

Long Term Analysis of Water Quality Trends in the Hiwassee and Nottely River Watersheds: Year Seven

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Acknowledgments

The Hiwassee River Watershed Coalition was incorporated in 1995, primarily in response to local people's concern about a decline in the fish community of Brasstown Creek, a major tributary of the Hiwassee River. Currently, the Coalition's coverage area consists of the entire upper half of the Hiwassee River watershed in four counties and two states. Major waters include the Hiwassee, Nottely, and Valley Rivers, Hightower, Brasstown, Shooting, and Tusquittee Creeks, as well as Chatuge, Nottely, Hiwassee, and Apalachia reservoirs. For more than 10 years, the Coalition has provided water quality education, funding for and implementation of voluntary watershed restoration projects, services in coordinating communication between various government agencies, and opportunities to volunteer.

The Coalition's volunteer monitoring effort began in October of 2002 when a partnership was struck with the Environmental Quality Institute/University of North Carolina-Asheville to begin monthly sampling of the main tributaries to Lake Chatuge. Data collection was established in this watershed in order to support a larger study of a late 1990s decline of TVA's ecological health rating for Lake Chatuge. By July 2003, the Coalition had enlisted enough volunteers to begin monitoring major tributaries to Lake Nottely as well.

The Coalition's volunteer monitoring program is called *Ani'ama'*, a Cherokee word pronounced *Ah nee' ah wah'* (in the lower dialect) and meaning "The Water People" or "People of the Water". In 2008 & 2009, Coalition volunteers collected samples and data from 18 sites in the upper Hiwassee River watershed. These volunteers spend many hours every year dedicated to the improvement of their watersheds. Without community volunteers, these programs would not be possible.

Chatuge *Ani'ama'* volunteers in 2008-09 include Dick Adelman, Norm & Jan Bennett, Bob Biletdeaux, John Kay, Ben Kennedy, Martin Kelly, Fred & Mary Stewart King, Anne Mather, Anne Mitchell, Bob & Betty Rogers, Hygie Starr, Ken Synder, Chuck Underwood, and Dick & Kay Wrobel.

Nottely *Ani'ama'* volunteers in 2008-09 include Glen & Jan Boland, Ethelwyn Bowen, John Bowen, Doug & Nancy Calkins, Roy & Bev Cardell, Cindy Cohen, Andrea Compton & Terry Glass, Ellen Cowgill, Donald & Mary Ann Foster, Frank & Michelle Maloney, Dan & Karen Malte, Jim & Nancy Malte, Dayton & Martha Miller, Don & Barbara Ransom, Doug & Nancy Triestram, Monroe Tuttle, and Dick Williams. Special thanks are extended to the coordinators of the Nottely team, Charlie Krick, and to Pat Krick, Barbara Ransom, and others for working at the Blairsville drop-off location each month.

Finally, thanks to Callie D. Moore, Tony Ward, Leslie Gray and Cassie Broshears, staff of the Coalition, for putting all the pieces together. The community of the upper Hiwassee River watershed is fortunate to have so many concerned and dedicated people willing to give their time and energy to ensure the continued good health of these lakes and their tributaries.

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 Hiwassee River Watershed Coalition, the Nottely Improvement Association, the Friends of Lake Glenville, Inc., the Watershed Association of the Tuckasegee River, the Environmental Conservation Organization (ECO), the Pacolet Area Conservancy (PAC), the Lake James Environmental Association, and the Lake Lure Lakefront Owners Association 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. Volunteers venture out once per month to collect water samples from designated sites along streams and rivers in the region.

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 can use this data to identify streams of high water quality that need to be preserved, as well as streams that cannot support further development without significant water quality degradation. In addition, the information allows planners to assess the impacts of increased development and the success of pollution control measures. Thus, this program provides the 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 27 stream sites in Buncombe County. The program expanded to 45 sites by November of 1990. Since that time, most counties in Western North Carolina have also begun monitoring local streams, rivers, and lakes to bring the total monitoring sites to over 200. In October 2009, sampling was halted when UNC-Asheville closed EQI due to budget cuts. Laboratory services are expected to resume in the summer of 2010 when EQI reopens as a nonprofit organization. Monthly sampling of these sites provides extensive water quality information for the French Broad, Broad, Catawba, Tuckasegee, New, Watauga, and Hiwassee River Watersheds in western North Carolina and northern Georgia.

The Hiwassee River Watershed Coalition Monitoring Program

The Hiwassee River Watershed Coalition is a grassroots organization dedicated to improving water quality in the watershed. The Coalition began monitoring twelve sites on streams flowing into Lake Chatuge in October 2002. Two of these sites have since been discontinued. Volunteers not only collect samples, but also test air and water temperature and dissolved oxygen concentrations each time they collect samples. In July 2003 the Nottely Improvement Association joined the monitoring program with seven sites monitored monthly. Three more sites were added in August 2004, April 2005, and December 2005. With sedimentation and other pollutants from continued development around the lakes a growing concern and the alarming deterioration of water quality in Lake Chatuge and Lake Nottely, many

citizens realize the need for continuous monitoring of the streams flowing into the lake as a means of trying to pinpoint sources of water quality problems. The approximate location of all the monitoring sites can be found on the maps in Figure 1 and 2. Tables 1 and 2 list the monitoring sites. This report represents statistical analyses and interpretation of data gathered by VWIN volunteers from July 2002 through October 2009.

Table 1: Hiwassee Monitoring Sites

1. Upper Hiwassee River
 2. Martin's Creek
 3. Hightower Creek
 4. Scataway Creek
 5. Geisky Creek
 6. Eagle Fork Creek (discontinued 8/05)
 7. Upper Shooting Creek
 8. Lower Shooting Creek
 9. Upper Bell Creek
 10. Upper Fodder Creek (discontinued 7/04)
 11. Hog Creek
 12. Woods Creek
-

Table 2: Nottely Monitoring Sites

1. Upper Nottely River (monitoring began 4/05)
 2. Arkaqua Creek
 3. Nottely River
 4. Butternut Creek
 5. Coosa Creek
 6. Anderson Creek
 7. Young Cane Creek
 8. Ivy Log Creek
 9. Conley Creek (monitoring began 8/04)
 10. Upper Youngcane Creek (monitoring began 12/05)
-

Figure 1: Hiwassee monitoring sites

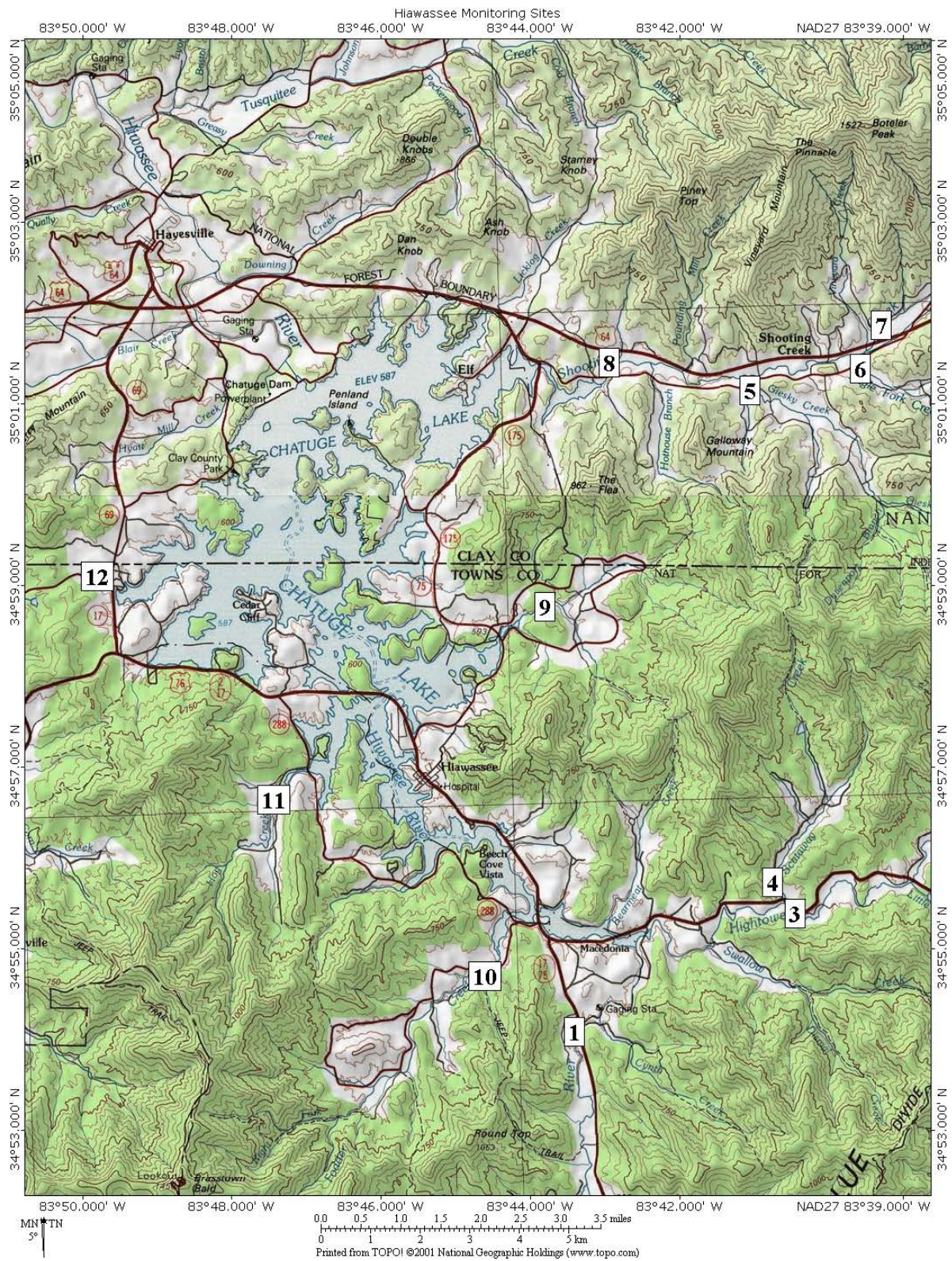
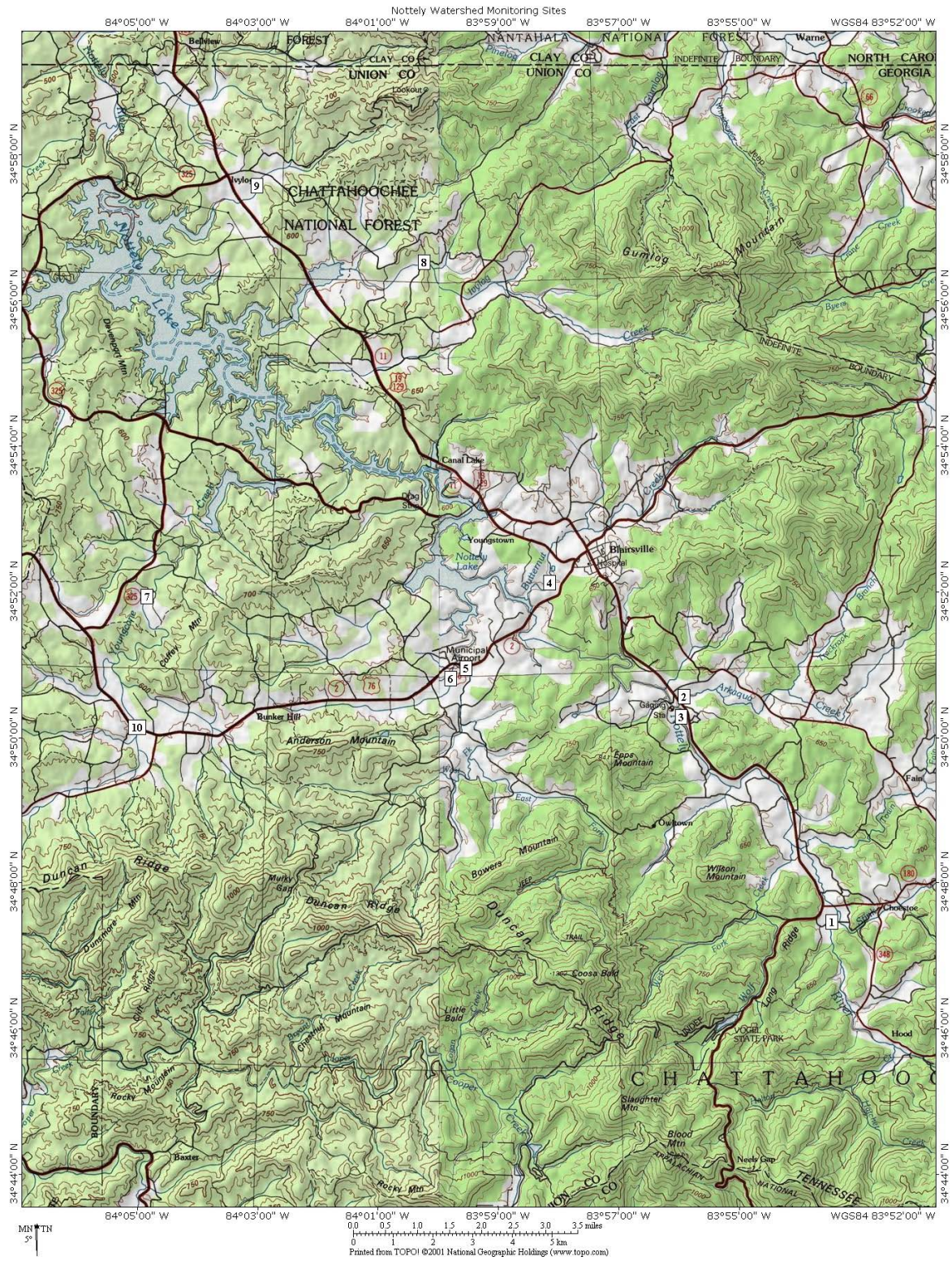


Figure 2: Nottely watershed monitoring sites



II. Methodology

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

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

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

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

III. Results and Discussion

This discussion is based on data gathered between October 2002 and October 2009 for the Hiwassee watershed samples, and data gathered between July 2003 and October 2009 for the Nottely watershed samples. The Upper Fodder Creek site was discontinued in 2004 and there will be no discussion of that site in this report. The Eagle Fork Creek site was discontinued during much of the past three years and discussion of that site will be limited. Monitoring at the Young Cane Creek site did not begin until December 2005. 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. One of the main purposes for analyzing these two watersheds for the Hiwassee River Watershed Coalition is to locate potential sources of pollutants to Lake Chatuge and Lake Nottely. The water quality of both of these lakes has been deteriorating in recent years, and it is important to find the probable sources of pollutants and address these problems.

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 the Hiwassee watershed samples (Appendix E), site 1 had a median TSS concentration of 1.2 mg/L over the past three years, which is equivalent to 1.2 ppm. Thus if you filter one liter of water from site 1 on average you will collect sediments that weigh 1.2 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 (Table 3). 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 C describes the criteria used for the grading system for each parameter. This report shows site-

Table 3: Classification Grades Based on Parameters and Ranges

Hiwassee River Watershed

Site	Description	pH	Alkalinity	Turbidity	TSS	Cond	Copper	Lead	Zinc	Ortho P	Ammonia-N	Nitrate-N
1	Upper Hiwassee River	A	D	A	A	A	A	A	A	A	A	A
2	Martin's Creek	A	D	A	A	A				A	A	A
3	Hightower Creek	A	D	A	A	A				A	A	A
4	Scataway Creek	A	D	B	A	A				A	A	A
5	Geisky Creek	A	D	B	A	A				A	A	B
6	Eagle Fork Creek	A	C	B	A	A				A	A	A
7	Upper Shooting Creek	A	C	A	A	B				A	A	A
8	Lower Shooting Creek	A	C	A	A	A	A	A	A	A	A	A
9	Upper Bell Creek	A	C	B	A	A				A	A	A
11	Hog Creek	A	D	A	A	A				A	A	A
12	Woods Creek	A	C	A	A	B	A	A	A	A	A	B

Nottely River Watershed

Site	Description	pH	Alkalinity	Turbidity	TSS	Cond	Copper	Lead	Zinc	Ortho P	Ammonia-N	Nitrate-N
1	Nottely River upstream	A	D	A	A	A				A	A	A
2	Arkaqua Creek	A	B	B	A	B				B	A	B
3	Nottely River	A	C	A	A	B	A	A	B	A	A	A
4	Butternut Creek	A	B	C	A	D	A	A	B	C	B	B
5	Coosa Creek	A	D	A	A	A				A	A	A
6	Anderson Creek	A	B	B	A	C				C	A	B
7	Young Cane Creek	A	D	B	A	A				B	A	A
8	Ivy Log Creek	A	D	B	A	A				A	A	A
9	Conley Creek	A	D	A	A	A				B	A	A
10	Young Cane Creek upstream	A	D	A	A	A				A	A	A

specific grades for each parameter using only the past three years of data. 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.

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

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

Appendix E contains summarized statistical data collected over the course of this study for the Hiwassee sites and Appendix F contains summarized statistical data for the Nottely sites. It is a list of minimum, maximum, and median concentrations or values.

The data from almost 200 sites throughout Western North Carolina in the VWIN program are used in this report to compare water quality from the stream sites in the Hiwassee and Nottely watersheds 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 relatively undisturbed forested watersheds are included to show typical water quality in streams that are relatively unaffected by human disturbance. For most parameters, sites that show median values approaching the forested stream median levels exhibit better water quality. In the case of pH and alkalinity, however, the differences may also be 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 is 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. When inspecting for trends in one variable, the statistical methodology adjusts for changes in the other variables. For example, when a chemical parameter has a significant increase over time it indicates that it would have been expected to increase over that ten-year time period if there were not changes in flows during that time and there were equal numbers of samples taken each season.

Trends related to flow are determined using flow measurements from nearby U.S. Geological Survey gauging stations. Although this method may present some problems as gauging stations can only truly represent the streams on which they are located, it provides a reasonable adjustment for differences in flow rates over different time periods. With this method the control for flow allows for more precise examination of the effects of other factors. The USGS gauging stations on the Tallulah River near Clayton, Georgia (02178400) was utilized to estimate relative flow for the Hiwassee and Nottely River monitoring sites. 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 monitoring program in 2002 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.

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.

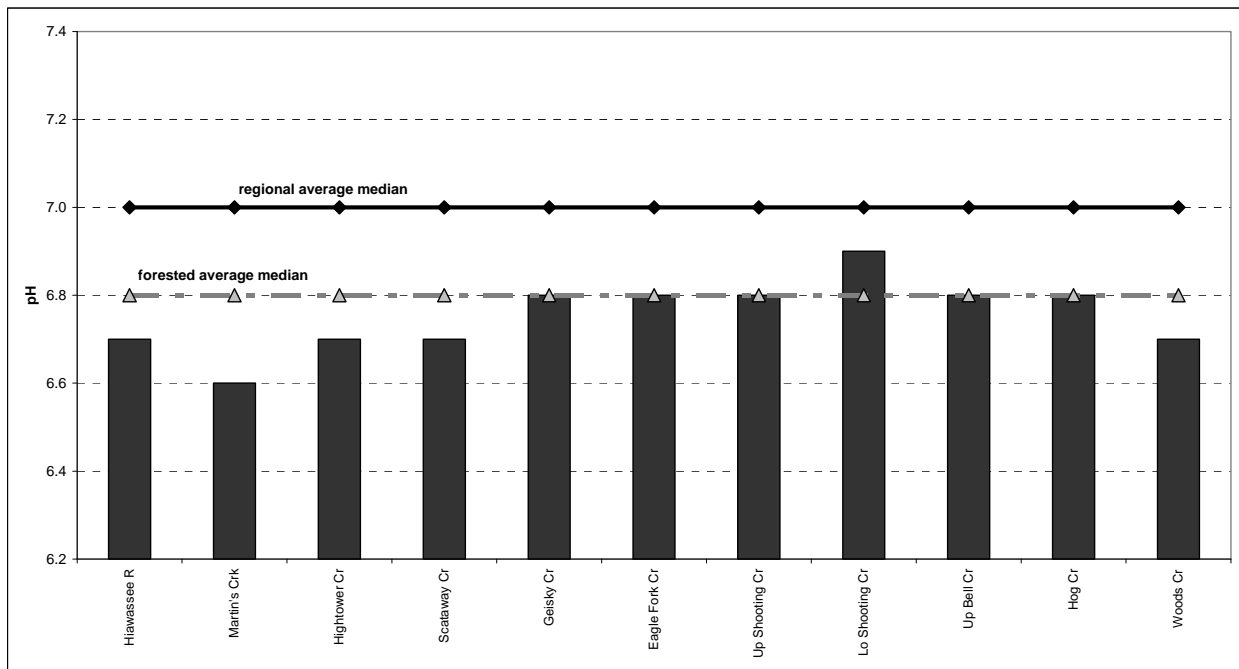
Because organisms in aquatic environments have adapted to the pH conditions of natural waters, even small pH fluctuations can interfere with the reproduction of those organisms or can even kill them outright. The pH is an important water quality parameter because it has the potential to seriously affect 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. High alkalinity waters 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 3-6 show median pH and alkalinity levels at the Hiwassee and Nottely River monitoring sites over the past three years compared to WNC regional median levels and levels in largely undisturbed areas.

Figure 3: Median pH levels at each Hiwassee River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas



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

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

Figure 4: Median alkalinity levels at each Hiwassee River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

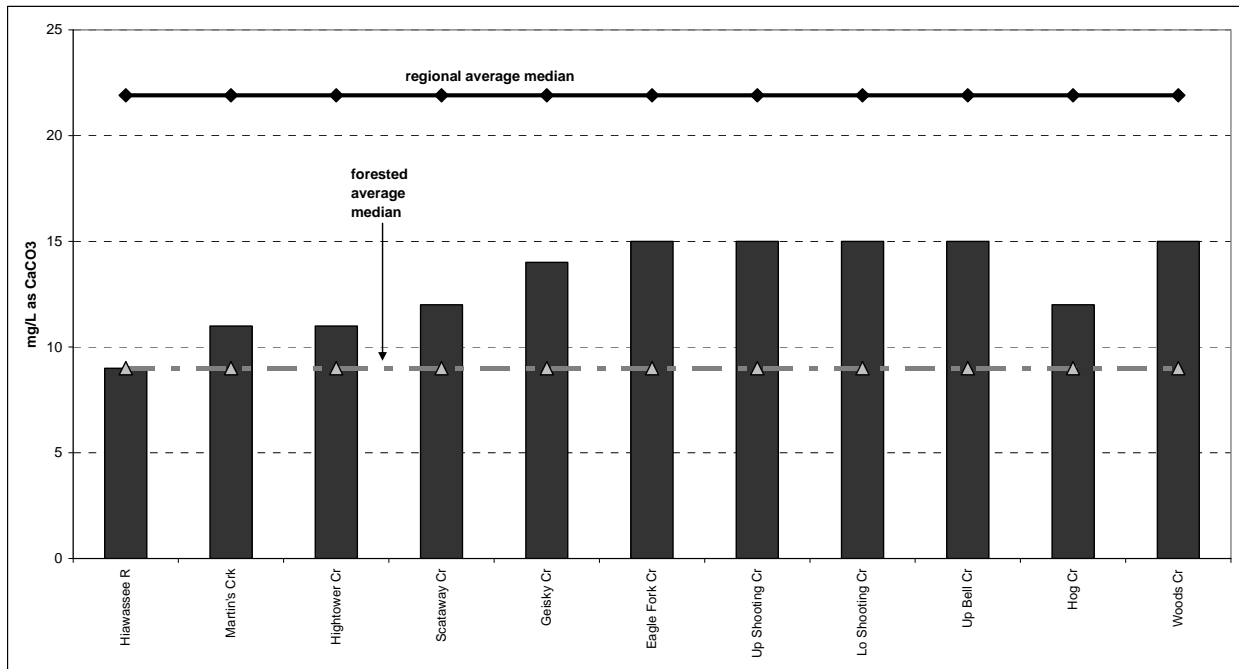


Figure 5: Median pH levels at each Nottely River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

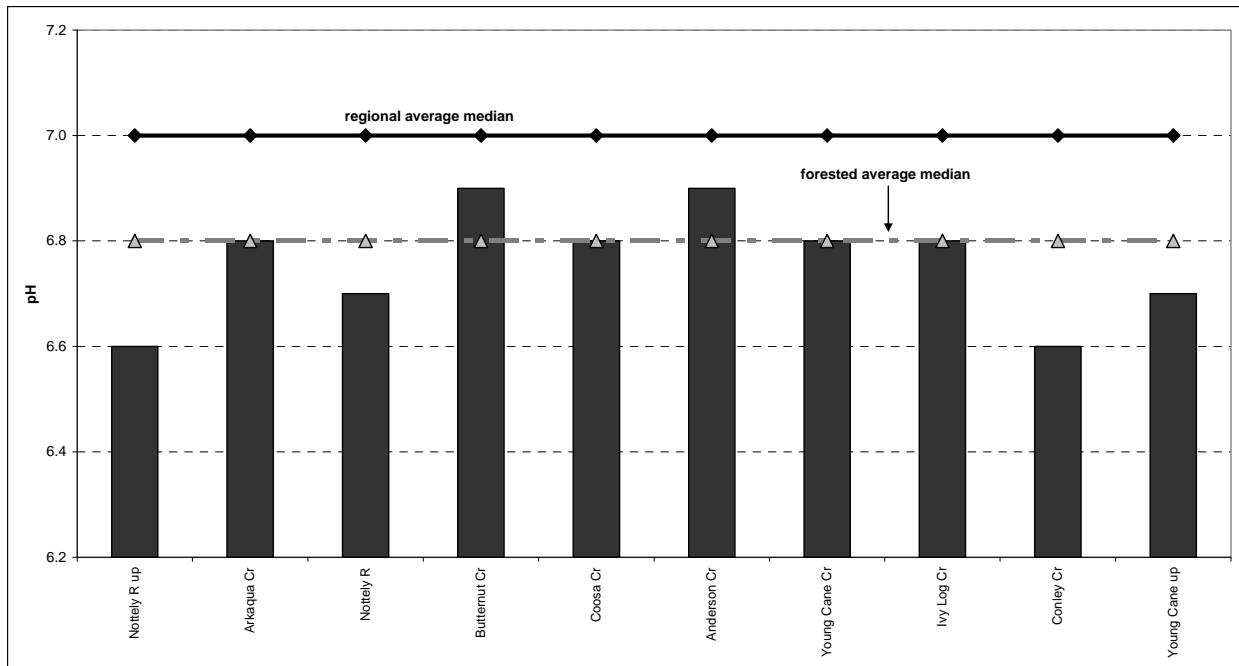
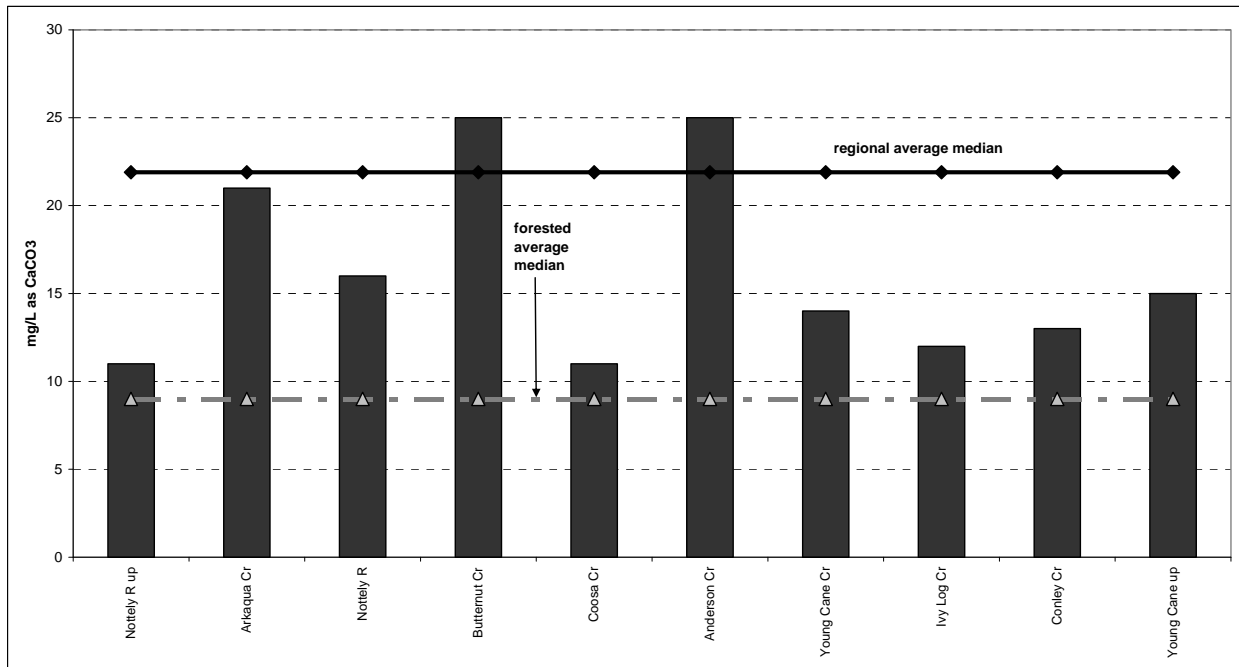


Figure 6: Median alkalinity levels at each Nottely River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas



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

Figures 7-10 show median turbidity and total suspended solids levels at the Hiwassee and Nottely River monitoring sites over the past three years compared to WNC regional median levels and levels in largely undisturbed areas.

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

Figure 7: Median turbidity levels at each Hiwassee River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

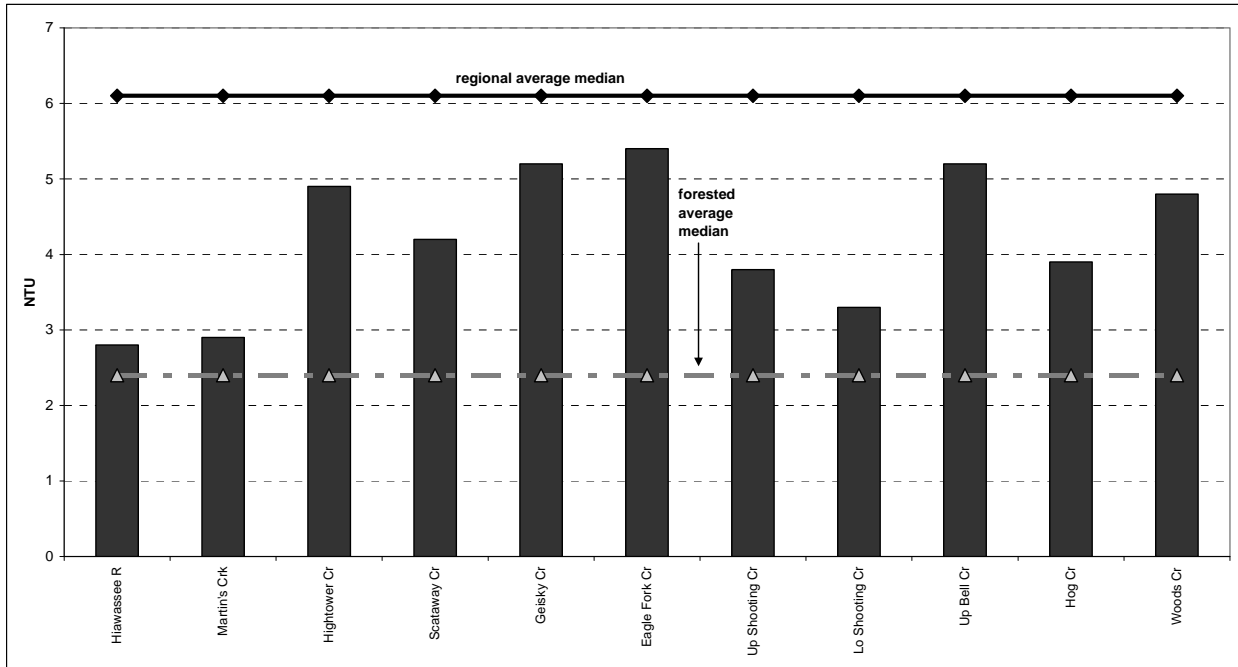


Figure 8: Median total suspended solids concentrations at each Hiwassee River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

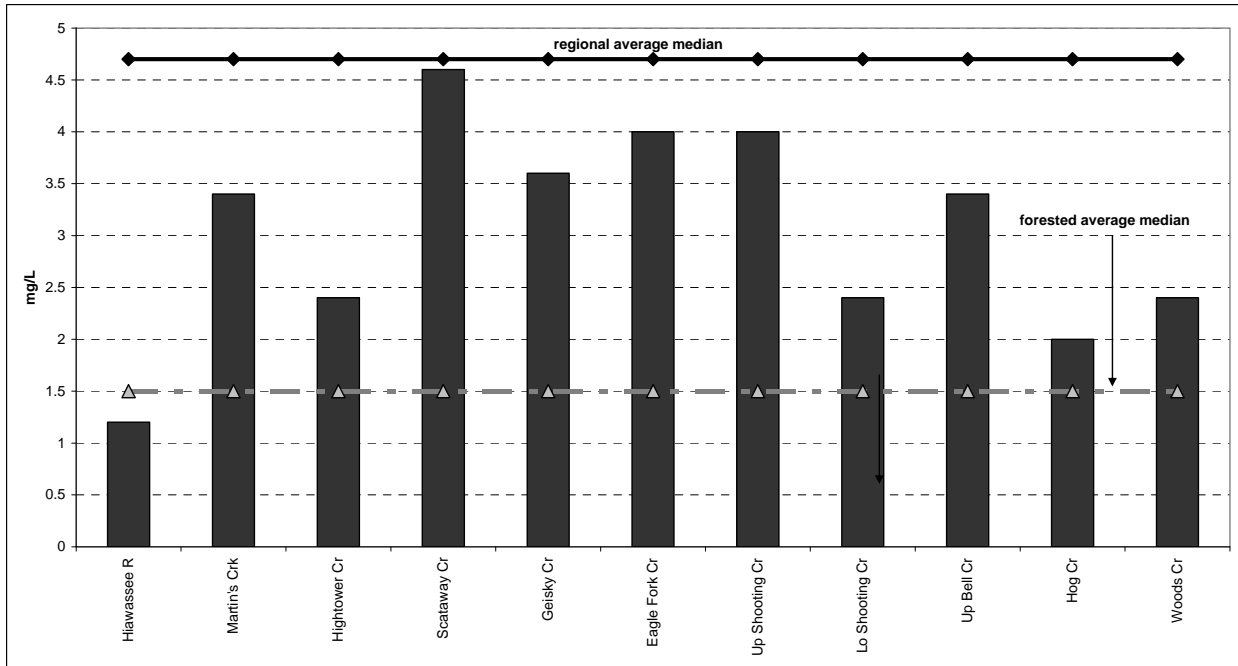


Figure 9: Median turbidity levels at each Nottely River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

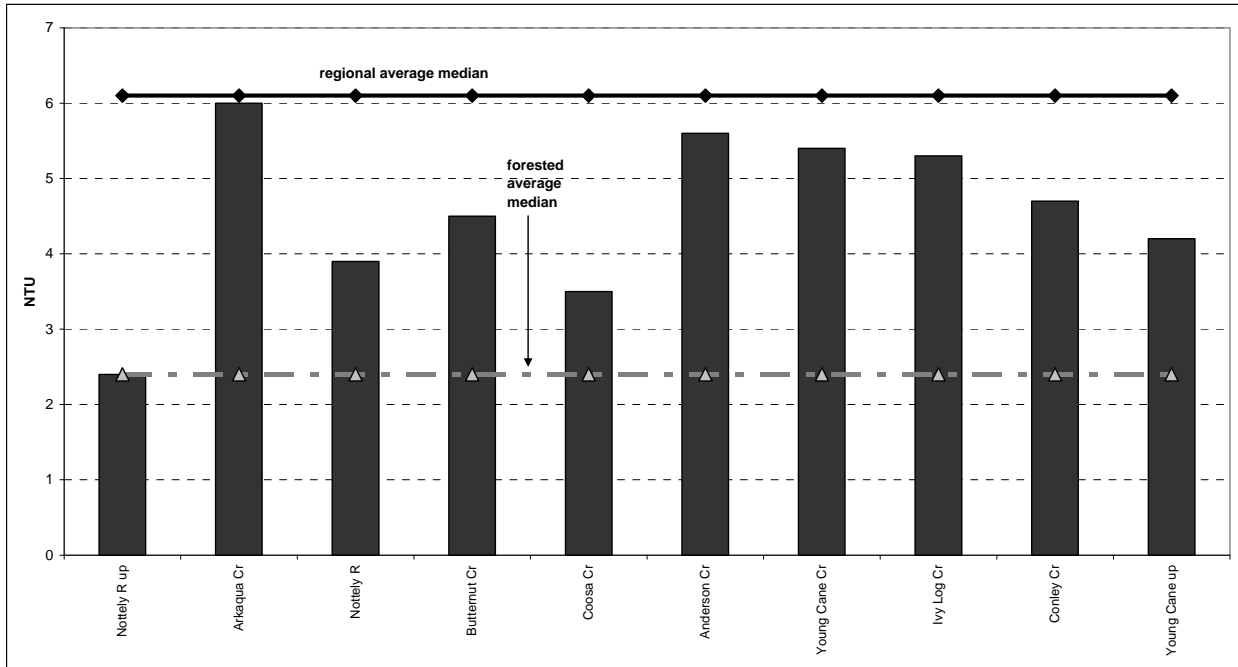
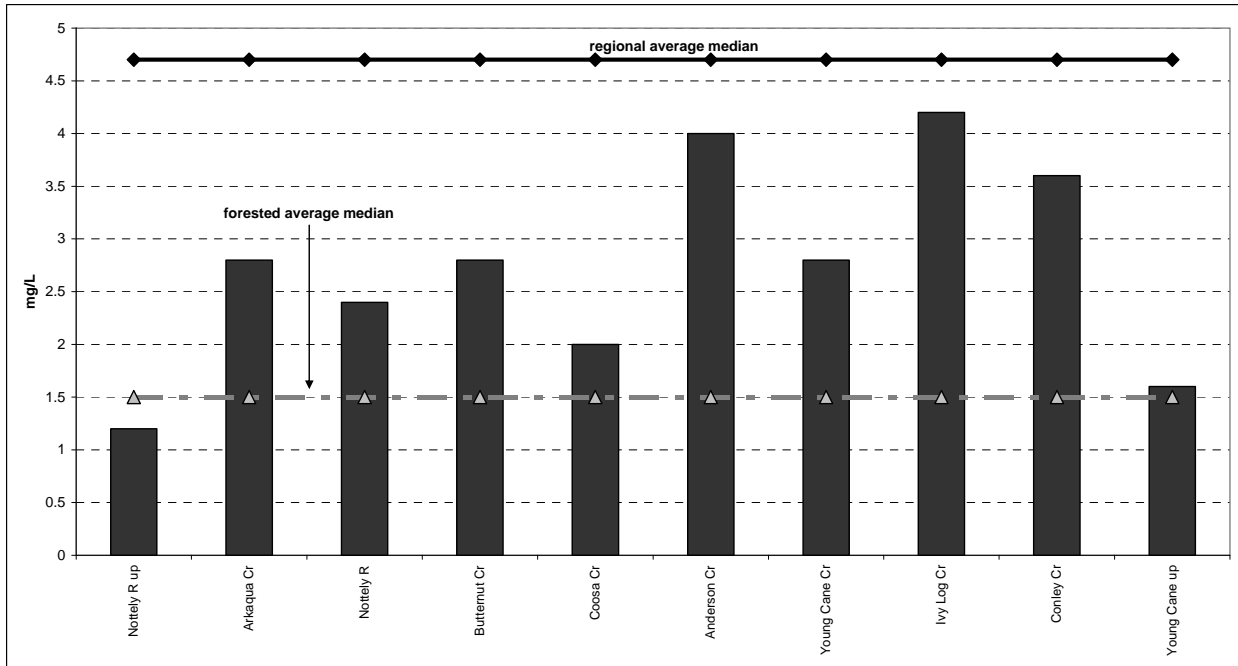


Figure 10: Median total suspended solids concentrations at each Nottely River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas



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 sometimes contain high lead levels, resulting in elevated stream concentrations if these soils are subject to erosion.

Zinc: The surface water standard is 50.0 ug/l. Typical ambient levels of zinc are approximately 5.0 ug/l. Zinc is a major metal component of tire rubber, brake linings, and galvanized crash barriers. Studies have been conducted linking this to zinc contamination from urban runoff. Because zinc is a by-product of the auto tire vulcanization process as well as the galvanization of iron, its presence in water may also result from industrial or domestic wastewater. Elevated levels of conductivity and heavy metals are most often seen in streams receiving industrial or domestic wastewater or urban runoff. These substances also occur naturally in soils and may show higher levels in streams where severe erosion and runoff are occurring.

Figures 11 and 12 show median conductivity levels at the Hiwassee and Nottely River monitoring sites over the past three years compared to WNC regional median levels and levels in largely undisturbed areas.

D. Nutrients (Orthophosphate (PO_4^{3-}), Ammonia-Nitrogen ($\text{NH}_4^+/\text{NH}_3$), and Nitrate/Nitrite-Nitrogen ($\text{NO}_3^-/\text{NO}_2^-$): Phosphorus is an essential nutrient for aquatic plants and algae. It occurs naturally in water and is, in fact, usually the limiting nutrient in most aquatic systems. In other words, plant growth is restricted by the availability of phosphorus in the system. Excessive phosphorus inputs stimulate the growth of algae and diatoms on rocks in a stream and cause periodic algal blooms in reservoirs downstream. Slippery green mats of algae in a stream, or blooms of algae in a lake are usually the result of an introduction of excessive phosphorus into the system that has caused algae or aquatic plants to grow at abnormally high rates.

Figure 11: Median conductivity levels at each Hiwassee River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

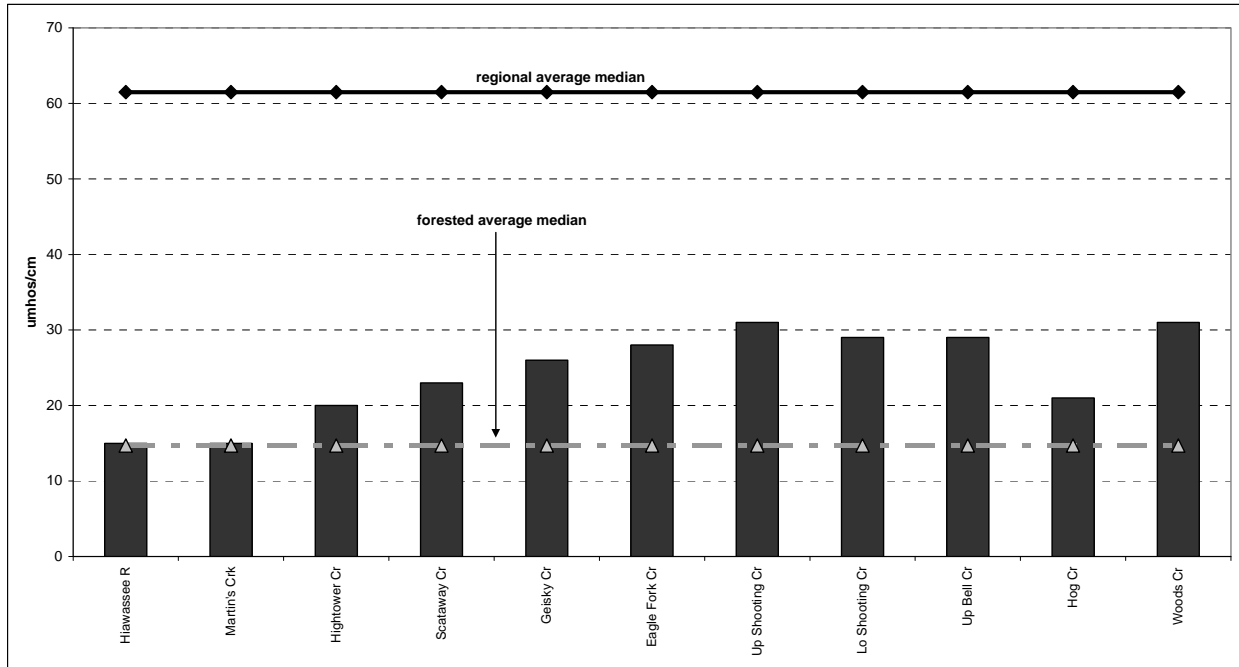
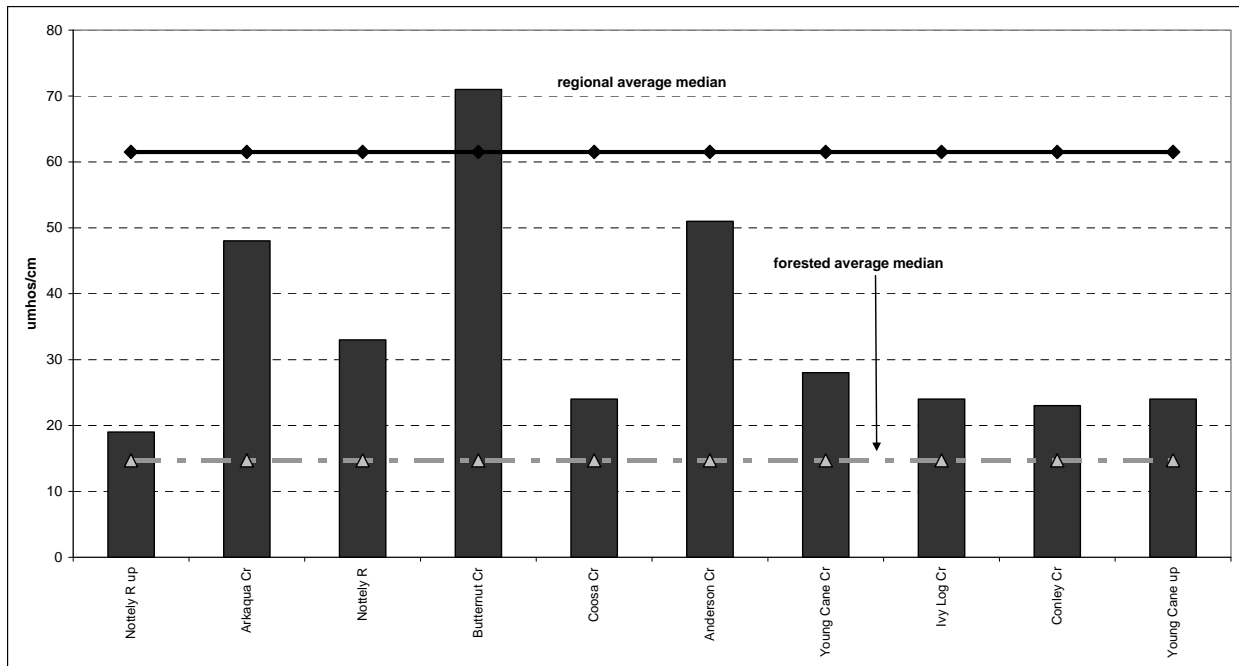


Figure 12: Median conductivity levels at each Nottely River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas



Eutrophication is the term used to describe this growth of algae due to an over abundance of a limiting nutrient. Sources of phosphorus include soil, disturbed land, wastewater treatment plants, failing septic systems, runoff from fertilized crops and lawns, and livestock waste storage areas. Phosphates have an attraction for soil particles, and phosphorus concentrations can increase greatly during rains where surface runoff is a problem. **In this report orthophosphate is reported in the form of orthophosphate (PO_4^{3-}). To isolate phosphorus (P) from the measurement, divide the reported amount by 3.07.**

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

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

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

Monitoring nutrient concentrations is particularly important for streams entering lakes. Elevated nutrient concentrations in lakes can easily lead to extensive algae growth in the less mobile lake water. Algae only live a short time, and as they die the bacteria consume the dead algae, thus the greater the amount of algae growth the greater the concentration of bacteria. Excessive bacterial growth can deplete the oxygen in the lake resulting in fish kills.

Figures 13-18 show median orthophosphate, ammonia-nitrogen, and nitrate/nitrite-nitrogen concentrations at the Hiwassee and Nottely River monitoring sites over the past three years compared to WNC regional median levels and levels in largely undisturbed areas.

E. Dissolved Oxygen

Volunteers with the Hiwassee River Watershed Coalition test dissolved oxygen on site each time samples are collected using the Winkler method. Water temperature is tested at the same time. This information is given to EQI on the chain-of-custody forms completed by each volunteer. Dissolved oxygen concentrations in mountain streams are normally near saturation because the stream water is constantly exposed to oxygen from the air as the water tumbles over

Figure 13: Median orthophosphate concentrations at each Hiwassee River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

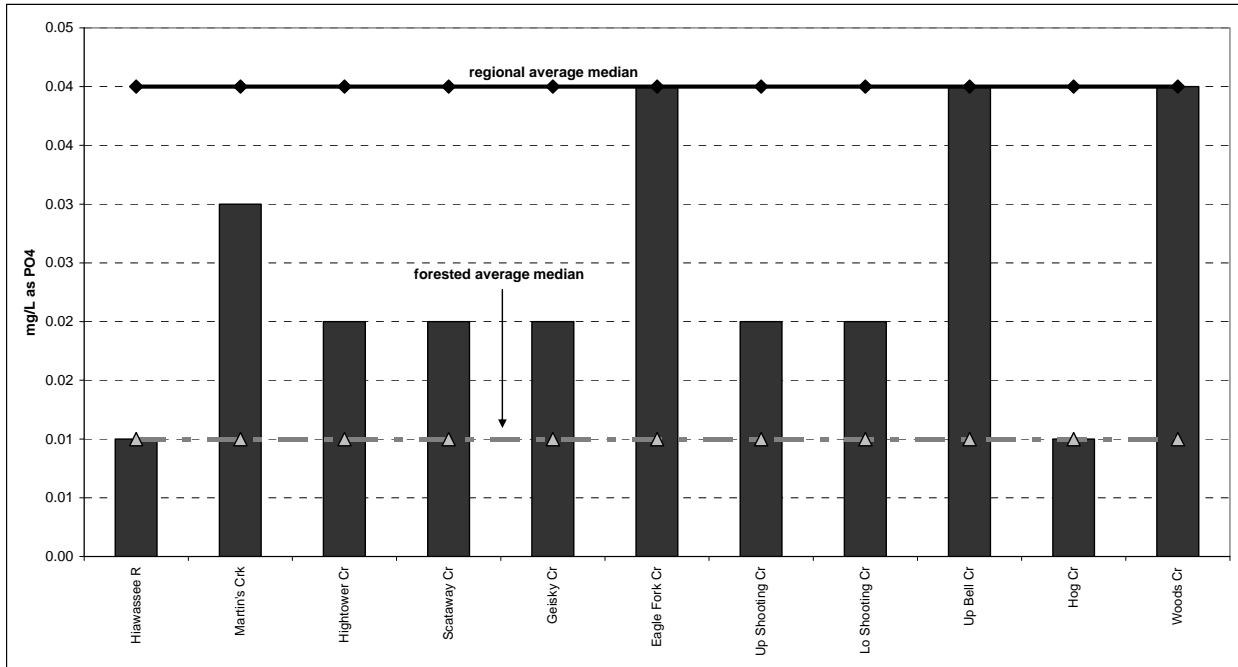


Figure 14: Median ammonia-nitrogen concentrations at each Hiwassee River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

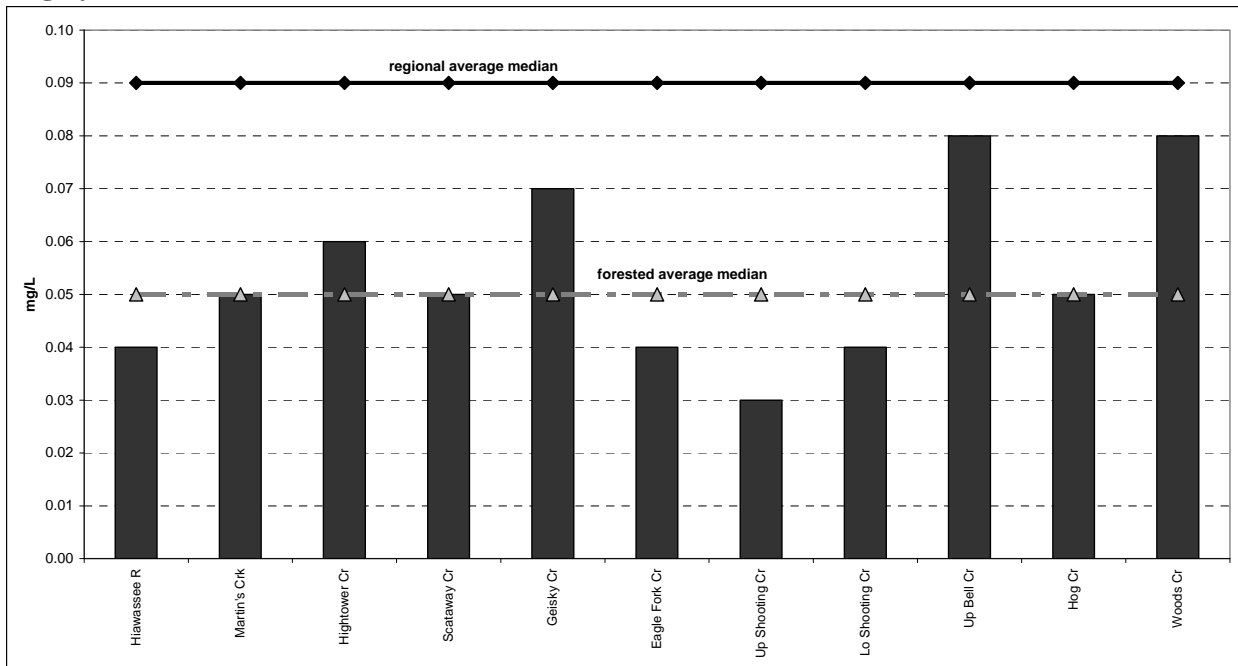


Figure 15: Median nitrate/nitrite-nitrogen concentrations at each Hiwassee River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

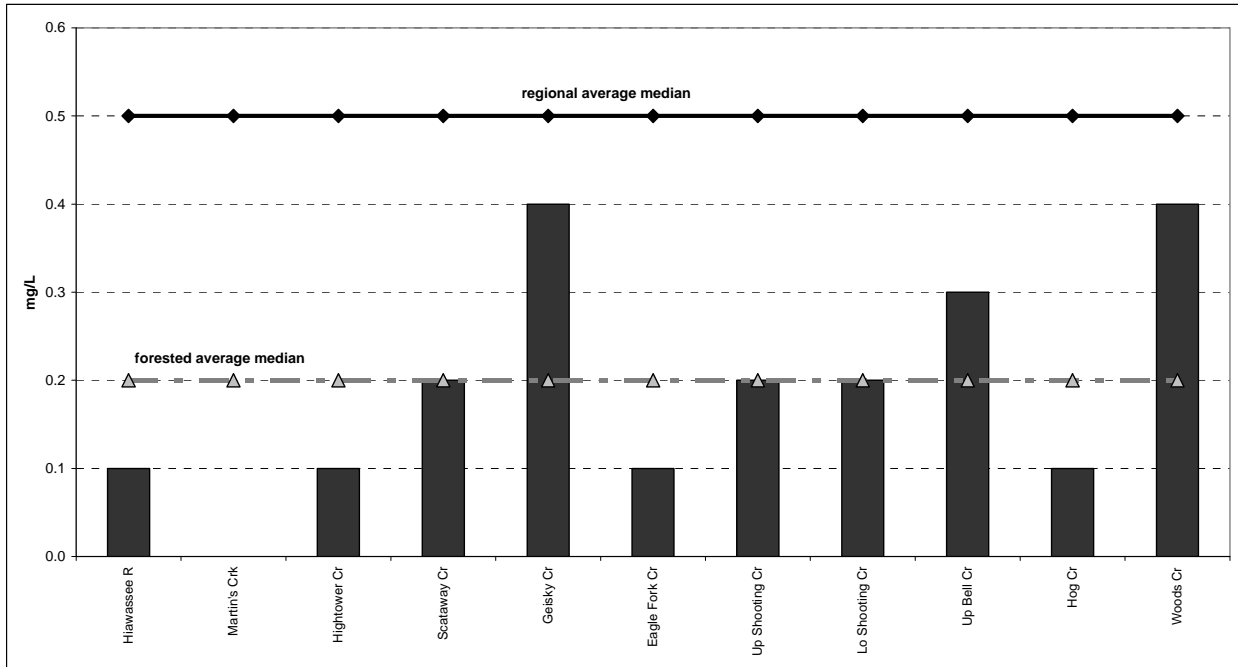


Figure 16: Median orthophosphate concentrations at each Nottely River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

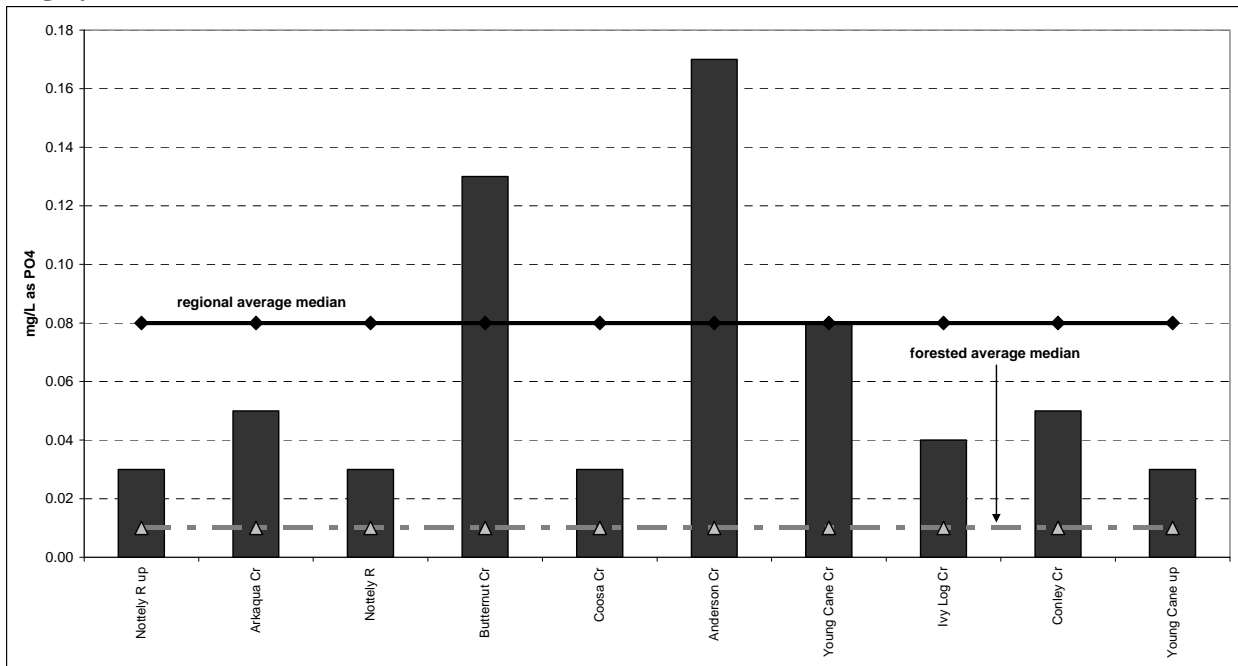


Figure 17: Median ammonia-nitrogen concentrations at each Nottely River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas

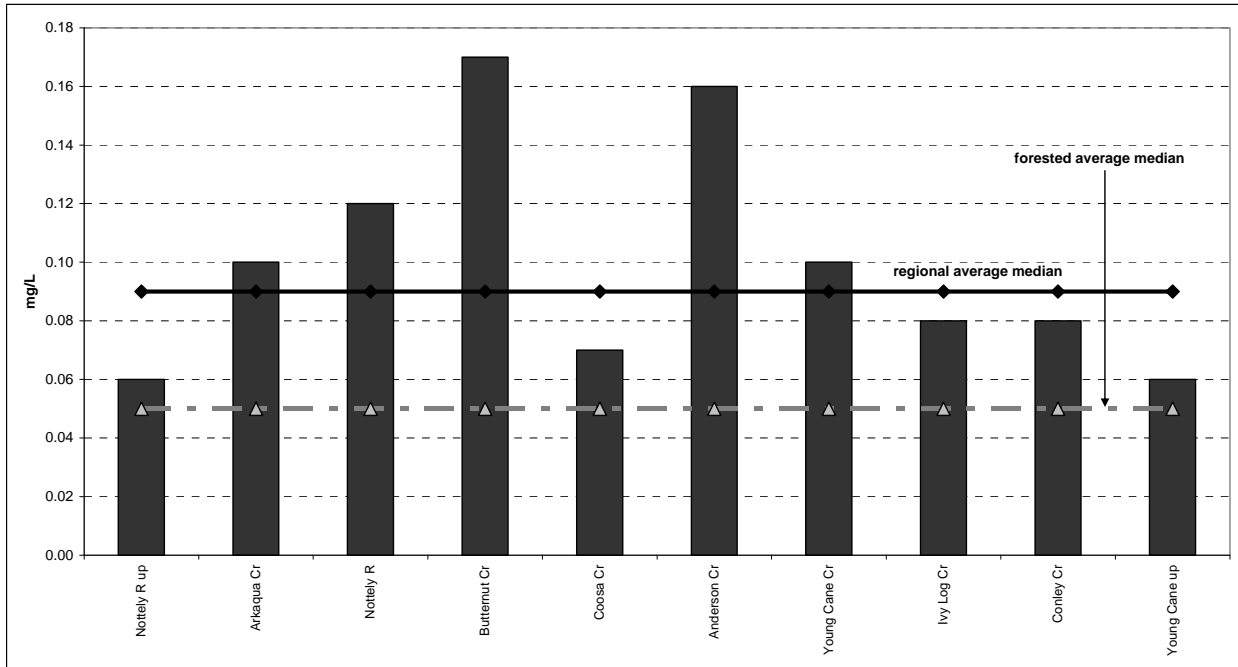
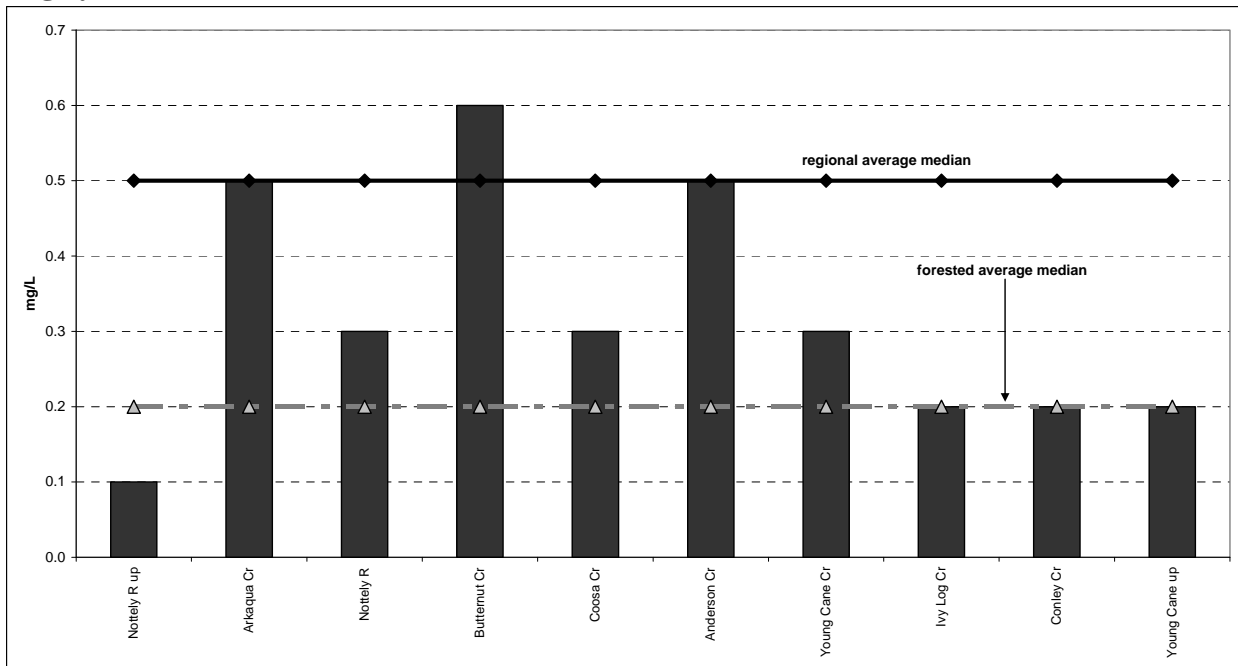


Figure 18: Median nitrate/nitrite-nitrogen concentrations at each Nottely River watershed monitoring site compared with the mountain regional median and the median at sites in largely undisturbed forest areas



rocks. Oxygen can be consumed by respiration of aquatic animals and by decomposition of organic matter. The aquatic organisms in mountain streams have adapted to high concentrations of oxygen. Significant reductions in oxygen concentrations can adversely affect the aquatic life of these streams.

The amount of oxygen that can be dissolved in water is temperature and pressure dependent. The higher the temperature, the less oxygen can be dissolved in the water, and the higher the pressure the more oxygen can be dissolved in the water. Percent saturation is the amount of oxygen (mg/L) in the water relative to the amount of oxygen that water could hold at a given temperature and pressure. Saturation was calculated for an elevation of 1,928 feet above sea level and using the temperature of the water provided by each volunteer on the chain of custody form.

Figures 19-22 show minimum, median, and maximum dissolved oxygen concentrations and percent oxygen saturation at the Hiwassee and Nottely River monitoring sites over the past three years.

Figure 19: Minimum, median, and maximum oxygen concentrations at each Hiwassee River watershed monitoring site over the past three years

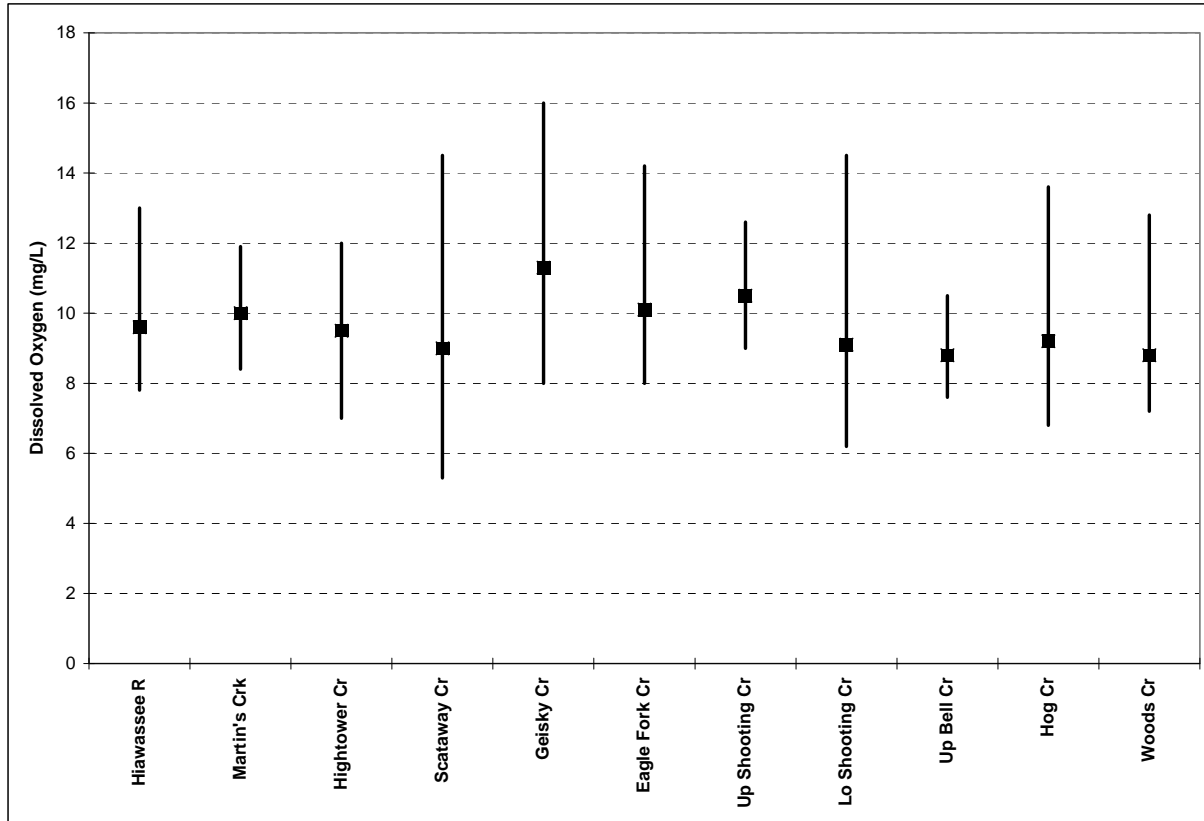


Figure 20: Minimum, median, and maximum percent oxygen saturation at each Hiwassee River watershed monitoring site over the past three years

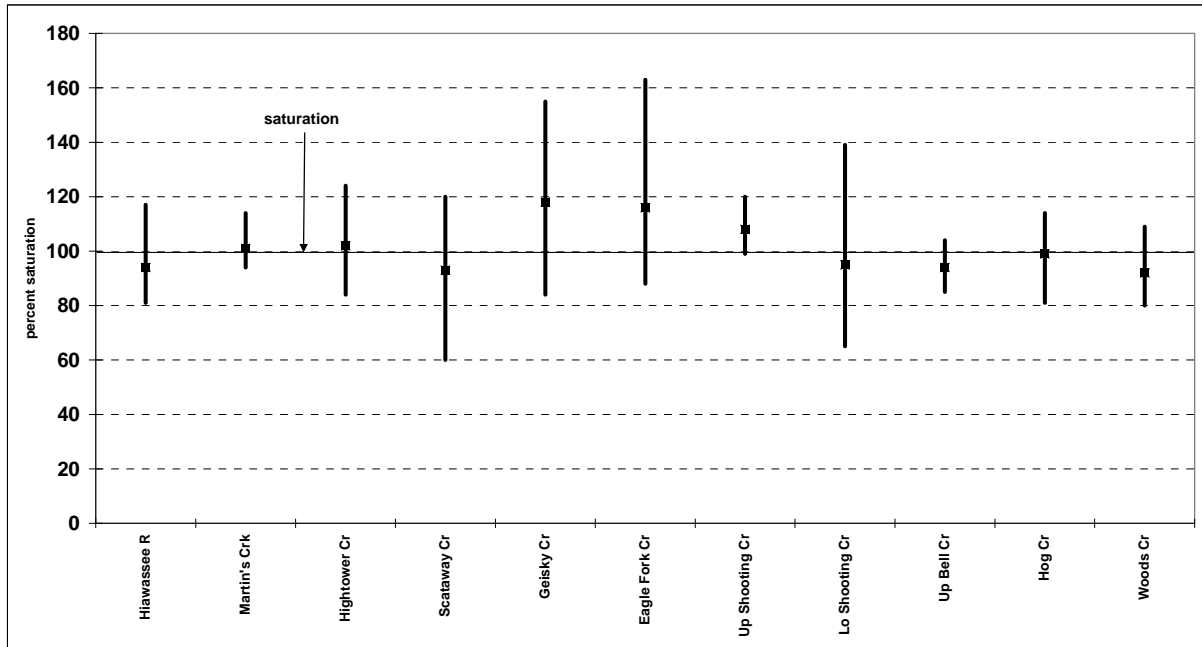


Figure 21: Minimum, median, and maximum oxygen concentrations at each Nottely River watershed monitoring site over the past three years

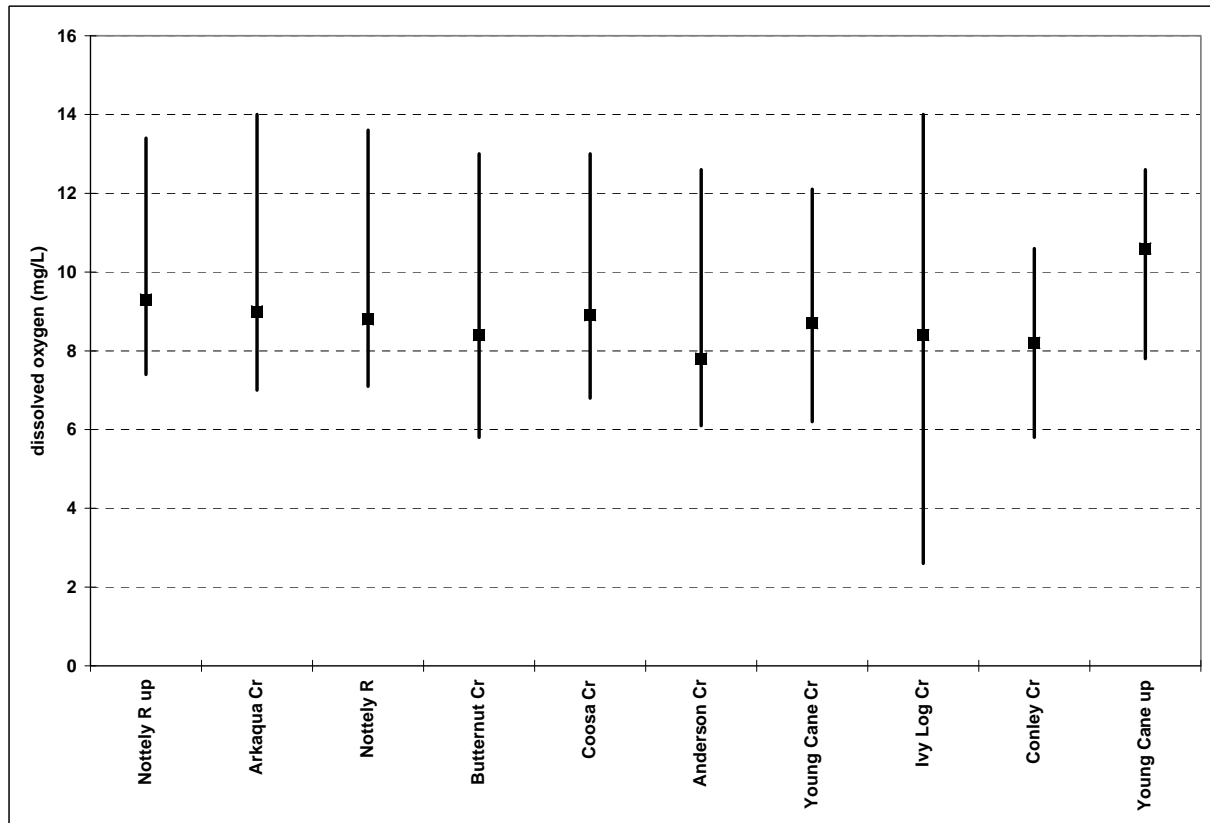
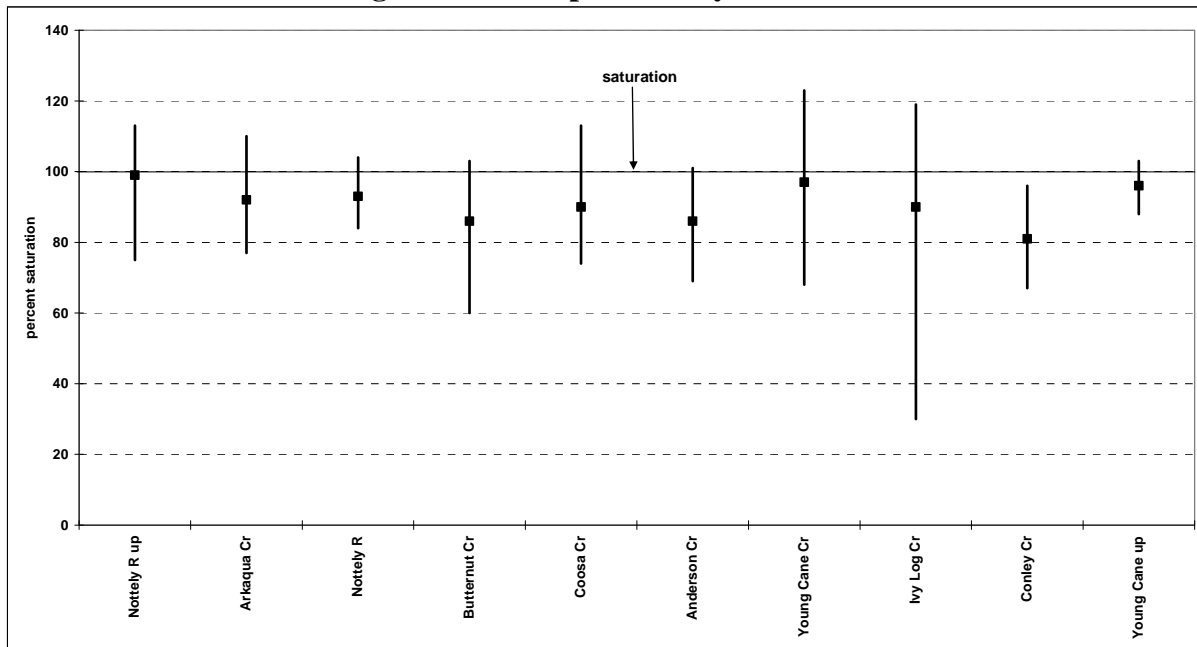


Figure 22: Minimum, median, and maximum percent oxygen saturation at each Nottely River watershed monitoring site over the past three years



IV. Summary and Conclusions

Chemical analysis of samples collected at Hiwassee and Nottely River watershed 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. Until July 2009 the VWIN program was monitoring nearly 200 sites throughout Western North Carolina. A comparison of Hiwassee and Nottely stream sites with all other sites in the program is presented in Appendix D. Summarized observations and trends for the Hiwassee and Nottely stream sites are presented below.

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. Since heavy metals analysis was discontinued at most sites in 2005, the grading in that category is less reliable, but the method was retained so that the ranking system remained comparable. Tables 4 and 5 are summaries of ranking of the Hiwassee and Nottely sites by water quality issues and by watershed. With this information it is easier to focus on specific areas with related water quality problems.

Table 4: Index rating for Hiwassee River stream monitoring sites

site #	site name	sediment	metals	nutrients	overall	rating
VWIN - WNC Regional Average		74	86	85	82	
1	Upper Hiwassee River	100	100	100	100	excellent
2	Martin's Creek	100	100	100	100	excellent
3	Hightower Creek	100	100	100	100	excellent
4	Scataway Creek	88	100	100	96	excellent
5	Geisky Creek	88	100	92	93	excellent
6	Eagle Fork Creek	88	100	100	96	excellent
7	Upper Shooting Creek	100	94	100	98	excellent
8	Lower Shooting Creek	100	100	100	100	excellent
9	Upper Bell Creek	88	100	100	96	excellent
11	Hog Creek	100	100	100	100	excellent
12	Woods Creek	100	94	92	95	excellent
average for Hiwassee stream sites		96	99	99	98	
percent sites below regional average		0%	0%	0%	0%	

Table 5: Index rating for Nottely River stream monitoring sites

site #	site name	sediment	metals	nutrients	overall	rating
VWIN - WNC Regional Average		74	86	85	82	
1	Nottely River upstream	100	94	100	98	excellent
2	Arkaqua Creek	75	94	92	87	good
3	Nottely River	100	94	100	98	excellent
4	Butternut Creek	63	81	75	73	average
5	Coosa Creek	88	100	100	96	excellent
6	Anderson Creek	63	88	75	75	average
7	Young Cane Creek	75	100	92	89	good
8	Ivy Log Creek	75	100	100	92	excellent
9	Conley Creek	100	100	100	100	excellent
10	Young Cane Creek upstream	88	100	100	96	excellent
average for Nottely stream sites		83	95	93	90	
percent sites below regional average		20%	10%	20%	20%	

The Hiwassee River Watershed sites include the upper Hiwassee River, Martin's Creek, Hightower Creek, Scataway Creek, Geisky Creek, Upper Shooting Creek, Lower Shooting Creek, Upper Bell Creek, Hog Creek, and Woods Creek. All of the monitored sites in the Hiwassee River watershed continue to rate **excellent**. Over the past three years none of the sites have exhibited excessive levels of any parameter analyzed, and all sites show median levels of every parameter lower than the regional median levels. Woods Creek has the poorest rating of the ten current sites. There is a greater percentage of deforested land in the Woods Creek watershed upstream from the monitoring site than there is in the other Hiwassee monitored watersheds, thus a greater potential for surface erosion. Although the Hiwassee watershed sites have not exhibited serious sedimentation problems, trend analysis shows turbidity levels increasing over time at all sites except Hog Creek and Woods Creek (Appendix H). All sites except Upper Hiwassee River and Hog Creek show conductivity levels increasing over time, and the Martin's Creek site continues to show total suspended solids concentrations increasing over time. It is too soon to determine if these trends are real or related to periods of drought versus periods of greater rainfall. None of the monitored streams flowing into Lake Chatuge appear to be significant contributors of pollutants to the lake.

The Nottely River Watershed sites include Arkaqua Creek, Butternut Creek, Coosa Creek, Anderson Creek, two sites on Young Cane Creek, Ivy Log Creek, Conley Creek, and two sites on the Nottely River. The Butternut Creek and Anderson Creek sites rate **average**, the Arkaqua Creek and Young Cane Creek sites rate **good**, and the other six sites rate **excellent**. Turbidity levels exceeded the 10 NTU trout standard more than 10% of the time at 5 of the 10 Nottely watershed sites in the past three years. In contrast, the standard was exceeded more than 10% of the time at only 2 of the 10 sites in the Hiwassee watershed in the past three years (Table 5). Although none of the Nottely watershed sites exceed typical median turbidity or total suspended solids levels for the region, most Nottely sites show maximum levels considerably higher than Hiwassee sites. The Butternut Creek and Anderson Creek sites exhibit unusually elevated median orthophosphate and ammonia-nitrogen concentrations. Median conductivity levels at the Butternut Creek site are also greater than average compared to the other Nottely and Hiwassee watershed sites. Butternut Creek flows through Blairsville and it is the receiving stream for the Blairsville wastewater treatment plant. Wastewater effluent typically has high conductivity, orthophosphate, and ammonia-nitrogen levels. However, trend analysis continues to show orthophosphate and ammonia-nitrogen concentrations decreasing over time at the Butternut Creek site. Unlike the Hiwassee watershed sites that all show median dissolved oxygen saturation levels above 90%, three of the Nottely watershed sites show median levels below 90%. These include Butternut Creek, Anderson Creek, and Conley Creek, all of whose trends show decreasing dissolved oxygen saturation levels over time. The elevated nutrient concentrations in Butternut Creek and Anderson Creek probably contribute to the loss of oxygen. An important purpose of this study is to determine the main pollutant sources to Lake Nottely. Of the eight creeks monitored, thus far Butternut Creek and Anderson Creek have exhibited the greatest threats to lake water quality.

Table 6: Percent samples exceeding 10 NTU standard for trout streams in past three years

Hiawassee		%	Nottely		%
1	Upper Hiawassee River	0.0	1	Nottely River upstream	0
2	Martin's Creek	5.6	2	Arkaqua Creek	17.2
3	Hightower Creek	3.8	3	Nottely River	6.9
4	Scataway Creek	15.4	4	Butternut Creek	10.3
5	Geisky Creek	8.7	5	Coosa Creek	0
6	Eagle Fork Creek- disc		6	Anderson Creek	17.2
7	Upper Shooting Creek	0.0	7	Young Cane Creek	14.8
8	Lower Shooting Creek	3.6	8	Ivy Log Creek	14.3
9	Upper Bell Creek	11.5	9	Conley Creek	8.7
11	Hog Creek	3.4	10	Young Cane Creek upstream	0
12	Woods Creek	6.9			

Appendix A: Chain of Custody form

Water Monitoring

Hiwassee River Watershed

- 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)

_____ .

Dissolved Oxygen _____ mg/L (ppm)

Air Temperature _____ °C Water Temperature _____ °C

Parameter Results (For Lab Use Only)

<u>Parameter and Result</u>	<u>Date of Analysis</u>
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.

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

Approximate Analytical Reporting Limits for VWIN Water Quality Parameters.

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

Appendix C: 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 mg/L (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 ug/L
- Grade B= exceeded 7 ug/L in less than 10% of samples
- Grade C= exceeded 7 ug/L in 10 to 20% of samples
- Grade D= exceeded 7 ug/L in more than 20% of samples

Appendix C (continued)

Total Lead -

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

Total Zinc -

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

Total Phosphorous (as P)-

- Grade A= median not above 0.03 mg/L
- Grade B= median greater than 0.03 mg/L but less than 0.07 mg/L.
- Grade C= median greater than 0.07 mg/L but less than 0.10 mg/L
- Grade D= median greater then 0.10 mg/L

Orthophosphate (as PO_4^{3-}) -

- 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 D: 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 = Hiwassee River Watershed

HY = Haywood County

J = Jackson/Lake Glenville

LJ = Lake James

LL = Lake Lure

M = Madison County

NOT=Nottely River Watershed

P = Polk County

TOE = Toe River Watershed

TU = Tuckasegee River watershed

	site #	site description	Excellent
1	B28	Bent Creek below Lake Powhatan	100
2	H11	Green River below Lake Summit	100
3	H12	Green River at Terry's Creek Rd	100
4	H7	North Fork Mills River	100
5	H9	Mills River at SR 191 (Davenport Bridge)	100
6	HW1	Upper Hiwassee River	100
7	HW11	Hog Creek	100
8	HW2	Martin's Creek	100
9	HW3	Hightower Creek	100
10	HW8	Lower Shooting Creek	100
11	HY1	West Fork Pigeon River/Bethel	100
12	HY2	East Fork Pigeon River/Bethel	100
13	J1	Hurricane Creek/Norton Br Rd (Tuckasegee R wtrshd)	100
14	J2	Norton Creek at Norton Rd br (Tuckasegee R wtrshd)	100
15	J5	Cedar Creek at Beetree Rd (Tuckasegee R wtrshd)	100
16	J7	Norton Creek/up Grassy Cmp (Tuckasegee R wtrshd)	100
17	NOT5	Coosa Creek	100
18	Toe3	South Toe River	100
19	TU1	East Fork Tuckasegee River	100
20	B9A	Beetree Creek (Swannanoa River watershed)	98
21	HW7	Upper Shooting Creek	98
22	HY13	Allens Creek (Richland Creek watershed)	98
23	LL6	Pool Creek (Broad River watershed)	98
24	B22	Ivy Creek at Dillingham Road	97
25	J3	Mill Creek/dnstrm Norton br (Tuckasegee R wtrshd)	97
26	NOT9	Conley Creek	97
27	B31	Swannanoa River at Grassy Branch confluence	96

Appendix D: Stream Ranking Index -continued

28	H10	Mills River at Hooper Lane	96
29	H19	Green River at Old Hwy 25 S	96
30	HW4	Scataway Creek	96
31	HW9	Upper Bell Creek	96
32	HY3	East Fork Pigeon River/Cruso	96
33	NOT3	Nottely River	96
34	NOT8	Ivy Log Creek	96
35	B12A	Bent Creek at SR 191	95
36	HW12	Woods Creek	95
37	J6	Glenville Creek at Tator Knob Rd (Tuckasegee R)	95
38	B24	Swannanoa River at confluence with North Fork	94
39	LJ5	Linville River at Hwy 126	94
40	NOT1	Nottely River upstream	94
41	H24	Little Willow Creek at River Road	93
42	HW5	Geisky Creek	93
43	LL10	Fairfield Mts Creek (Broad River watershed)	93
44	LL9	Buffalo Creek (Broad River watershed)	93
45	NOT7	Young Cane Creek	93
46	B17A	Swannanoa River at NC 81	92
47	B33	North Fork Swannanoa River at Grovestone Quarry	92
48	LJ1	Catawba River at SR 1501	92
49	P13	Green River at Hwy 9	92
50	P6	Horse Creek at SR 1516 (River Rd) (N Pacolet River wtrshd)	92
51	TU3	Caney Fork (Tuckasegee River watershed)	92
52	B20	Ivy Creek at Buckner Branch Road	91
53	B5B	Reems Creek at Ox Creek	91
54	H13	Big Hungry River below dam (Green River watershed)	91
55	HY10	Richland Creek at West Waynesville	91
56	LL2	Hickory Creek at Bat Cave (Broad River watershed)	91
57	LL3	Broad River at Bat Cave	91
<hr/>			
			Good
58	H23	Big Willow Creek at Patterson Rd	89
59	H26	Brittain Creek at Patton Park (Mud Creek watershed)	89
60	B38	Swannanoa River at Bull Creek	88
61	H21	Mud Creek at Berea Church Road	88
62	LJ2	Catawba River at US 221A	88
63	LL8	Cane Creek upstream from Tryon Bay (Broad Rvr wtrshd)	88
64	NOT2	Arkaqua Creek	88
65	P1	White Oak Creek at SR 1137/Houston Road	88
66	Toe1	Cane Creek at Bakersville	88
67	Toe5	Cane River at MH High Sch	88
68	TU10	Barker's Creek (Tuckasegee River watershed)	88
69	TU14	Deep Creek (Tuckasegee River watershed)	88
70	TU5	Tuckasegee River upstream from Scott's Creek	88
71	B1A	Big Ivy Creek at Forks of Ivy	87
72	B43	Ross Creek at Swannanoa River (Swannanoa R wtrshd)	87
73	H3	Mud Creek at Erkwood Road	87
74	LL5	Broad River at Lake Lure	87
75	LL7	Public Golf Course Creek at Hwy 64/74 (Broad Rvr wtrshd)	87
76	B16A	Cane Creek at Mills Gap Road	86
77	H15	Bat Fork Creek at Tabor Road (Mud Creek watershed)	86
78	TU4	Cullowhee Creek (Tuckasegee River watershed)	86

Appendix D: Stream Ranking Index -continued

79	B30	Grassy Branch (Swannanoa River watershed)	85
80	B5A	Ox Creek at Reems Creek (Reems Creek watershed)	85
81	H29	Brandy Branch at Mills River Village (Mills River watershed)	85
82	J4	Pine Creek/Pine Creek Rd br (Tuckasegee R wtrshd)	85
83	LJ12	North Fork of the Catawba River below Limekiln Creek	85
84	LL15	Buffalo Creek at Bald Mtn Lake (Broad R watershed)	85
85	P5	Horse Creek at SR 1516 (River Road) N Pacolet R wtrshd)	85
86	TU2	West Fork Tuckasegee River	85
87	Toe2	Cane Creek at Loafer's Glory	84
88	H14	Boylston Creek at Ladson Road	83
89	H5	Clear Creek at Nix Road (Mud Creek watershed)	83
90	H8	South Fork Mills River	83
91	HY11	Richland Creek at Lake Junaluska	83
92	HY9	Plott Creek in Hazelwood (Richland Crk watershed)	83
93	LJ4	Catawba River at Resistoflex	83
94	LL4	Broad River at Chimney Rock	83
95	NOT6	Anderson Creek	83
96	P15	North Pacolet River at Melrose	83
97	P16	North Pacolet River at Rte 108	83
98	TU11	Connelley Creek (Tuckasegee River watershed)	83
99	TU12	Tuckasegee River downstream from Bryson City	83
100	TU9	Tuckasegee River at Barker's Creek	83
101	B15A	Cane Creek at Hwy 74 (FBR watershed)	82
102	B23	French Broad River at Jean Webb Park - Asheville	82
103	H22	Hoopers Creek at Jackson Rd (Cane Creek watershed)	82
104	H28	Shaw Creek at Hunters Glen	82
105	HY31	Beaverdam Creek just downstream from I-40	82
106	LL1	Reedypatch Creek at Bat Cave (Broad River watershed)	82
107	P9	Joels Creek upstream (N. Pacolet Rvr watershed)	82
108	TU15	Oconoluftee River (Tuckasegee River watershed)	82
109	B21	Paint Fork at Barnardsville (Ivy River watershed)	81
110	H1	French Broad River at Banner Farm Road in Horseshoe	81
111	HY12	Jonathan Creek near confluence with Pigeon River	81
112	HY27	Jonathan Creek at Maggie Valley	81
113	P7	North Pacolet River at SR 1516 (S River Rd)	81
114	TU7	Savannah Creek (Tuckasegee River watershed)	81
115	B40	Ross Creek at Lower Chunns Cove Rd(Swannanoa R wtrshd)	80
116	B41	Ross Creek at Tunnel Road (Swannanoa River watershed)	80
117	H20	Clear Creek at Apple Valley Rd (Mud Crk watershed)	80
118	LJ3	North Fork of the Catawba River at SR 1552	80
			Average
119	B15B	Ashworth Creek at Hwy 74 & Cane Crk Rd (Cane Ck wtrshd)	79
120	M4	East Fork Bull Creek (Ivy River watershed)	79
121	TU13	Kirkland Creek (Tuckasegee River watershed)	79
122	TU8	Green's Creek (Tuckasegee River watershed)	79
123	B10	Bull Creek at Swannanoa River (Swannanoa R wtrshd)	78
124	B35	Smith Mill Creek at Louisiana Blvd.	78
125	B6B	Reems Creek at French Broad River	78
126	HY6	Rush Fork at Crabtree (Crabtree Creek watershed)	78
127	P4	White Oak Creek at SR 1322 (Moore Road)	78
128	P8	Demannu Creek at SR 1140 and Hwy 9 (Green River wtrshd)	78
129	B27	Flat Creek at NC 19/23	77

Appendix D: Stream Ranking Index -continued

130	H27	Mill Pond Creek at South Rugby Road	77
131	H30	Devils Fork at Dana Road (Mud Creek watershed)	77
132	HY25	Raccoon Creek downstream (Richland Creek watershed)	77
133	M11	Bull Creek (Ivy River watershed)	77
134	P2	White Oak Creek at SR 1531 (Fox Mt Rd)	77
135	B12B	French Broad River at Bent Creek	76
136	B17B	Haw Creek at NC 81 (Swannanoa River watershed)	76
137	B2	Lower Sandymush Creek	76
138	B34	Lower Hominy Creek at NC 191	76
139	B9B	Swannanoa River at Beetree Creek	76
140	H18	Mud Creek at 7th Avenue	76
141	HY24	Raccoon Creek upstream (Richland Creek watershed)	75
142	HY26	Crabtree Creek at Crabtree Rd	75
143	B47	Reed Creek at entrance to UNCA	74
144	B7A	Reed Creek at UNCA Botanical Gardens	74
145	B8	Beaverdam Creek at Beaver Lake	74
146	HY8	Eaglenest Creek in Hazelwood (Richland Creek watershed)	74
147	LJ13	North Fork of the Catawba River at Old Linville Rd	74
148	B25	South Turkey Creek (Sandymush Creek watershed)	73
149	H2	French Broad River at Butler Bridge Road	73
150	M15	Paint Fork at Beech Glen (Ivy River watershed)	73
151	P14	White Oak Creek at Briar Hill Farm	73
152	P18	Camp Creek (Green River watershed)	73
153	B26	North Turkey Creek (Sandymush Creek watershed)	72
154	H25	Gash Creek at Etowah School Road	72
155	HY32	Beaverdam Creek upstream	72
156	HY4	Pigeon River downstream from Canton	72
157	M13	California Creek at Beech Glen (Ivy River watershed)	72
158	NOT4	Butternut Creek	72
159	B1B	Little Ivy Creek (Ivy River watershed)	71
160	Toe4	North Toe River at Red Hill	71
161	B7B	Glenn Creek at UNCA Bot Gardens (Reed Ck wtrshd)	70
162	M12	Grapevine Creek (Ivy River watershed)	70
163	M14	Middle Fork at Beech Glen (Ivy River watershed)	70
Below Average			
164	B14	Lower Flat Creek	69
165	B42	Ross Creek at Upper Chunns Cove (Swannanoa R wtrshd)	69
166	M19	Laurel Valley Creek (Laurel River watershed)	69
167	M20	Puncheon Fork (Laurel River watershed)	69
168	M3	French Broad River at Hot Springs	69
169	HY7	Fines Creek downstream	68
170	B32	French Broad River at Walnut Island Park	67
171	B6A	French Broad River at the Ledges Park	67
172	HY19	Fines Creek upstream	67
173	HY23	Ratcliff Cove Branch (Raccoon Creek watershed)	67
174	Toe6	Bald Creek at Bald Crk Elem	67
175	TU6	Scott's Creek (Tuckasegee River watershed)	67
176	HY5	Pigeon River at Hepco Bridge	66
177	H4	Mud Creek at North Rugby Road	65
178	HY28	Hyatt Creek left branch	65
179	B4	Lower Newfound Creek	64
180	HY15	Fines Creek midstream	64

Appendix D: Stream Ranking Index -continued

181	B13	French Broad River at Corcoran Park (Hend/Bunc line)	62
182	H16	Cane Creek at Howard Gap Road	62
183	B37	Newfound Creek at Leicester Hwy	61
184	M17	Gabriel's Creek at Ivy River	61
185	B36	Newfound Creek at Dark Cove Road	60
186	B3B	Sandymush Creek at Willow Creek	60
187	HY14	Rush Fork upstream (Crabtree Crk watershed)	60
188	M2	French Broad River at Barnard Bridge	60
189	P10	Joels Creek downstream (N Pacolet River watershed)	60
			Poor
190	HY20	Cove Creek at NC 209 (Fines Creek watershed)	58
191	B48	South Creek Pond/Beaver Lake (Beaverdam Crk wtrshd)	56
192	HY22	Hyatt Creek downstream (Richland Creek watershed)	56
193	HY29	Hyatt Creek Owl Ridge branch	56
194	M1	Ivy River at NC 25/70	56
195	HY30	Hyatt Creek Green Valley branch	52
196	HY21	Hyatt Creek upstream (Richland Creek watershed)	51
197	B39	South Creek at Beaver Lake (Beaverdam Crk watershed)	49

	Percent - Excellent	Good	Average	Below Average	Poor
Buncombe	20	22	36	18	4
Henderson	29	46	18	7	0
Haywood	18	17	24	24	17
Hiwassee	100	0	0	0	0
Jackson/Lake Glenville	86	14	0	0	0
Lake James	29	57	14	0	0
Lake Lure	45	55	0	0	0
Madison	0	0	50	42	8
Nottely	67	22	11	0	0
Polk	14	43	36	7	0
Tuckasegee River	13	67	13	7	0
Toe	17	50	17	16	0
TOTAL	29	31	23	13	4

Appendix E: Data Summary for Hiwassee River Watershed

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

<u>pH - Last 3 Years</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	29	6.3	6.7	7.2	66	6.8
2	18	6.2	6.6	7.1	60	6.7
3	26	6.5	6.7	7.1	70	6.8
4	26	6.5	6.7	7.1	73	6.8
5	23	6.5	6.8	7.0	69	6.9
6	9	6.5	6.8	7.0	40	7.0
7	9	6.5	6.8	7.2	51	7.1
8	28	6.6	6.9	7.2	69	7.0
9	26	6.5	6.8	7.2	62	6.8
11	29	6.6	6.8	7.0	77	6.9
12	29	6.4	6.7	7.0	77	6.8

<u>Alkalinity (mg/L) - Last 3 Years/rep. limit 1 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	29	6	9	14	66	9
2	18	7	11	16	60	10
3	26	8	11	19	70	11
4	26	9	12	17	73	11
5	23	7	14	19	69	14
6	9	12	15	16	40	15
7	9	13	15	17	51	15
8	28	10	15	21	69	15
9	26	11	15	21	62	14
11	29	7	12	17	77	12
12	29	12	15	23	77	15

<u>Turbidity (NTU) - Last 3 Years/rep. limit 1 NTU</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	29	1.1	2.8	8.7	66	2.6
2	18	<1	2.9	15	60	3.0
3	26	1.6	4.9	22	70	4.5
4	26	2.5	4.2	16	73	4.8
5	23	2.6	5.2	16	69	4.7
6	9	2.6	5.4	9.9	40	3.1
7	9	2.3	3.8	6.3	51	3.1
8	28	<1	3.3	12	69	3.3
9	26	3.0	5.2	19	62	5.0
11	29	1.3	3.9	21	77	3.6
12	29	1.4	4.8	29	77	5.7

<u>TSS (mg/L) - Last 3 Years/rep. limit 4 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	29	<4	1.2	6.8	66	1.4
2	18	<4	3.4	22.4	60	3.2
3	26	<4	2.4	15.6	70	3.2
4	26	<4	4.6	26.8	73	5.2
5	23	<4	3.6	10.8	69	4.0
6	9	<4	4.0	8.8	40	3.2
7	9	<4	4.0	7.4	51	4.0
8	28	<4	2.4	10.4	69	2.4
9	26	<4	3.4	12.0	62	4.0
11	29	<4	2.0	17.2	77	2.4
12	29	<4	2.4	13.2	77	3.2

Appendix E: Data Summary for Hiwassee River Watershed – continued

<u>Conductivity - Last 3 Years/rep. limit 10 umhos/cm</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	29	13	15	19	66	15
2	18	13	15	16	60	14
3	26	15	20	30	70	19
4	26	19	23	27	73	21
5	23	23	26	33	69	25
6	9	24	28	33	40	24
7	9	28	31	35	51	30
8	28	26	29	38	69	27
9	26	24	29	37	62	26
11	29	15	21	28	77	18
12	29	28	31	35	77	30

<u>Copper (ppb) - Last 3 Years/rep. limit 2 ppb</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	<2	0.2	<2	65	0.3
2	0	.	.	.	16	0.6
3	0	.	.	.	45	0.4
4	0	.	.	.	40	0.6
5	0	.	.	.	18	0.5
6	0	.	.	.	17	0.3
7	0	.	.	.	20	0.4
8	28	<2	0.6	3.1	67	0.5
9	0	.	.	.	13	0.5
11	0	.	.	.	17	0.4
12	28	<2	0.4	2.1	75	0.5

<u>Lead (ppb) - Last 3 Years/rep. limit 2 ppb</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	<2	0.1	<2	65	0.1
2	0	.	.	.	16	0.2
3	0	.	.	.	44	0.2
4	0	.	.	.	40	0.2
5	0	.	.	.	18	0.1
6	0	.	.	.	17	0.2
7	0	.	.	.	20	0.2
8	28	<2	0.2	<2	67	0.1
9	0	.	.	.	13	0.1
11	0	.	.	.	17	0.1
12	28	<2	0.2	<2	75	0.2

<u>Zinc - Last 3 Years/rep. limit 20 ppb</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28.0	<20	0.7	<20	65.0	0.6
2	0.0	.	.	.	16.0	0.2
3	0.0	.	.	.	44.0	1.7
4	0.0	.	.	.	40.0	2.1
5	0.0	.	.	.	18.0	1.3
6	0.0	.	.	.	17.0	0.9
7	0.0	.	.	.	20.0	0.5
8	28.0	<20	2.1	<20	67.0	1.1
9	0.0	.	.	.	13.0	1.7
11	0.0	.	.	.	17.0	1.8
12	28.0	<20	1.3	<20	75.0	1.3

Appendix E: Data Summary for Hiwassee River Watershed – continued

<u>Orthophosphate (mg/L as PO4)-Last 3 Yrs/rep. lim. 0.02 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	29	<0.02	0.01	0.10	66	0.02
2	18	<0.02	0.03	0.13	60	0.03
3	26	<0.02	0.02	0.07	70	0.02
4	26	<0.02	0.02	0.15	73	0.02
5	23	<0.02	0.02	0.13	69	0.02
6	9	<0.02	0.04	0.08	40	0.03
7	9	<0.02	0.02	0.08	51	0.03
8	28	<0.02	0.02	0.10	69	0.02
9	26	<0.02	0.04	0.32	62	0.03
11	29	<0.02	0.01	0.12	77	0.02
12	29	<0.02	0.04	0.12	77	0.04

<u>Ammonia-nitrogen (mg/L) - Last 3 Years/rep. lim. 0.02 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	29	<0.02	0.04	0.08	66	0.04
2	18	<0.02	0.05	0.14	60	0.05
3	26	0.02	0.06	0.19	70	0.05
4	26	0.02	0.05	0.12	73	0.05
5	23	0.03	0.07	0.15	69	0.05
6	9	0.02	0.04	0.12	40	0.04
7	9	<0.02	0.03	0.06	51	0.04
8	28	<0.02	0.04	0.10	69	0.04
9	26	0.02	0.08	0.17	62	0.07
11	29	<0.02	0.05	0.11	77	0.05
12	29	0.02	0.08	0.13	77	0.08

<u>Nitrate/nitrite-nitrogen (mg/L)- Last 3 Years/rep. limit 0.1 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	29	<0.1	0.1	0.2	66	0.1
2	18	<0.1	0.0	0.1	60	0.1
3	26	<0.1	0.1	0.3	70	0.1
4	26	0.1	0.2	0.4	73	0.2
5	23	0.2	0.4	0.6	69	0.3
6	9	0.1	0.1	0.3	40	0.1
7	9	0.1	0.2	0.4	51	0.2
8	28	0.1	0.2	0.7	69	0.2
9	26	<0.1	0.3	0.5	62	0.3
11	29	0.1	0.1	0.4	77	0.1
12	29	0.2	0.4	0.6	77	0.4

Appendix E: Data Summary for Hiwassee River Watershed – continued

<u>Dissolved Oxygen (mg/L)</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	29	7.8	9.6	13.0	66	9.6
2	18	8.4	10.0	11.9	60	9.2
3	26	7.0	9.5	12.0	68	9.7
4	25	5.3	9.0	14.5	72	8.6
5	22	8.0	11.3	16.0	66	10.0
6	8	8.0	10.1	14.2	38	9.5
7	9	9.0	10.5	12.6	50	9.5
8	28	6.2	9.1	14.5	68	9.0
9	25	7.6	8.8	10.5	60	9.1
11	29	6.8	9.2	13.6	77	9.0
12	29	7.2	8.8	12.8	75	9.0

<u>Dissolved Oxygen Percent Saturation</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	81%	94%	117%	64	96%
2	18	94%	101%	114%	60	93%
3	26	84%	102%	124%	66	98%
4	22	60%	93%	120%	67	90%
5	22	84%	118%	155%	65	99%
6	8	88%	116%	163%	37	97%
7	9	99%	108%	120%	44	95%
8	28	65%	95%	139%	65	93%
9	25	85%	94%	104%	60	95%
11	29	81%	99%	114%	77	96%
12	29	80%	92%	109%	75	93%

Appendix F: Data Summary for Nottely River Watershed

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

<u>pH - Last 3 Years</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	6.3	6.6	7.0	46	6.7
2	29	6.5	6.8	7.3	69	7.0
3	29	6.5	6.7	7.1	69	6.8
4	29	6.5	6.9	7.1	69	6.9
5	29	6.5	6.8	7.2	69	6.9
6	29	6.6	6.9	7.1	69	6.9
7	27	6.5	6.8	7.1	67	6.9
8	28	6.4	6.8	7.1	68	6.9
9	23	6.4	6.6	6.9	48	6.7
10	8	6.5	6.7	6.9	16	6.8

<u>Alkalinity (mg/L) - Last 3 Years/rep. limit 1 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	7	11	18	46	11
2	29	18	21	30	69	20
3	29	11	16	24	69	16
4	29	19	25	39	69	24
5	29	7	11	23	69	12
6	29	12	25	36	69	22
7	27	10	14	22	67	14
8	28	10	12	22	68	12
9	23	10	13	20	48	13
10	8	11	15	24	16	15

<u>Turbidity (NTU) - Last 3 Years/rep. limit 1 NTU</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	1.0	2.4	5.5	46	2.5
2	29	2.3	6.0	32	69	6.0
3	29	2.1	3.9	18	69	4.1
4	29	1.6	4.5	55	69	4.9
5	29	1.7	3.5	9.3	69	3.7
6	29	1.8	5.6	27	69	6.3
7	27	1.6	5.4	27	67	5.0
8	28	1.9	5.3	17	68	5.3
9	23	2.3	4.7	14	48	4.8
10	8	2.0	4.2	10	16	3.8

<u>TSS (mg/L) - Last 3 Years/rep. limit 4 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	<4	1.2	4.8	46	1.6
2	29	<4	2.8	20.4	69	3.2
3	29	<4	2.4	10.0	69	2.8
4	29	<4	2.8	21.2	69	3.6
5	29	<4	2.0	6.8	69	2.4
6	29	<4	4.0	24.2	69	3.8
7	27	<4	2.8	22.4	67	3.6
8	28	<4	4.2	38.4	68	5.2
9	23	<4	3.6	8.0	48	3.8
10	8	<4	1.6	6.8	16	2.0

Appendix F: Data Summary for Nottely River Watershed – continued

<u>Conductivity - Last 3 Years/rep. limit 10 umhos/cm</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	10	19	25	46	20
2	29	39	48	56	69	43
3	29	21	33	47	69	33
4	29	49	71	125	69	60
5	29	20	24	43	69	22
6	29	23	51	61	69	44
7	27	21	28	34	67	27
8	28	23	24	29	68	23
9	23	20	23	31	48	22
10	8	21	24	27	16	23

<u>Copper (ppb) - Last 3 Years/rep. limit 2 ppb</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	0	.	.	.	18	1.1
2	0	.	.	.	20	0.4
3	24	<2	1.5	5.1	64	1.9
4	29	<2	1.3	3.0	69	1.0
5	0	.	.	.	20	0.1
6	0	.	.	.	20	0.3
7	0	.	.	.	20	0.3
8	0	.	.	.	20	0.2
9	0	.	.	.	21	0.2
10	0	.	.	.	10	0.4

<u>Lead (ppb) - Last 3 Years/rep. limit 2 ppb</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	0	.	.	.	18	0.3
2	0	.	.	.	20	0.1
3	24	<2	0.3	<2	64	0.3
4	29	<2	0.2	<2	69	0.2
5	0	.	.	.	20	0.1
6	0	.	.	.	20	0.2
7	0	.	.	.	20	0.1
8	0	.	.	.	20	0.2
9	0	.	.	.	21	0.4
10	0	.	.	.	10	0.1

<u>Zinc - Last 3 Years/rep. limit 20 ppb</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	0	.	.	.	18	6.3
2	0	.	.	.	20	1.3
3	24	<20	7.0	251.1	64	8.0
4	29	<20	6.5	32.1	69	4.3
5	0	.	.	.	20	2.1
6	0	.	.	.	20	2.8
7	0	.	.	.	20	1.3
8	0	.	.	.	20	0.5
9	0	.	.	.	21	1.0
10	0	.	.	.	10	0.6

Appendix F: Data Summary for Nottely River Watershed – continued

<u>Orthophosphate (mg/L as PO4)-Last 3 Yrs/rep. lim. 0.02 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	<0.02	0.03	0.11	46	0.03
2	29	<0.02	0.05	0.24	69	0.05
3	29	<0.02	0.03	0.18	69	0.03
4	29	0.02	0.13	1.52	69	0.17
5	29	<0.02	0.03	0.12	69	0.03
6	29	0.02	0.17	0.31	69	0.11
7	27	0.02	0.08	0.19	67	0.07
8	28	<0.02	0.04	0.16	68	0.04
9	23	<0.02	0.05	0.13	48	0.04
10	8	<0.02	0.03	0.06	16	0.03

<u>Ammonia-nitrogen (mg/L) - Last 3 Years/rep. lim. 0.02 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	<0.02	0.06	0.20	46	0.06
2	29	0.04	0.10	0.22	69	0.08
3	29	0.02	0.12	0.38	69	0.12
4	29	0.06	0.17	0.51	69	0.19
5	29	0.02	0.07	0.17	69	0.06
6	29	0.04	0.16	0.26	69	0.16
7	27	0.04	0.10	0.24	67	0.10
8	28	0.03	0.08	0.18	68	0.07
9	23	0.02	0.08	0.27	48	0.07
10	8	0.02	0.06	0.14	16	0.06

<u>Nitrate/nitrite-nitrogen (mg/L)- Last 3 Years/rep. limit 0.1 mg/L</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	0.1	0.1	0.2	46	0.1
2	29	0.2	0.5	1.0	69	0.5
3	29	0.2	0.3	0.7	69	0.3
4	29	<0.1	0.6	1.8	69	0.5
5	29	0.1	0.3	0.5	69	0.3
6	29	0.1	0.5	1.0	69	0.5
7	27	<0.1	0.3	0.7	67	0.3
8	28	0.1	0.2	0.7	68	0.2
9	23	0.1	0.2	0.5	48	0.2
10	8	0.1	0.2	0.3	16	0.2

Appendix F: Data Summary for Nottely River Watershed – continued

<u>Dissolved Oxygen (mg/L)</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	7.4	9.3	13.4	46	9.2
2	29	7.0	9.0	14.0	69	9.0
3	29	7.1	8.8	13.6	69	9.1
4	29	5.8	8.4	13.0	69	8.4
5	29	6.8	8.9	13.0	69	9.0
6	29	6.1	7.8	12.6	68	8.4
7	26	6.2	8.7	12.1	66	9.1
8	28	2.6	8.4	14.0	68	8.9
9	23	5.8	8.2	10.6	48	8.2
10	7	7.8	10.6	12.6	15	10.4

<u>Dissolved Oxygen Percent Saturation</u>					<u>All Results</u>	
<u>site</u>	<u>sample #</u>	<u>low</u>	<u>median</u>	<u>high</u>	<u>sample #</u>	<u>median</u>
1	28	75%	99%	113%	46	99%
2	29	77%	92%	110%	69	96%
3	28	84%	93%	104%	66	93%
4	29	60%	86%	103%	68	89%
5	29	74%	90%	113%	69	92%
6	29	69%	86%	101%	68	87%
7	25	68%	97%	123%	65	95%
8	28	30%	90%	119%	65	93%
9	23	67%	81%	96%	47	85%
10	7	88%	96%	103%	15	96%

Appendix G: Trends for Each Site Related to Flow

Hiwassee River Watershed

increases as flow increases

site #	site name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	Dissolved Oxygen
1	Upper Hiwassee Rvr			X	X								
2	Martin's Creek												
3	Hightower Crk			X	X								
4	Scataway Creek			X	X						X		
5	Geisky Crk			X	X								
7	Upper Shooting Crk			X	X						X		
8	Lower Shooting Crk			X	X		X				X		
9	Upper Bell Creek			X	X								
11	Hog Crk				X								
12	Woods Crk			X	X	X							

decreases as flow increases

site #	site name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	Dissolved Oxygen
						X							
						X							
													X
		X	X										
		X				X							
						X						X	
		X				X						X	

Nottely River Watershed

site #	site name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	Dissolved Oxygen
1	Nottely River												
2	Arkaqua Creek				X								
3	Nottely River				X								
4	Butternut Creek			X	X								
5	Coosa Creek			X	X								
6	Anderson Creek												
7	Young Cane Creek					X							
8	Ivy Log Creek			X	X								
9	Conley Creek			X	X	X						X	

site #	site name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	Dissolved Oxygen
		X				X							
		X											
		X	X			X				X			
		X	X			X				X		X	
		X											
		X								X		X	

Appendix H: Trends for Each Site Related to Time

Hiwassee River Watershed

increasing over time

site #	site name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	Dissolved Oxygen
1	Upper Hiwassee Rvr			X									
2	Martin's Creek			X	X	X							X
3	Hightower Crk			X		X							
4	Scataway Creek			X		X							X
5	Geisky Crk			X		X					X		
7	Upper Shooting Crk			X		X							
8	Lower Shooting Crk			X		X							
9	Upper Bell Creek			X		X				X			
11	Hog Crk												
12	Woods Crk					X							

decreasing over time

site #	site name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	Dissolved Oxygen
1	Upper Hiwassee Rvr												X
2	Martin's Creek												
3	Hightower Crk												
4	Scataway Creek	X											
5	Geisky Crk									X			
7	Upper Shooting Crk	X	X										
8	Lower Shooting Crk	X											
9	Upper Bell Creek	X											
11	Hog Crk												
12	Woods Crk	X											

Nottely River Watershed

site #	site name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	Dissolved Oxygen
1	Nottely River												
2	Arkaqua Creek		X			X							
3	Nottely River												
4	Butternut Creek			X			X	X					
5	Coosa Creek												
6	Anderson Creek		X			X				X			
7	Young Cane Creek					X							
8	Ivy Log Creek			X		X							
9	Conley Creek			X	X	X				X	X	X	

site #	site name	pH	Alkalinity	Turbidity	TSS	Conductivity	Copper	Lead	Zinc	Ortho-phos	Ammonia-N	Nitrate-N	Dissolved Oxygen
1	Nottely River	X											
2	Arkaqua Creek	X											X
3	Nottely River	X											
4	Butternut Creek	X								X	X	X	X
5	Coosa Creek	X											
6	Anderson Creek	X										X	X
7	Young Cane Creek	X											
8	Ivy Log Creek	X											
9	Conley Creek	X											X

Appendix I: Seasonal Trends

Hiwassee and Nottely sites (19 sites, but only 5 sites for metals)

parameter	hi winter	hi spring	hi summer	hi fall	lo winter	lo spring	lo summer	lo fall	trend sites	% sites showing trend
pH			13	1	14				14	73.7%
alkalinity			1	12	12	1			13	68.4%
turbidity		8	7		3			12	15	78.9%
total susp sol		9	10		8			11	19	100.0%
conductivity			7	8	3	12			15	78.9%
copper		2	1		2			1	3	60.0%
lead									0	0.0%
zinc	1							1	1	20.0%
orthophos.		8	3	1	11			1	12	63.2%
ammonia-N			8	1	9				9	47.4%
nitrate-N			1		1				1	5.3%

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	0	2	88	35	104	19	0	2	125	70.6%
alkalinity	0	0	42	94	61	75	0	0	136	76.8%
turbidity	2	28	91	0	60	1	0	60	121	68.4%
total susp sol	0	39	95	1	82	0	0	53	135	76.3%
conductivity	12	4	47	78	22	111	4	4	141	79.7%
copper	1	13	42	0	41	1	1	13	56	34.4%
lead	1	9	30	0	18	2	0	20	40	24.5%
zinc	9	7	17	0	8	5	3	17	33	20.2%
orthophos.	0	9	64	5	55	19	0	4	78	44.1%
ammonia-N	1	6	92	11	91	10	1	8	110	62.1%
nitrate-N	77	9	39	0	11	12	24	78	125	70.6%