# Section 2

## Monitoring Data and Water Quality Assessments

Water quality is assessed every two years to fulfill the reporting requirements of Section 303(d) and 305(b) of the Federal Clean Water Act (CWA). Chemical, physical and biological parameters are regularly assessed by the Division of Water Resources (DWR) to determine how well waterbodies are meeting their best-intended use. When enough samples are collected, waterbodies are determined to be meeting or exceeding criteria based on a five-year dataset. The waterbody's classification is factored into the assessment as well as existing water quality standards. Impaired waters are waterbodies where water quality samples are exceeding water quality standards for a particular parameter. Procedures used to evaluate water quality and assign categories are explained in detail in the Integrated Report (IR) methodology. For the purposes of this report, the 2016 methodology was used.

### 2.1 Interpreting Data

In North Carolina, criteria are established to protect the surface water classification, or designation, of a waterbody. The criteria define the maximum pollutant concentrations, goals, conditions or other requirements in order for a waterbody to maintain or attain its designation. In the Watauga River basin, water quality was assessed for aquatic life, recreation, fish consumption and water supply. Water supplies were assessed on a monitored or evaluated basis. Fish consumption advisories are based off of information collected from the North Carolina Department of Health and Human Services. Waters are assessed based on the parameter of interest and are found to be:

- Meeting Criteria (meeting standards),
- Exceeding Criteria (exceeding standards, also referred to as impaired) or
- Data Inconclusive (data does not allow for an assessment to be made).

Biological (benthic and fish community) samples are given a bioclassification based on the data collected at the site by DWR biologists in the Water Sciences Section (WSS) Biological Assessment Branch (BAB). The bioclassifications (also referred to as ratings) are Excellent, Good, Good-Fair, Not Impaired, Not Rated, Fair or Poor and include measurements for diversity, abundance and the number of pollution tolerant or intolerant species found within a particular waterbody. For specific methodology defining how these ratings are given, refer to the Benthic Standard Operating Procedures (SOP) or the Fish Community SOP available through WSS.

Ambient monitoring data are analyzed based on the percent of samples exceeding the state standard for individual parameters for each site within a five-year period. In general, if more than 10 percent of the samples exceed the standard for a water quality parameter with 90% statistical confidence, the stream segment is Exceeding Criteria, or impaired, for that parameter. The standard for fecal coliform bacteria (FCB) is the exception to the rule.

Each biological parameter (benthic and fish) and each ambient parameter is assessed independently and assigned a category based on its rating or percent exceedance. Each monitored stream segment is given an overall category number. Table 2.1 illustrates how bioclassifications for biological samples and ambient data are translated into categories. For example, if the ambient data is meeting criteria for all parameters but the bioclassification is exceeding the criteria established for fish, the waterbody will be assigned to Category 5 and placed on the 303(d) list. Categories are defined in more detail in the IR methodology.

Table 2.1: Water Quality Assessments and Categories (2014)

| Biological Ratings (Bioclassifications) | Water Quality Assessment Based on North Carolina Standards (EPA Categories) | Ambient Monitoring Data |
|---|---|---|
| Excellent | Meeting Criteria (Categories 1 and 2) | Numerical standard exceeded in ≤ 10% of the samples collected |
| Good | | |
| Good-Fair | | |
| Not Impaired | | |
| Not Rated | Data Inconclusive (Category 3) | Less than 10 samples were collected |
| Fair | Exceeding Criteria (Categories 4 and 5[*]) | Numerical standard exceeded in ≥ 10% of the samples collected with 90% statistical confidence |
| Poor | | |

[*] Category 4 is assigned when a parameter is exceeding criteria, but (1) the development of a total daily maximum load (TMDL) is not required, (2) a TMDL or management strategy is already in place, and/or (3) a variance is in place. The development of a TMDL includes a study of the watershed to identify the sources of the pollutant(s), calculations and modeling to identify the pollutant(s) contributing to the impairment and reductions needed from point and nonpoint sources of pollution. Category 5 is assigned when a parameter is exceeding criteria, and a TMDL is required. Category 5 assessments are the 303(d) list, which is also referred to as the impaired waters list. Definitions and more detailed information about each category can be found in the 2014 IR methodology. The methodology is also referred to as the 2016 Water Quality Assessment Process.

## 2.2 Biological Monitoring Data

Overall, 43 biological samples were collected during cycle 4, and 36 were collected during cycle 5. Information presented here also includes monitoring that was conducted during cycle 3 and presented in the 2007 Watauga River Basin Water Quality Plan. Table 2.2 identifies the five-year sampling cycles for the Watauga River basin and the total number of samples collected. Thirteen benthic sites have been sampled for the last three consecutive cycles. Three fish community sites have been sampled over the last three consecutive cycles. The remaining samples were collected for the first time as part of a special study.

Table 2.2: Basin Sampling Cycle in the Watauga River Basin

| Cycle Number | Dates | Benthic Samples Collected | Fish Samples Collected |
|---|---|---|---|
| 3 | September 1999 – August 2004 | 15 | 10 |
| 4 | September 2004 – August 2009 | 30 | 13 |
| 5 | September 2009 – August 2014 | 22 | 14 |

### 2.2.1 Benthic Communities

A total of 30 benthic sites were sampled during cycle 4. A total of 22 sites were sampled during cycle 5. The majority of the sites sampled rated Excellent or Good with only 3 percent Not Rated during cycle 4. Any changes in species abundance, diversity and tolerance noted by biologists were likely due to extreme weather conditions (i.e., higher than normal stream flow due to heavy precipitation, low stream flow due to drought conditions) before samples were collected. Figure 2.1 shows the location and bioclassification of the most recent sampling event. Table 2.3 lists all basin and special study sites and includes previous ratings for sites where multiple samples were collected. Figure 2.2 provides a graphic representation, or summary, of what percentage of sites received an Excellent, Good, Good-Fair, Not Rated or Not Impaired bioclassification.

Figure 2.1: Benthic Macroinvertebrate Sampling Sites (2004-2014)

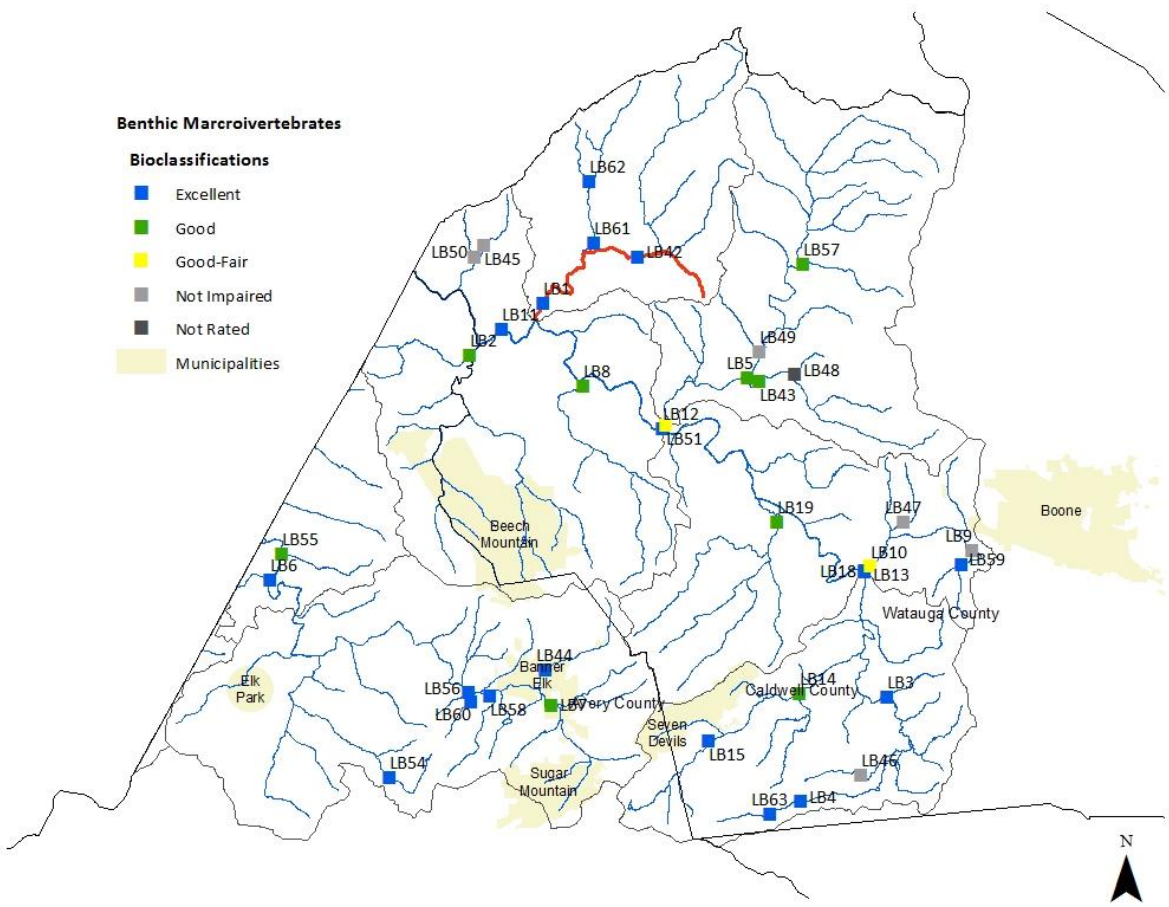


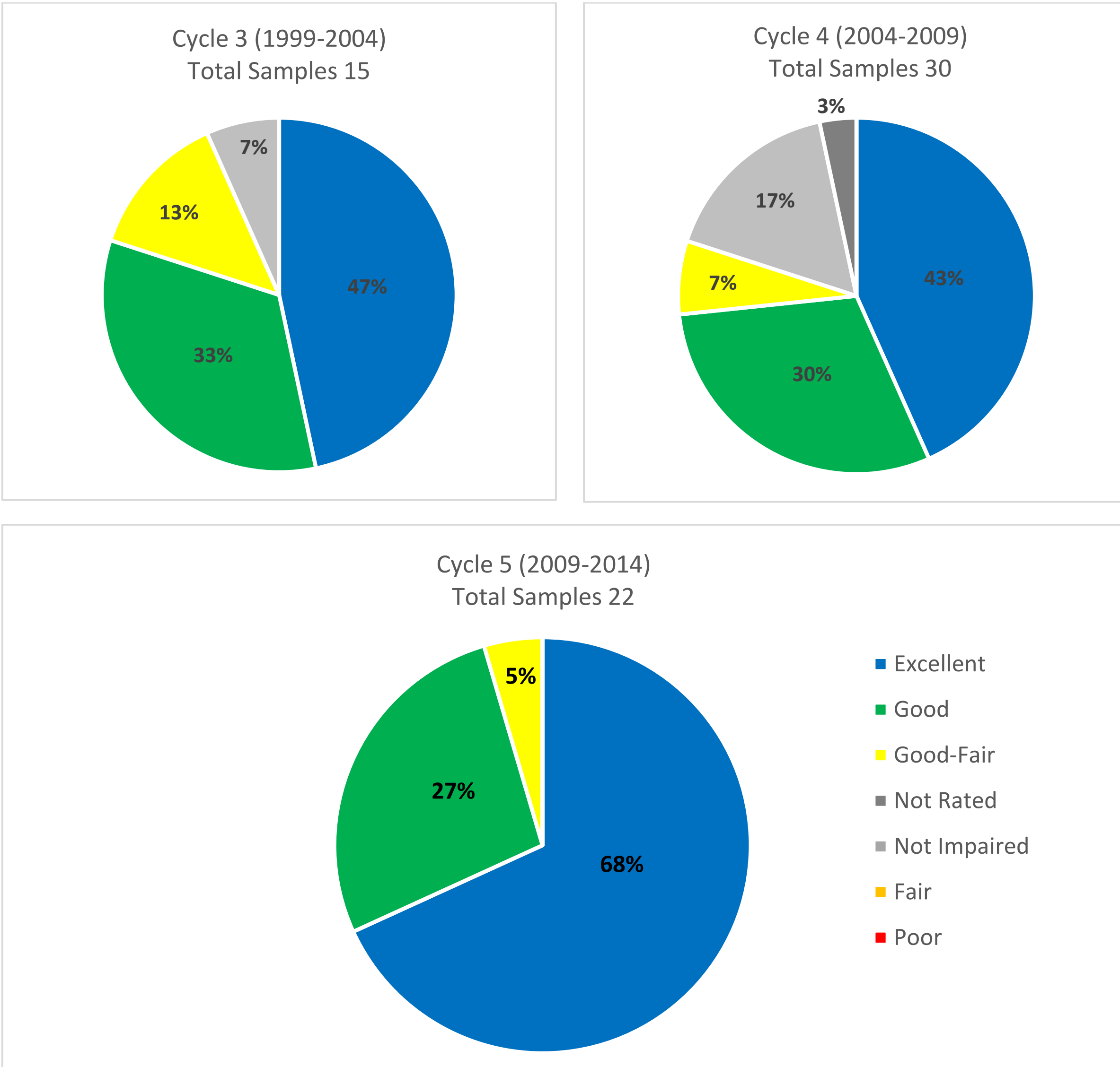

Table 2.3: Biological Monitoring Data Results – Benthic Macroinvertebrates HUC 06010103

| Station ID | Waterbody Name | AU# | Location | Sampling Date | Rating | Type of Study |
|---|---|---|---|---|---|---|
| LB1 | Beaverdam Creek | 8-19 | SR 1202 | 8/17/2004 | Good | Basin Sample |
| | | | | 6/16/2008 | Excellent | Basin Sample |
| | | | | 3/23/2009 | Excellent | Special Study |
| | | | | 7/16/2013 | Excellent | Basin Sample |
| LB10 | Laurel Fork | 8-10 | SR 1111 | 8/18/2004 | Good-Fair | Basin Sample |
| | | | | 7/28/2008 | Good | Basin Sample |
| | | | | 7/16/2013 | Good-Fair | Basin Sample |

| Station ID | Waterbody Name | AU# | Location | Sampling Date | Rating | Type of Study |
|---|---|---|---|---|---|---|
| LB11 | Watauga River | 8-(16) | SR 1200 | 8/17/2004 | Excellent | Basin Sample |
| | | | | 7/29/2008 | Excellent | Basin Sample |
| | | | | 8/13/2013 | Excellent | Basin Sample |
| LB12 | Watauga River | 8-(1)b | SR 1121 | 8/17/2004 | Excellent | Basin Sample |
| | | | | 12/2/2004 | Good | Special Study |
| | | | | 7/29/2008 | Good | Basin Sample |
| | | | | 8/12/2013 | Excellent | Basin Sample |
| LB13/ LB18 | Watauga River | 8-(1)a | NC 105 | 8/18/2004 | Excellent | Basin Sample |
| | | | | 7/28/2008 | Excellent | Basin Sample |
| | | | | 8/12/2013 | Excellent | Basin Sample |
| LB14 | Watauga River | 8-(1)a | SR 1580 | 8/18/2004 | Good | Basin Sample |
| | | | | 7/28/2008 | Excellent | Basin Sample |
| | | | | 7/16/2013 | Good | Basin Sample |
| LB15 | Watauga River | 8-(1)a | SR 1594 | 8/16/2004 | Excellent | Special Study |
| LB2 | Beech Creek | 8-20 | US 321 | 8/17/2004 | Excellent | Basin Sample |
| | | | | 7/29/2008 | Excellent | Basin Sample |
| | | | | 7/17/2013 | Good | Basin Sample |
| LB3 | Boone Fork (Price Lake) | 8-7 | SR 1558 | 8/18/2004 | Excellent | Basin Sample |
| | | | | 7/31/2008 | Excellent | Basin Sample |
| | | | | 7/16/2013 | Excellent | Basin Sample |
| LB4 | Boone Fork (Price Lake) | 8-7 | SR 1561 | 8/18/2004 | Excellent | Basin Sample |
| | | | | 8/1/2008 | Excellent | Basin Sample |
| | | | | 7/16/2013 | Excellent | Basin Sample |
| | | | | 6/16/2014 | Excellent | Basin Sample |
| LB42 | Beaverdam Creek | 8-19 | SR 1211 | 6/16/2008 | Excellent | Special Study |
| LB43 | Brushy Fork | 8-15-10 | SR 1117 | 6/16/2008 | Good | Special Study |
| LB44 | Shawneehaw Creek | 8-22-7 | OFF NC 194 | 6/16/2008 | Excellent | Special Study |
| LB45 | Stone Mountain Branch | 8-21 | SR 1201 | 5/15/2007 | Not Impaired | Special Study |
| LB46 | Cold Prong | 8-7-1 | Price Lake Loop Trail | 7/9/2007 | Not Impaired | Special Study |
| LB47 | Upper Laurel Fork | 8-10-3 | SR 1114 | 5/16/2007 | Not Impaired | Special Study |
| LB48 | George Branch | 8-15-10-2 | SR 1310 | 5/15/2007 | Not Rated | Special Study |
| LB49 | George Gap Branch | 8-15-9 | SR 1213 | 5/15/2007 | Not Impaired | Special Study |
| LB5 | Cove Creek | 8-15 | SR 1149 | 8/17/2004 | Good | Basin Sample |
| | | | | 12/1/2004 | Good-Fair | Special Study |

| Station ID | Waterbody Name | AU# | Location | Sampling Date | Rating | Type of Study |
|---|---|---|---|---|---|---|
| | | | | 7/29/2008 | Good | Basin Sample |
| | | | | 8/12/2013 | Good | Basin Sample |
| LB50 | UT Stone Mountain Branch | 8-21ut3 | SR 1206 | 5/15/2007 | Not Impaired | Special Study |
| LB51 | Cove Creek | 8-15 | OFF SR 1121 | 5/15/2007 | Good | Special Study |
| LB51 | Cove Creek | 8-15 | OFF SR 1121 | 3/23/2009 | Good-Fair | Special Study |
| LB54 | Greenbrier Creek | 8-22-16-2-1 | SR 1361 | 7/30/2008 | Good | Special Study |
| | | | | 7/15/2009 | Excellent | Special Study |
| LB55 | Fall Creek | 8-22-20 | OFF SR 1305 | 7/30/2008 | Good | Special Study |
| LB56 | Ramp Branch | 8-22-12 | OFF NC194 | 6/21/2011 | Excellent | Special Study |
| LB57 | Sharp Creek | 8-15-6 | SR 1306 | 6/22/2011 | Good | Special Study |
| LB58 | Leroy Creek | 8-22-9 | OFF NC 194 | 6/21/2011 | Excellent | Special Study |
| LB59 | Harrison Branch | 8-10-1 | OFF SR 1551 | 6/22/2011 | Excellent | Special Study |
| LB6 | Elk River | 8-22-(14.5) | SR 1305 | 8/16/2004 | Good | Basin Sample |
| | | | | 7/30/2008 | Excellent | Basin Sample |
| | | | | 8/13/2013 | Excellent | Basin Sample |
| LB60 | Clear Branch | 8-22-11 | OFF NC 194 | 6/22/2011 | Excellent | Special Study |
| LB61 | Rube Creek | 8-19-3 | SR 1201 | 6/20/2011 | Excellent | Special Study |
| LB62 | West Fork Rube Creek | 8-19-3-2 | OFF SR 1222 | 6/20/2011 | Excellent | Special Study |
| LB63 | Boone Fork (Price Lake) | 8-7 | OFF BRP | 5/7/2014 | Excellent | Special Study |
| LB7 | Elk River (Mill Pond) | 8-22-(3) | NC 184 | 8/16/2004 | Good-Fair | Basin Sample |
| | | | | 7/30/2008 | Good | Basin Sample |
| | | | | 8/13/2013 | Good | Basin Sample |
| LB8 | Laurel Creek | 8-17 | SR 1123 | 8/17/2004 | Good | Basin Sample |
| | | | | 7/29/2008 | Excellent | Basin Sample |
| | | | | 7/17/2013 | Good | Basin Sample |
| LB9 | Laurel Fork | 8-10 | SR 1552 | 8/18/2004 | Not Impaired | Special Study |

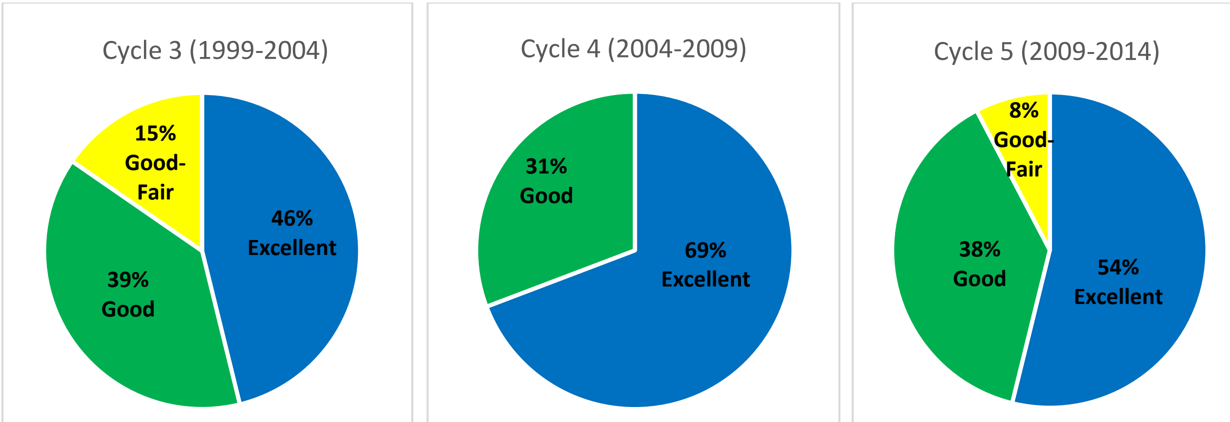
Figure 2.2: Percent of Benthic Macroinvertebrate Bioclassifications for All Sites Sampled during Cycle 3, Cycle 4 and Cycle 5




## Basinwide Sampling Sites – Benthic Communities

Thirteen benthic sites were sampled during the last three consecutive sampling periods. Significant improvements were observed in the samples collected between cycle 3 and cycle 4 with all thirteen sites rating Excellent or Good during cycle 4. A slight change was observed between cycle 4 and cycle 5 with one site rating Good-Fair and the remaining sites receiving an Excellent or Good bioclassification. Several sites received the same rating during all three cycles. Overall, water quality in the basin continues to meet criteria for benthic macroinvertebrates.

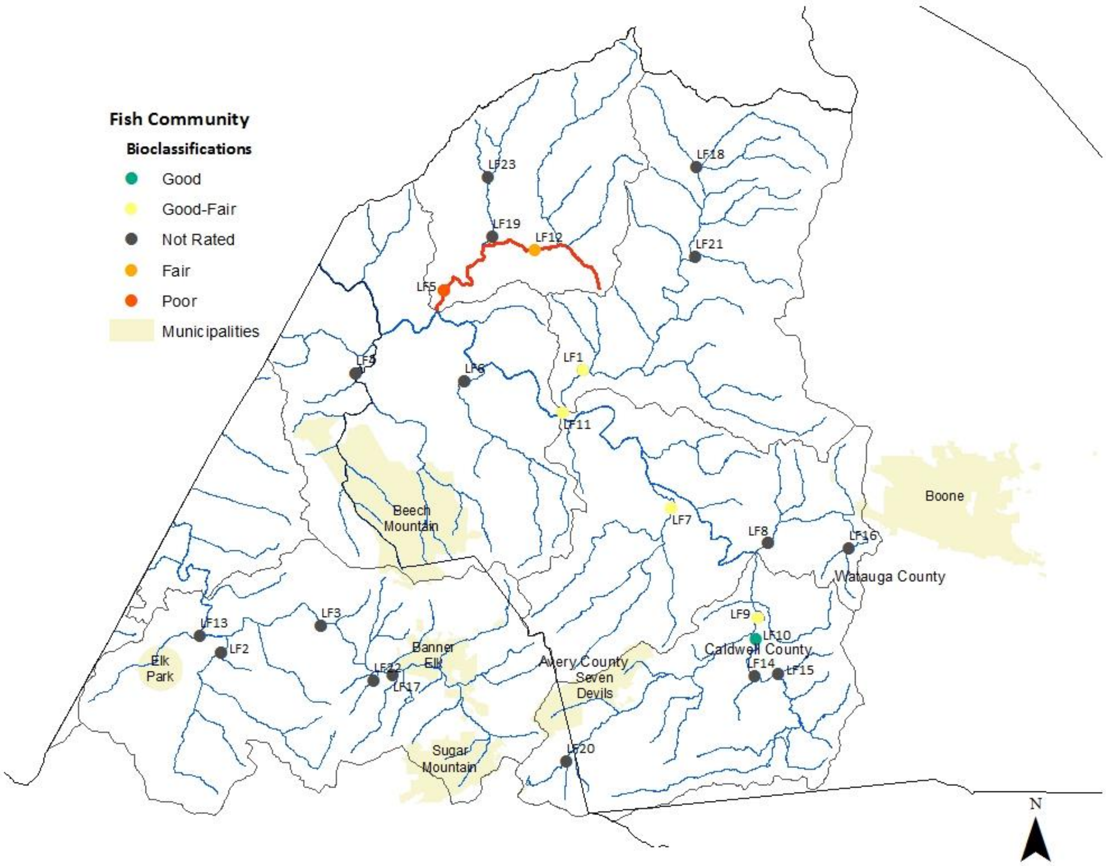
Figure 2.3: Shifts in Benthic Macroinvertebrate Communities for the 13 Basinwide Sampling Sites




### 2.2.2 Fish Community

A total of 13 fish sites were sampled during cycle 4. A total of 14 sites were sampled during cycle 5. Fish communities were sampled for the first time by DWR in 2004 (cycle 3) and the 2004 data serves as a baseline for fish communities sampled during subsequent monitoring cycles. The majority of the sites sampled were Not Rated because criteria and metrics have not been developed for small, Southern Appalachian trout streams (NCDENR, 2012). Samples that were rated, however, used methodology found in the Fish Community SOP. Figure 2.4 shows the location and bioclassification of the most recent sampling event (cycle 5). Table 2.4 lists all basin and special study sites and includes previous ratings for sites where multiple samples were collected. Figure 2.5 provides a graphic representation, or summary, of the percentage of sites that received a Good, Good-Fair, Not Rated or Poor bioclassification.

## Figure 2.4: Fish Community Sampling Sites (2004-2014)



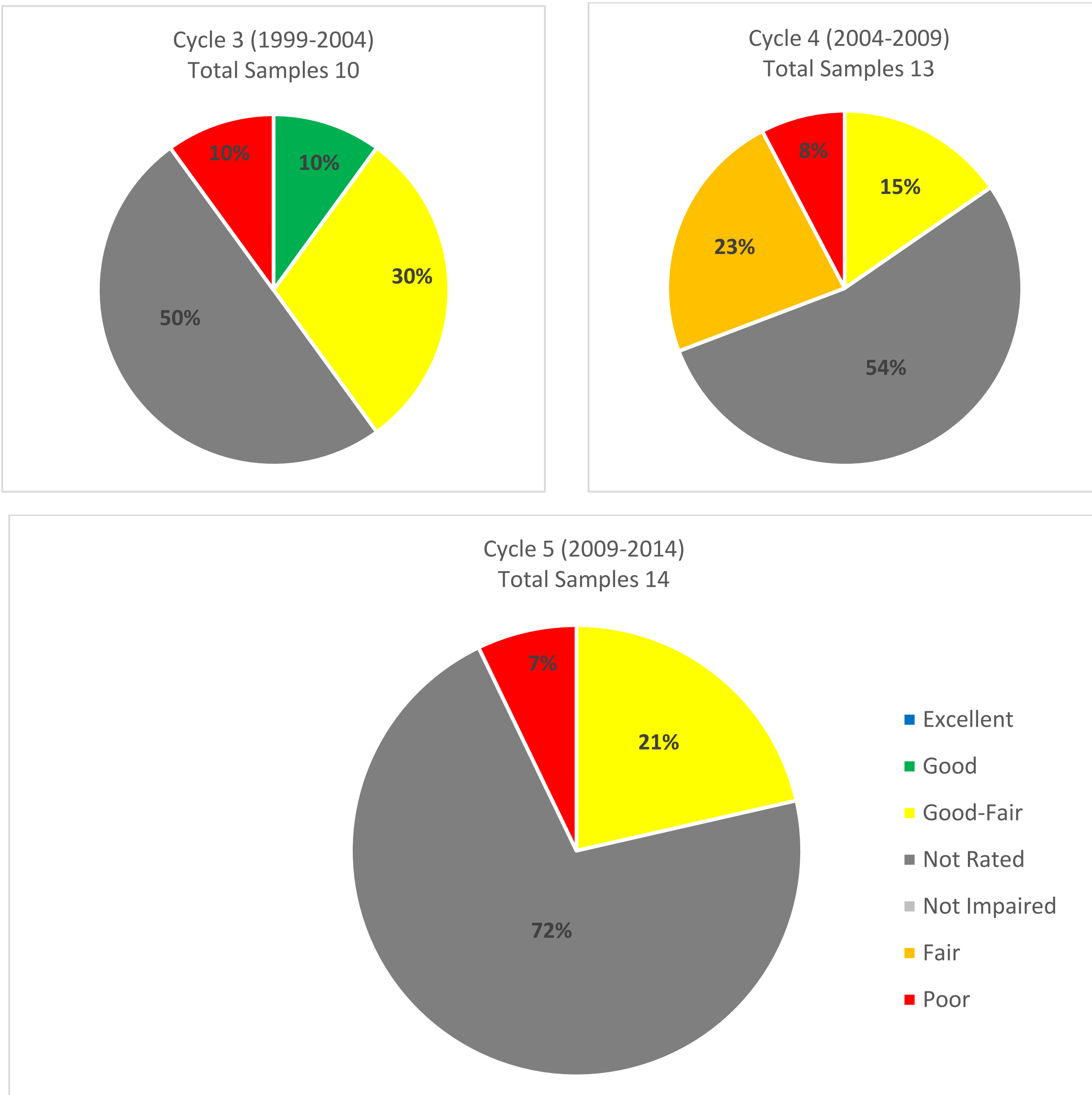

## Table 2.4: Biological Monitoring Data Results – Fish Community HUC 06010103

| Station ID | Waterbody Name | AU# | Location | Sampling Date | Rating | Type of Study* |
|---|---|---|---|---|---|---|
| LF1 | Cove Creek | 8-15 | SR 1149 | 5/5/2004 | Good-Fair | Basin Sample |
| | | | | 12/2/2004 | Not Rated | Special Study |
| LF11 | Cove Creek | 8-15 | off SR 1121 | 6/17/2008 | Fair | Basin Sample |
| | | | | 3/23/2009 | Good-Fair | Basin Sample |
| | | | | 5/29/2013 | Good-Fair | Basin Sample |
| LF13 | Little Elk Creek | 8-22-17 | off SR 1305 | 6/18/2008 | Not Rated | Basin Sample |
| LF14 | Bee Tree Creek | 8-7-6 | off SR 1558 | 10/13/2009 | Not Rated | Special Study |
| LF15 | Cannon Branch | 8-7-5 | off SR 1558 | 10/12/2009 | Not Rated | Special Study |
| LF16 | Harrison Branch | 8-10-1 | off SR 1551 | 10/13/2009 | Not Rated | Special Study |
| LF17 | Leroy Creek | 8-22-9 | off NC 194 | 10/12/2009 | Not Rated | Special Study |
| LF18 | North Fork Cove Creek | 8-15-2 | SR 1233/1227 | 10/13/2009 | Not Rated | Special Study |
| LF19 | Rube Creek | 8-19-3 | SR 1221 | 10/13/2009 | Not Rated | Special Study |

| Station ID | Waterbody Name | AU# | Location | Sampling Date | Rating | Type of Study* |
|---|---|---|---|---|---|---|
| LF2 | Cranberry Creek | 8-22-16 | NC 194 | 5/3/2004 | Not Rated | Basin Sample |
| | | | | 6/19/2008 | Not Rated | Basin Sample |
| LF20 | Shanty Spring Branch | 8-2 | off NC 105 | 10/12/2009 | Not Rated | Special Study |
| LF21 | Sharp Creek | 8-15-6 | SR 1306 | 10/13/2009 | Not Rated | Special Study |
| LF22 | Clear Branch | 8-22-11 | off NC 194 | 10/12/2009 | Not Rated | Special Study |
| LF23 | West Fork Rube Creek | 8-19-3-2 | off SR 1222 | 10/13/2009 | Not Rated | Special Study |
| LF3 | Elk River | 8-22-(14.5) | SR 1326 | 5/3/2004 | Not Rated | Basin Sample |
| | | | | 6/19/2008 | Not Rated | Basin Sample |
| LF4 | Beech Creek | 8-20 | off SR 1312 | 5/4/2004 | Not Rated | Basin Sample |
| | | | | 6/18/2008 | Not Rated | Basin Sample |
| LF12 | Beaverdam Creek (Upstream) | 8-19 | SR 1211 | 6/17/2008 | Fair | Special Study |
| LF5 | Beaverdam Creek | 8-19 | SR 1202 | 5/4/2004 | Poor | Basin Sample |
| | | | | 6/18/2008 | Fair | Basin Sample |
| | | | | 3/23/2009 | Poor | Basin Sample |
| | | | | 5/30/2013 | Poor | Basin Sample |
| LF6 | Laurel Creek | 8-17 | SR 1123 | 5/4/2004 | Not Rated | Basin Sample |
| | | | | 6/17/2008 | Not Rated | Basin Sample |
| LF7 | Dutch Creek | 8-12-(1.5) | SR 1112/ NC 194 | 5/5/2004 | Good-Fair | Basin Sample |
| | | | | 6/16/2008 | Good-Fair | Basin Sample |
| | | | | 5/30/2013 | Good-Fair | Basin Sample |
| LF8 | Laurel Fork | 8-10 | SR 1111 | 5/5/2004 | Not Rated | Basin Sample |
| | | | | 6/16/2008 | Not Rated | Basin Sample |
| LF9 | Watauga River | 8-(1)a | off SR 1557 | 5/6/2004 | Good-Fair | Basin Sample |
| | | | | 5/30/2013 | Good-Fair | Basin Sample |
| LF10 | Boone Fork (Price Lake) | 8-7 | off SR 1558 | 5/6/2004 | Good | Basin Sample |

*Three sites (LF1/LF11 – Cove Creek, LF5 – Beaverdam Creek, LF7 – Dutch Creek) have been sampled for three consecutive cycles. Several of the sites labeled as “Basin Sample” were used to help develop criteria for small, Southern Appalachian trout streams.

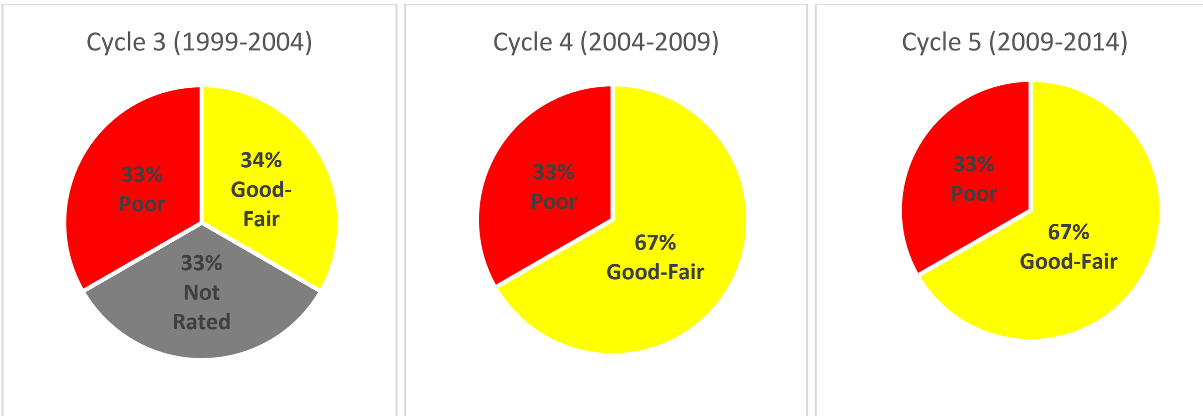
Figure 2.5: Percent of Fish Community Bioclassifications for All Sites Sampled during Cycle 3, Cycle 4 and Cycle 5




## Basinwide Sampling Sites – Fish Community

Three fish community sites were sampled during the last three consecutive sampling periods. Overall, water quality in the basin is meeting criteria for fish communities sampled in the basin except for one – Beaverdam Creek (LF5). Despite the Excellent bioclassification given to the benthic community (LB1), Beaverdam Creek was placed on the 303(d) in 2008 due to a Poor fish bioclassification. The site continues to be rated Poor for fish, but Good or Excellent for benthic macroinvertebrates. Biologists noted that the watershed continues to be impacted by adjacent and upstream land uses. Several best management practices (BMPs) have been installed throughout the watershed and include several agriculture BMPs such as stream protection systems (fencing livestock, alternate watering source), streambank stabilization and riparian buffer plantings. One stormwater BMP (rain garden) was also constructed. Additional BMPs are scheduled to be installed over the next several years. Working with local partners, DWR will continue to monitor Beaverdam Creek.

Figure 2.6: Shifts in Fish Communities for the 3 Basinwide Sampling Sites




## 2.3 Ambient Data

All parameters measured through the network of ambient monitoring stations are important to human health, aquatic life and/or the aquatic ecosystem, and many of the parameters are related to one another. Parameters collected at each site depend on the waterbody's classification but typically include conductivity, dissolved oxygen, pH, temperature, turbidity, nutrients, and fecal coliform. Each classification has an associated set of water quality standards the parameter must meet in order to be considered supporting its designated use(s). Ten sample results are required within the five-year data collection window to evaluate the water quality parameter and compare it to the water quality standards.

There are currently two ambient monitoring system (AMS) stations in the Watauga River basin where ten or more samples were collected by DWR over the five-year data window (Table 2.5). In addition, two stations were monitored as part of the Random Ambient Monitoring System (RAMS). RAMS is a component of the AMS and is a probabilistic monitoring initiative in which sampling locations are randomly selected and located on freshwater streams throughout the state. The stations are sampled once a month for two years and then "retired." RAMS focuses on smaller streams and allows the division to collect data on water quality parameters that are not evaluated through AMS and allows the division to answer broad questions about water quality in North Carolina's smaller streams. Parameters collected through RAMS that are not collected through AMS include: chloride, fluoride, sulfate, dissolved organic carbon, metals, mercury, and volatile organic compounds. Two stations (L0450000 and L4650000) were sampled as part of RAMS from 2007-2008. Information collected from these two stations was included in a 2007-2010 RAMS report. Individual parameter information collected from the RAMS stations is shared here as needed to explain data collected at the AMS stations.

Table 2.5: Ambient Monitoring Stations in the Watauga River Basin

| Station ID | Station Type | Active Date | Waterbody | AU | Station Location |
|---|---|---|---|---|---|
| L1700000 | AMS | 07/2000 - Current | Watauga River | 8-(1)a | SR1557<br>Shull Mills |
| L4700000 | AMS | 06/1975 - Current | Watauga River | 8-(1)b | SR1121<br>Sugar Grove |
| L0450000 | RAMS | 01/2007 - 12/2008 | Cold Prong | 8-7-1 | Price Lake Loop Trail |
| L4650000 | RAMS | 01/2007 - 12/2008 | Cove Creek | 8-15 | SR1121<br>Sugar Grove |

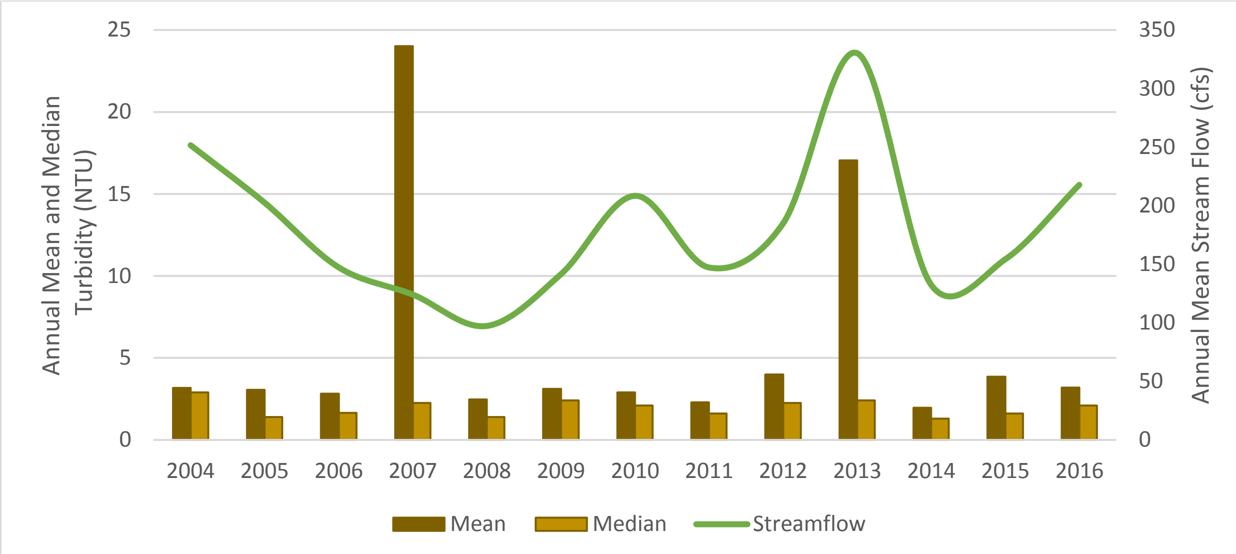
Water quality standards were meeting criteria during the last two monitoring cycles. Below is information about parameters collected in the Watauga River basin. Data collected from both AMS stations (L1700000 and L4700000) is presented and provides an overall view of water quality in the basin. Each parameter has a graph that displays the calculated annual mean concentration for both AMS stations and include data collected between January 2004 to July 2016. Medians are also displayed. The graphs are not intended to provide statistically significant trend information or loading numbers. Instead, they provide an idea of how changes in land use, stream flow and/or changes in climate effect parameter measurements over the long term. All water quality standards are being met in the Watauga River basin.

### 2.3.1 Turbidity

The turbidity standard for freshwater streams is 50 NTUs. The turbidity standard for streams that hold the supplemental classification of trout (Tr) is 10 NTUs. Turbidity is a measure of cloudiness in water and is often accompanied with excessive sediment deposits in the streambed. Excessive sediment deposited on stream and lake bottoms can choke spawning beds (reducing fish survival and growth rates), harm fish food sources, fill in pools (reducing cover from prey and high temperature refuges), and reduce habitat complexity in stream channels. Excessive suspended sediments can also make it difficult for fish to find prey and at high levels can cause direct physical harm, such as clogged gills. Sediments can also cause taste and odor problems, block water supply intakes, foul treatment systems, and fill reservoirs.

Soil erosion is the most common source of turbidity. Some erosion is a natural phenonmenon, but human actions and land use practices can accelerate the process to unhealthy levels. Construction sites, mining operations, agricultural opertions, logging operations, and excessive stormwater flow off of impervious surfaces are all potential sources of erosion and turbidiy in a stream channel.

Figure 2.7: Annual Turbidity Measurements January 2004- July 2016



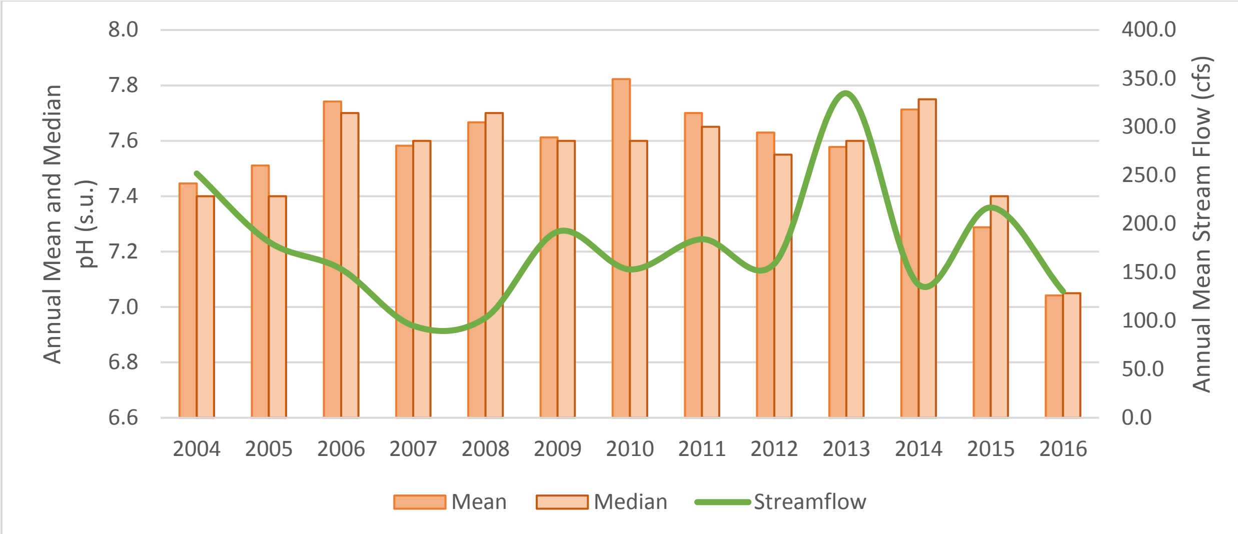

Turbidity readings were high at the ambient monitoring station (L4700000) located near Sugar Grove on February 21, 2007. The high reading (500 NTU) resulted in a higher than normal annual mean in 2007. The station is located near the confluence with Cove Creek. From 2007 to 2008, a RAMS station was in Cove Creek near the confluence with the Watauga River. Turbidity readings were also high (550 NTU) at the RAMS station (L4650000) on February 21, 2007. Mean daily stream flows is measured in cubic feet per second (cfs). Average daily stream flows recorded at USGS gage station 03479000 near Sugar Grove between February 15 and February 27, 2007 were between 83.0 cfs and 170 cfs with the highest stream flow (170 cfs) measured on February 21, 2007. Phosphorus readings were also higher on February 21, 2007, which resulted in a higher than normal annual mean for phosphorus as well (Figure 2.19). Field notes were not recorded on the day of sampling. Based on the data collected and the average daily stream flow recorded at the USGS gage station on the day of sampling, the high turbidity reading was likely due to land-disturbing activities in the Cove Creek watershed prior to or during the sampling event. Turbidity readings in January and March were 3.2 and 2.3 NTU, respectively.

Higher than normal turbidity readings in 2013 were likely the result of increased precipitation throughout northwestern North Carolina between 2012 and 2013. More information about stream flow and increased precipitation can be found in Chapter 1.

### 2.3.2 pH

The water quality standard for pH in surface freshwater is 6.0 to 9.0 standard units. It is the measure of hydrogen ion concentration that is used to express whether a solution is acidic or alkaline (basic). Low values (< 7.0) can be found in waters rich in dissolved organic matter, such as swamp lands, whereas high values (> 7.0) may be found during algal blooms. Lower values can have chronic effects on the community structure of macroinvertebrates, fish and phytoplankton.

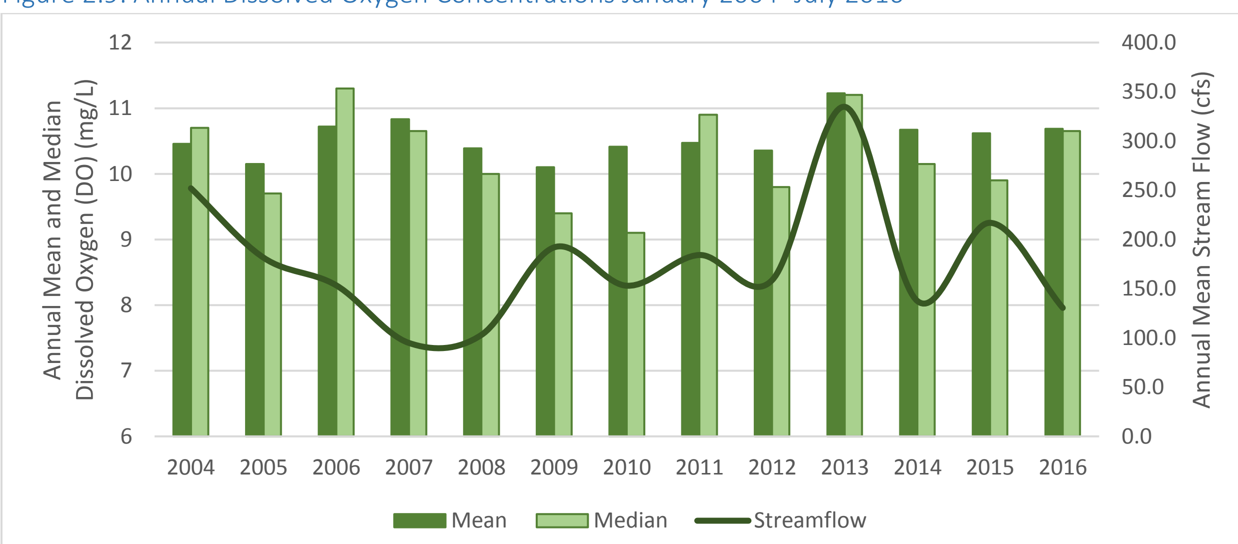
Figure 2.8: Annual pH Measurements January 2004- July 2016




### 2.3.3 Dissolved Oxygen

The dissolved oxygen (DO) water quality standard for freshwater is not less than a daily average of 5 mg/L or a minimum instantaneous value of not less than 4 mg/L. DO levels are often the product of wind or wave action mixing air into the water. It is also a produced through aquatic plant photosynthesis. During the day, DO levels are higher when photosynthesis occurs. Levels drop at night with aquatic organism respiration. High DO levels are often found in cool, swift moving waters. Low levels are found in warm, slow moving waters. In slow moving waters, such as reservoirs, depth is also a factor. Wind action and plants can cause these waters to have a higher dissolved oxygen concentration near the surface, while biochemical reactions lower in the water column may result in concentrations as low as zero at the bottom.

Figure 2.9: Annual Dissolved Oxygen Concentrations January 2004- July 2016

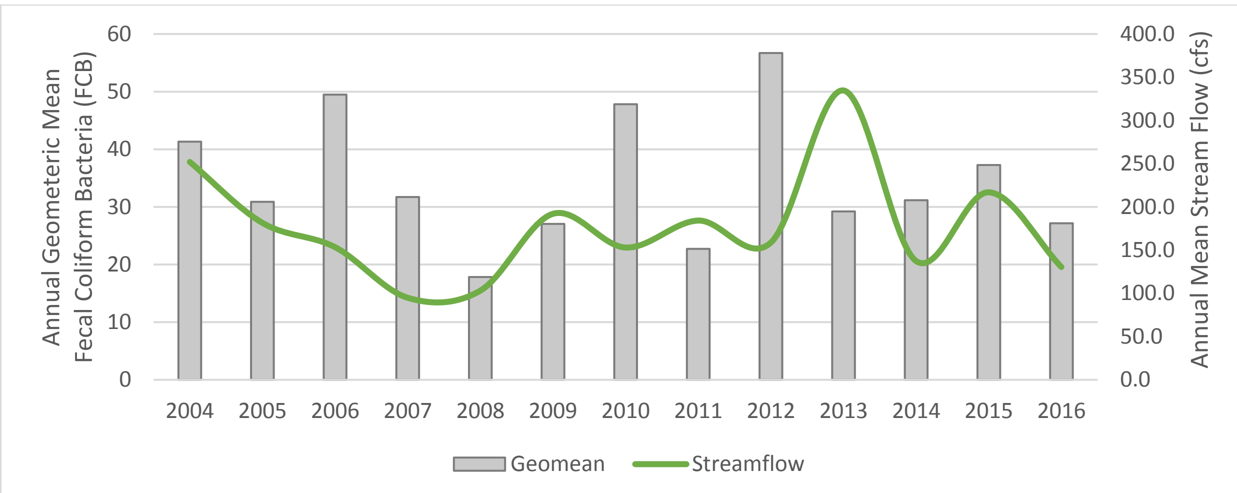


### 2.3.4 Fecal Coliform Bacteria

The fecal coliform bacteria standard for freshwater streams is not to exceed the geomean of 200 colonies/100ml or 400 colonies/100ml in 20% of the samples where five samples have been taken in a 30-day period (5-in-30). Only results from a 5-in-30 study are used to determine if the stream is impaired (exceeding criteria) or supporting (meeting criteria). Waters with a classification of B (primary recreation) will receive priority for 5-in-30 studies. Other waterbodies will be studied as resources permit.

The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with fecal material from humans or other warm-blooded animals. At the time of occurrence, the source water might have been contaminated by pathogens or disease producing bacteria or viruses that can also exist in fecal material. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to the water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste.

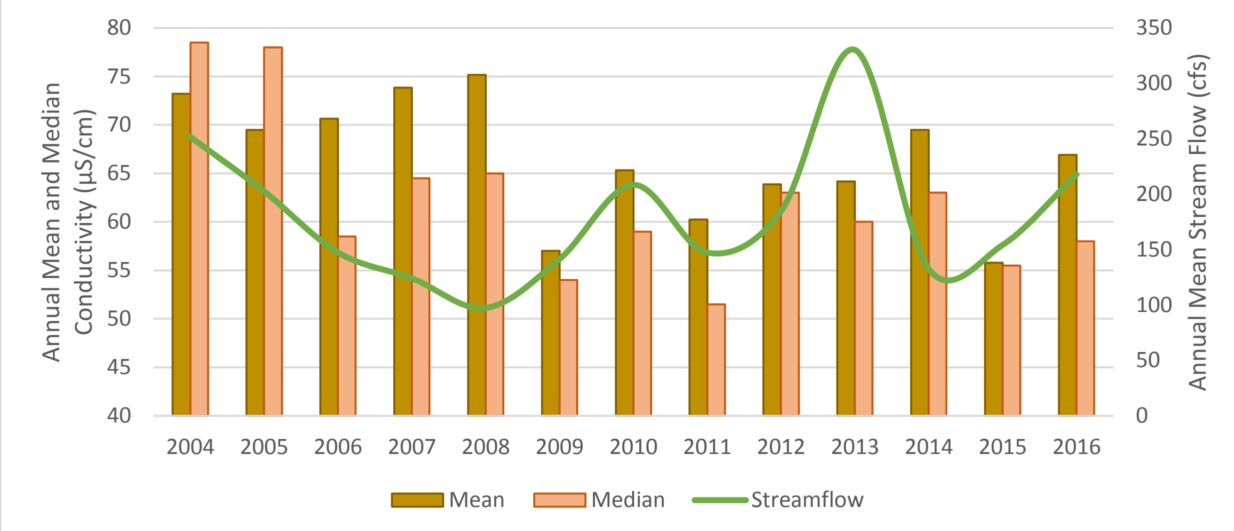
Figure 2.10: Annual Fecal Coliform Bacteria (FCB) January 2004- July 2016




### 2.3.5 Specific Conductance

Specific conductance, also referred to as conductivity, is a measure of the ability of water to pass an electrical current. Higher conductivity concentrations can be an indicator of pollutants associated with discharge of chlorides, phosphates, nitrates and other inorganic dissolved solids. There is no standard for specific conductance in North Carolina.

Figure 2.11: Annual Specific Conductance January 2004- July 2016




## 2.3.6 Temperature

All aquatic species require specific temperature ranges in order to be healthy and reproduce. An aquatic species becomes stressed when water temperatures exceed their preferred temperature range, often making them more susceptible to injury and disease. Trout, for example, prefer temperatures below 20°C (68°F) and cannot survive in the water reservoirs of the piedmont and coastal plain where temperatures can exceed 30°C (86°F). Changes to natural conditions or weather patterns can often change the ambient water temperature. For example, higher ambient water temperatures are expected during years with severe drought in areas where there is little shade. Higher ambient water temperatures can also be expected when air temperatures are high during summer months.

North Carolina water quality standards state that discharge from permitted facilities should not exceed the natural temperature of the receiving waterbody by more than 2.8°C (5.04°F) and that waters should never exceed 29°C (84.2°F) for the mountain or upper piedmont regions. The discharge of heated liquids to trout waters (Tr) should not increase the natural temperature by more than 0.5°C (0.9°F), and in no case, exceed 20°C (68°F) (15A NCAC 02B .0211 Fresh Surface Water Quality Standards for Class C Waters).

Streams in the mountains and upper piedmont can be impaired for aquatic life when greater than 10 percent of the samples are above 29°C (84.2°F) during the monitoring cycle. A minimum of 10 samples must to be collected and assessed in order to determine if the temperature standard is being met. Climatic conditions are also taken into account and include extreme drought, hurricanes, flooding, and/or dam failures. When climatic conditions result in the temperature standard being exceeded, the stream is identified as Data Inconclusive or Not Rated.  Waterbodies with the supplemental classification of Trout (Tr) can also be identified as Data Inconclusive or Not Rated if a heated discharge cannot to be identified.

Figure 2.12: Annual Temperature Measurements (°C) January 2004- July 2016

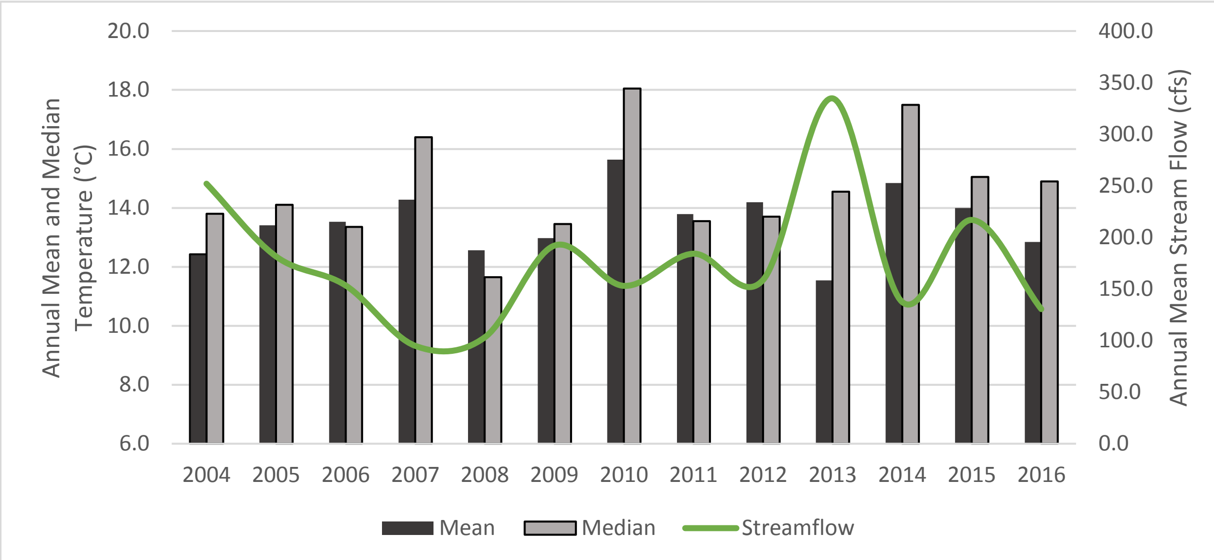
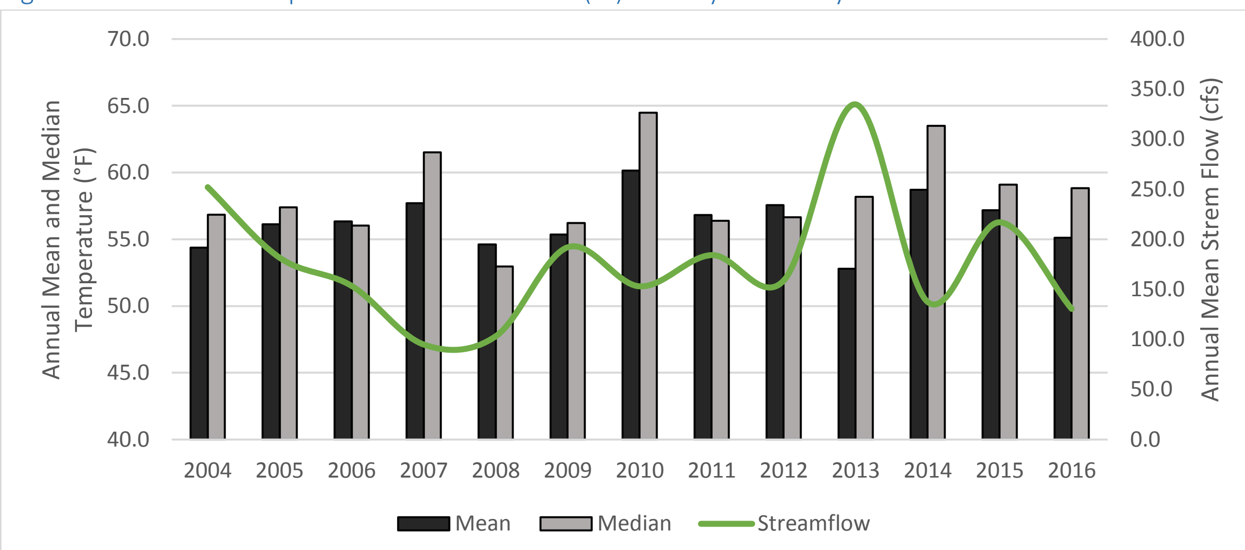



Figure 2.13: Annual Temperature Measurements (°F) January 2004- July 2016




## Special Study: Temperature

Because trout fishing represents a significant portion of angling opportunities in North Carolina's mountains, the North Carolina Wildlife Resources Commission (WRC) continually strives to protect, identify and preserve streams that support self-sustaining populations of wild trout. Currently, three segments of the Watauga River are identified as trout fishing areas on the WRC North Carolina Fishing Areas Interactive Map. To identify additional trout fishing areas, WRC conducted a temperature study in the mainstem of the Watauga River from NC 194 to US 321 between May 2015 and March 2016 (Figure 2.14). Temperature was collected from five stations every two hours and recorded in degrees Fahrenheit (°F). The special study found that temperatures exceeded 68°F (20°C), the ideal temperature for self-sustaining trout waters, for most of the days in June, July and August of 2015 (Figure 2.15).

WRC has also observed several areas throughout western North Carolina where water temperature is increasing and is often excessively high during summer months. WRC shared temperature data from the special study conducted in the Watauga River basin to highlight a growing water quality concern for trout waters throughout western North Carolina. Temperature readings at each sampling location are included in Table 2.6 and indicate that water temperature generally increased from the upper reach of the river to the US 321 bridge crossing downstream. Comparing temperatures from AMS station L1700000 (upstream of NC194, not included in Figure 2.14) in the headwaters to the most downstream station collected by WRC at US 321, there is a temperature increase from as little as 1.3°F in October 2015 to as much as 4.0°F in August 2015 (Table 2.6).

Figure 2.14: Temperature Monitoring Locations WRC (WRC, 2017) and DWR Ambient Monitoring Station (L4700000 Sugar Grove)

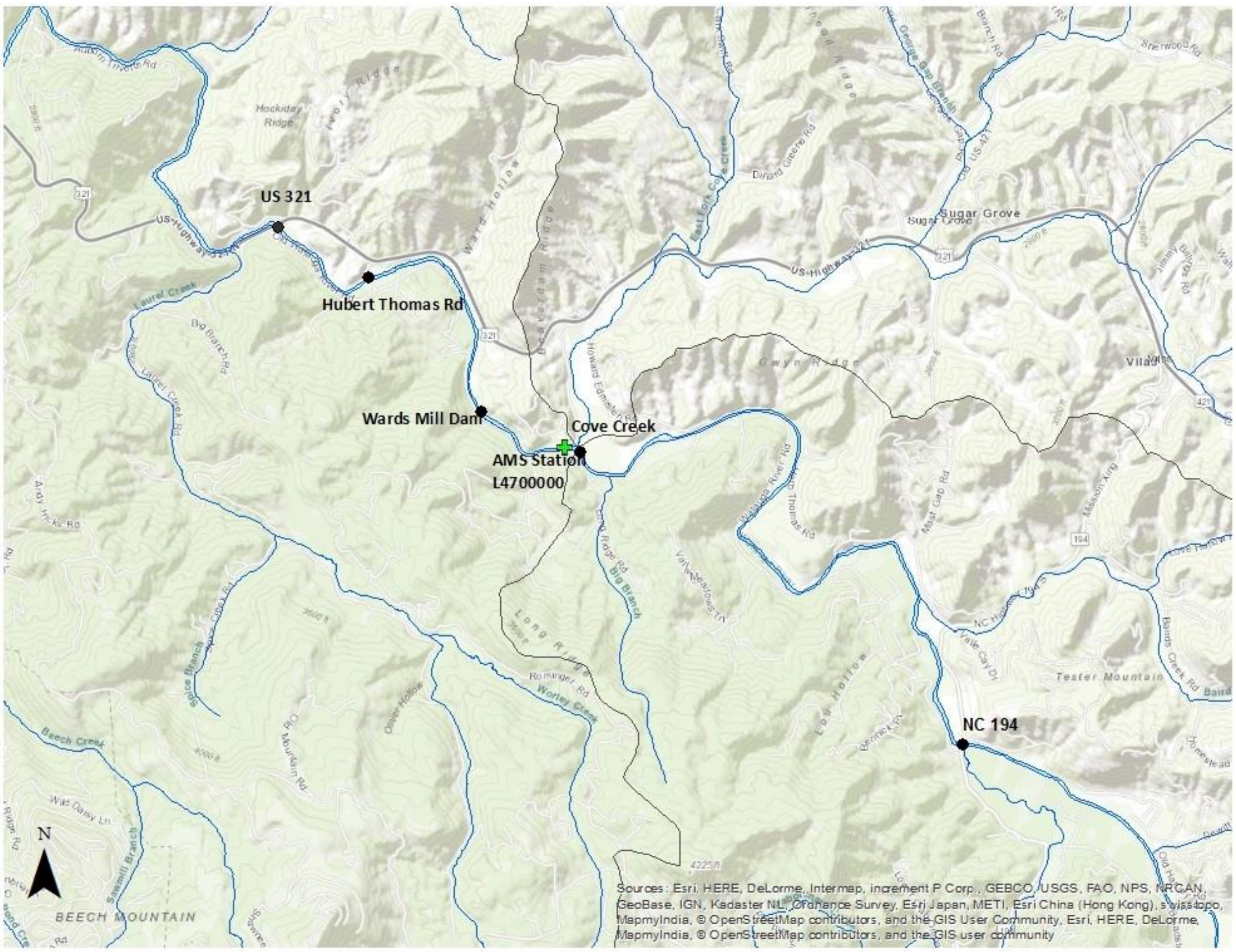


Figure 2.15: Temperatures Recorded between May 2015 and October 2015 (WRC, 2017)

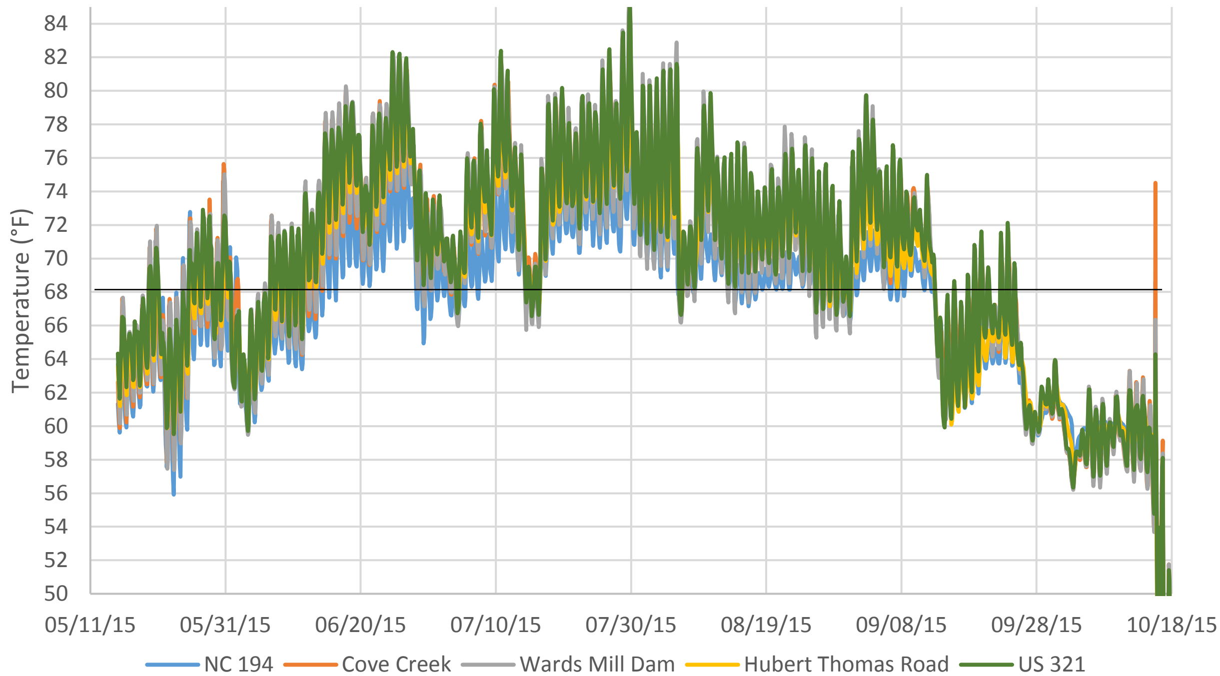



Table 2.6: Temperatures (°F) Recorded by WRC and DWR May through October 2015[1]

| Sampling Date | L1700000 Shulls Mill | NC 194 | Cove Creek | L4700000 Sugar Grove | Wards Mill Dam | Hurbert Thomas Rd | US 321 | Average Monthly Air Temperature (CRONOS)[2] | Change (°F) |
|---|---|---|---|---|---|---|---|---|---|
| 05/18/15 | 63.9 | 65.1 | 65.4 | 66.4 | 64.5 | 64.5 | 66.0 | 61.4 | 2.1 |
| 06/02/15 | 61.2 | 63.4 | 63.7 | 63.5 | 63.4 | 63.0 | 63.1 | 68.7 | 1.9 |
| 07/20/15 | 73.6 | 71.7 | 74.3 | 69.4 | 73.5 | 73.3 | 73.6 | 70.1 | 0.1 |
| 08/12/15 | 70.0 | 70.1 | 72.1 | 73.4 | 73.5 | 71.7 | 72.2 | 66.8 | 2.2 |
| 09/16/15 | 59.7 | 62.2 | 63.7 | 66.0 | 62.4 | 62.1 | 63.6 | 61.7 | 3.8 |
| 10/06/15 | 58.8 | 59.8 | 58.3 | 59.4 | 58.3 | 58.5 | 58.6 | 52.0 | -0.2 |

[1] The date temperatures were collected by WRC and DWR were matched. DWR collected water quality data monthly whereas WRC recorded temperature every two hours during the study period. The time at which the temperature was recorded varied. Temperature from the AMS stations were collected between 12:50 pm and 2:30 pm. WRC recorded temperatures at 11:36 am, 1:36 pm and 3:36pm. The temperatures recorded by DWR and WRC were then used to identify fluctuations in temperature from downstream to upstream. For this evaluation, we used temperatures recorded by WRC at 1:36pm. Several factors can influence water temperature as it moves downstream including shade along the streambanks, a rain or snow event, stormwater runoff, recreational activities, weather conditions such as cloud cover, residency time, etc. These factors are not included here.

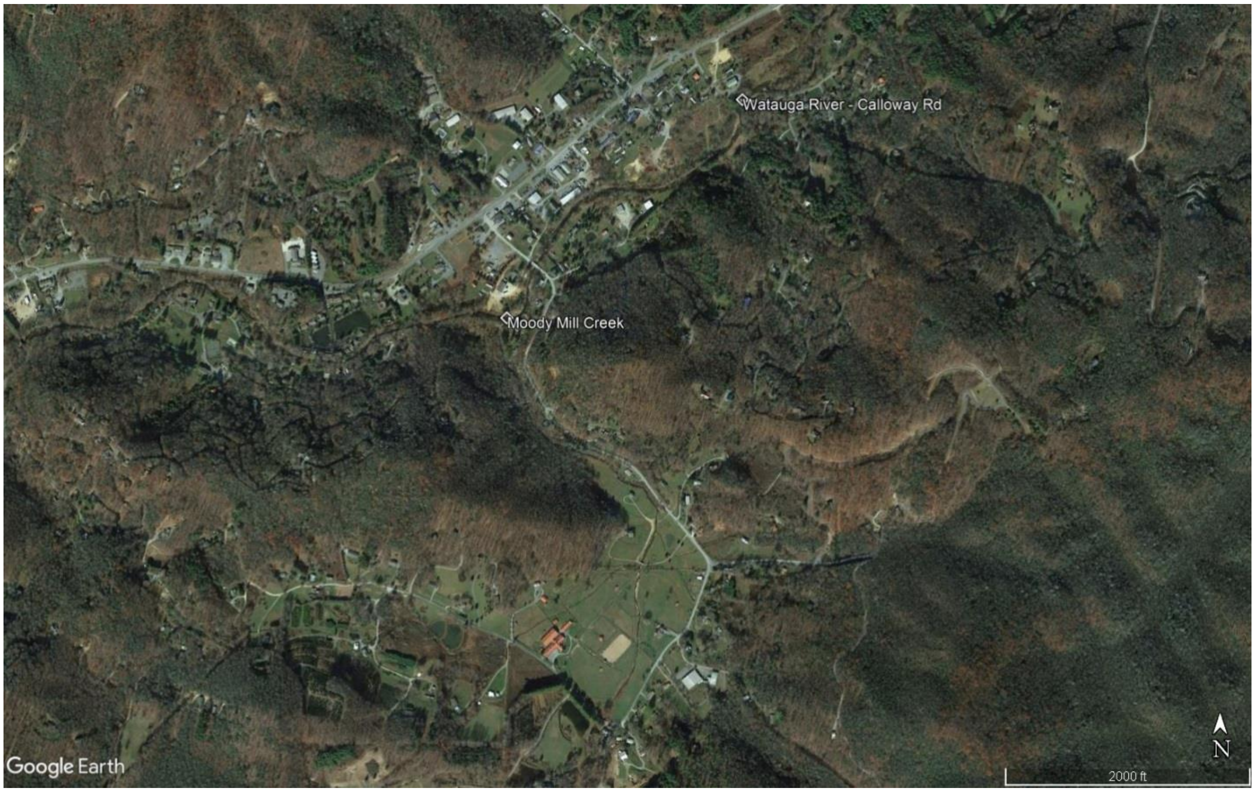
[2] Monthly average air temperatures can be found in the Climate Retrieval and Observations Network of the Southeast Database (CRONOS) developed by the State Climate Office of North Carolina at North Carolina State University (NCSU).

Variations in temperature are often the result of seasonal and daily variations in solar radiation and air temperature. Stormwater can also impact surface water temperature as well as recreational activities. Traveling along the river from NC 194 downstream to US 321, there are several areas where the river is wide, riparian areas are sparse, and agricultural land is directly adjacent to the river (Figure 2.16). These wide, open areas allow sunlight to directly warm the water in the river, which in turn decreases the level of dissolved oxygen, which can impact aquatic life. Overhanging trees and shrubs naturally keep flowing water cool by providing adequate shade during summer months and protecting aquatic organisms from elevated temperatures (NCSU Cooperative Extension Service, 2014). Vegetation along the streambanks also help retain soils during high flow events, reducing streambank erosion and sedimentation and preserving habitat and pools for aquatic organisms to escape direct sunlight and increasing water temperature.

Figure 2.16: Imagery and Land Use Along the Watauga River (Google Earth Image Retrieved 12/18/17)


WRC conducted a second special study during the summer of 2017. The second study was in response to some unusually high temperature readings between the Avery County line and the Shulls Mill area. WRC identified an area in the Watauga River near the confluence with Moody Mill Creek where there is an abrupt change in water temperature. In addition to elevated temperature, WRC biologists also noted that the fish habitat changes from a cold-water fishery to a cool/warm water fishery habitat. Moody Mill Creek and its tributaries are characterized by a lack of woody riparian vegetation and little shade with pastures located along the streambanks. Several ponds are located throughout the catchment. Water released from these ponds can also contribute to increased temperatures downstream (Figure 2.17).

Figure 2.17: Imagery and Land Use Near Moody Mill Creek (Google Earth Image Retrieved 02/06/18)




Only a small portion of the most downstream section of the 2015-2016 special study area is designated as delayed harvest trout waters. Protective measures are needed in order to maintain trout habitat and protect the river's designation as Trout (Tr), High Quality Waters (HQW). Protective measures should include practices that protect streambanks, prevent or reduce solar radiation, and reduce overland flow. Encouraging off-line ponds and retrofitting in-line ponds with cold water releases could lessen temperature impacts from ponds. WRC recommends surveys to identify the distribution of brook trout along with three additional aquatic species (banded sculpin, Grandfather Mountain crayfish, Green Floater) identified as species of greatest conservation need (SGCN) in the basin. Long-term monitoring is needed to assess species and ecosystem health over time and understand species resiliency to changing water quality conditions. Education and management measures are also needed to prevent the introduction or spread of invasive nonnative species, and WRC supports stream and riparian area conservation and restoration initiatives throughout the basin to protect, improve or enhance existing conditions. More information about WRC recommendations can be found in Section 4.5.18 of the [2015 Wildlife Action Plan (WAP)](#).

### 2.3.7 Nutrient Enrichment

Compounds with nitrogen and phosphorus are major components of living organisms and thus are essential to maintain life. These compounds are collectively referred to as "nutrients". Nitrogen compounds include ammonia as nitrogen ($NH_3$), Total Kjeldahl Nitrogen (TKN) and nitrite + nitrate nitrogen ($NO_2$+$NO_3$). Total nitrogen (TN) is the sum of TKN and $NO_2$+NO3. DWR measures phosphorus as total phosphorus (TP). The annual mean for TP was higher in 2007 and 2013. This correlates with higher turbidity readings measured during the same timeframe (Figure 2.7: Turbidity) and are likely associated with high stream flows and heavy precipitation.

When nutrients are introduced to an aquatic ecosystem from municipal and industrial treatment processes or runoff from urban or agricultural land, the growth of algae and other plants may be accelerated as a result of nutrient over-enrichment (eutrophication). In addition to the possibility of causing algal blooms, ammonia-nitrogen ($NH_3$) may combine with high pH water to form ammonium hydroxide ($NH_4OH$), a form toxic to fish and other aquatic organisms.

Figure 2.18: Annual Nitrogen Concentrations January 2004- July 2016

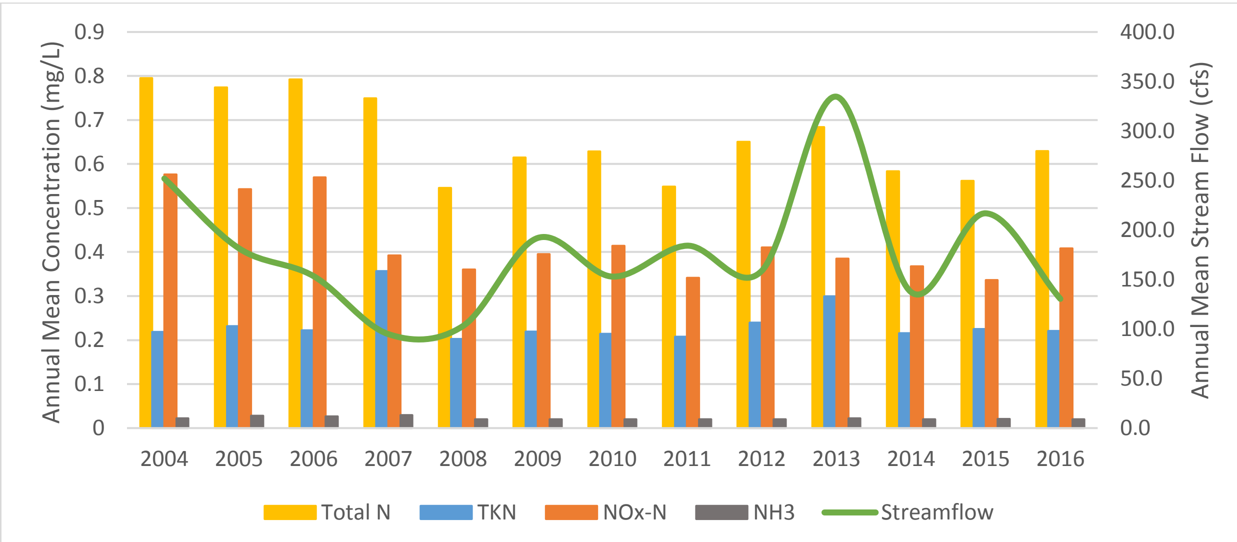
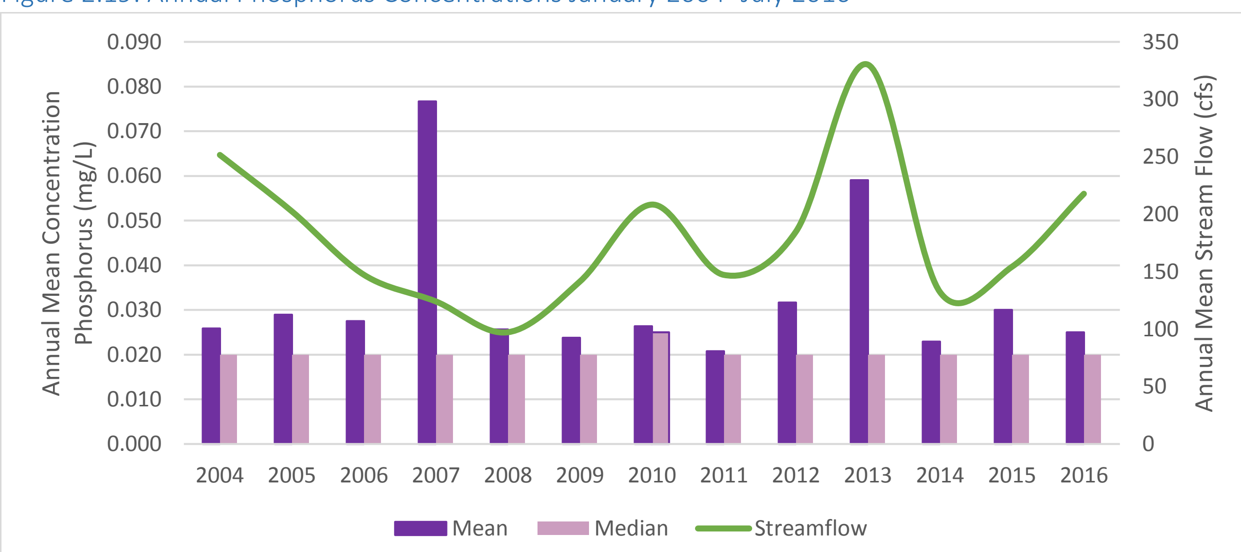



Figure 2.19: Annual Phosphorus Concentrations January 2004- July 2016




## 2.4 Fish Consumption Advisories

Fish consumption advisories are issued by the Occupational and Environmental Epidemiology (OEE) Branch of the Division of Public Health (DPH) in the Department of Health and Human Services (DHHS). Fish consumption for North Carolina's IR is assessed based on site-specific fish consumption advisories developed using fish tissue data collected by DWR as well as other agencies and/or universities. Because several fish species are under a statewide advisory for mercury, all waters in North Carolina are listed in Category 5 of the IR for mercury.

## 2.5 Additional Surface Water Quality Data

North Carolina continually accepts information and "existing and readily available" data as part of the basin planning process and assessing water quality for the integrated report and the 303(d) list. Both quantitative and qualitative information is accepted. The quality and reliability of the information or data that is submitted determines what can be used for water quality assessment or included in the basin plan. DWR can use outside data to adjust the location of biological and chemical monitoring sites or identify areas for special studies. To use quantitative data for assessing water quality, a Quality Assurance Project Plan (QAPP) must be approved and on file with DWR. The QAPP assures that the data were collected and analyzed in a manner that is consistent with DWR's sampling methodology.

The Volunteer Water Information Network (VWIN) provides chemical and physical monitoring on nearly 160 stream, river and lake sites in 10 counties in Western North Carolina. Working with the Environmental Quality Institute (EQI), a nonprofit environmental laboratory, samples are collected by community volunteers who are trained on how to collect water quality samples. Thirteen sites are actively being sampled in the Watauga River basin (2016-2017) (Table 2.7). Samples are analyzed for major nutrients, turbidity, total suspended solids, conductivity, alkalinity and pH. Stream flow is also measured and notes are made about weather conditions, clarity, odors and trash. Working with the Waterkeepers Alliance, North Carolina Chapter, a QAPP for data collected through VWIN and analyzed through EQI has been submitted to DWR for review. Once approved, future data may be used to assess water quality submitted by VWIN through the Waterkeepers Alliance approved QAPP. More information about submitting data for water quality assessment can be found on the Water Quality Data Assessment webpage.

Table 2.7: VWIN Monitoring Locations

| VWIN Site Number | Name/Location | Latitude | Longitude | End Date |
|---|---|---|---|---|
| 12 | Watauga River at Adams Apple Rd Bridge | 36.126124 | -81.822690 | |
| 3 | Watauga River at Hwy 105 - WR-3 | 36.189670 | -81.746080 | |
| 13 | Watauga River at Old Ford Rd Bridge | 36.192507 | -81.758525 | |
| 14 | Watauga River at Valle Crucis Community Park | 36.212795 | -81.776150 | |
| 15 | Watauga River at Broadstone Bridge | 36.216705 | -81.786379 | |
| 16 | Watauga River before Rominger | 36.236794 | -81.817953 | |
| 2 | Watauga River at gauging station - WR-2 | 36.237530 | -81.824120 | |
| 1 | Watauga River/state line - WR-1 | 36.286830 | -81.918250 | 11/2008 |
| 20 | Watauga River at Wilbur Dam Rd Bridge | 36.351716 | -82.154885 | |
| 21 | Watauga River at Smalling Rd Bridge | 36.345888 | -82.283010 | |
| 4 | Cove Creek - CC-1 | 36.252330 | -81.815470 | 11/2008 |
| 5 | Laurel Fork - LF-1 | 36.203350 | -81.735470 | 11/2008 |
| 6 | Dutch Creek - DC-1 | 36.208270 | -81.777920 | 11/2008 |
| 7 | Brushy Fork - BRUF-1 | 36.252330 | -81.769470 | 11/2008 |
| 8 | Boone Fork - BF-1 | 36.138580 | -81.730220 | 11/2008 |

| VWIN Site Number | Name/Location | Latitude | Longitude | End Date |
|---|---|---|---|---|
| 9 | Elk River at Elk River Falls - ER-1 | 36.221630 | -81.969950 | 11/2008 |
| 10 | Elk River near Lees McRae - ER-2 | 36.156750 | -81.869900 | |
| 17 | Laurel Creek off US-321 | 36.249404 | -81.860187 | |
| 18 | Beaverdam Creek at Bethel Rd Bridge | 36.272064 | -81.871314 | |
| 19 | Elk River US-321 Bridge | 36.277009 | -81.990245 | |

## 2.6 Groundwater Quality

Subsurface aquifer conditions vary across the state. These variations can be seen not only in changes in groundwater availability but also in groundwater quality. Since groundwater quality is affected by naturally occurring conditions, as well as existing land use, it is important that information be collected to determine whether groundwater may require treatment to ensure it is safe for human consumption. The Watauga River basin is located almost solely within the Western Blue Ridge geologic terrane. The Western Blue Ridge terrane is a complex mixture of igneous, sedimentary and metamorphic rock and contains minerals that can release contaminants into local groundwater supplies (DEMLR, 2015).

The quality of groundwater available for public use in the Watauga River basin can be generally assessed using water samples collected from private drinking water wells. To understand the regional distribution of groundwater and its quality, the Ground Water Management Branch (GWMB) is mapping commonly sampled chemical constituents that have been found in groundwater across the state. This effort to characterize state groundwater quality is expanding to include all available groundwater quality information.

### Sampling Private Drinking Water Wells in North Carolina

Public water supply systems (PWSS) serving at least 25 persons or having 15 service connections must meet drinking water quality standards established by the Environmental Protection Agency (EPA) through the Safe Drinking Water Act (SDWA) and the National Primary Drinking Water Regulations (NPDWR). The SDWA is the federal law that protects public drinking water supplies throughout the nation. The NPDWR are legally enforceable primary standards and treatment techniques that apply to a PWSS to protect public health by limiting the levels of contaminants in drinking water. There is no mandated oversight of private well water quality, however, and it is the responsibility of the homeowner to monitor the quality of their private well water.

Despite the large number of private wells in North Carolina, fewer than 200,000 were tested for contaminants in the last decade (2000-2010). Since 2008, however, all newly constructed drinking water wells in North Carolina must be tested for bacterial and chemical contaminants within 30 days of well completion. No additional tests are required for private wells in North Carolina. The Division of Public Health (DPH) in the Department of Health and Human Services (DHHS), however, recommends that private well owners test their well water every year for total fecal coliform bacteria; every two years for heavy metals, nitrates, lead, copper and volatile organic compounds (VOCs); and every five years for pesticides. Samples can be analyzed by either the State Laboratory of Public Health (SLPH) operated by DHHS or by private laboratories. When a constituent within an individual well exceeds drinking water health standards or groundwater standards established by the Department of Environmental Quality

(DEQ) for one or more constituents, the local health department, along with DHHS, provides the well owner with information about the constituents identified in the groundwater sample and what steps may be necessary to protect the well users' health.

North Carolina groundwater standards are performance standards and "are the maximum allowable concentrations resulting from any discharge of contaminants to the land or waters of the state, which may be tolerated without creating a threat to human health or which would otherwise render the groundwater unsuitable for its intended best usage" [15A NCAC 02L .0202(a)]. Some constituents may exceed standards due to naturally occurring aquifer conditions. In those instances, the concentration becomes the local standard and well water treatment may be necessary for drinking water purposes. DHHS uses EPA Primary and Secondary Maximum Contaminant Levels (MCL) to advise private well owners regarding groundwater treatment. Where appropriate, local health departments contact the Department of Environmental Quality (DEQ) for assistance in identifying a potential source of contamination.

In addition to identifying concerns for private well owners, the DEQ's DWR is using information collected by the SLPH and the county health departments to understand where groundwater quality issues of concern are occurring and where more information is needed about groundwater quality. A total of 92 samples were collected from private drinking water wells in the Watauga River basin between October 1998 and December 2004 and analyzed for various constituents. The samples were analyzed by DHHS's SLPH and provided to DWR. Constituents are listed in Table 2.8 along with the groundwater standard defined in North Carolina's administrative code and the number and percent of samples exceeding the state's groundwater standard. The information presented is not a comprehensive effort to assess state groundwater quality, but rather an initial and expanding effort to understand the state's groundwater resources using information collected from private wells. Samples collected and analyzed from well water were taken from both the wellhead and from kitchen faucets or other indoor faucets. Water flowing through a home distribution system may have a different quality than water in the well itself. In a few cases, a single well may have been sampled more than once, often after filtering or other treatment had been installed.

Metals such as arsenic, iron, manganese, and zinc are known to be naturally present in North Carolina groundwater, particularly in the piedmont and mountains. Metals concentrations above health standards in drinking groundwater from private wells, consumed long term, can have adverse health effects. The presence of metals in groundwater in the Watauga River basin is an indication of naturally occurring leaching of subsurface materials. Metal concentrations are often influenced by pH. Water with a lower than normal pH is not in itself a health risk, but the combination of low pH and metals could increase the leaching of metals into the drinking water used in that location.

To create maps (Figure 2.20) to identify areas of groundwater quality concern, geocoding must be performed. The process uses online services to match addresses of where well water samples were collected with locational information (latitude and longitude). The purpose of spatially locating (geocoding) well sample information is not to precisely locate individual wells, but to place a well's groundwater quality information at a location useful for showing overall groundwater quality in the region. Well locations for this dataset were identified as part of ongoing research through DWR's Resource Evaluation Program (REP). The program was established in 1999 with the primary purpose of increasing the hydrogeologic knowledge base of groundwater and surface water in the crystalline rock environments of the piedmont and mountains of North Carolina. The REP accomplishes its objectives primarily throughout the installation of groundwater quality monitoring stations to monitor water quality through cooperative studies with other government agencies and academic institutions. Information collected through the program will assist with developing standards for groundwater quality, evaluating potential man-made and natural threats to groundwater quality, providing information needed to effectively response to contaminants, and guide local community development (Pippen, 2005).

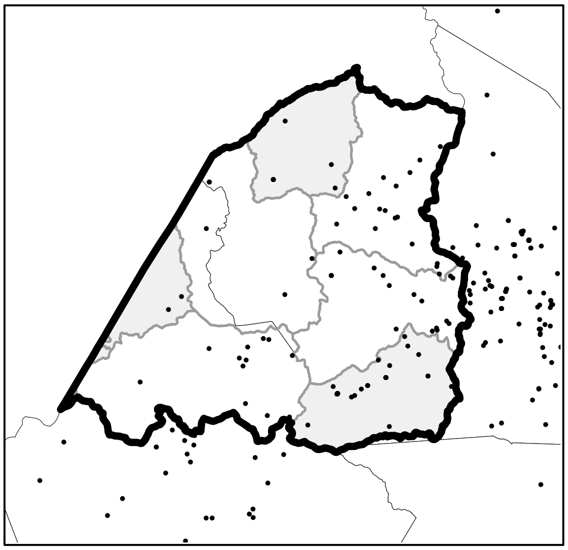
Table 2.8: Private Well Sample Analyses in the Watauga Basin (October 1998 – December 2004)[1]

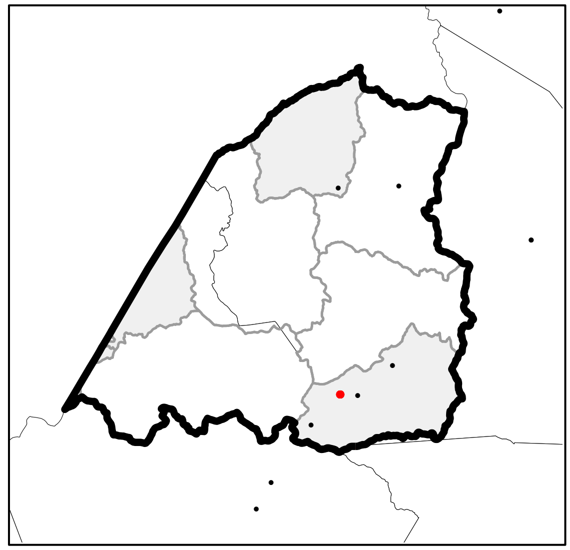
| Constituent | State Groundwater Standard [2] / EPA MCL[3] or Secondary MCL[4] | Samples Exceeding State Groundwater Standard | Percent of Samples Exceeding State Groundwater Standard |
|---|---|---|---|
| Arsenic | 10 / 10 ppb | 1 | 1.09% |
| Cadmium | 2 / 5 ppb | 0 | 0.00% |
| Copper | 1000 / 1300 ppb | 5 | 5.43% |
| Fluoride | 2000 / 2000[4] ppb | 3 | 3.26% |
| Iron | 300 / 300 ppb | 13 | 14.13% |
| Lead | 15 / 15ppb | 0 | 0.00% |
| Manganese | 50 / 50 ppb | 12 | 13.04% |
| pH | 6.5-8.5 / 6.5-8.5 | 35 | 38.04% |
| Zinc | 1000 / 5000 ppb | 4 | 4.35% |

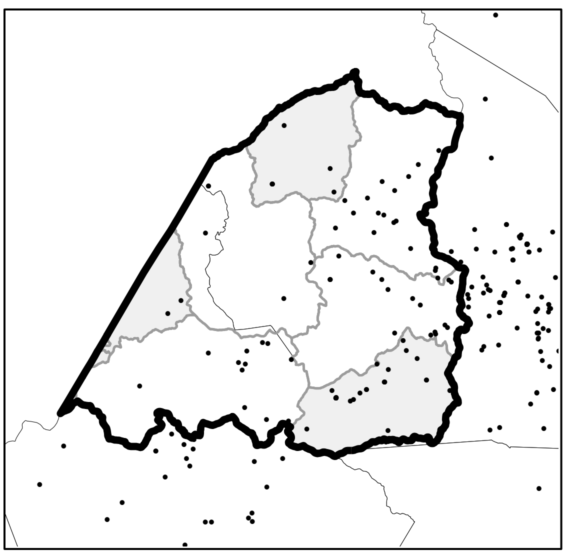
[1] NC DHHS State Laboratory for Public Health (SLPH) analyses.
[2] North Carolina Administrative Code Title 15A NCAC 02L .0202 Groundwater Standards.
[3] EPA National Primary Drinking Water Regulations Maximum Contaminant Levels (MCLs). MCLs are the highest level of a contaminant that is allowed in regulated public drinking water.
[4] EPA Secondary Drinking Water Standards Maximum Contaminant Levels (SMCLs). SMCLs are the highest level of a contaminant due to aesthetic, cosmetic or technical effects. ppb = parts per billion of dissolved constituent (micrograms per liter).

## Figure 2.20: Private Well Sample Analyses in the Watauga Basin (October 1998 – December 2004)

Locations are geocoded based on address and show where groundwater samples were collected in the Watauga River basin and surrounding area. Samples were analyzed by the SLPH. Black and red points are locations where the constituents were detected. Red points are where the constituent exceeded North Carolina's groundwater standard.


Sample Locations


Arsenic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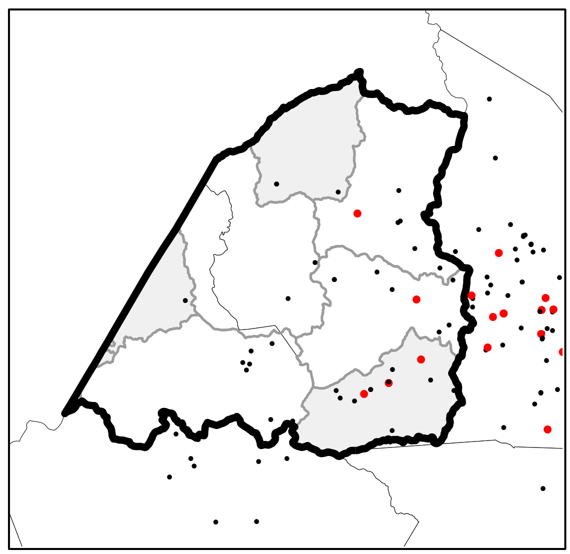
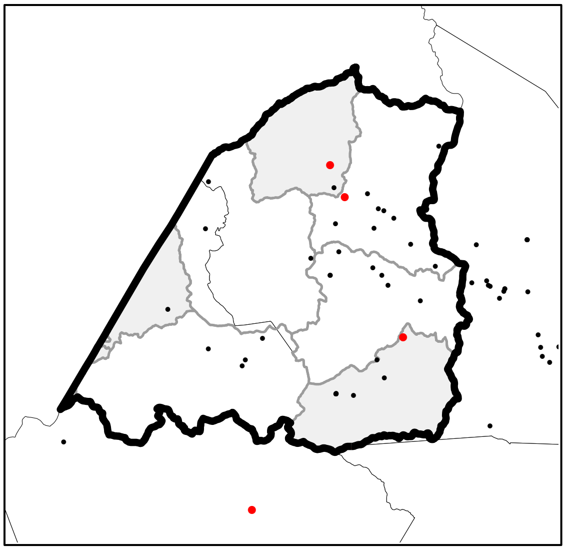
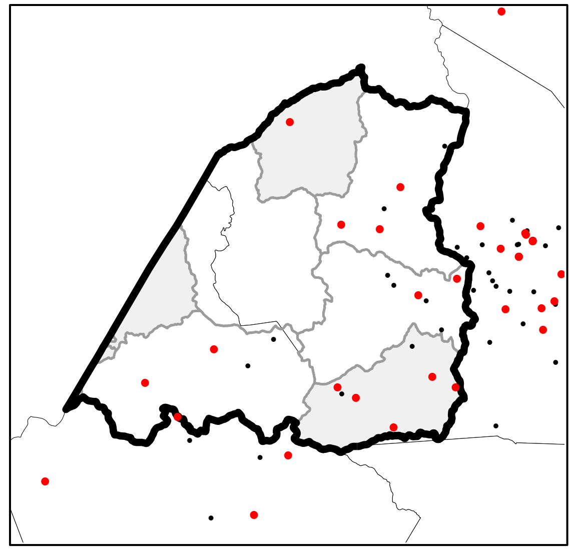
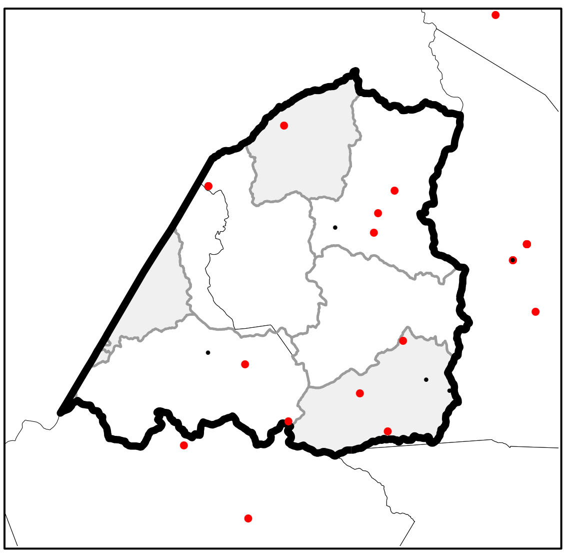
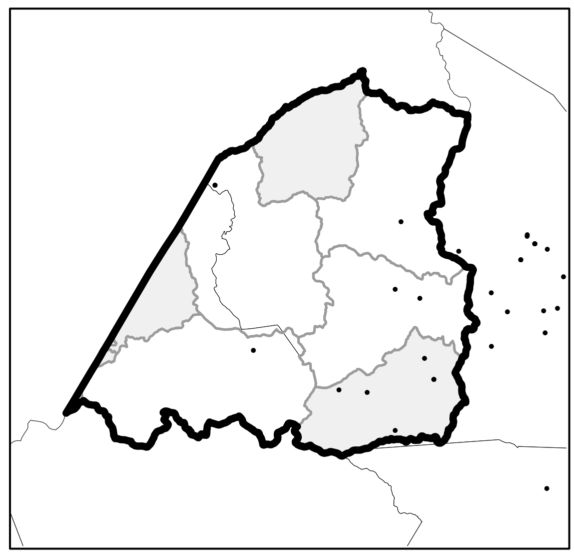

Copper


Fluoride


Iron


Manganese


Lead

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