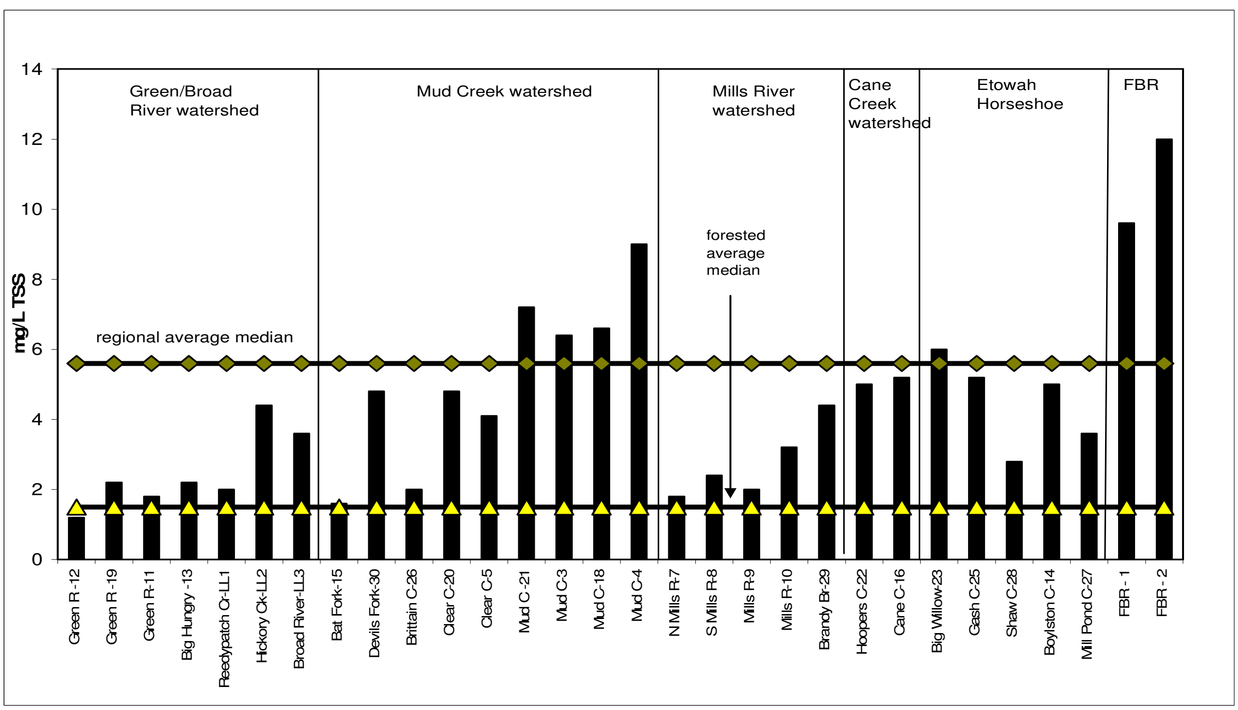


Figure 5: Median total suspended solids concentrations for each VWIN monitoring site compared with the average median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



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. 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. The 2007 drought resulted in extremely infrequent significant stream rise and very few samples collected.

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

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

Broad River site upper Broad Rvr wtrshd	med peak flow prior 114 CFS 8/99-12/02 median mg/L	sample count	med peak flow prior 881 CFS 2003 median mg/L	sample count	med peak flow prior 773 CFS 2004 median mg/L	sample count
Clear Branch	1808.0	4	878.8	13	1869.2	18
Upper Middle Broad River	219.4	24	476.2	13	521.1	11
Rock Creek	209.0	17	625.7	20	4579.8	11
Sand Branch	1470.1	6	901.8	13	1333.3	23
Rush Branch	487.7	15	554.6	15	497.6	11
Lower Flat Creek	349.1	44	705.4	28	3220.6	19
Hemlock Falls Creek	3750.0	7	3276.9	17	5595.0	17
Hickory Creek watershed						
Bearwallow Creek	966.6	16	935.7	5	3383.3	13
Tom's Fork Creek	1043.8	10	1406.6	6	1922.7	7
Reedypatch Creek watershed						
Hominy Mill Branch	2345.8	3	855.4	6	2063.6	12
Lower Reedypatch Creek	215.5	27	337.5	13	708.7	12

Broad River site upper Broad Rvr wtrshd	med peak flow prior 675 CFS 2005 median mg/L	sample count	med peak flow prior 504 CFS 2006 median mg/L	sample count	med peak flow prior 511 CFS 2007 median mg/L	sample count
Clear Branch	834.1	13	4750.0	6	635.1	1
Upper Middle Broad River	455.1	25	3079.1	12	106.8	7
Rock Creek	273.3	18	1987.0	10	176.8	1
Sand Branch	482.8	17	2860.0	9	1127.5	3
Rush Branch	821.6	11	3371.4	3	181.4	1
Lower Flat Creek	641.8	25	882.1	9	557.7	4
Hemlock Falls Creek	752.1	21	1708.4	4	3842.1	9
Hickory Creek watershed						
Bearwallow Creek	2957.7	3	2102.0	4	847.4	2
Tom's Fork Creek	1602.3	4	2261.9	6	1963.4	8
Reedypatch Creek watershed						
Hominy Mill Branch	390.2	2	1094.0	6	1559.9	3
Lower Reedypatch Creek	687.3	20	1895.2	8	558.9	8

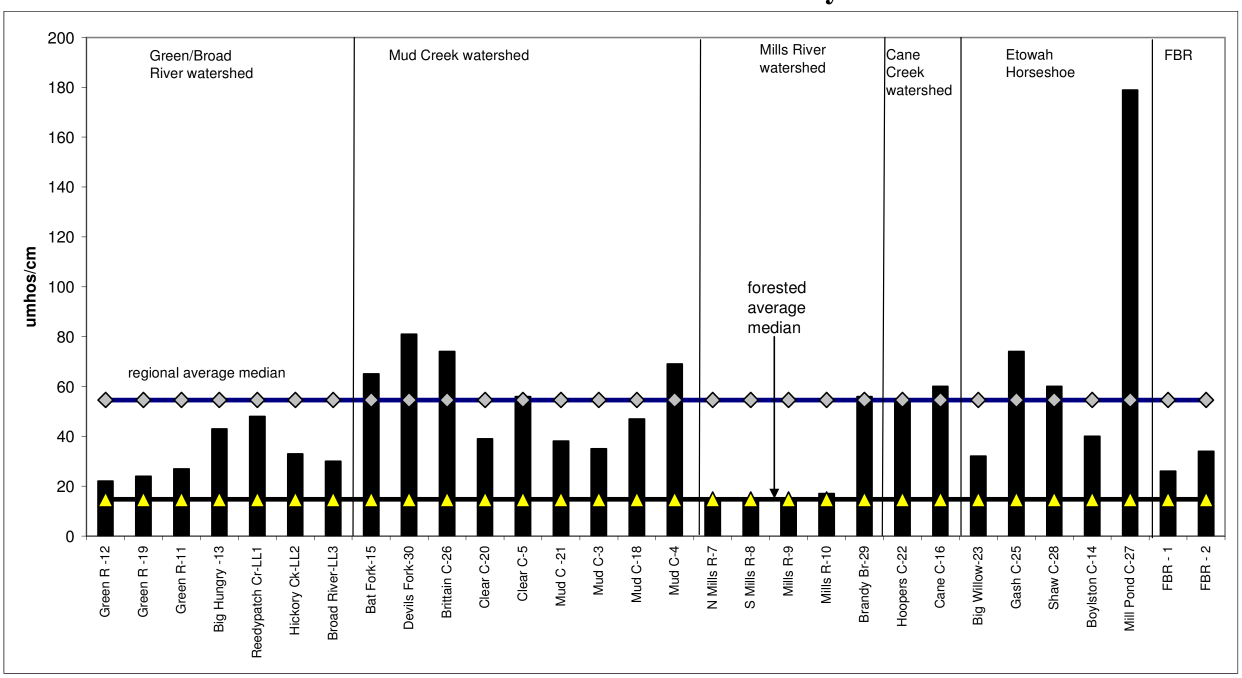
to erosion.

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.

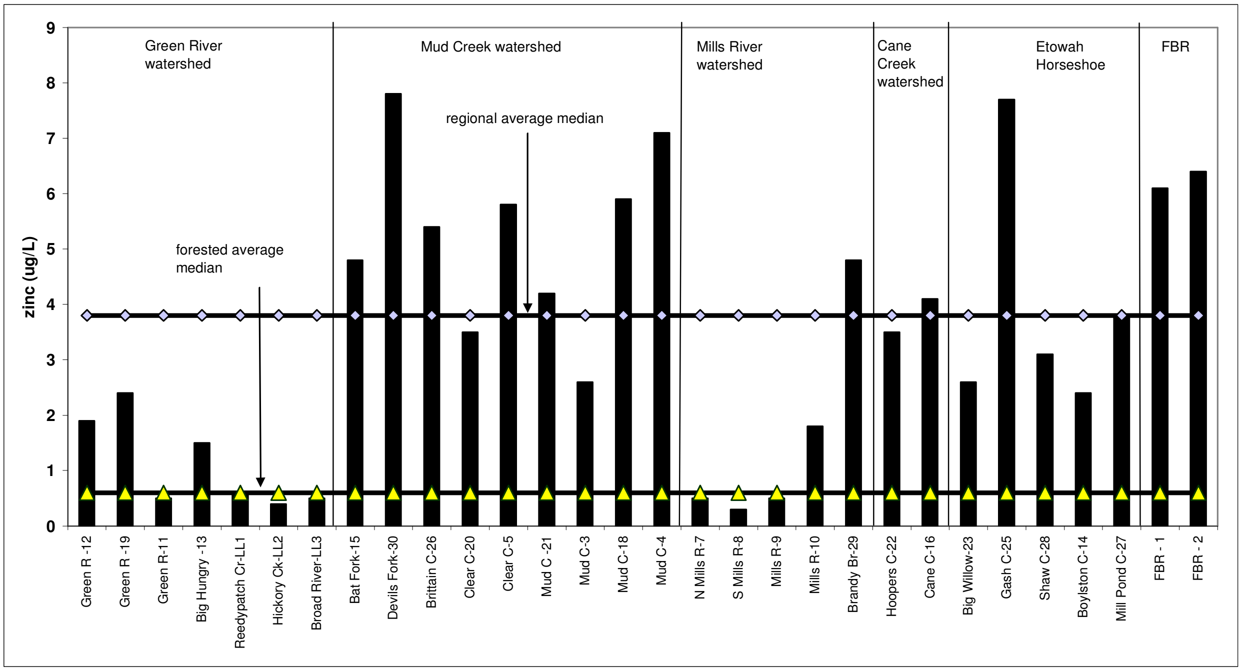
Figure 6 shows median conductivity levels for each monitoring site compared to median levels for all sites in Western North Carolina and to sites in relatively undisturbed areas. Figure 7 shows median zinc concentrations for each monitoring site compared to median concentrations for all sites in Western North Carolina and to sites in relatively undisturbed areas. Table 5 shows the number of times each site has exceeded water quality standards for copper, lead, and zinc in the past three years.

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



D. Nutrients (Orthophosphate (PO_4^{3-}), Ammonia-Nitrogen (NH_4^+/NH_3), and Nitrate/Nitrite-Nitrogen (NO_3^-/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

Figure 7: Median zinc concentrations at each VWIN monitoring sites compared with the median for all VWIN sites in WNC and with sites in relatively undisturbed forested areas



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 (NH_4^+/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.

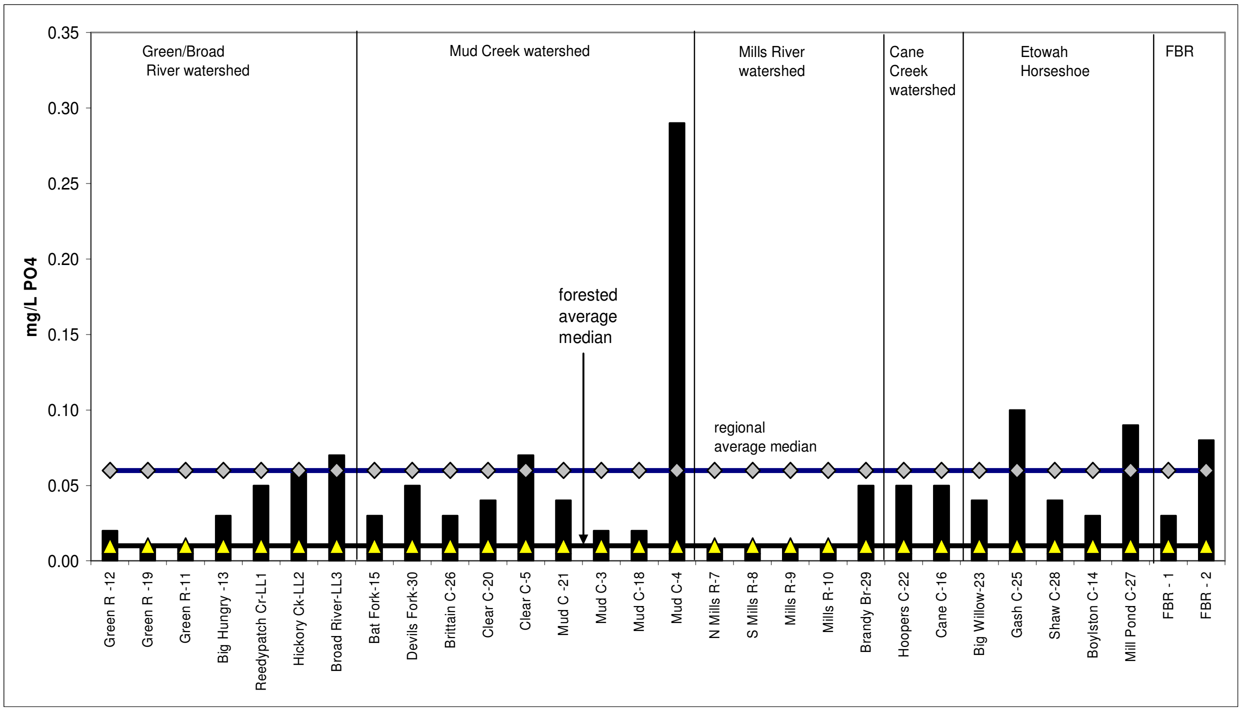
Like phosphorus, **nitrate/nitrite-nitrogen (NO_3^-/NO_2^-)** serves as an algal nutrient contributing to excessive stream and reservoir algal growth. In addition, nitrate is highly toxic to infants and the unborn causing inhibition of oxygen transfer in the blood stream at high doses.

Table 5: The number of times each site has exceeded water quality standards for copper, lead, and zinc in the past three years

site		copper	lead	zinc
site	**Green River/Broad River Watershed**			
12	Green River at Terry's Creek Road	0	0	1
19	Green River upstream Lake Summit	0	0	0
11	Green River dwnstrm Lake Summit	0	0	0
13	Big Hungry River downstream	1	0	1
LL1	Reedypatch Creek	0	0	0
LL2	Hickory Creek	1	0	0
LL3	Broad River at Bat Cave	0	0	0
	Mud Creek Watershed			
21	Mud Creek at Berea Church Road	0	0	0
3	Mud Creek at Erkwood Road	0	0	1
18	Mud Creek at 7th Avenue	0	0	0
15	Bat Fork Creek	0	0	0
30	Devil's Fork	0	0	0
26	Brittain Creek	0	0	0
20	Clear Creek at Bearwallow	1	0	1
5	Clear Creek at Nix Road	0	0	0
4	Mud Creek at N Rugby Rd	0	0	0
	Mills River Watershed			
7	North Fork Mills River	0	0	0
8	South Fork Mills River	0	0	0
9	Mills River at Davenport Bridge	0	0	0
29	Brandy Branch	0	0	2
10	Mills River at Hooper Lane	0	0	0
	Cane Creek watershed			
22	Hoopers Creek	0	0	0
16	Cane Creek at Howard Gap Rd	1	1	1
	Etowah/Horseshoe			
23	Big Willow Creek	0	0	2
25	Gash Creek	0	0	0
28	Shaw Creek	1	0	0
27	Mill Pond Creek	0	0	0
14	Boylston Creek	0	0	0
	French Broad River			
1	French Broad River/Horseshoe	0	0	0
2	French Broad River/Mt Home	3	0	2

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. Figures 8, 9, and 10 show median orthophosphate, ammonia-nitrogen, and nitrate-nitrite-nitrogen concentrations for each monitoring site compared to median levels for all sites in Western North Carolina and to sites in relatively undisturbed areas.

Figure 8: 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



E. Biological Monitoring: This was the sixth 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 - 2007 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. Figure 11 shows high, median, and low biological monitoring scores for the six-year period. Figure 12 shows ratings from 2002 through 2004 monitoring compared to ratings

Figure 9: 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

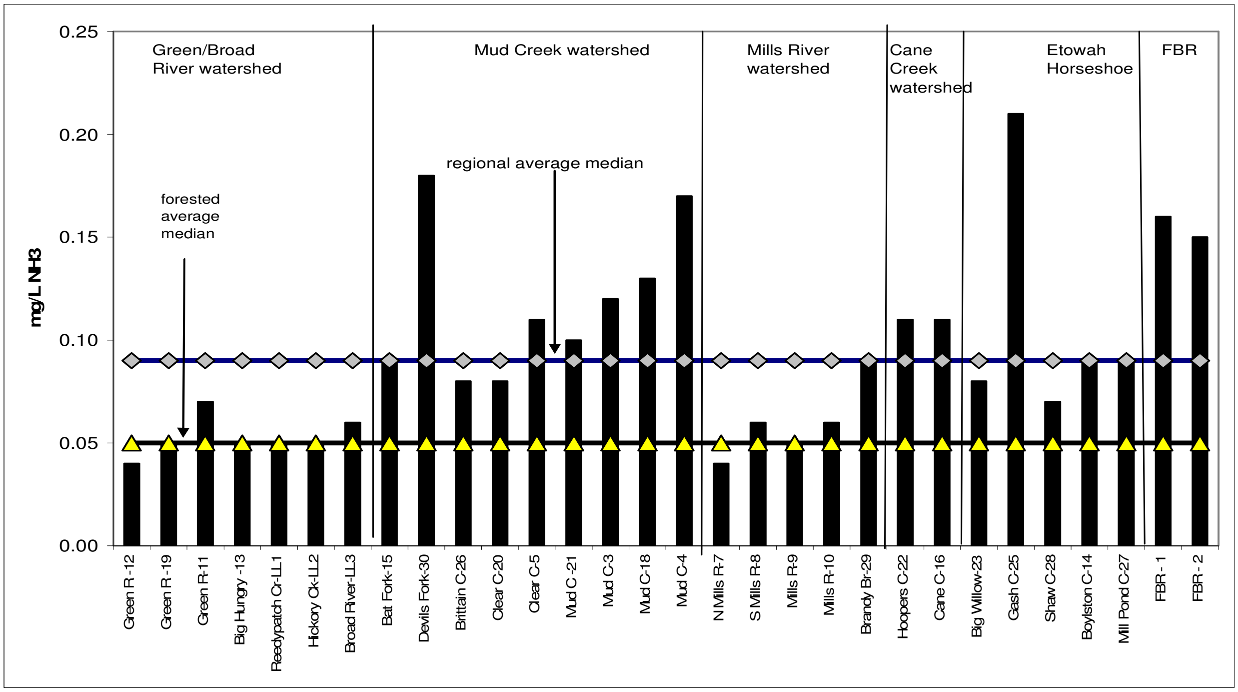
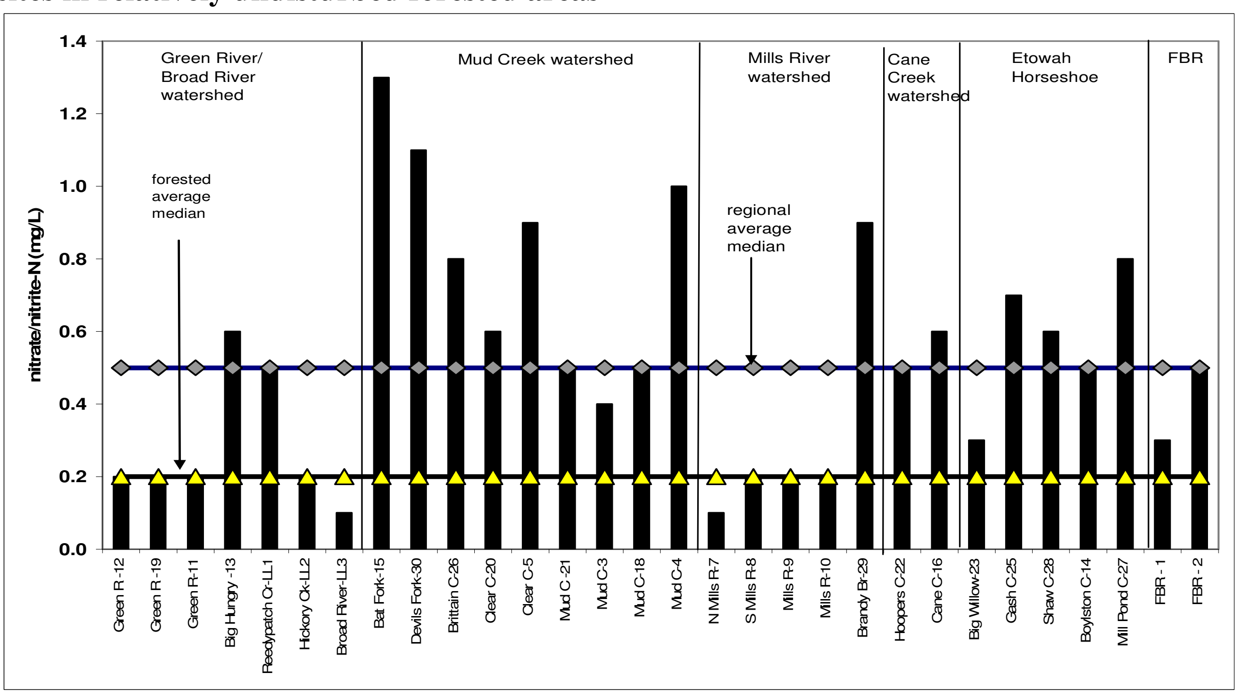
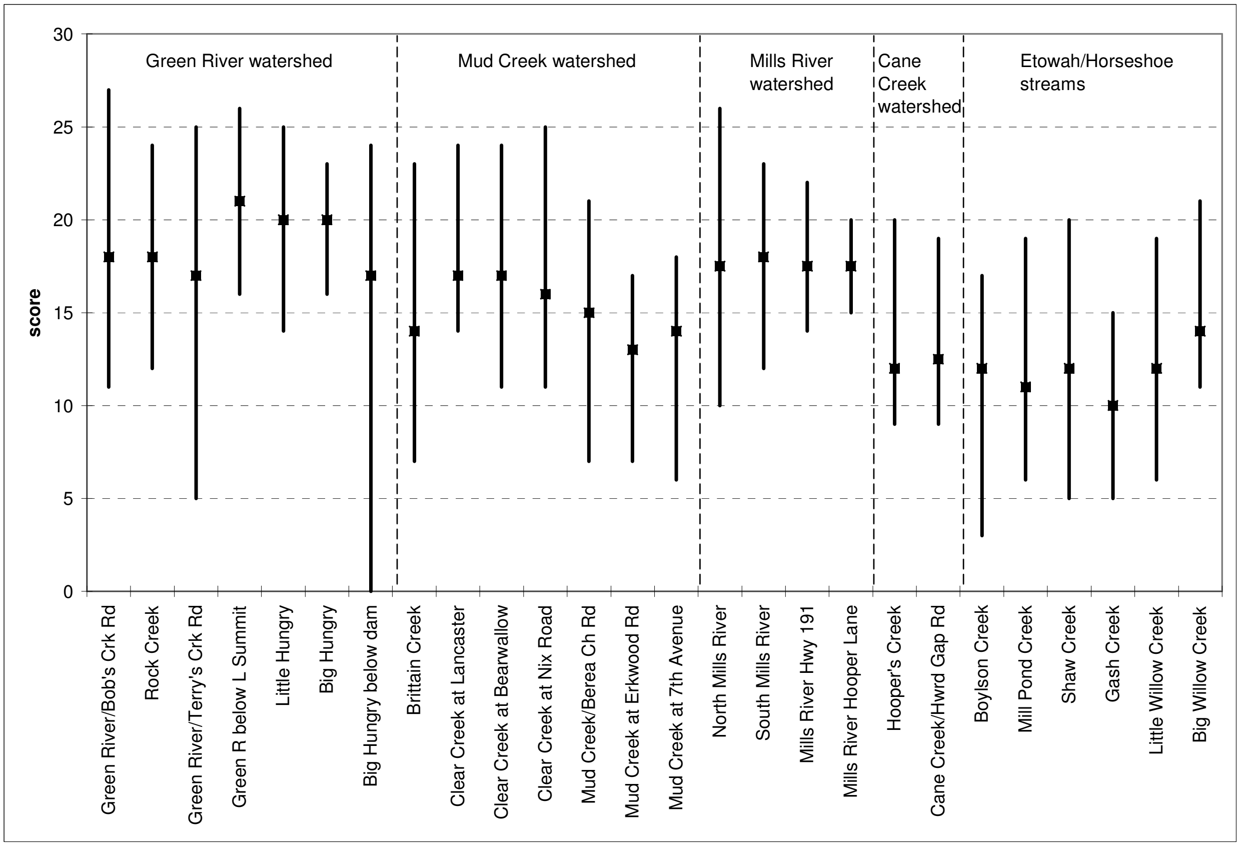


Figure 10: Median nitrate/nitrite-nitrogen concentrations for each VWIN monitoring site compared to the average median for all VWIN sites in WNC and to the average median for sites in relatively undisturbed forested areas



from 2005-2007 monitoring. Figure 13 shows comparative ratings for the April and October monitoring events. Most sites show slightly better scores during the October monitoring.

Figure 11: High, median, and low biological monitoring scores at each site over the past six 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 fifteen years of monitoring are used to determine trends.

Figure 12: Average ratings from 2002 through 2004 biological monitoring compared to average ratings from 2005-2007 monitoring

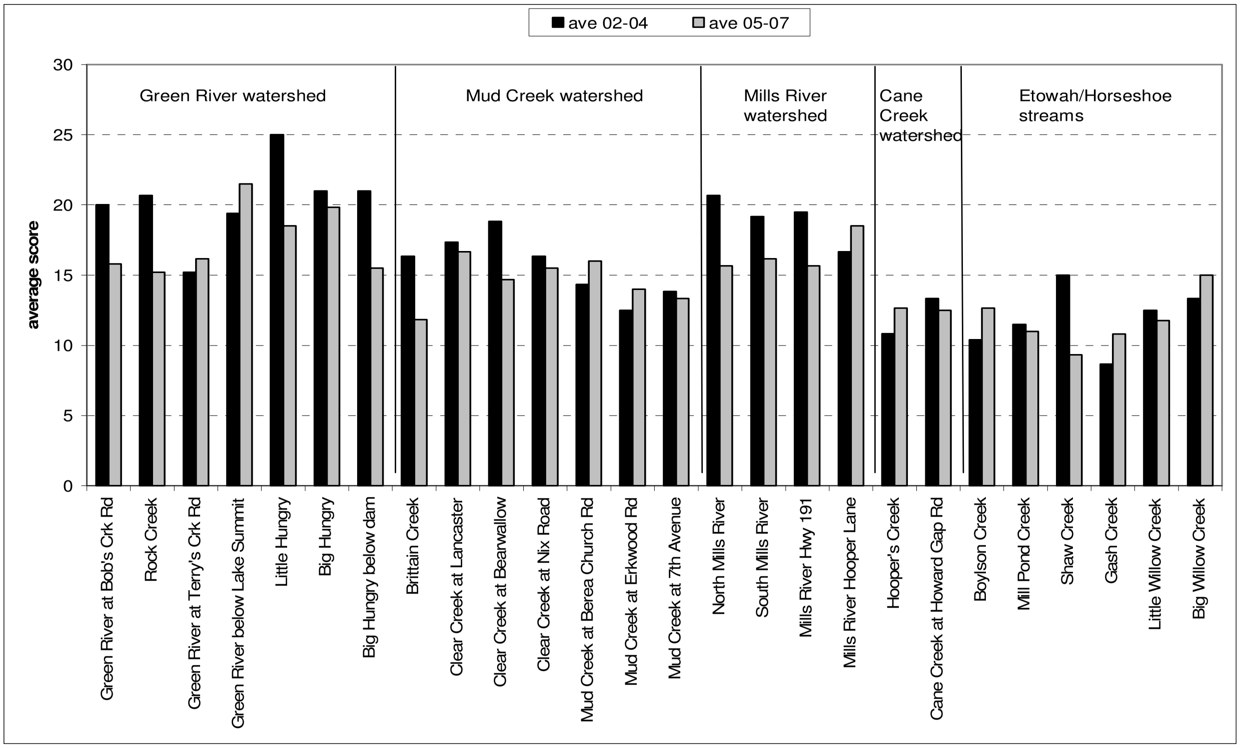
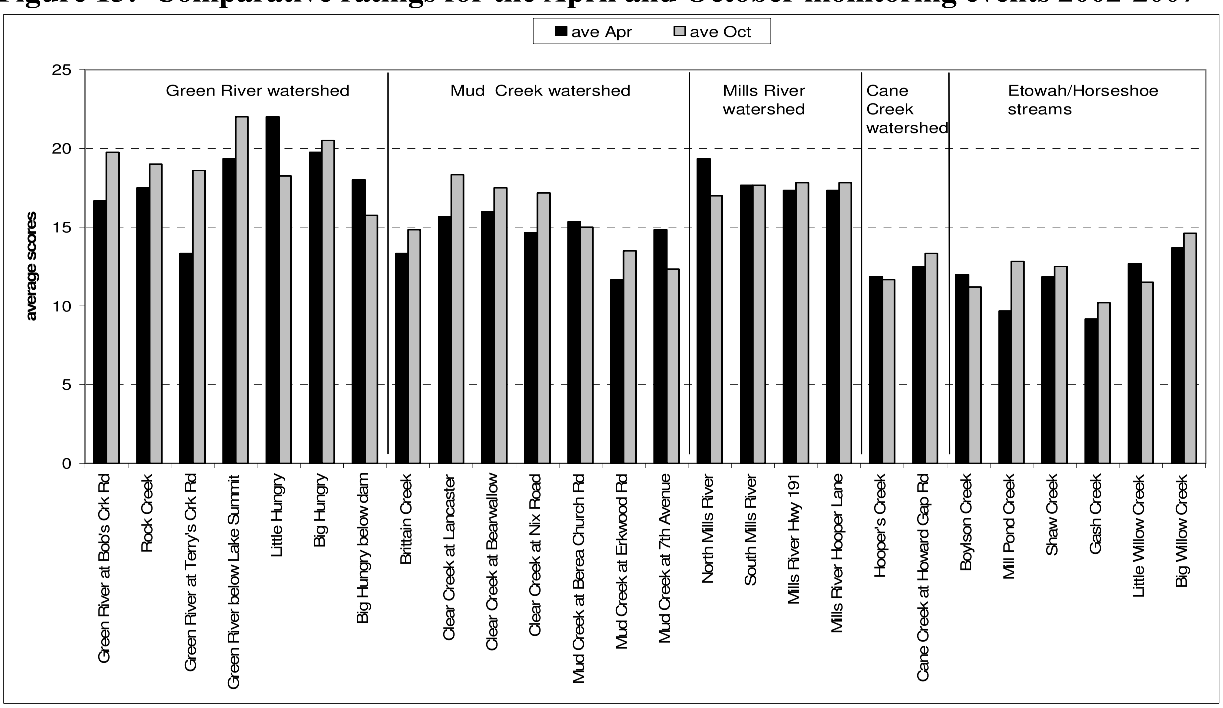


Figure 13: Comparative ratings for the April and October monitoring events 2002-2007



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**	**87**	**82**			
	Green River/Broad River Watershed							
	Rock Creek						15	**Fair**
	Green River at Bob's Creek Road						16	**Fair**
12	Green River at Terry's Creek Road	100	94	92	95	**excellent**	16	**Fair**
19	Green River upstream Lake Summit	88	100	100	96	**excellent**		
11	Green River dwnstrm Lake Summit	88	100	100	96	**excellent**	22	**Good**
	Little Hungry River						19	**Good**
	Big Hungry River upstream						20	**Good**
13	Big Hungry River downstream	100	81	92	91	**excellent**	16	**Fair**
LL1	Reedypatch Creek	63	94	83	80	**good**		
LL2	Hickory Creek	100	88	92	93	**excellent**		
LL3	Broad River at Bat Cave	88	100	92	93	**excellent**		
	Average for this grouping	**90**	**94**	**93**	**92**			
	% sites below regional average	**14%**	**14%**	**14%**	**14%**			

site #	site name	sediment	metals	nutrients	overall	chemical rating	biological score	biological rating
	Mud Creek Watershed							
21	Mud Creek at Berea Church Road	75	94	92	87	**good**	16	**Fair**
3	Mud Creek at Erkwood Road	63	81	92	78	**average**	14	**Fair**
18	Mud Creek at 7th Avenue	75	81	92	83	**good**	13	**Fair**
15	Bat Fork Creek	100	88	83	90	**excellent**		
30	Devil's Fork	75	81	75	77	**average**		
26	Brittain Creek	63	81	92	78	**average**	12	**Fair**
	Clear Creek at Lancaster						17	**Good**
20	Clear Creek at Bearwallow	88	75	92	85	**good**	15	**Fair**
5	Clear Creek at Nix Road	88	81	75	81	**good**	16	**Fair**
4	Mud Creek at N Rugby Rd	50	81	58	63	**below average**		
	Average for this grouping	**75**	**83**	**83**	**80**			
	% sites below regional average	**33%**	**78%**	**44%**	**56%**			

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**	**87**	**82**			
	Mills River Watershed							
7	North Fork Mills River	100	100	92	97	**excellent**	16	**Fair**
8	South Fork Mills River	100	94	75	90	**excellent**	16	**Fair**
9	Mills River at Davenport Bridge	100	100	100	100	**excellent**	16	**Fair**
29	Brandy Branch	88	81	75	81	**good**		
10	Mills River at Hooper Lane	100	100	100	100	**excellent**	19	**Good**
	Average for this grouping	**98**	**95**	**88**	**94**			
	% sites below regional average	**0%**	**20%**	**40%**	**20%**			
	Cane Creek watershed							
22	Hoopers Creek	63	88	83	78	**average**	13	**Fair**
16	Cane Creek at Howard Gap Rd	63	69	83	72	**average**	13	**Fair**
	Average for this grouping	**63**	**79**	**83**	**75**			
	% sites below regional average	**100%**	**50%**	**100%**	**100%**			
	Etowah/Horseshoe							
23	Big Willow Creek	75	88	100	88	**good**	15	**Fair**
	Little Willow Creek						12	**Fair**
25	Gash Creek	50	81	58	63	**below average**	11	**Fair**
28	Shaw Creek	88	81	92	87	**good**	9	**Poor**
27	Mill Pond Creek	88	81	75	81	**good**	11	**Fair**
14	Boylston Creek	75	94	92	87	**good**	13	**Fair**
	Average for this grouping	**75**	**85**	**83**	**81**			
	% sites below regional average	**20%**	**60%**	**40%**	**40%**			
	French Broad River							
1	French Broad River/Horseshoe	50	94	100	81	**good**		
2	French Broad River/Mt Home	25	75	83	61	**below average**		
	Average for this grouping	**38**	**85**	**92**	**71**			
	% sites below regional average	**100%**	**50%**	**50%**	**100%**			
	Overall County Rating							
	Average for All Sites	**78**	**87**	**87**	**84**			
	% sites below regional average	**30%**	**47%**	**40%**	**43%**			

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 continue to 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. Trend analysis shows pH, conductivity, and nitrogen levels increasing over time at all of these sites. Biological monitoring scores for the past three years have declined somewhat from scores for the first three years at several sites, but especially at the sites on the Green River at Bob's Creek Road, Rock Creek, the Little Hungry River, and the Big Hungry River below the dam.

The sites on Hickory Creek and the Broad River rate **excellent** and the site on Reedypatch Creek rates **good**. While median turbidity and total suspended solids levels remain low at the Reedypatch Creek site, maximum levels in the past three years have been well above most other Henderson County sites. Stormwater samples collected for the Upper Broad River Protection Program (UBRPP) also indicate high concentrations of sediment in Reedypatch Creek during rain events. Although median and maximum levels of turbidity and total suspended solids levels have been low the past three years at the VWIN Hickory Creek site, UBRPP storm flow samples in two of the tributaries, Bearwallow Creek and Tom's Fork Creek, exhibit very high sediment concentrations during storms. These two creeks have consistently exhibited high sediment concentrations during storm flow for the past eight years. Also in Henderson County, the UBRPP site on Hemlock Falls Creek in the Bat Cave area has exhibited consistently elevated sediment concentrations during the eight-year study period.

The Mud Creek Watershed

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

Of all the sites monitored in the Mud Creek watershed only Bat Fork Creek rates **excellent**. This is quite an improvement from early years of monitoring at this site when it often rated much lower. Although turbidity and total suspended solids levels are lower than at most sites, median conductivity levels are higher than average, and maximum levels are higher than at most Henderson County sites. The greatest problem at this site continues to be nitrate levels, though. Median concentrations are higher than at any other site in the county, and more than double the regional median. Elevated nitrate concentrations are often an indication of either livestock or urban runoff, or possibly both.

Four sites in the Mud Creek watershed rate **good** including the two sites on Clear Creek, and the sites on Mud Creek at Berea Church Road and at Seventh Avenue. Median and maximum levels of most parameters have remained near or below the regional median at the two sites on Clear Creek over the past three years. The exceptions are heavy metal and nitrate concentrations at the downstream site on Clear Creek at Nix Road, and to a lesser extent nitrate concentrations at the upstream site on Clear Creek at Bearwallow. Urban road runoff is probably responsible for elevated heavy metals concentrations at the downstream site. Trend analysis also shows lead and zinc concentrations increasing as stream flow increases (generally the result of rainfall) at the downstream site. Although median heavy metals concentrations are higher than average at the downstream site on Clear Creek, they have not exceeded acceptable limits in the past three years. However, zinc levels exceeded acceptable standards at the upstream site on Clear Creek in January 2006, and copper concentrations exceeded acceptable levels in March 2005 at that site. In both cases the other analyzed heavy metals concentrations were also higher than normal, but sediment concentrations were normal, so metals attached to sediment were probably not a significant factor.

Although both sites on Clear Creek currently rate **good**, trend analysis show levels of most parameters increasing over time at both sites. Thus, while water quality is improving at many of the other sites in the Mud Creek watershed, water quality is declining at the two sites on Clear Creek. The ratings during periods of drought often reflect less pollutant runoff from lack of rain rather than from actual water quality improvement. However, trend analysis takes stream levels into account.

Both sites on Clear Creek rate **fair** for biological analysis during the past three years. At the upstream site this reflects a decline from a **good** rating in the first three years of monitoring. Biological ratings at the downstream site have remained fairly stable over the past six years. There is an additional biological monitoring site on Clear Creek at Lancaster Road and this site rates **good**, but numerically is only slightly better than the other two sites.

Although the sites on Mud Creek at Berea Church Road and at Seventh Avenue rate **good**, stream sedimentation has occasionally been a problem in the past three years. Median levels are slightly higher than the regional average, and maximum levels, especially at the Berea Church Road site, have been quite elevated. Median zinc concentrations are also higher than the regional median at the Seventh Avenue site. This is a more urban area and urban runoff probably influences water quality more at this site. However, trend analysis shows zinc concentrations decreasing over time at the Seventh Avenue site. Turbidity, copper, and orthophosphate levels are also declining over time. At the Berea Church Road site nutrient concentrations and conductivity levels are declining over time. The closing of a dairy farm that frequently violated regulations can probably account for at least some of the water quality improvements.Biological ratings at the sites on Mud Creek at Berea Church Road and at Seventh Avenue are both **fair**, but the Berea Church Road site usually rates slightly better than the Seventh Avenue site, and have improved slightly in the past three years relative to the first three years of biological monitoring.

Three sites in the Mud Creek watershed rate **average**. These include Mud Creek at Erkwood Road, Devil's Fork, and Brittain Creek. The site on Mud Creek at Erkwood Road is between the two sites discussed above at Berea Church Road and at Seventh Avenue, and ratings are actually quite similar to those other two sites, but stream sedimentation at the Erkwood Road site has been a more consistent problem. In fact biological monitoring was discontinued in 2005 and 2006 because excessive stream bed sediment made it impossible to locate suitable macroinvertebrate habitat at that location. Acceptable zinc concentrations were also exceeded October 2006 during a dry period when total suspended solids concentrations were low, thus were not entering the stream attached to sediment. Like several of the Mud Creek watershed sites, trend analysis shows water quality improving over time at the Erkwood Road site. Conductivity, copper, zinc, and orthophosphate levels are declining. Also like the other Mud Creek sites, the biological rating for the Erkwood Road site is **fair**. During the periods that biological analysis took place the ratings remained fairly consistent.

The rating at the Brittain Creek site is largely influenced by urban runoff, and possibly development in the watershed. Median conductivity, nitrate/nitrite-nitrogen, and zinc levels are higher than average, and maximum conductivity, turbidity, and total suspended solids levels have been exceptionally elevated. Trend analysis shows heavy metals and orthophosphate decreasing over time, but there are fewer parameters showing improvement in this watershed than at the other Mud Creek watershed sites. Like the other Mud Creek watershed sites, biological monitoring rates Brittain Creek **fair**, but the numerical score has declined in the past three years compared to the first three years.

Ratings at the Devil's Fork site are also influenced by urban runoff, but agricultural runoff is also probably a factor. Median levels of most parameters exceed the regional average median levels, although maximum levels are not excessive. Median zinc and nitrogen concentrations are particularly elevated. Elevated zinc concentrations are usually the result of urban runoff, and elevated nitrogen concentrations occur both as a result of urban and agricultural runoff. No biological monitoring is performed at this site because the stream bed is heavily silted.

The site on Mud Creek at Rugby Road improved slightly from a rating of **poor** to a rating of **below average**. However, the slight improvement is in the stream sedimentation category and is probably the result of less runoff from lower rainfall than from any long-term water quality improvement. Trend analysis shows only zinc concentrations decreasing over time, and pH, alkalinity, orthophosphate, ammonia-nitrogen, and nitrate/nitrite-nitrogen levels increasing over time. Median levels of all parameters except pH exceed the regional average median, but median levels of the nutrients analyzed are particularly high. This site on Mud Creek is near the confluence with the French Broad River and pollutants from all other sources upstream, including the Hendersonville wastewater treatment plant, influence water quality. No biological monitoring is performed at this site because the stream is deep and the stream bed is heavily silted.

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

The sites on the North and South Forks of the Mills River and the two sites on the Mills River continue to rate **excellent**. Median levels of all parameters are at or near levels that are typical of streams in heavily forested areas. However, the numerical rating for the site on the South Fork declined considerably as a result of an incident that occurred in June 2007 when nutrient concentrations reached toxic levels from an accidental overflow of livestock waste into the river. There are few temporal trends at the Mills River sites, but nitrogen concentrations are increasing at most sites, zinc concentrations are decreasing at the North Fork site, turbidity levels are decreasing at the South Fork site, and conductivity and orthophosphate levels are declining at the site on the Mills River at Hooper Lane.

Biological monitoring is carried out at all four sites on the Mills River and upper forks. The numerical biological rating at the site on Hooper Lane has improved slightly in the past three years, but remains in the **good** range. The ratings at the other three sites have declined from **good** to **fair**. The reasons are uncertain, but increased vegetable farming might be having an effect on pesticide usage in the watershed. Since this watershed is a major source of drinking water for the region, increased monitoring by the NC Division of Water Quality is recommended.

The one tributary stream monitored in the watershed, Brandy Branch, rates **good**. This is a slight improvement from past ratings. Trend analysis shows water quality improving for almost every parameter analyzed. Median levels of almost every parameter have declined considerably in recent years. Improvements are probably related to land use changes in the upper part of the watershed and to upgrades at the Hendersonville water treatment plant. No biological monitoring occurs at this site.

The Cane Creek Watershed

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

Both sites in this watershed rate **average**. Although median levels of all parameters are near or only slightly above the regional average, maximum levels of many parameters, especially at the Cane Creek site, have been extremely elevated. The site on Cane Creek is the only Henderson County site that has exceeded acceptable levels for all three heavy metals analyzed in the past three years, and it has had the highest turbidity and second highest total suspended solids levels. Stream sedimentation has been a chronic problem in this watershed. Trend analysis shows conductivity, copper, ammonia-nitrogen, and nitrate/nitrite-nitrogen concentrations increasing over time at the Cane Creek site. Biological ratings are **average** at both sites and have shown little overall change during the past six years.

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

All sites in this group except Gash Creek rate **good**. The rating for the Mill Pond Creek site improved slightly from previous years. Although all of these sites rate **good**, they all experience at least one problem parameter. Median turbidity and total suspended solids levels are slightly higher at the Big Willow Creek site than at most other sites in Henderson County, and zinc concentrations have been unusually elevated, frequently exceeding water quality standards, since April 2007. Potential sources of zinc to Big Willow Creek should be investigated. The biological rating for this site is **fair** and it has remained relatively stable for the past six years. Biological monitoring is also carried out at a site on Little Willow Creek and that site has also consistently rated **fair**.

Water quality at the Shaw Creek site has changed little over time. Stream sedimentation is an occasional problem, but low rainfall in recent years has reduced sediment levels. Median conductivity and nitrate/nitrite-nitrogen levels are slightly higher than the regional average, but have not been excessively elevated. Turbidity, copper, orthophosphate, and ammonia-nitrogen concentrations are declining over time at the Shaw Creek site. The greatest concern is the decline in the biological rating from **fair** to **poor** with a numerical score decline from 15 to 9. The decline could be from loss of habitat.

There has been no rating change at the Boylston Creek site since the last report. This is still a relatively turbid stream compared with most other sites in Henderson County, but the low rainfall has resulted in less runoff and few excessive sediment events in recent years. The only long term trends exhibited are increasing pH, alkalinity, and ammonia-nitrogen levels over time, and decreasing zinc concentrations. Biological ratings have remained fairly stable over the years as well. Average rating for the first three years and most recent three years remains **fair**. There is a great deal of silt in the stream bed. Until some of the silt and sand are washed out the habitat for macroinvertebrates will remain marginal.

Although the Mill Pond Creek rating has improved from **average** to **good**, median conductivity levels continue to be greater than twice the regional median, and orthophosphate and nitrate-nitrogen concentrations also exceed regional median concentrations. Nutrient concentrations could be influenced by yard and garden runoff from the neighborhoods upstream, and possibly from package wastewater treatment plant effluent from the two schools in the watershed, but conductivity levels will probably continue to be extremely elevated because the main source is groundwater from the landfill at the headwaters. Trend analysis shows turbidity, heavy metals, and nutrient levels decreasing over time at this site. New construction in the watershed has slowed in recent years and this could be contributing to the improved water quality. The average biological rating at the Mill Pond Creek site has remained **fair** throughout the six years of monitoring.

Gash Creek is one of only three sites in Henderson County that currently rates **below average**, but this is actually an improvement from earlier years of monitoring. With the exception of turbidity and total suspended solids, all other pollutant parameters show declining levels over time. The most notable declines are from zinc and orthophosphate concentrations. Some of the declines are certainly the result of the diversion of Etowah wastewater effluent to the French Broad River, but others may be the result of improved stormwater management techniques upstream. But median turbidity levels are still very high and exceed the trout standard, which is quite unusual for a mountain stream. As with some other waterways in the county, there is a great deal of silt in the streambed and the biological rating at this site has consistently been **poor** for the past six years.

The French Broad River

Includes two sites on the French Broad River

The upstream site on the French Broad River rates **good** and the downstream site rates **below average**. Median levels of most parameters are slightly higher at the downstream site, but median orthophosphate concentrations are significantly greater at the downstream site. This is almost certainly from the influence of inflow from Mud Creek on the downstream site. There are also five sites on the French Broad River in Buncombe County and two in Madison County. Median levels of all parameters except ammonia-nitrogen increase as the river flows through Henderson County, and continue to increase to the site at Corcoran Park a short distance from the Henderson/Buncombe County line (Table 7). From that point median levels remain the same or decline until the river reaches Asheville. Most parameters show a second and, in most cases, a greater peak at the site just downstream from Asheville. But turbidity, total suspended solids, and zinc levels are almost equal to or greater than the peak Buncombe County levels at the Henderson County sites. Eroding river banks in Transylvania and Henderson County are probably the main source of sediment to the river, but Mud Creek is also an important contributor. Based on data from discontinued sites in Transylvania County, the main source of zinc seems to be from Henderson County.

During years of low rainfall the influence of Mud Creek on the French Broad River probably increases. Although relatively clean water from the Mills River also flows into the French Broad River in the same area as Mud Creek, much of the Mills River flow is being drawn down for drinking water before it reaches the French Broad River. Much of that water is returned to Mud Creek as wastewater effluent from the Hendersonville wastewater treatment plant. With increased withdrawals from the newer Asheville water treatment plant on the Mills River, the ratio of Mud Creek flow to Mills River flow is even greater. That could be one of the main reasons that water quality is declining at the downstream site on the French Broad River in Henderson County, but not declining at the upstream site.

Table 7: Median levels of parameters analyzed at each site on the French Broad River from Horseshoe in Henderson 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
H-1	at Horseshoe	9.5	9.6	26	6.1	1.4	0.03	0.16	0.3
H-2	at Mountain Home	11.5	12.0	34	6.4	1.5	0.08	0.15	0.5
B-13	at Corcoran Park	10.0	12.4	37	6.5	1.4	0.10	0.15	0.5
B-12B	at Bent Creek	7.2	7.8	37	2.2	1.0	0.09	0.12	0.5
B-23	at Jean Webb Park	8.9	7.8	53	3.7	1.0	0.05	0.10	0.5
B-6A	at Ledges Park	12.0	10.2	61	4.6	1.8	0.29	0.30	0.7
B-32	at Walnut Island Park	11.5	8.1	64	5.3	1.9	0.21	0.21	0.8
M-2	at Barnard Bridge	12.0	9.8	63	4.2	1.5	0.20	0.17	0.7
M-3	at Hot Springs	10.4	8.8	60	3.1	1.2	0.16	0.12	0.6

Appendix A: Sample Chain of Custody Form

Volunteer Water Information Network

Henderson County

1) Sample Site Number ______________________________ .

2) Sample Site Name ______________________________.

3) Collection Date ________________ Day ________________.

4) Time Collected ______________________________.

5) Temperature at drop-off site (in cooler)______________________________.

6) Volunteer's Name ______________________________.

7)Volunteer's Phone# &/or Email: ______________________________.

________________ (please provide current mailing address if there has been a change)

8) Water Flow Rate (please circle one) Very High High Normal Low

9) Type of Rain in past 3 days (please circle one) Heavy Medium Light Dry

10) General Observations (turbidity, waste matter, dead animals upstream, anything out of the ordinary)

______________________________ .

______________________________ .

______________________________ .

Parameter Results (For Lab Use Only)

Parameter and Result Date of Analysis

NH3 ________________ mg/L ________________.

NO3 ________________ mg/L ________________.

Po ________________ mg/L ________________.

Turb ________________ NTU ________________.

TSS ________________ mg/L ________________.

Cond ________________ umhos/cm ________________.

Alk ________________ mg/L ________________.

Cu ________________ ug/L ________________.

Zn ________________ ug/L ________________.

Pb ________________ ug/L ________________.

pH ________________.

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.

PARAMETER	REPORTING LIMIT	UNITS
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
☐ caddisfly larvae	☐ beetle larvae	☐ aquatic worms
☐ hellgrammite	☐ clams	☐ blackfly larvae
☐ mayfly nymphs	☐ crane fly larvae	☐ leeches
☐ gilled snails	☐ crayfish	☐ midge larvae
☐ riffle beetle adult	☐ damselfly nymphs	☐ pouch (and other) snails
☐ stonefly nymphs	☐ dragonfly nymphs	
☐ water penny larvae	☐ scuds	
	☐ sowbugs	
	☐ fishfly larvae	
	☐ alderfly larvae	
☐ # of letters times 3 = _____ index value +	☐ # of letters times 2 = _____ index value +	☐ # 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)528-1818

Defenders of Air, Woods, 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: 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=Hiawassee River Watershed
HY = Haywood County
LG = Lake Glenville
LJ = Lake James
LL = Lake Lure
M = Madison County
NOT=Nottely River Watershed
P = Polk County
TU = Tuckasegee River watershed

	site #	site description
1	**H9**	**Mills River at SR 191 (Davenport Bridge)**
2	**H10**	**Mills River at Hooper Lane**
3	HW1	Upper Hiawassee River
4	HW2	Martin's Creek
5	HW3	Hightower Creek
6	HW6	Eagle Fork Creek
7	HW7	Upper Shooting Creek
8	HW9	Upper Bell Creek
9	HW1	Upper Fodder Creek
10	HW1	Hog Creek
11	HY1	West Fork Pigeon River/Bethel
12	HY2	East Fork Pigeon River/Bethel
13	LG1	Hurricane Creek/Norton Br Rd (Tuckasegee R wtrshd)
14	LG5	Cedar Creek at Beetree Rd (Tuckasegee R wtrshd)
15	LG7	Norton Creek/up Grassy Cmp (Tuckasegee R wtrshd)
16	LL6	Pool Creek (Broad River watershed)
17	TU1	East Fork Tuckasegee River
18	HY3	East Fork Pigeon River/Cruso
19	NOT1	Nottely River upstream
20	B12A	Bent Creek at SR 191
21	B22	Ivy Creek at Dillingham Road
22	**H7**	**North Fork Mills River**
23	LG2	Norton Creek at Norton Rd br (Tuckasegee R wtrshd)
24	**H19**	**Green River at Old Hwy 25 S**
25	**H11**	**Green River below Lake Summit**
26	HW4	Scataway Creek
27	HW5	Geisky Creek
28	HW8	Lower Shooting Creek
29	HY13	Allens Creek (Richland Creek watershed)
30	LL9	Buffalo Creek (Broad River watershed)
31	NOT3	Nottely River

Appendix E: Stream Ranking Index – continued

32	NOT5	Coosa Creek	96
33	NOT9	Conley Creek	96
34	NOT10	Young Cane Creek upstream	96
35	**H12**	**Green River at Terry's Creek Rd**	**95**
36	LG3	Mill Creek/dnstrm Norton br (Tuckasegee R wtrshd)	93
37	LJ5	Linville River at Hwy 126	93
38	LL2	Hickory Creek at Bat Cave (Broad River watershed)	93
39	LL3	Broad River at Bat Cave	93
40	LL15	Buffalo Creek at Bald Mtn Lake (Broad R watershed)	93
41	B28	Bent Creek below Lake Powhatan	92
42	HW12	Woods Creek	92
43	NOT7	Young Cane Creek	92
44	NOT8	Ivy Log Creek	92
45	P1	White Oak Creek at SR 1137/Houston Road	92
46	TU3	Caney Fork (Tuckasegee River watershed)	92
47	**H13**	**Big Hungry River below dam (Green River watershed)**	**91**
48	LG6	Glenville Creek at Tator Knob Rd (Tuckasegee R)	91
49	LL7	Public Golf Course Creek at Hwy 64/74 (Broad Rvr wtrshd)	91
50	LL8	Cane Creek upstream from Tryon Bay (Broad Rvr wtrshd)	91
51	B30	Grassy Branch (Swannanoa River watershed)	90
52	**H8**	**South Fork Mills River**	**90**
53	**H15**	**Bat Fork Creek at Tabor Road (Mud Creek watershed)**	**90**
54	P13	Green River at Hwy 9	90
55	P16	North Pacolet River at Rte 108	90
			Good
56	**H23**	**Big Willow Creek at Patterson Rd**	**88**
57	M8	Little Laurel Creek (Laurel River watershed)	88
58	P5	Horse Creek at SR 1516 (River Road) N Pacolet R wtrshd)	88
59	P6	Horse Creek at SR 1516 (River Rd) (N Pacolet River wtrshd)	88
60	TU5	Tuckasegee River upstream from Scott's Creek	88
61	TU10	Barker's Creek (Tuckasegee River watershed)	88
62	TU14	Deep Creek (Tuckasegee River watershed)	88
63	B20	Ivy Creek at Buckner Branch Road	87
64	**H14**	**Boylston Creek at Ladson Road**	**87**
65	**H21**	**Mud Creek at Berea Church Road**	**87**
66	**H28**	**Shaw Creek at Hunters Glen**	**87**
67	HY11	Richland Creek at Lake Junaluska	87
68	HY12	Jonathan Creek near confluence with Pigeon River	87
69	LL10	Fairfield Mts Creek (Broad River watershed)	87
70	M9	Shelton Laurel Creek (Laurel River watershed)	87
71	NOT2	Arkaqua Creek	87
72	M18	Big Laurel Creek	86
73	TU4	Cullowhee Creek (Tuckasegee River watershed)	86
74	B17A	Swannanoa River at NC 81	85
75	B31	Swannanoa River at Grassy Branch confluence	85
76	B43	Ross Creek at Swannanoa River (Swannonoa R wtrshd)	85
77	**H20**	**Clear Creek at Apple Valley Rd (Mud Crk watershed)**	**85**
78	HY10	Richland Creek at West Waynesville	85
79	LG4	Pine Creek/Pine Creek Rd br (Tuckasegee R wtrshd)	85
80	LJ1	Catawba River at SR 1501	85
81	LJ2	Catawba River at US 221A	85
82	LJ4	Catawba River at Resistoflex	85
83	P4	White Oak Creek at SR 1322 (Moore Road)	85
84	P15	North Pacolet River at Melrose	85
85	TU2	West Fork Tuckasegee River	85
86	**H18**	**Mud Creek at 7th Avenue**	**83**

Appendix E: Stream Ranking Index – continued

87	LL4	Broad River at Chimney Rock	83
88	LL5	Broad River at Lake Lure	83
89	TU9	Tuckasegee River at Barker's Creek	83
90	TU11	Connelley Creek (Tuckasegee River watershed)	83
91	TU12	Tuckasegee River downstream from Bryson City	83
92	P17	White Oak Creek at Weidman's	82
93	TU15	Oconoluftee River (Tuckasegee River watershed)	82
94	B9A	Beetree Creek (Swannanoa River watershed)	81
95	**H1**	**French Broad River at Banner Farm Road in Horseshoe**	**81**
96	**H5**	**Clear Creek at Nix Road (Mud Creek watershed)**	**81**
97	**H27**	**Mill Pond Creek at South Rugby Road**	**81**
98	**H29**	**Brandy Branch at Mills River Village (Mills River watershed)**	**81**
99	HY9	Plott Creek in Hazelwood (Richland Crk watershed)	81
100	M10	Laurel River	81
101	P2	White Oak Creek at SR 1531 (Fox Mt Rd)	81
102	P7	North Pacolet River at SR 1516 (S River Rd)	81
103	TU7	Savannah Creek (Tuckasegee River watershed)	81
104	B5B	Reems Creek at Ox Creek	80
105	LL1	Reedypatch Creek at Bat Cave (Broad River watershed)	80
106	M7	Spring Creek	80
			Average
107	HY6	Rush Fork at Crabtree (Crabtree Creek watershed)	79
108	TU8	Green's Creek (Tuckasegee River watershed)	79
109	TU13	Kirkland Creek (Tuckasegee River watershed)	79
110	B16A	Cane Creek at Mills Gap Road	78
111	B33	North Fork Swannanoa River at Grovestone Quarry	78
112	**H3**	**Mud Creek at Erkwood Road**	**78**
113	**H22**	**Hoopers Creek at Jackson Rd (Cane Creek watershed)**	**78**
114	**H26**	**Brittain Creek at Patton Park (Mud Creek watershed)**	**78**
115	M14	Middle Fork at Beech Glen (Ivy River watershed)	78
116	P8	Demannu Creek at SR 1140 and Hwy 9 (Green River wtrshd)	78
117	P14	White Oak Creek at Briar Hill Farm	78
118	**H30**	**Devils Fork at Dana Road (Mud Creek watershed)**	**77**
119	B9B	Swannanoa River at Beetree Creek	76
120	B10	Bull Creek at Swannanoa River (Swannanoa R wtrshd)	76
121	B24	Swannanoa River at confluence with North Fork	76
122	B38	Swannanoa River at Bull Creek	76
123	HY27	Jonathan Creek at Maggie Valley	76
124	M13	California Creek at Beech Glen (Ivy River watershed)	76
125	P9	Joels Creek upstream (N. Pacolet Rvr watershed)	76
126	B1A	Big Ivy Creek at Forks of Ivy	75
127	NOT6	Anderson Creek	75
128	HY4	Pigeon River downstream from Canton	75
129	HY26	Crabtree Creek at Crabtree Rd	75
130	B15A	Cane Creek at Hwy 74 (FBR watershed)	74
131	B35	Smith Mill Creek at Louisiana Blvd.	74
132	LJ3	North Fork of the Catawba River at SR 1552	74
133	M15	Paint Fork at Beech Glen (Ivy River watershed)	74
134	P18	Camp Creek (Green River watershed)	74
135	B15B	Ashworth Creek at Hwy 74 & Cane Crk Rd (Cane Ck wtrshd)	73
136	HY25	Raccoon Creek downstream (Richland Creek watershed)	73
137	B17B	Haw Creek at NC 81 (Swannanoa River watershed)	72
138	B41	Ross Creek at Tunnel Road (Swannanoa River watershed)	72
139	**H16**	**Cane Creek at Howard Gap Road**	**72**
140	M6	Big Pine Creek	72
141	B8	Beaverdam Creek at Beaver Lake	71

Appendix E: Stream Ranking Index – continued

142	B40	Ross Creek at Lower Chunns Cove Rd(Swannanoa R wtrshd)	71
143	LJ12	North Fork of the Catawba River below Limekiln Creek	71
144	M12	Grapevine Creek (Ivy River watershed)	71
145	M19	Laurel Valley Creek (Laurel River watershed)	71
146	NOT4	Butternut Creek	70
147	M20	Puncheon Fork (Laurel River watershed)	70
			Below Average
148	B5A	Ox Creek at Reems Creek (Reems Creek watershed)	69
149	B12B	French Broad River at Bent Creek	69
150	HY5	Pigeon River at Hepco Bridge	69
151	P10	Joels Creek downstream (N Pacolet River watershed)	69
152	B7B	Glenn Creek at UNCA Bot Gardens (Reed Ck wtrshd)	68
153	B14	Lower Flat Creek	68
154	B26	North Turkey Creek (Sandymush Creek watershed)	68
155	B7A	Reed Creek at UNCA Botanical Gardens	67
156	B13	French Broad River at Corcoran Park (Hend/Bunc line)	67
157	HY8	Eaglenest Creek in Hazelwood (Richland Creek watershed)	67
158	HY24	Raccoon Creek upstream (Richland Creek watershed)	67
159	M3	French Broad River at Hot Springs	67
160	TU6	Scott's Creek (Tuckasegee River watershed)	67
161	HY7	Fines Creek downstream	66
162	LJ13	North Fork of the Catawba River at Old Linville Rd	66
163	M11	Bull Creek (Ivy River watershed)	66
164	B21	Paint Fork at Barnardsville (Ivy River watershed)	65
165	B23	French Broad River at Jean Webb Park - Asheville	65
166	B42	Ross Creek at Upper Chunns Cove (Swannanoa R wtrshd)	65
167	B47	Reed Creek at entrance to UNCA	65
168	HY19	Fines Creek upstream	65
169	M4	East Fork Bull Creek (Ivy River watershed)	65
170	B27	Flat Creek at NC 19/23	64
171	HY15	Fines Creek midstream	64
172	B2	Lower Sandymush Creek	63
173	B36	Newfound Creek at Dark Cove Road	63
174	**H4**	**Mud Creek at North Rugby Road**	**63**
175	**H25**	**Gash Creek at Etowah School Road**	**63**
176	HY23	Ratcliff Cove Branch (Raccoon Creek watershed)	63
177	B25	South Turkey Creek (Sandymush Creek watershed)	62
178	B34	Lower Hominy Creek at NC 191	62
179	B37	Newfound Creek at Leicester Hwy	62
180	B6B	Reems Creek at French Broad River	61
181	**H2**	**French Broad River at Butler Bridge Road**	**61**
182	B3B	Sandymush Creek at Willow Creek	60
183	HY14	Rush Fork upstream (Crabtree Crk watershed)	60
			Poor
184	B32	French Broad River at Walnut Island Park	58
185	HY20	Cove Creek at NC 209 (Fines Creek watershed)	58
186	M2	French Broad River at Barnard Bridge	58
187	M17	Gabriel's Creek at Ivy River	57
188	HY29	Hyatt Creek Owl Ridge branch	56
189	B6A	French Broad River at the Ledges Park	55
190	HY28	Hyatt Creek left branch	52
191	B1B	Little Ivy Creek (Ivy River watershed)	51
192	B4	Lower Newfound Creek	51
193	HY21	Hyatt Creek upstream (Richland Creek watershed)	51
194	M1	Ivy River at NC 25/70	51

Appendix E: Stream Ranking Index – continued

195	HY22	Hyatt Creek downstream (Richland Creek watershed)	50
196	B48	South Creek Pond/Beaver Lake (Beaverdam Crk wtrshd)	48
197	HY30	Hyatt Creek Green Valley branch	47
198	B39	South Creek at Beaver Lake (Beaverdam Crk watershed)	42

Percent -	**Excellent**	**Good**	**Average**	**Below Average**	**Poor**
Buncombe	8	12	29	39	12
Henderson	**33**	**37**	**19**	**11**	**0**
Haywood	15	15	18	30	22
Hiawassee	100	0	0	0	0
Lake Glenville	86	14	0	0	0
Lake James	14	43	29	14	0
Lake Lure	64	36	0	0	0
Madison	0	28	39	17	16
Nottely	70	10	20	0	0
Polk	20	47	26	7	0
Tuckasege e River	13	67	13	7	0
TOTAL	28	26	21	18	7

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)

pH – Last 3 Years					All Results		Alkalinity – Last 3 Years/rept. Limit 1 mg/L					All Results	
site	sample#	low	median	high	sample #	median	site	sample#	low	median	high	sample#	median
1	36	6.4	6.8	7.2	162	6.8	1	36	8	14	20	164	16
2	36	6.4	6.8	7.1	171	6.8	2	36	8	16	22	172	17
3	35	6.3	6.8	7.1	173	6.7	3	36	10	17	25	176	17
4	36	6.6	6.9	7.3	166	6.9	4	36	17	26	37	167	24
5	36	6.6	7.0	7.2	164	6.9	5	36	8	23	70	165	20
7	36	6.5	6.9	7.5	173	6.8	7	36	5	10	18	174	10
8	36	6.4	6.8	7.2	171	6.6	8	36	6	10	58	172	10
9	35	6.4	6.8	7.2	175	6.7	9	36	5	10	16	176	10
10	36	6.4	6.8	7.2	178	6.7	10	36	5	11	31	178	10
11	36	6.4	6.7	7.2	150	6.7	11	36	10	15	24	151	14
12	36	6.4	6.9	7.2	166	6.8	12	36	8	13	22	166	12
13	36	6.8	7.2	7.6	167	7.1	13	36	13	21	31	167	18
14	36	6.7	7.1	7.5	163	7.0	14	36	8	18	29	163	18
15	36	6.5	6.8	7.4	159	6.7	15	36	13	20	27	160	20
16	34	6.7	7.2	7.5	157	7.1	16	34	18	27	34	156	26
18	35	6.7	7.0	7.3	153	6.9	18	35	14	19	28	156	19
19	36	6.5	6.9	7.2	114	6.8	19	36	7	14	20	115	12
20	35	6.6	7.0	7.3	133	6.9	20	35	14	18	28	134	16
21	35	6.5	6.9	7.2	101	6.9	21	35	12	17	25	101	18
22	35	6.7	7.0	7.3	108	7.0	22	35	13	23	32	108	24
23	35	6.6	7.0	7.4	101	6.8	23	35	12	17	39	101	16
25	35	6.5	6.8	7.1	105	6.8	25	35	12	31	47	105	31
26	35	6.7	7.0	7.4	101	7.0	26	35	14	28	40	101	27
27	34	6.9	7.1	9.0	106	7.1	27	34	22	35	48	106	34
28	35	6.8	7.0	7.4	104	7.0	28	35	16	24	35	105	24
29	35	5.5	6.9	7.8	104	6.8	29	35	9	15	78	105	15
30	35	6.5	6.9	7.1	106	6.8	30	35	13	30	40	107	29
LL1	35	6.8	7.4	8.2	131	7.3	LL1	35	13	22	33	131	22
LL2	35	6.9	7.3	7.9	131	7.2	LL2	35	10	16	24	131	16
LL3	35	6.7	7.3	7.7	131	7.3	LL3	35	13	17	30	131	16

Appendix F: Data Summary – Continued

Turbidity (NTU) - Last 3 Years/rept. limit 1 NTU					All Results		TSS (mg/L) - Last 3 Years/rept. limit 4 mg/L					All Results	
site	sample #	low	median	high	sample #	median	site	sample #	low	median	high	sample #	median
1	36	3.4	9.5	29	164	9.0	1	36	<4	9.6	316.0	163	10.4
2	36	3.6	11.5	130	172	9.0	2	36	<4	12.0	135.5	171	10.8
3	36	2.7	6.5	70	176	7.4	3	36	<4	6.4	152.0	175	6.4
4	36	4.4	9.3	100	167	11.0	4	36	<4	9.0	88.4	166	10.4
5	36	2.3	6.3	23	164	7.3	5	36	<4	4.1	50.6	163	5.6
7	36	<1	2.5	28	174	2.8	7	36	<4	1.8	30.0	171	2.0
8	36	<1	2.9	16	172	3.2	8	36	<4	2.4	20.8	169	2.4
9	36	1.4	3.3	27	177	3.0	9	36	<4	2.0	40.4	175	2.0
10	36	1.5	3.8	14	179	3.7	10	36	<4	3.2	16.0	175	3.2
11	36	1.5	4.1	31	151	3.7	11	36	<4	1.8	34.4	150	1.6
12	36	<1	3.2	9	167	3.0	12	36	<4	1.2	6.0	165	1.6
13	36	<1	4.2	13	168	4.0	13	36	<4	2.2	37.6	166	3.6
14	36	3.0	6.4	32	164	7.0	14	36	<4	5.0	38.4	164	6.0
15	36	1.6	3.8	23	160	5.4	15	36	<4	1.6	16.0	158	2.8
16	34	1.8	7.3	340	157	7.0	16	34	<4	5.2	282.7	156	6.0
18	35	3.9	7.1	32	156	7.3	18	35	<4	6.6	51.6	155	6.8
19	36	1.9	4.4	28	115	4.1	19	36	<4	2.2	44.0	111	2.8
20	35	2.3	6.0	20	134	5.2	20	35	<4	4.8	24.0	132	4.4
21	35	3.5	6.8	35	101	6.2	21	35	<4	7.2	134.4	101	7.2
22	35	1.4	5.9	71	108	5.6	22	35	<4	5.0	69.6	108	5.2
23	35	2.2	5.8	29	101	5.0	23	35	<4	6.0	29.2	101	4.8
25	35	6.1	11.0	34	105	9.8	25	35	<4	5.2	32.4	105	6.0
26	35	1.3	3.5	210	101	3.4	26	35	<4	2.0	155.6	101	2.0
27	34	2.3	5.3	45	106	4.9	27	34	<4	3.6	42.4	106	3.2
28	35	1.5	3.6	18	105	4.2	28	35	<4	2.8	53.6	105	2.8
29	35	2.1	3.7	25	106	4.9	29	35	<4	4.4	14.0	106	5.6
30	35	3.4	7.6	34	107	7.3	30	35	<4	4.8	21.2	107	4.8
LL1	35	1.5	3.4	160	131	4.1	LL1	35	<4	2.0	125.3	132	3.6
LL2	35	1.6	3.8	15	131	5.0	LL2	35	<4	4.4	17.6	132	6.8
LL3	35	1.9	4.2	36	131	4.8	LL3	35	<4	3.6	32.8	132	5.6

Appendix F: Data Summary – continued

Conductivity - Last 3 Years/rept. limit 10 umhos/cm					All Results		Copper (ppb) - Last 3 Years/rept. limit 2 ppb					All Results	
site	sample #	low	median	high	sample #	median	site	sample #	low	median	high	sample #	median
1	36	21	26	35	164	35	1	36	<2	1.4	4.8	163	1.6
2	36	27	34	46	172	40	2	36	<2	1.5	9.2	172	1.6
3	36	31	35	55	176	40	3	36	<2	0.7	4.4	174	1.1
4	36	34	69	91	167	71	4	36	<2	1.7	6.7	167	1.6
5	36	14	56	67	165	55	5	36	<2	0.9	3.8	164	0.8
7	36	13	15	18	174	15	7	36	<2	0.3	<2	173	0.5
8	36	12	15	130	172	15	8	36	<2	0.2	5.3	171	0.2
9	36	13	15	18	176	16	9	36	<2	0.2	<2	176	0.3
10	36	15	17	25	178	18	10	36	<2	0.5	2.9	178	0.6
11	36	22	27	33	151	26	11	36	<2	0.3	<2	150	0.4
12	36	19	22	54	166	22	12	36	<2	0.1	<2	166	0.2
13	36	37	43	53	167	43	13	36	<2	0.6	11.0	167	0.5
14	36	26	40	51	163	40	14	36	<2	0.6	3.4	164	0.7
15	36	44	65	88	159	72	15	36	<2	0.6	2.7	159	1.0
16	34	49	60	76	156	61	16	34	<2	0.9	20.4	156	0.7
18	35	40	47	59	156	48	18	35	<2	1.4	8.9	154	1.4
19	36	19	24	30	115	24	19	36	<2	0.4	5.1	113	0.4
20	35	31	39	48	134	39	20	35	<2	0.5	16.0	133	0.6
21	35	32	38	88	101	41	21	35	<2	0.4	4.2	100	0.6
22	35	44	54	67	108	57	22	35	<2	0.8	2.5	107	1.0
23	35	28	32	42	101	32	23	35	<2	0.4	2.1	100	0.5
25	35	58	74	98	105	78	25	35	<2	0.9	3.5	104	1.3
26	35	62	74	316	101	74	26	35	<2	0.7	2.8	100	0.9
27	34	20	179	256	106	175	27	34	<2	0.7	<2	106	0.7
28	35	52	60	69	105	61	28	35	<2	0.3	8.2	104	0.4
29	35	39	56	157	106	62	29	35	<2	0.6	<2	105	0.9
30	35	66	81	87	107	81	30	35	<2	1.5	4.0	105	1.7
LL1	35	43	48	61	131	50	LL1	35	<2	0.4	2.6	129	0.5
LL2	35	29	33	59	131	33	LL2	35	<2	0.4	23.2	129	0.5
LL3	35	27	30	38	131	30	LL3	35	<2	0.4	2.1	129	0.5

Appendix F: Data Summary – continued

Lead (ppb) – Last 3 Years/rept. Limit 1 ppb					All Results		Zinc – Last 3 Years/rept. Limit 20 ppb					All Results	
site	sample #	low	median	high	sample #	median	site	sample #	low	median	high	sample #	median
1	36	<2	1.1	4.3	163	1.1	1	36	<20	6.1	28.7	162	8.6
2	36	<2	1.2	12.2	171	1.0	2	36	<20	6.4	57.9	172	7.7
3	36	<2	0.5	10.5	175	0.4	3	36	<20	2.6	121.2	175	3.3
4	36	<2	0.9	5.0	167	0.9	4	36	<20	7.1	21.6	167	8.2
5	36	<2	0.7	3.0	165	0.5	5	36	<20	5.8	<20	164	5.4
7	36	<2	0.2	3.2	174	0.2	7	36	<20	0.5	<20	174	1.5
8	36	<2	0.2	<2	172	0.2	8	36	<20	0.3	<20	172	1.2
9	36	<2	0.2	5.2	177	0.2	9	36	<20	0.5	<20	177	1.5
10	36	<2	0.4	6.1	179	0.3	10	36	<20	1.8	27.7	179	2.7
11	36	<2	0.2	<2	151	0.2	11	36	<20	0.5	20.0	151	0.9
12	36	<2	0.3	<2	167	0.2	12	36	<20	1.9	60.5	167	2.1
13	36	<2	0.4	2.5	168	0.3	13	36	<20	1.5	86.9	168	1.9
14	36	<2	0.6	3.3	164	0.4	14	36	<20	2.4	<20	164	3.9
15	36	<2	0.4	<2	160	0.4	15	36	<20	4.8	20.6	160	8.1
16	34	<2	0.7	27.8	157	0.5	16	34	<20	4.1	51.6	157	3.8
18	35	<2	0.8	3.0	155	0.6	18	35	<20	5.9	21.2	155	6.5
19	36	<2	0.4	2.0	114	0.5	19	36	<20	2.4	23.6	114	3.3
20	35	<2	0.6	18.2	134	0.4	20	35	<20	3.5	130.4	134	2.4
21	35	<2	0.6	3.0	101	0.4	21	35	<20	4.2	<20	101	2.5
22	35	<2	0.8	5.5	108	0.6	22	35	<20	3.5	<20	108	3.5
23	35	<2	0.4	3.9	101	0.3	23	35	<20	2.6	129.3	101	2.2
25	35	<2	0.6	3.5	105	0.7	25	35	<20	7.7	36.8	105	14.8
26	35	<2	0.3	5.6	101	0.3	26	35	<20	5.4	32.9	101	5.1
27	34	<2	0.3	5.0	106	0.3	27	34	<20	3.8	21.9	106	6.1
28	35	<2	0.2	2.0	105	0.2	28	35	<20	3.1	39.3	105	2.3
29	35	<2	0.2	<2	105	0.3	29	35	<20	4.8	92.2	105	6.0
30	35	<2	0.9	7.9	107	0.8	30	35	<20	7.8	<20	107	6.9
LL1	35	<2	0.2	6.5	131	0.2	LL1	35	<20	0.6	20.3	130	0.6
LL2	35	<2	0.2	<2	131	0.2	LL2	35	<20	0.4	44.8	130	0.8
LL3	35	<2	0.2	<2	131	0.2	LL3	35	<20	0.5	<20	130	0.2

Appendix F: Data Summary – continued

Orthophosphate (mg/L as PO4)-Last 3 Yrs/rept. Lim. 0.02 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	36	<0.02	0.03	0.12	162	0.04
2	36	<0.02	0.08	0.39	170	0.07
3	36	<0.02	0.02	0.09	174	0.05
4	36	0.03	0.29	1.57	166	0.29
5	36	<0.02	0.07	0.21	163	0.06
7	36	<0.02	0.01	0.07	172	0.02
8	36	<0.02	0.01	8.20	170	0.03
9	36	<0.02	0.01	0.13	176	0.03
10	36	<0.02	0.01	0.10	177	0.03
11	36	<0.02	0.01	0.15	149	0.02
12	36	<0.02	0.02	0.07	165	0.03
13	36	<0.02	0.03	0.18	166	0.04
14	36	<0.02	0.03	0.14	163	0.05
15	36	<0.02	0.03	0.34	158	0.06
16	34	<0.02	0.05	0.40	155	0.06
18	35	<0.02	0.02	0.15	154	0.05
19	36	<0.02	0.01	0.18	115	0.03
20	35	<0.02	0.04	0.20	134	0.06
21	35	<0.02	0.04	0.16	101	0.09
22	35	<0.02	0.05	0.21	108	0.09
23	35	<0.02	0.04	0.15	101	0.07
25	35	<0.02	0.10	0.35	105	0.18
26	35	<0.02	0.03	0.11	101	0.05
27	34	<0.02	0.09	0.21	106	0.11
28	35	<0.02	0.04	0.15	105	0.07
29	35	<0.02	0.05	0.13	106	0.12
30	35	<0.02	0.05	0.25	107	0.09
LL1	35	<0.02	0.05	0.20	131	0.08
LL2	35	<0.02	0.06	0.16	131	0.09
LL3	35	0.02	0.07	0.18	131	0.08

Appendix F: Data Summary – continued

Ammonia-nitrogen (mg/L) - Last 3 Years/rept. Lim. 0.02 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	36	0.06	0.16	0.24	161	0.13
2	36	0.05	0.15	0.39	170	0.13
3	36	0.06	0.12	0.28	174	0.12
4	36	0.09	0.17	0.32	166	0.17
5	36	0.05	0.11	0.23	163	0.08
7	36	<0.02	0.04	0.22	172	0.03
8	36	0.02	0.06	9.40	170	0.06
9	36	<0.02	0.05	0.24	176	0.04
10	36	0.02	0.06	0.15	177	0.05
11	36	0.04	0.07	0.22	149	0.06
12	36	<0.02	0.04	0.52	165	0.04
13	36	<0.02	0.05	0.13	166	0.05
14	36	0.04	0.09	0.18	163	0.09
15	36	0.04	0.09	0.20	158	0.10
16	34	0.03	0.11	0.29	155	0.09
18	35	0.07	0.13	0.22	154	0.13
19	36	0.02	0.05	0.19	115	0.05
20	35	0.02	0.08	0.24	133	0.07
21	35	0.04	0.10	0.20	101	0.11
22	35	0.04	0.11	0.33	108	0.11
23	35	0.02	0.08	0.25	101	0.08
25	35	0.12	0.21	1.29	105	0.23
26	35	0.03	0.08	0.20	101	0.08
27	34	0.04	0.09	0.65	106	0.10
28	35	0.02	0.07	0.18	105	0.08
29	35	0.03	0.09	0.36	106	0.13
30	35	0.08	0.18	0.31	107	0.18
LL1	35	<0.02	0.05	0.16	131	0.05
LL2	35	<0.02	0.05	0.13	131	0.05
LL3	35	<0.02	0.06	0.19	131	0.05

Nitrate/nitrite-nitrogen (mg/L)- Last 3 Years/rept. Limit 0.1 mg/L					All Results	
site	sample #	low	median	high	sample #	median
1	36	0.1	0.3	0.6	162	0.3
2	36	0.3	0.5	1.2	170	0.4
3	36	0.2	0.4	1.0	174	0.5
4	36	0.5	1.0	1.6	166	1.0
5	36	0.5	0.9	1.2	163	0.8
7	36	<0.1	0.1	1.1	172	0.1
8	36	<0.1	0.2	0.8	170	0.1
9	36	<0.1	0.2	0.3	176	0.1
10	36	0.1	0.2	0.6	177	0.2
11	36	0.1	0.2	0.4	149	0.2
12	36	<0.1	0.2	0.7	164	0.2
13	36	0.3	0.6	0.9	165	0.5
14	36	0.3	0.5	0.9	163	0.5
15	36	0.7	1.3	1.8	158	1.4
16	34	0.2	0.6	1.6	155	0.5
18	35	0.3	0.5	0.7	154	0.6
19	36	<0.1	0.2	0.8	115	0.2
20	35	0.4	0.6	0.8	134	0.6
21	35	0.3	0.5	0.8	101	0.5
22	35	0.2	0.5	1.3	108	0.5
23	35	0.1	0.3	0.6	101	0.3
25	35	0.4	0.7	1.3	105	0.9
26	35	0.5	0.8	1.6	101	0.8
27	34	0.5	0.8	1.1	106	0.8
28	35	0.3	0.6	0.8	105	0.6
29	35	0.3	0.9	1.9	106	1.2
30	35	0.6	1.1	1.5	107	1.1
LL1	35	0.2	0.5	1.5	131	0.5
LL2	35	<0.1	0.2	0.4	131	0.2
LL3	35	<0.1	0.1	0.5	131	0.1

Appendix G: Trends for Each Site Related to Flow

increases as flow increases

site #	site name	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			
19	Green River above L Summit			X	X							
11	Green River below L Summit			X	X		X					X
13	Big Hungry River			X	X							
LL1	Reedypatch Creek			X	X							X
LL2	Hickory Creek			X	X			X				X
LL3	Broad River			X	X				X			X
	Mud Creek watershed											
21	Mud Creek at Berea Ch Rd			X	X		X	X	X		X	X
3	Mud Creek at Erkwood Road			X	X			X	X			X
18	Mud Creek at 7th Ave/H'ville			X	X			X	X			
15	Bat Fork Creek			X	X			X				
30	Devil's Fork			X	X		X		X		X	X
26	Brittain Creek			X					X		X	
20	Clear Creek upstream				X							
5	Clear Creak downstream			X	X			X	X			
4	Mud Creek at N Rugby Rd			X	X			X				
	Mills River watershed											
7	North Fork Mills River				X							
8	South Fork Mills River			X	X							
9	Mills River at 191/280				X							
29	Brandy Branch					X			X			X
10	Mills River at Hooper Ln			X	X							

decreases as flow increases

site #	site name	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		
19	Green River above L Summit		X			X			X		X	
11	Green River below L Summit		X			X						
13	Big Hungry River		X			X					X	
LL1	Reedypatch Creek		X			X				X		
LL2	Hickory Creek		X			X						
LL3	Broad River	X	X			X						
	Mud Creek watershed											
21	Mud Creek at Berea Ch Rd	X	X									
3	Mud Creek at Erkwood Road	X	X			X						
18	Mud Creek at 7th Ave/H'ville	X	X			X				X		
15	Bat Fork Creek	X	X			X						X
30	Devil's Fork	X	X									
26	Brittain Creek	X	X									
20	Clear Creek upstream	X	X			X				X	X	X
5	Clear Creak downstream	X	X			X				X		
4	Mud Creek at N Rugby Rd	X	X			X				X	X	X
	Mills River watershed											
7	North Fork Mills River		X			X				X	X	
8	South Fork Mills River											
9	Mills River at 191/280					X					X	
29	Brandy Branch											
10	Mills River at Hooper Ln	X				X				X		

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

		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**
	Cane Creek watershed																						
22	Hooper's Creek				X								X	X			X						
16	Cane Creek/Howard Gap Rd			X	X							X		X			X						
	Etowah/Horseshoe																						
23	Big Willow Creek											X											
25	Gash Creek			X					X				X	X			X				X		
28	Shaw Creek				X		X		X		X		X	X									
27	Mill Pond Creek			X	X				X		X	X	X	X			X				X		
14	Boylston Creek			X	X				X				X	X									
	French Broad River																						
1	French Broad River/Horseshoe			X	X								X	X			X				X	X	
2	French Broad River/Mt Home			X	X			X	X				X	X			X				X		

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											
19	Green River above L Summit	X				X					X	X											
11	Green River below L Summit	X				X					X	X			X				X	X			
13	Big Hungry River	X	X			X					X	X											
LL1	Reedypatch Creek	X	X								X	X											
LL2	Hickory Creek	X									X	X				X					X		
LL3	Broad River		X								X	X											
	Mud Creek watershed																						
21	Mud Creek at Berea Ch Rd	X															X	X			X	X	X
3	Mud Creek at Erkwood Road													X			X	X		X	X		
18	Mud Creek at 7th Ave/H'ville	X														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		X	X		
20	Clear Creek upstream	X	X	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			
	Mills River watershed																						
7	North Fork Mills River	X									X	X								X			
8	South Fork Mills River	X									X	X			X								
9	Mills River at 191/280										X												
29	Brandy Branch														X		X	X	X		X	X	X
10	Mills River at Hooper Ln	X									X						X				X		

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

		increasing over time											decreasing over time										
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
	Cane Creek watershed																						
22	Hooper's Creek		X															X			X		
16	Cane Creek/Howard Gap Rd	X	X			X	X				X	X											
	Etowah/Horseshoe																						
23	Big Willow Creek	X	X															X			X		
25	Gash Creek																X	X	X	X	X	X	X
28	Shaw Creek	X													X			X			X	X	
27	Mill Pond Creek	X	X												X				X	X	X	X	
14	Boylston Creek	X	X								X									X			
	French Broad River																						
1	French Broad River/Horseshoe										X	X		X			X	X		X			
2	French Broad River/Mt Home			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	high winter	high spring	high summer	high fall	low winter	low spring	low summer	low fall	trend sites	% sites showing trend
pH		2	11	5	18				18	66.7%
alkalinity			3	16	5	14			19	70.4%
turbidity	2	1	13		3			13	16	59.3%
total susp sol		2	18		7			13	20	74.1%
conductivity	2		2	14		17	1		18	66.7%
copper			5	1	2	2		2	6	22.2%
lead			7		3	1		3	7	25.9%
zinc	4		2				4	2	6	22.2%
orthophos.			5		3	2			5	18.5%
ammonia-N			9	1	5	1		4	10	37.0%
nitrate-N	16		2			3	4	11	18	66.7%

Totals for All VWIN Sites Examined for Trends
number of sites examined for trends = 177

parameter	high winter	high spring	high summer	high fall	low winter	low spring	low summer	low fall	trend sites	% sites showing trend
pH		3	59	33	78	16		1	95	53.7%
alkalinity			35	82	25	92			117	66.1%
turbidity	5	29	92		64	2		60	126	71.2%
total susp sol	1	34	107		84	10		48	142	80.2%
conductivity	10	3	34	93	22	112	3	3	140	79.1%
copper		2	31	3	27	3		6	36	20.3%
lead	1	6	38		25	3		17	45	25.4%
zinc	8	4	28		16	5	5	14	40	22.6%
orthophos.			70	4	45	19		10	74	41.8%
ammonia-N	2	2	68	8	54	10	2	14	80	45.2%
nitrate-N	88	13	40	1	14	15	16	97	142	80.2%

Appendix J: Biological monitoring scores from 2002 through 2004 and overall rating for that period

VWIN SITE #	SITE NAME	Apr-02 WQ # RATING	Oct-02 WQ # RATING	Apr-03 WQ # RATING	Oct-03 WQ # RATING	Apr-04 WQ # RATING	Oct-04 WQ # RATING	2002-2004 WQ # AVE	2002-2004 WQ LETTER RATING
	Mills River Watershed								
7	North Mills River	26	22	19	19	24	14	21	Good
8	South Mills River	21	22	13	23	21	15	19	Good
9	Mills River Hwy 191	22	17	21	19	18	20	20	Good
10	Mills River Hooper Lane	16	16	17	19	17	15	17	Good
	Clear Creek Watershed								
	Clear Creek at Lancaster	17	24	16	17	16	14	17	Good
20	Clear Creek at Bearwallow	24	23	22	18	14	12	19	Good
5	Clear Creek at Nix Road	17	15	18	15	15	18	16	Fair
	Cane Creek Watershed								
22	Hooper's Creek	10	13	9	12	10	11	11	Fair
16	Cane Creek at Howard Gap Rd	9	14	15	14	19	9	13	Fair
	Etowah-Horseshoe								
14	Boylson Creek	17	15	3	11	6		10	Poor
27	Mill Pond Creek	10	12	10	19	9	9	12	Fair
28	Shaw Creek	20	18	16	16	11	9	15	Fair
25	Gash Creek	8	10	7	11	11	5	9	Poor
24	Little Willow Creek	19	9	6	16	17	8	13	Fair
23	Big Willow Creek	14	13	15	15	12	11	13	Fair
	Mud Creek Watershed								
21	Mud Creek at Berea Church Rd	21	7	12	15	14	17	14	Fair
3	Mud Creek at Erkwood Rd	17	16	11	11	7	13	13	Fair
18	Mud Creek at 7th Avenue	18	18	12	15	14	6	14	Fair
26	Brittain Creek	15	23	17	14	15	14	16	Fair
	Green River Watershed								
	Green River at Bob's Crk Rd	15	20	27	20	18		20	Good
	Rock Creek	24	23	16	24	22	15	21	Good
12	Green River at Terry's Crk Rd	9	17	15	19	16		15	Fair
11	Green River below Lake Summit	22	21	16	17	21		19	Good
	Little Hungry					25	25	25	Excellent
	Big Hungry					21	21	21	Good
13	Big Hungry below dam					21	21	21	Good

Appendix K: Biological monitoring scores from 2005 through 2007 and overall rating for that period

VWIN SITE #	SITE NAME	Apr-05 WQ # RATING	Oct-05 WQ # RATING	Apr-06 WQ # RATING	Oct-06 WQ # RATING	Apr-07 WQ # RATING	Oct-07 WQ # RATING	2005-2007 WQ # AVE	2005-2007 WQ LETTER RATING
	Mills River Watershed								
7	North Mills River	14	16	14	10	19	21	16	Fair
8	South Mills River	19	15	18	12	14	19	16	Fair
9	Mills River Hwy 191	15	15	14	17	14	19	16	Fair
10	Mills River Hooper Lane	19	19	18	20	17	18	19	Fair
	Clear Creek Watershed								
	Clear Creek at Lancaster	15	15	15	16	15	24	17	Good
20	Clear Creek at Bearwallow	11	14	12	15	13	23	15	Fair
5	Clear Creek at Nix Road	14	14	11	16	13	25	16	Fair
	Cane Creek Watershed								
22	Hooper's Creek	11	12	11	11	20	11	13	Fair
16	Cane Creek at Howard Gap Rd	9	12	12	13	11	18	13	Fair
	Etowah-Horseshoe								
14	Boylson Creek	12	10	17	9	17	11	13	Fair
27	Mill Pond Creek	6	10	14	15	9	12	11	Fair
28	Shaw Creek	12	6	7	14	5	12	9	Poor
25	Gash Creek	5		9	10	15	15	11	Fair
24	Little Willow Creek	9		12		13	13	12	Fair
23	Big Willow Creek	12		14	13	15	21	15	Fair
	Mud Creek Watershed								
21	Mud Creek at Berea Church Rd	15	17	11	21	19	13	16	Fair
3	Mud Creek at Erkwood Rd						14	14	Fair
18	Mud Creek at 7th Avenue	11	10	16	12	18	13	13	Fair
26	Brittain Creek	7	13	18	9	8	16	12	Fair
	Green River Watershed								
	Green River at Bob's Crk Rd	11		16	20	13	19	16	Fair
	Rock Creek	15		13	12	15	21	15	Fair
12	Green River at Terry's Crk Rd	14	25	5	10	21	22	16	Fair
11	Green River below Lake Summit	17	26	22	20	18	26	22	Good
	Little Hungry	23	16	19	14	21	18	19	Good
	Big Hungry	19	18	23	22	16	21	20	Good
13	Big Hungry below dam	9	0	24	18	18	24	16	Fair