

Little Tennessee River Basin Ambient Monitoring System Report

January 1, 2005 through December 31, 2009



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Evaluation Levels

In order to assist the reader in developing a rapid understanding of the summary statistics provided throughout this data review, concentrations of water quality variables may be compared to an Evaluation Level (EL). Evaluation levels may be a water quality standard, an action level, an ecological threshold, or simply an arbitrary threshold that facilitates a rapid data review. Evaluation levels are further examined for frequency to determine if they have been exceeded in more than 10 percent of the observed samples. This summary approach facilitates a rapid and straightforward presentation of the data but may not be appropriate for making specific use support decisions necessary for identification of impaired waters under the Clean Water Act's requirements for 303(d) listings. The reader is advised to review the states 303(d) listing methodology for this purpose. (see <http://portal.ncdenr.org/web/wq/ps/mtu/assessment>).

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EXECUTIVE SUMMARY

A general understanding of human activities and natural forces that affect pollution loads and their potential impacts on water quality can be obtained through routine sampling from fixed water quality monitoring stations. During this assessment period (January 1, 2005 through December 31, 2009) chemical and physical measurements were obtained by the Division of Water Quality (DWQ) from five stations located in the Little Tennessee River Basin.

DWQ uses a 10% criteria to determine whether a water body is meeting the applicable water quality standards. If more than 10% of the monitoring results violate the standard in question then the water body is not meeting the standard. In a typical basin there will be several or many such 10% exceedances. However in the Little Tennessee River Basin there were none. Similarly in the 2005 Little Tennessee River Basin Ambient Monitoring Report there were also none reported, except for one 10% exceedance for Iron. Iron is naturally occurring in North Carolina surface waters. Based on the data from the five AMS stations, this river basin has remained in good health throughout the past eight years, and there are no worrisome trends. Its waters are among the highest quality waters in the state.

Based on failure of a screening test in 2007, one AMS station in the basin was tested against the fecal coliform standard in 2008. The station met the standard; the results were well below the evaluation level of 200 colonies per 100mL.

INTRODUCTION

The DWQ's Ambient Monitoring System (AMS) is a network of stream, lake, and estuarine stations strategically located for the collection of physical and chemical water quality data. The stations are located at convenient access points (e.g. bridge crossings) that are sampled on a monthly basis. These locations were chosen to characterize the effects of point source dischargers and nonpoint sources such as agriculture, animal operations, and urbanization within watersheds.

The data are used to identify long term trends within watersheds, to develop Total Maximum Daily Loads (TMDLs) and to compare measured values with water quality standards to identify possible areas of impairment. Parametric coverage is determined by freshwater or saltwater waterbody classification and corresponding water quality standards. Under this arrangement, core parameters are based on Class C waters with additional parameters added when justified (**Table 1**).

Within this document, an analysis of how monitoring results compare with water quality standards and evaluation levels is presented. An educational and conceptual overview of water quality standards is provided at: <http://www.epa.gov/waterscience/standards>. Specific information on North Carolina water quality standards is provided at: <http://portal.ncdenr.org/web/wq/ps/mtu/assessment>. A summary of selected water quality standards are listed in **Table 2**.

Water quality data in this report are evaluated in five year periods. Some stations have little or no data for several parameters over the period. However, for the purpose of standardization, data summaries for each station are included in this report. DWQ monitored water quality and collected samples at five stations in the basin throughout the assessment period. The locations of the sampling sites are illustrated in **Figure 1**, and listed in **Table 3**.

In January 2007 the DWQ began collection of samples from a series of randomly determined sites. A description of the Random Ambient Monitoring System (RAMS) can be found here: <http://portal.ncdenr.org/web/wq/ess/eco/rams>. Three past RAMS stations were located in this basin, and there is currently one RAMS site in the basin scheduled to begin sampling in January 2011. Because the basinwide reports assess in five-year windows and RAMS stations will only have 2 years of data, they are not included in the ambient reports. Once a sufficient number of samples have been collected statewide, RAMS data will be discussed in a separate report.

Table 1. Parametric coverage for the Ambient Monitoring System.

Parameter
Dissolved oxygen (s)
pH (s)
Specific conductance
Temperature (s)
Total phosphorus
Ammonia as N
Total Kjeldahl as N
Nitrate+nitrite as N (s)
Total suspended solids
Turbidity (s)
Fecal coliform bacteria (s)
Chlorophyll <i>a</i> (s)

Notes:

An 's' indicates the parameter has a numeric standard.

Chlorophyll *a* and nutrient sampling is only done in areas of concern, such as NSW, estuaries, lakes, and areas with known enrichment issues.

Table 2. Selected Water Quality Standards

Parameter	Standards for All Freshwater			Standards to Support Additional Uses		
	Aquatic Life	Human Health	Water Supply Classifications	Trout Water	HQW	Swamp Waters
Chloride (mg/l)	230		250			
Chlorophyll <i>a</i> (ug/L)	40 ²			15 ²		
Coliform, total (MFTCC/100 ml) ³			50 ² (WS-I only)			
Coliform, fecal (MFFCC/100 ml) ⁴		200 ²				
Dissolved oxygen (mg/L)	4.0 ^{5,6}			6.0		2, 6
Hardness, total (mg/L)			100			
Nitrate nitrogen (mg/L)			10			
pH (units)	6.0 - 9.0 ^{2,6}					2, 6
Solids, total suspended (mg/L)					10 Trout, 20 other ⁷	
Turbidity (NTU)	50, 25 ²			10 ²		

Notes:

Standards apply to all classifications. For the protection of water supply and supplemental classifications, standards listed under Standards to Support Additional Uses should be used unless standards for aquatic life or human health are listed and are more stringent. Standards are the same for all water supply classifications (Administrative Code 15A NCAC 2B 0200, eff. August 1, 2005).

²Refer to 2B.0211 for narrative description of limits.

³Membrane filter total coliform count per 100 ml of sample.

⁴Membrane filter fecal coliform count per 100 ml of sample.

⁵An instantaneous reading may be as low as 4.0 mg/L, but the daily average must be 5.0 mg/L or more.

⁶Designated swamp waters may have a dissolved oxygen less than 5.0 mg/L and a pH as low as 4.3, if due to natural conditions.

⁷For effluent limits only, refer to 2B.0224(1)(b)(ii).

Figure 1. DWQ's Ambient Monitoring System in the Little Tennessee River Basin.

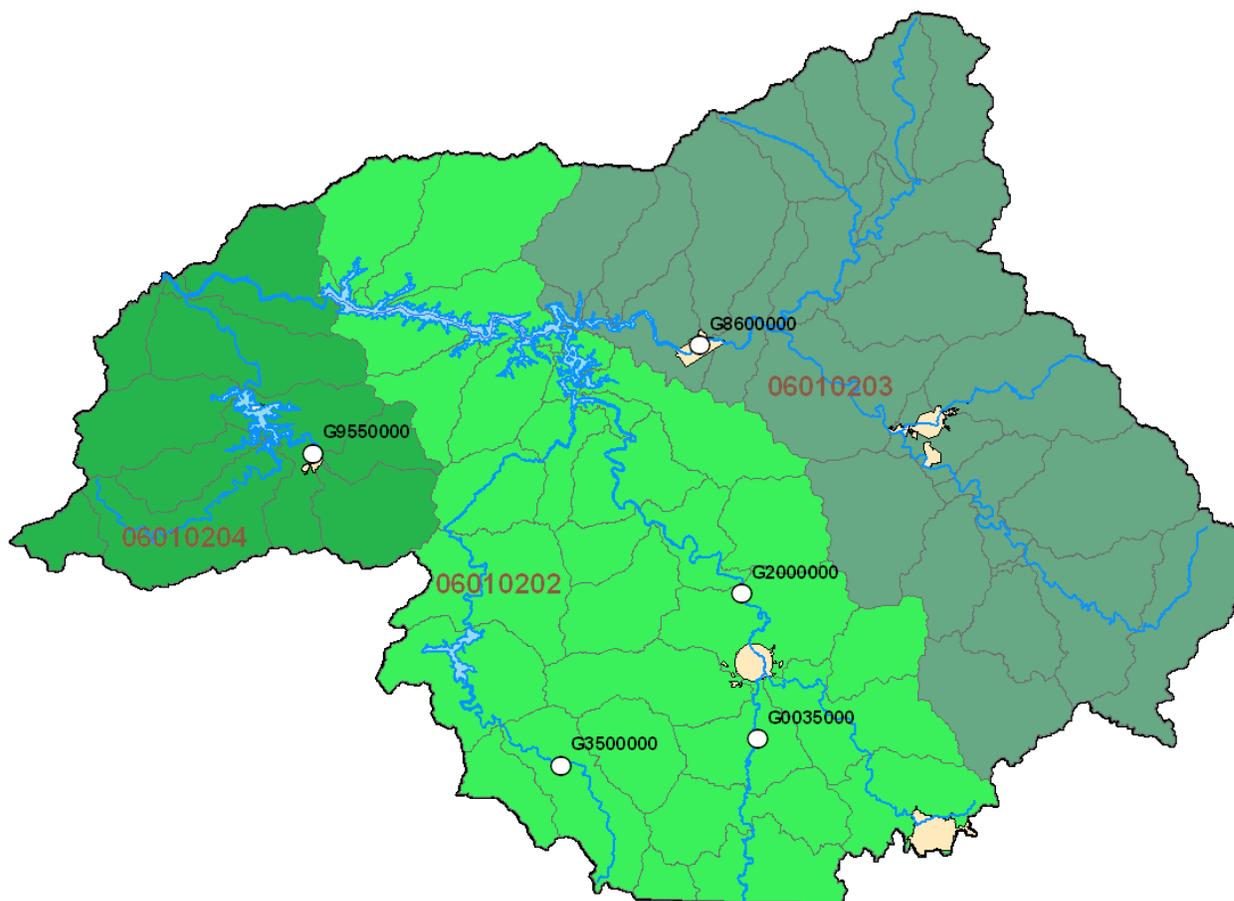


Table 3. Monitoring stations in the Little Tennessee River Basin

Station	Location	Stream Class	First Sample	Latitude	Longitude
HUC 06010202: Little Tennessee River					
G0035000	Little Tennessee River at SR 1651 near Prentiss	C	3/16/1981	35.12215	-83.37432
G2000000	Little Tennessee River at NC 28 at lotla	B	5/27/1968	35.23490	-83.39579
G3500000	Natahala River at US 64 near Rainbow Springs	B Tr ORW	11/19/1973	35.09422	-83.55992
HUC 06010203: Tuckasegee River					
G8600000	Tuckasegee River at SR 1364 at Bryson City	B	9/12/1973	35.42835	-83.44595
HUC 06010204: Lower Little Tennessee River					
G9550000	Cheoah River at SR 1138 at Robbinsville	C Tr	10/1/1973	35.32910	-83.80976

Primary Water Use Classifications

C: Aquatic Life

B: Primary Recreation

WS-I, WS-II, WS-III, WS-IV, WS-V: Water Supply

SA: Saltwater Shellfish Harvesting

SB: Saltwater Primary Recreation

SC: Saltwater Aquatic Life

Secondary Water Use Classifications

Sw: Swamp Water

HQW: High Quality Water

ORW: Outstanding Resource Water

Tr: Trout Waters

CA, +: Critical Area

NSW: Nutrient Sensitive Waters

PARAMETERS

Dissolved Oxygen

Dissolved oxygen is one of the most important of all the chemical measurements. Dissolved oxygen provides valuable information about the ability of the water to support aquatic life and the capacity of water to assimilate point and nonpoint discharges. Water quality standards for dissolved oxygen vary depending on the classification of the body of water. For freshwaters, 15A NCAC 02B .0211 (3)(b) specifies:

Dissolved oxygen: not less than 6.0 mg/l for trout waters; for non-trout waters, not less than a daily average of 5.0 mg/l with a minimum instantaneous value of not less than 4.0 mg/l; swamp waters, lake coves or backwaters, and lake bottom waters may have lower values if caused by natural conditions.

pH

The pH of natural waters can vary throughout the state. Low values, such as less than 7.0 Standard Units (SU), can be found in waters rich in dissolved organic matter, such as swamp lands. High values, such as greater than 7.0 SU may be found during algal blooms. Point source dischargers can also influence the pH of a stream. The measurement of pH is relatively easy; however the accuracy of field measurements is limited by the abilities of the field equipment, which is generally accurate to within 0.2 SU. This is due, in part, because the scale for measuring pH is logarithmic (i.e. a pH of 8 is ten times less concentrated in hydrogen ions than a pH of 7). The water quality standards for pH in freshwaters consider values less than 6.0 SU or greater than 9.0 SU to warrant attention. In swamp waters, a pH below 4.3 SU is of concern.

Specific Conductance

In this report, conductivity is synonymous with specific conductance. It is reported in micro-mhos per centimeter ($\mu\text{mhos/cm}$) at 25°C. Conductivity is a measure of the ability of water to conduct an electric current. The presence of ions and temperature are major factors in the ability of water to conduct a current. Clean freshwater has a low conductivity, whereas high conductivities may indicate polluted water or saline conditions. Measurements reported are corrected for temperature, thus the range of values reported over a period of time indicate the relative presence of ions in water. North Carolina freshwater streams have a natural conductance range of 17-65 $\mu\text{mhos/cm}$ (USGS 1992).

Conductivity can be used to evaluate variations in dissolved mineral concentrations (ions) among sites with varying degrees of impact resulting from point source discharges. Generally, impacted sites show elevated and widely ranging values for conductivity.

Turbidity

Turbidity data may denote episodic high values on particular dates or within narrow time periods. These can often be the result of intense or sustained rainfall events; however elevated values can occur at other times.

Nutrients

Compounds of 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-nitrogen (NH₃-N), total Kjeldahl nitrogen (TKN) and nitrite+nitrate nitrogen (NO₂+NO₃-N). Phosphorus is measured as total phosphorus. When nutrients are introduced to an aquatic ecosystem from municipal and industrial treatment processes, or runoff from urban or agricultural land, the excessive growth of algae and other plants may occur (i.e. algal blooms and infestations).

At neutral pH in water, ammonia normally forms an ionized solution of ammonium hydroxide, with only a small amount of ammonia. However, as pH increases, more ammonia is left unionized. Unionized ammonia is toxic to fish and other aquatic organisms.

Fecal Coliform Bacteria

Concentrations of fecal coliform bacteria can vary greatly. The descriptive statistics used to evaluate fecal coliform bacteria data include the geometric mean and the median depending on the classification of the waterbody. For all freshwater sites in the Little Tennessee River Basin, the standard specified in Administrative Code 15A NCAC 02B.0211 (3)(e) (May 1, 2007) is applicable:

“Organisms of the coliform group: fecal coliforms shall not exceed a geometric mean of 200/100ml (MF count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results, the MPN 5-tube dilution technique shall be used as the reference method.”

Fecal coliform problems are screened using annual summaries of Ambient sampling results. If the screening indicates that the station may be in violation of the standard, the standard is assessed using the method required by law. All such class B (and class SB/SA in coastal basins) waters are assessed, and other waters as resources permit. The required assessment method is known as “5 in 30”, collecting a minimum five samples within a span of 30 days. If a water body exceeds the standard more than 20% of the time during the 30-day period or the geomean for the 30-day period is greater than 200, then that water body is considered impaired and is added to the impaired water list, the 303(d) list.

WATER QUALITY MONITORING RESULTS SUMMARY

Water Quality within the basin during the evaluation period is summarized in the following tables. **Table 4** shows how often water quality evaluation levels were exceeded. **Table 5** shows average values, for comparison against HUC and basinwide averages.

Table 4. Frequency of Evaluation Level Exceedances

Station ID	Stream Class	pH		Turbidity		Fecal Coliform (>400 colonies/100 mL) Freshwater
		(<6 SU) Freshwater	(>9 SU) Freshwater	(>50 NTU) Freshwater	(>10 NTU) Troutwater	
HUC 06010202: Little Tennessee River						
G0035000	C	6.2%	0.0%	3.9%	NA	19.6%
G2000000	B	6.1%	0.0%	7.8%	NA	15.7%
G3500000	B Tr ORW	8.3%	0.0%	NA	2.0%	2.0%
HUC 06010203: Tuckasegee River						
G8600000	B	8.3%	2.1%	0.0%	NA	4.0%
HUC 06010204: Lower Little Tennessee River						
G9550000	C Tr	4.3%	0.0%	NA	8.0%	12.0%

notes:

NA: This evaluation level is **Not Applicable** for this parameter in this stream class.

NC: Samples for this parameter were **Not Collected**.

L10: **Less than ten** samples were collected for this parameter.

If there are no exceedances for a given combination of evaluation level, stream class, and parameter during the assessment period, then that column is not included in the table.

1. There were no exceedances for **dissolved oxygen** during the assessment period.
2. There were no exceedances for **water temperature** during the assessment period.
3. No samples were collected for **chlorophyll a** during the assessment period.

Table 5a. Summary of Water Quality Parameter Averages

Station	Stream Class	Water Temperature (°C)		D.O. (mg/L)		pH (SU)		Spec. conductance (umhos/cm at 25°C)		Turbidity (NTU)		Fecal coliform (# colonies per 100mL)	
		n	mean	n	mean	n	mean	n	mean	n	mean	n	mean
Entire Basin		247	14.2	232	10.0	240	6.6	238	31.5	253	8.5	253	50
HUC 06010202		150	13.6	144	9.9	145	6.5	142	33	153	10.2	153	42
G0035000	C	50	14.2	48	9.7	48	6.5	48	46	51	13.9	51	118
G2000000	B	50	15.0	48	9.9	49	6.5	47	39	51	14.5	51	84
G3500000	B Tr ORW	50	11.6	48	10.1	48	6.4	47	13	51	2.2	51	8
HUC 06010203		49	15.2	43	10.3	48	7.0	48	25	50	7.1	50	43
G8600000	B	49	15.2	43	10.3	48	7.0	48	25	50	7.1	50	43
HUC 06010204		48	14.7	45	9.8	47	6.6	48	34	50	5.0	50	94
G9550000	C Tr	48	14.7	45	9.8	47	6.6	48	34	50	5.0	50	94

Note: all means are arithmetic means, except for fecal coliform, which is a geometric mean.

Table 5b. Summary of Water Quality Parameter Averages for Nutrients

Station	Stream Class	Total Inorganic Nitrogen (mg/L)		Total Organic Nitrogen (mg/L)		NH3 as N (mg/L)		NO2 + NO3 as N (mg/L)		TKN as N (mg/L)		Total Phosphorus (mg/L)	
		n	mean	n	mean	n	mean	n	mean	n	mean	n	mean
Entire Basin		204	0.14	206	0.19	208	0.02	200	0.12	205	0.21	201	0.04
HUC 06010202		107	0.11	109	0.19	109	0.02	105	0.09	109	0.21	106	0.04
G0035000	C	6	0.15	6	0.18	6	0.02	6	0.13	6	0.20	6	0.03
G2000000	B	51	0.17	52	0.20	52	0.02	50	0.14	52	0.22	50	0.05
G3500000	B Tr ORW	50	0.06	51	0.19	51	0.02	49	0.03	51	0.21	50	0.02
HUC 06010203		48	0.17	48	0.19	49	0.02	47	0.15	48	0.21	47	0.04
G8600000	B	48	0.17	48	0.19	49	0.02	47	0.15	48	0.21	47	0.04
HUC 06010204		49	0.17	49	0.18	50	0.02	48	0.15	48	0.20	48	0.03
G9550000	C Tr	49	0.17	49	0.18	50	0.02	48	0.15	48	0.20	48	0.03

ASSESSMENT AND INTERPRETATION METHODS

Monitoring and sampling results considered in this report represent samples collected or measurements taken at less than one-meter depth.

Percentile statistics were calculated for most of the data using JMP statistical software (version 8.02; SAS Institute, Cary, NC). Values less than the minimum reporting level (non-detects) were evaluated as equal to the reporting level. Box and whisker plots (constructed using SigmaPlot version 9) and maps are presented for most water quality parameters collected at each monitoring station. Significant trends in water quality parameters (constructed using Microsoft Excel) are illustrated as scatterplots. Significant trends are found by assessing the probability that the linear model explains the data no better than chance. If that chance is 5% or less (an observed significance probability of 0.05 or less) then that is considered evidence of a regression effect in this document. The strength of the regression effect is given as an r^2 value, the portion of the data that is explained by the linear model. There are many other types of modeling (non-linear) that can be used to explore trends, but they were not used in this document.

Assessment Considerations

Total Metals

The North Carolina Division of Water Quality is currently reviewing water quality standards for metals. Review of historical total metals data and biological data has shown that no correlation exists between exceedance of total metals ambient standards and biological impairment. Therefore, as of May 2007 DWQ has suspended collection of total metals at AMS stations. Some stations in the Little Tennessee River Basin have total metals results from before the suspension. However, the only metal of concern detected was iron, which naturally occurs in North Carolina surface waters. Because of the likely natural source, these results are not considered in this report.

Providing Confidence in the Exceedance of Water Quality Standards

Historically, NC DWQ has used guidance provided by the US EPA for determining when the number of results that exceed a water quality standard indicate potential water quality issues. The US EPA has suggested that management actions be implemented when 10 percent of the results exceeded a water quality standard. This interpretation is the same whether 1 out of 10, or 5 out of 50, or 25 out of 250 results exceed a standard. Evaluating exceedances in this manner is termed the “raw-score” approach. Although this “10 percent exceedance criterion” defines a point where potential water quality issues may be present, it does not consider uncertainty. Some results are subject to chance or other factors such as calibration errors or sample mishandling. Uncertainty levels change with sample size. The smaller the sample size, the greater the uncertainty.

This document uses a nonparametric procedure (Lin *et al.* 2000) to identify when a sufficient number of exceedances have occurred that indicate a true exceedance probability of 10 percent. Calculating the minimum number of exceedances needed for a particular sample size was done using the BINOMDIST function in Microsoft Excel®. This statistical function suggests that at least three exceedances need to be observed in a sample of 10 in order to be [about] 95 percent confident that the results statistically exceed the water quality standard more than 10% of the time. For example, there is less statistical confidence associated with a 1 exceedance out of 10 (74 percent) than when there are 3 exceedances out of 10 (99 percent confidence) (**Table 6**).

Table 6. Exceedance Confidence

Number of Samples	Number of Exceedances																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
10	74%	93%	99%	100%													
12	66%	89%	97%	100%													
14	58%	84%	96%	99%	100%												
16	51%	79%	93%	98%	100%												
18	45%	73%	90%	97%	99%	100%											
20	39%	68%	87%	96%	99%	100%											
22	34%	62%	83%	94%	98%	100%											
24	29%	56%	79%	91%	97%	99%	100%										
26	25%	51%	74%	89%	96%	99%	100%										
28	22%	46%	69%	86%	94%	98%	100%										
30	18%	41%	65%	82%	93%	97%	99%	100%									
32	16%	37%	60%	79%	91%	96%	99%	100%									
34	13%	33%	55%	75%	88%	95%	98%	99%	100%								
36	11%	29%	51%	71%	85%	94%	98%	99%	100%								
38	10%	25%	46%	67%	83%	92%	97%	99%	100%								
40	8%	22%	42%	63%	79%	90%	96%	98%	99%	100%							
42	7%	20%	38%	59%	76%	88%	95%	98%	99%	100%							
44	6%	17%	35%	55%	73%	85%	93%	97%	99%	100%							
46	5%	15%	31%	51%	69%	83%	92%	96%	99%	100%							
48	4%	13%	28%	47%	65%	80%	90%	95%	98%	99%	100%						
50	3%	11%	25%	43%	62%	77%	88%	94%	98%	99%	100%						
52	3%	10%	22%	40%	58%	74%	86%	93%	97%	99%	100%						
54	2%	8%	20%	36%	54%	71%	83%	91%	96%	98%	99%	100%	100%	100%	100%	100%	100%
56	2%	7%	18%	33%	51%	67%	81%	90%	95%	98%	99%	100%	100%	100%	100%	100%	100%
58	2%	6%	16%	30%	47%	64%	78%	88%	94%	97%	99%	100%	100%	100%	100%	100%	100%
60	1%	5%	14%	27%	44%	61%	75%	86%	93%	97%	99%	99%	100%	100%	100%	100%	100%
62	1%	5%	12%	24%	40%	57%	72%	84%	91%	96%	98%	99%	100%	100%	100%	100%	100%
64	1%	4%	11%	22%	37%	54%	69%	81%	90%	95%	98%	99%	100%	100%	100%	100%	100%
66	1%	3%	9%	20%	34%	51%	66%	79%	88%	94%	97%	99%	99%	100%	100%	100%	100%
68	1%	3%	8%	18%	31%	47%	63%	76%	86%	93%	96%	98%	99%	100%	100%	100%	100%
70	1%	2%	7%	16%	29%	44%	60%	74%	84%	91%	96%	98%	99%	100%	100%	100%	100%
72	0%	2%	6%	14%	26%	41%	57%	71%	82%	90%	95%	97%	99%	100%	100%	100%	100%
74	0%	2%	5%	13%	24%	38%	54%	68%	80%	88%	94%	97%	99%	99%	100%	100%	100%
76	0%	1%	5%	11%	22%	35%	51%	65%	77%	86%	93%	96%	98%	99%	100%	100%	100%
78	0%	1%	4%	10%	20%	33%	48%	62%	75%	85%	91%	95%	98%	99%	100%	100%	100%
80	0%	1%	4%	9%	18%	30%	45%	59%	72%	83%	90%	95%	97%	99%	99%	100%	100%

Note: Bold entries indicate that there is at least 95% confidence that at least 10% of the possible samples exceed the evaluation level.

Methods Used to Summarize Results

Methods used to summarize the results in this report encompass both tabular and graphical formats. Box and whisker plots, scatterplots, and maps were used to depict data for a variety of water quality parameters throughout the basin. For the box plots, stations with fewer than 10 data points for a given parameter were not included. This occasionally occurred when a new station was added, an old station was removed, or a station was moved to a new location in the basin.

Individual station summary sheets provide details on station location, stream classification, along with specifics on what parameters were measured, the number of samples taken (i.e. sample size), the number of results below reporting levels, the number of results exceeding a water quality standard or evaluation level, statistical confidence that 10% of results exceeded the evaluation level, and a general overview of the distribution of the results using percentiles. These station summary sheets provide the greatest details on a station-by-station basis. They are included as **Appendix A** to this report.

The results were depicted in the following ways:

- Comparing stations – box plots
- Assessing stations – tables
- Illustrating regional variation – maps

Box and Whisker Plots

One method of analyzing data in this report is through the use of box and whisker plots. **Figure 2** is an annotated example of a box and whisker plot that illustrates the distribution of the results for a particular parameter at a single site. This box plot contains both the median and mean values. Differences between the median and mean can illustrate the distribution of the results. For example, if the mean is considerably larger than the median, then there are likely a few very high concentrations raising the mean. Another useful measure is to compare the 90th percentile against the evaluation level. For most parameters, 10% exceedance of the evaluation levels is considered a violation. Therefore the 90th (or 10th in the case of minimum evaluation levels) percentile exceeding the evaluation level is an equivalent statement. Box plots for each station are included in **Appendix B**.

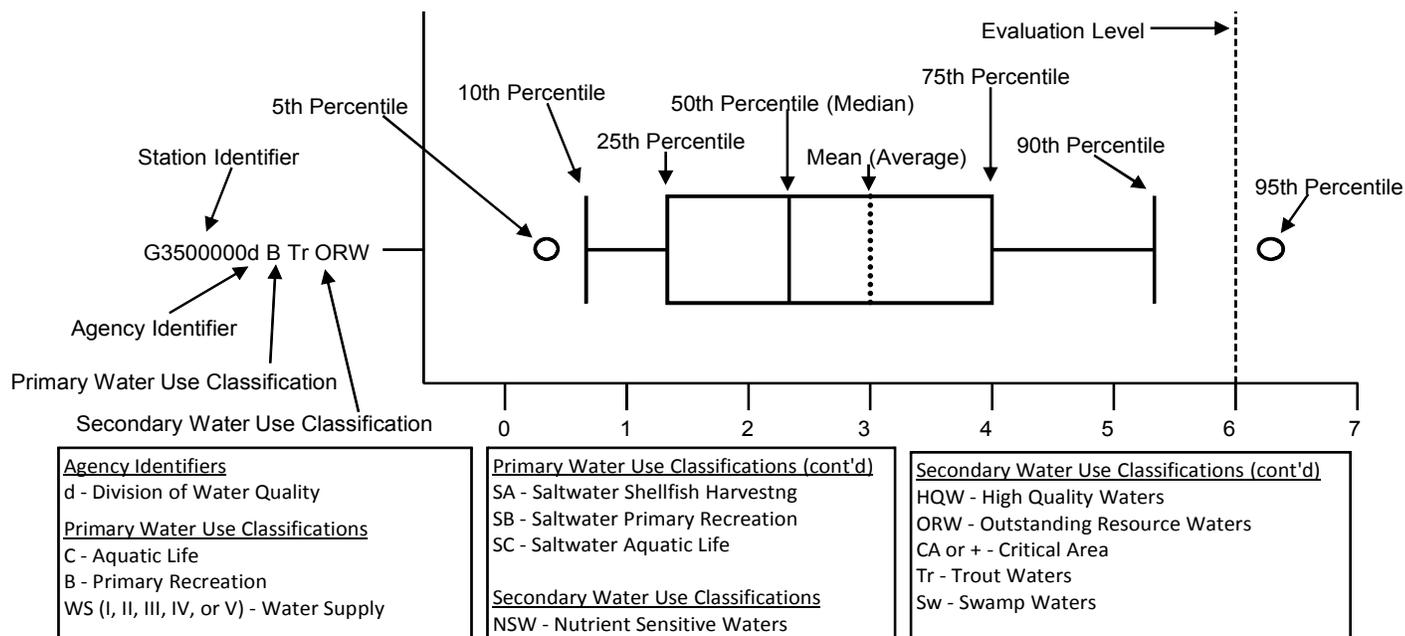
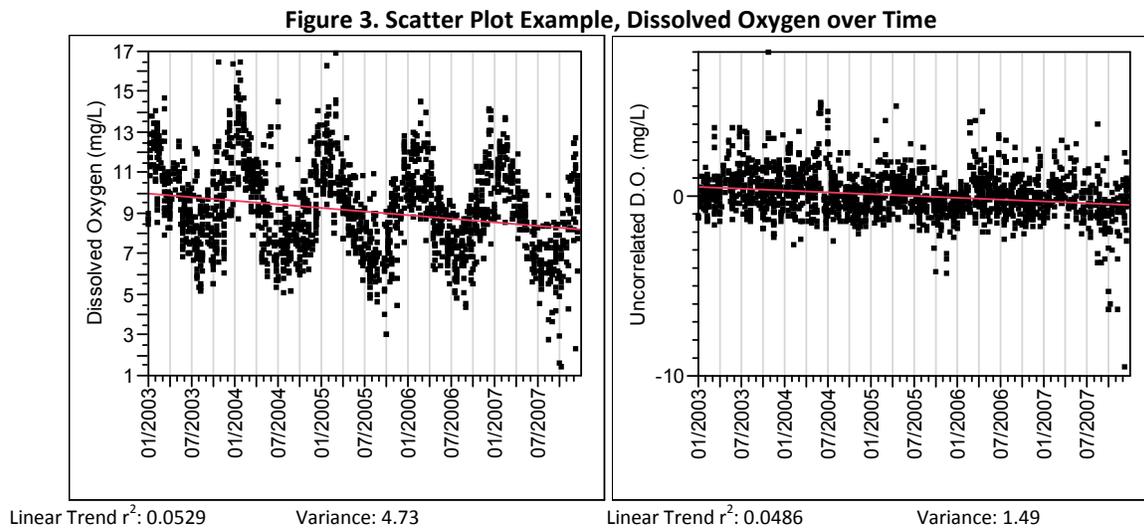


Figure 2. An Example Box Plot for a Station

Scatter Plots – Change Over Time and Trends

Constructing trends helps us to answer the question, “Are things getting better or worse?” In this document change over time trends are illustrated in scatterplots. If there is at least 95% confidence that a particular linear trend explains the data better than random chance (Prob > F of 0.05 or less) then that linear trend was included on the graph. Unfortunately clear trends are rare. Confounding effects, such as flow and seasonal change can mimic or obscure a trend. The figure below on the left shows dissolved oxygen data exhibiting a strong seasonal pattern. In order to search for an underlying trend we first need to remove the seasonal component.

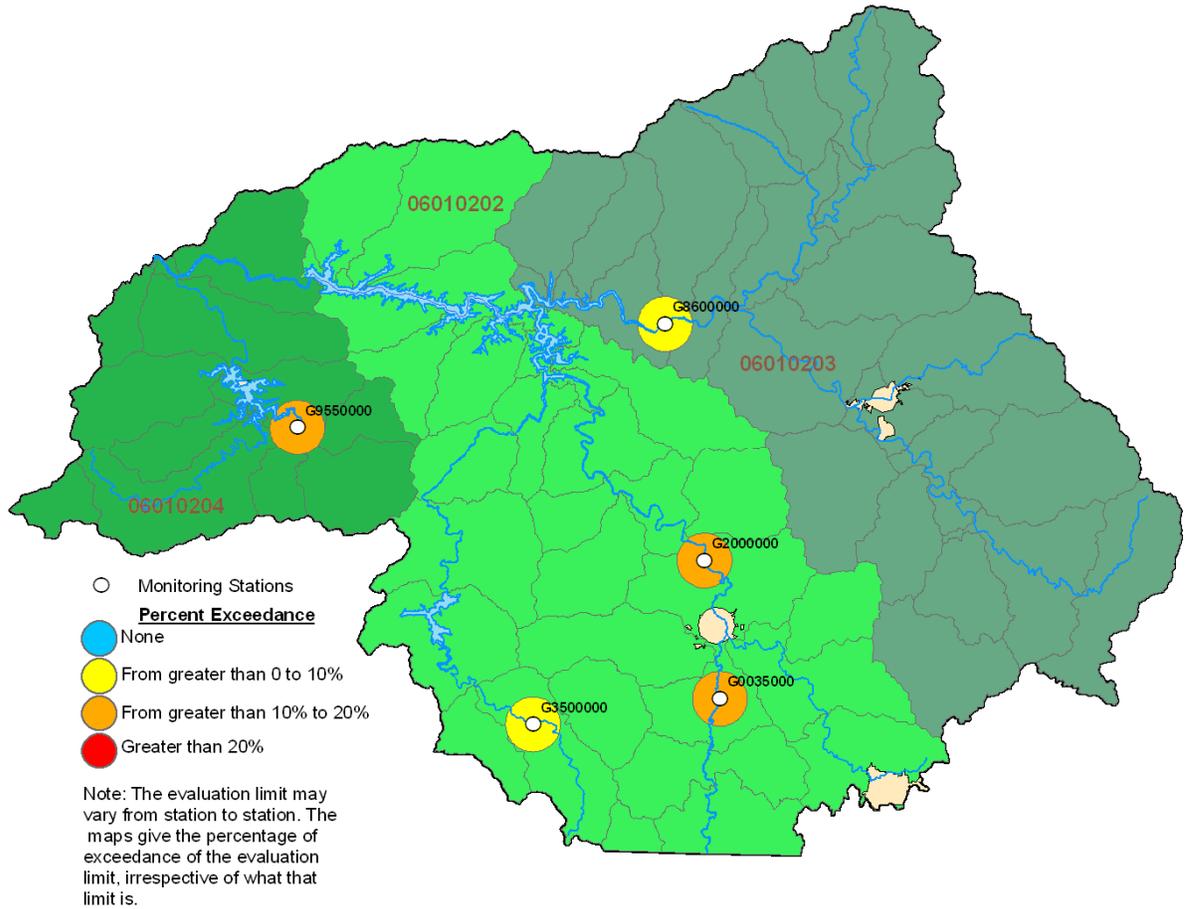
Linear regression can remove the seasonal effect by comparing the target parameter to another seasonally variable parameter, (in this case water temperature) and removing the variation that is common to both. Variation due to flow can be removed in the same fashion. The graph on the right shows the same dissolved oxygen data, but with the seasonal component removed. The data is considerably less variable now (as shown in the variance). The new graph still displays a trend, weaker than it was when influenced by water temperature.



Maps

Maps are used to display data for the whole basin at once, so that the relationship of stations to each other can be seen, and regional patterns become clear. The colors signify the degree of water quality exceedance at each location.

Figure 4. Example Map



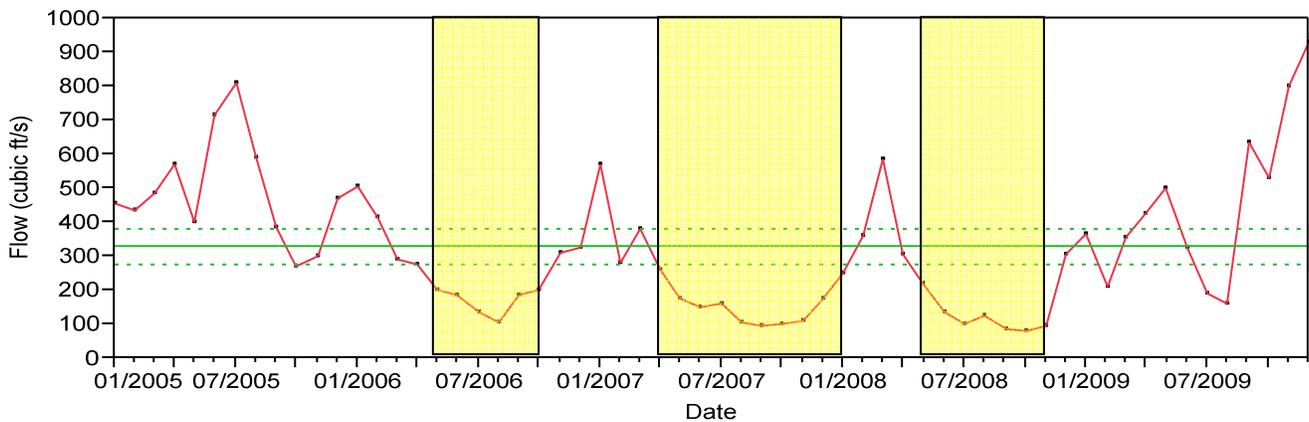
WATER QUALITY ANALYSIS

Stream Flow and Drought

The rate at which a volume of water moves through a stream (the flow rate) can have an impact on the measurement of other parameters. In particular, droughts can have major effects on parameters such as dissolved oxygen, turbidity, pH, and others by reducing stream flow. Therefore it is useful to track changes in stream flow over the course of the assessment period, to see when drought or high flow events might be present. In the following graphs the average monthly flow (red variable line) is displayed and compared to the average flow for the entire period (green line). The 95% confidence interval for the average (green dotted lines) is also given. For these graphs, any period with four or more consecutive months below the 95% confidence interval is considered a drought.

Three sites were assessed for drought: the Little Tennessee River near Prentiss, the Nantahala River near Rainbow Springs, and the Tuckasegee River at Bryson City. A drought affected these sites in 2006, 2007, and 2008. At the three sites 23, 20, and 16 months out of 36 were drought months, respectively. Figure 5 displays the water flow at these three stations.

Figure 5. Average Monthly Flow in the Little Tennessee River Basin
Little Tennessee River near Prentiss



Nantahala River near Rainbow Springs

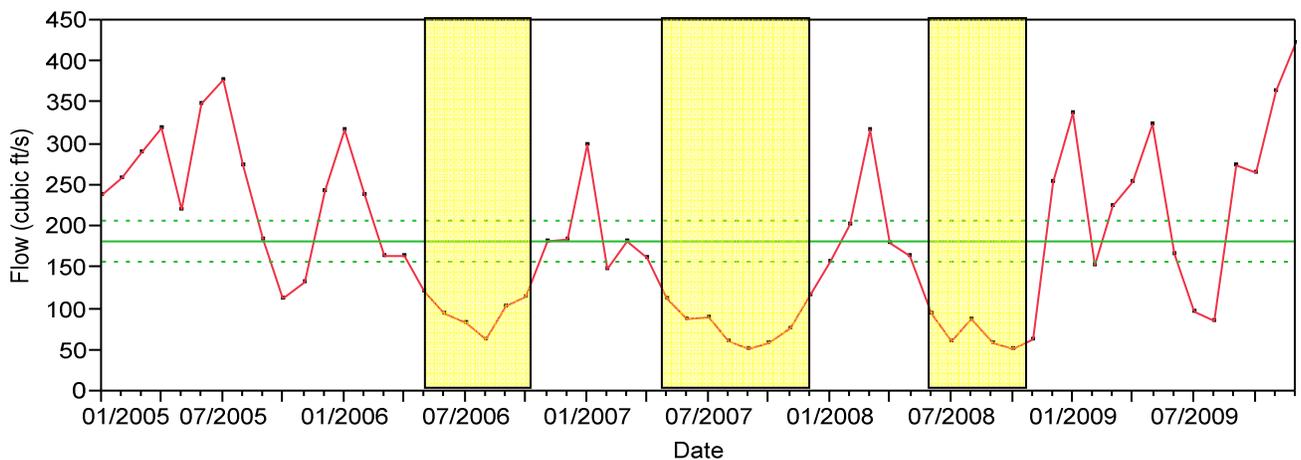
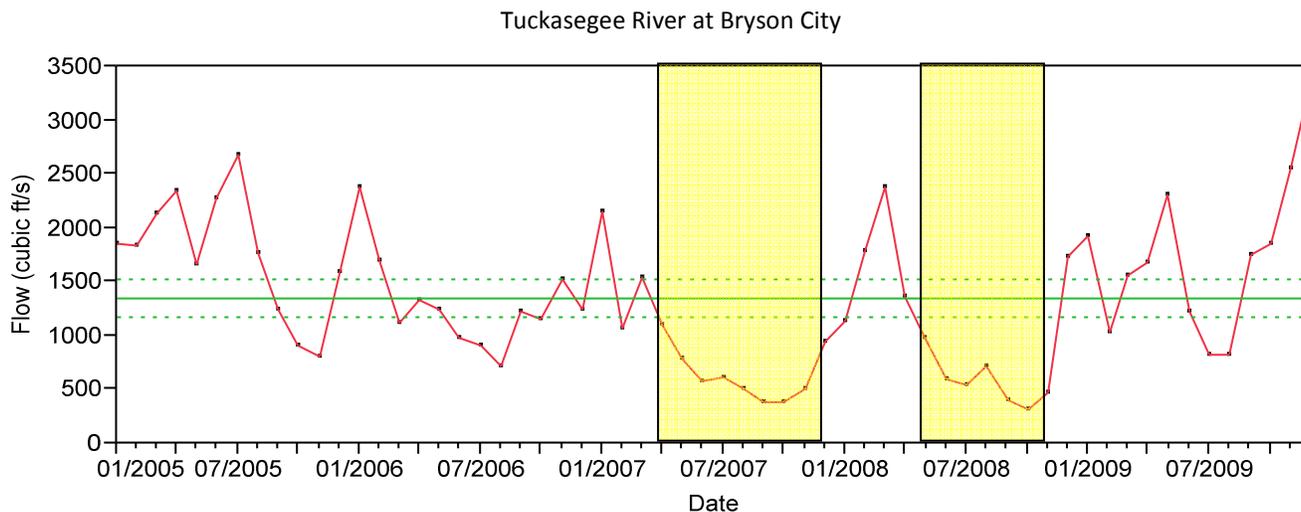


Figure 5. Average Monthly Flow in the Little Tennessee River Basin (continued)



Long Term Trends

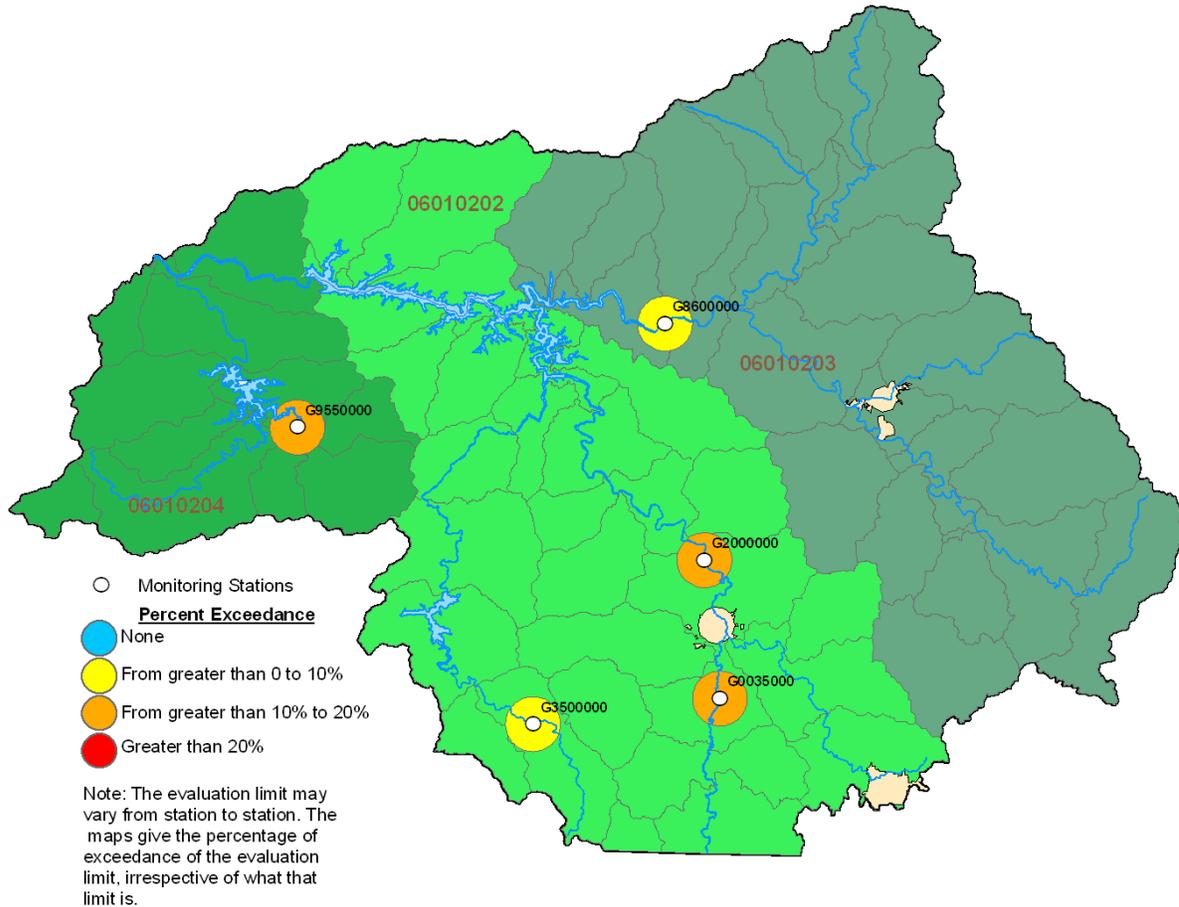
In order to develop useful long term trends, it is important to remove as many confounding effects as possible. The most common confounding effect is flow rate. Many environmental parameters can be affected by flow rate. If flow is not accounted for, a drought may accidentally be interpreted as a significant historical shift. In addition, some parameters have strong seasonal components that can be removed in order to see an underlying trend. Flow is less useful in tidal saltwater rivers where retrograde flow is common.

Water Quality Data collected by DWQ from inception through 2009 were downloaded from the EPA STORET database for three stations: G0035000 – Little Tennessee River near Prentiss, G3500000 – Nantahala River near Rainbow Springs, and G8600000 – Tuckasegee River at Bryson City. Flow data from the USGS website were also downloaded for each station. If flow or other confounding trends were found in the data, it was removed using linear regression. Linear regression and best professional judgment was then used to evaluate change over time.

The data were evaluated for the presence of trends for parameters including water temperature, specific conductance, pH, dissolved oxygen, turbidity, fecal coliform, ammonia, nitrates/nitrites, kjeldahl nitrogen, and phosphorus. Based on best professional judgement, there are currently no long-term trends of interest at these stations.

Geographic Assessment

Figure 6. Fecal Coliform in the Little Tennessee River Basin



Fecal coliform results are screened using annual summaries of ambient sampling results. When the screenings indicate that the standard may have been violated, the standard is assessed by collecting five samples within 30 days. Priority for assessment of the standard is given to waters with Class B (recreational) uses.

All sites in the Little Tennessee River Basin remained below the fecal coliform 20% evaluation criteria for the monitoring period. However in 2007, G2000000 (Little Tennessee River at lotla) did exceed this criteria for the year. The Little Tennessee at lotla is a Class B water and was assessed against the standard in July and August 2008. G2000000 met the standard. The five samples collected all were well below the evaluation level of 200 colonies per 100 mL.

Other Issues

Other than those already addressed in the previous sections, no significant new issues were identified in the Little Tennessee River basin. Information on specific parameters and specific stations can be found in **Appendix A** (station summary sheets) and **Appendix B** (box plots). Box plots were constructed for each of the following parameters: water temperature, dissolved oxygen, pH, specific conductance, turbidity, fecal coliform, ammonia, total kjeldahl nitrogen, total nitrates and nitrites, and total phosphorus.

Appendix A: Station Summary Sheets

Ambient Monitoring System Station
 NCDENR, Division of Water Quality
 Basinwide Assessment

Location: LITTLE TENNESSEE RIV AT SR 1651 NR PRENTISS
Station #: G0035000 **Hydrologic Unit Code:** 06010202
Latitude: 35.12215 **Longitude:** -83.37432 **Stream class:** C
Agency: NCAMBNT **NC stream index:** 2-(1)

Time period: 01/04/2005 to 12/03/2009

	# results	# ND	EL	Results not meeting EL			Percentiles						
				#	%	%Conf	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	48	0	<4	0	0		7.6	7.8	8.4	9.8	10.7	11.4	12.9
	48	0	<5	0	0		7.6	7.8	8.4	9.8	10.7	11.4	12.9
pH (SU)	48	0	<6	3	6.2		5.4	6.1	6.3	6.6	6.7	6.9	7.2
	48	0	>9	0	0		5.4	6.1	6.3	6.6	6.7	6.9	7.2
Spec. conductance (umhos/cm at 25°C)	48	0	N/A				15	22	23	28	71	93	147
Water Temperature (°C)	50	0	>29	0	0		2.5	7.3	9.7	14	19.9	22.2	24
Other													
TSS (mg/L)	20	4	N/A				2.5	2.6	6	9.6	14.8	15.9	41
Turbidity (NTU)	51	0	>50	2	3.9		2.3	2.7	5	8.2	12	34.8	120
Nutrients (mg/L)													
NH3 as N	6	6	N/A				0.02	0.02	0.02	0.02	0.02	0.02	0.02
NO2 + NO3 as N	6	0	N/A				0.1	0.1	0.1	0.12	0.15	0.19	0.19
TKN as N	6	6	N/A				0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total Phosphorus	6	1	N/A				0.02	0.02	0.02	0.02	0.03	0.04	0.04
Metals (ug/L)													
Aluminum, total (Al)	10	0	N/A				160	161	215	525	790	1075	1100
Arsenic, total (As)	10	10	>10	0	0		5	5	5	5	5	5	5
Cadmium, total (Cd)	10	10	>2	0	0		1	1	1.8	2	2	2	2
Chromium, total (Cr)	10	10	>50	0	0		10	10	21	25	25	25	25
Copper, total (Cu)	10	8	>7	0	0		2	2	2	2	2	4	5
Iron, total (Fe)	10	0	>1000	0	0		230	233	268	505	700	874	890
Lead, total (Pb)	10	10	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	8	8	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	10	10	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	10	8	>50	0	0		10	10	10	10	10	13	13
Fecal Coliform Screening(#/100mL)													
# results:	Geomean	# > 400:	% > 400:	%Conf:									
51	118.3	10	19.6										

Key:

result: number of observations
 # ND: number of observations reported to be below detection level (non-detect)
 EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
 Results not meeting EL: number and percentages of observations not meeting evaluation level
 %Conf : States the percent statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
 Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station
 NCDENR, Division of Water Quality
 Basinwide Assessment

Location: LITTLE TENNESSEE RIV AT NC 28 AT IOTLA
Station #: G2000000 **Hydrologic Unit Code:** 06010202
Latitude: 35.23490 **Longitude:** -83.39579 **Stream class:** B
Agency: NCAMBNT **NC stream index:** 2-(26.5)

Time period: 01/04/2005 to 12/03/2009

	# results	# ND	EL	Results not meeting EL			Percentiles						
				#	%	%Conf	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	48	0	<4	0	0		7.2	7.6	8.6	10.1	11.2	12	12.9
	48	0	<5	0	0		7.2	7.6	8.6	10.1	11.2	12	12.9
pH (SU)	49	0	<6	3	6.1		5	6	6.3	6.6	6.8	7	7
	49	0	>9	0	0		5	6	6.3	6.6	6.8	7	7
Spec. conductance (umhos/cm at 25°C)	47	0	N/A				24	26	29	36	45	54	88
Water Temperature (°C)	50	0	>29	0	0		4.8	7.4	9.9	13	20.4	24.5	26.4
Other													
TSS (mg/L)	19	5	N/A				2.5	4	5	6.2	12	27	37
Turbidity (NTU)	51	0	>50	4	7.8		1.9	3.4	4.4	7.7	13	42.4	100
Nutrients (mg/L)													
NH3 as N	52	38	N/A				0.02	0.02	0.02	0.02	0.02	0.02	0.05
NO2 + NO3 as N	50	0	N/A				0.03	0.09	0.11	0.15	0.18	0.21	0.25
TKN as N	52	38	N/A				0.2	0.2	0.2	0.2	0.2	0.28	0.49
Total Phosphorus	50	2	N/A				0.02	0.02	0.03	0.05	0.07	0.1	0.16
Metals (ug/L)													
Aluminum, total (Al)	10	0	N/A				150	156	240	315	430	487	490
Arsenic, total (As)	10	10	>10	0	0		5	5	5	5	5	5	5
Cadmium, total (Cd)	10	10	>2	0	0		1	1	1.8	2	2	2	2
Chromium, total (Cr)	10	10	>50	0	0		10	10	21	25	25	25	25
Copper, total (Cu)	10	10	>7	0	0		2	2	2	2	2	2	2
Iron, total (Fe)	10	0	>1000	0	0		320	321	352	415	578	681	690
Lead, total (Pb)	10	10	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	8	8	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	10	10	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	10	6	>50	0	0		10	10	10	10	13	15	15
Fecal Coliform Screening(#/100mL)													
# results:	Geomean	# > 400:	% > 400:	%Conf:									
51	83.5	8	15.7										

Key:

result: number of observations
 # ND: number of observations reported to be below detection level (non-detect)
 EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
 Results not meeting EL: number and percentages of observations not meeting evaluation level
 %Conf : States the percent statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
 Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station
 NCDENR, Division of Water Quality
 Basinwide Assessment

Location: NANTAHALA RIV AT US 64 NR RAINBOW SPRINGS
Station #: G3500000 **Hydrologic Unit Code:** 06010202
Latitude: 35.09422 **Longitude:** -83.55992 **Stream class:** B Tr ORW
Agency: NCAMBNT **NC stream index:** 2-57-(0.5)

Time period: 01/04/2005 to 12/03/2009

	# results	# ND	EL	Results not meeting EL			Percentiles						
				#	%	%Conf	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	48	0	<6	0	0		7.9	8.5	9.2	10.1	11	11.5	12.9
pH (SU)	48	0	<6	4	8.3		5.5	6	6.2	6.5	6.6	6.8	7
	48	0	>9	0	0		5.5	6	6.2	6.5	6.6	6.8	7
Spec. conductance (umhos/cm at 25°C)	47	0	N/A				11	11	12	13	15	16	17
Water Temperature (°C)	50	0	>29	0	0		1.4	5.9	7.8	11.9	16.3	18	19.8
Other													
TSS (mg/L)	21	18	N/A				2.5	2.5	2.5	6.2	6.2	10.8	17
Turbidity (NTU)	51	17	>10	1	2		1	1	1	1.2	2.3	4.4	11
Nutrients (mg/L)													
NH3 as N	51	48	N/A				0.02	0.02	0.02	0.02	0.02	0.02	0.13
NO2 + NO3 as N	49	13	N/A				0.02	0.02	0.02	0.03	0.04	0.06	0.08
TKN as N	51	46	N/A				0.2	0.2	0.2	0.2	0.2	0.25	0.42
Total Phosphorus	50	35	N/A				0.02	0.02	0.02	0.02	0.02	0.03	0.1
Metals (ug/L)													
Aluminum, total (Al)	10	5	N/A				50	50	50	52	94	119	120
Arsenic, total (As)	10	10	>10	0	0		5	5	5	5	5	5	5
Cadmium, total (Cd)	10	10	>0.4	0	0		1	1	1.8	2	2	2	2
Chromium, total (Cr)	10	10	>50	0	0		10	10	21	25	25	25	25
Copper, total (Cu)	10	10	>7	0	0		2	2	2	2	2	2	2
Iron, total (Fe)	10	2	>1000	0	0		50	50	59	72	142	159	160
Lead, total (Pb)	10	10	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	8	8	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	10	10	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	10	8	>50	0	0		10	10	10	10	10	31	33

Fecal Coliform Screening(#/100mL)

# results:	Geomean	# > 400:	% > 400: %Conf:
51	7.7	1	2

Key:

result: number of observations
 # ND: number of observations reported to be below detection level (non-detect)
 EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
 Results not meeting EL: number and percentages of observations not meeting evaluation level
 %Conf : States the percent statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
 Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station
 NCDENR, Division of Water Quality
 Basinwide Assessment

Location: TUCKASEGEE RIV AT SR 1364 AT BRYSON CITY
Station #: G8600000 **Hydrologic Unit Code:** 06010203
Latitude: 35.42835 **Longitude:** -83.44595 **Stream class:** B
Agency: NCAMBNT **NC stream index:** 2-79-(40.5)

Time period: 01/04/2005 to 12/08/2009

	# results	# ND	EL	Results not meeting EL			Percentiles						
				#	%	%Conf	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	43	0	<4	0	0		7.3	8.4	9	10.1	11.5	12.4	13.8
	43	0	<5	0	0		7.3	8.4	9	10.1	11.5	12.4	13.8
pH (SU)	48	0	<6	4	8.3		5.6	6.2	6.4	6.9	7.8	8.5	9.1
	48	0	>9	1	2.1		5.6	6.2	6.4	6.9	7.8	8.5	9.1
Spec. conductance (umhos/cm at 25°C)	48	0	N/A				10	22	22	24	27	30	44
Water Temperature (°C)	49	0	>29	0	0		3.2	7	10	16.6	20.8	23.6	25.9
Other													
TSS (mg/L)	20	10	N/A				2.5	3	5.3	6.2	11.1	20.9	38
Turbidity (NTU)	50	0	>50	0	0		1.1	1.8	2.7	4.5	7.3	13.9	37
Nutrients (mg/L)													
NH3 as N	49	47	N/A				0.02	0.02	0.02	0.02	0.02	0.02	0.02
NO2 + NO3 as N	47	0	N/A				0.05	0.1	0.12	0.15	0.19	0.22	0.27
TKN as N	48	41	N/A				0.2	0.2	0.2	0.2	0.2	0.22	0.35
Total Phosphorus	47	2	N/A				0.02	0.02	0.02	0.03	0.05	0.08	0.12
Metals (ug/L)													
Aluminum, total (Al)	10	0	N/A				120	122	162	255	832	2343	2500
Arsenic, total (As)	10	10	>10	0	0		5	5	5	5	5	5	5
Cadmium, total (Cd)	10	10	>2	0	0		1	1	1.8	2	2	2	2
Chromium, total (Cr)	10	10	>50	0	0		10	10	21	25	25	25	25
Copper, total (Cu)	10	9	>7	0	0		2	2	2	2	2	2	2
Iron, total (Fe)	10	0	>1000	2	20	93	180	185	252	355	995	3080	3300
Lead, total (Pb)	10	10	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	8	8	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	10	10	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	10	5	>50	0	0		10	10	10	10	15	22	22
Fecal Coliform Screening(#/100mL)													
# results:	Geomean	# > 400:	% > 400:	%Conf:									
50	43.2	2	4										

Key:

result: number of observations
 # ND: number of observations reported to be below detection level (non-detect)
 EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
 Results not meeting EL: number and percentages of observations not meeting evaluation level
 %Conf : States the percent statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
 Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Ambient Monitoring System Station
 NCDENR, Division of Water Quality
 Basinwide Assessment

Location: CHEOAH RIV AT SR 1138 AT ROBBINSVILLE
Station #: G9550000 **Hydrologic Unit Code:** 06010204
Latitude: 35.32910 **Longitude:** -83.80976 **Stream class:** C Tr
Agency: NCAMBNT **NC stream index:** 2-190-(3.5)

Time period: 01/04/2005 to 12/11/2009

	# results	# ND	EL	Results not meeting EL			Percentiles						
				#	%	%Conf	Min	10th	25th	50th	75th	90th	Max
Field													
D.O. (mg/L)	45	0	<6	0	0		7.1	8	8.6	9.7	10.8	12.1	12.7
pH (SU)	47	0	<6	2	4.3		5.7	6.1	6.5	6.7	6.9	7	7.2
	47	0	>9	0	0		5.7	6.1	6.5	6.7	6.9	7	7.2
Spec. conductance (umhos/cm at 25°C)	48	0	N/A				14	27	30	33	39	43	47
Water Temperature (°C)	48	0	>29	0	0		5	7.4	11.1	15.1	18.5	21.8	23.2
Other													
TSS (mg/L)	19	11	N/A				2.5	2.5	3	6.2	11	22	97
Turbidity (NTU)	50	1	>10	4	8		1	1.4	2	3.1	4.5	8.8	60
Nutrients (mg/L)													
NH3 as N	50	48	N/A				0.02	0.02	0.02	0.02	0.02	0.02	0.03
NO2 + NO3 as N	48	0	N/A				0.02	0.1	0.12	0.14	0.19	0.24	0.32
TKN as N	48	44	N/A				0.2	0.2	0.2	0.2	0.2	0.2	0.3
Total Phosphorus	48	15	N/A				0.02	0.02	0.02	0.02	0.03	0.05	0.12
Metals (ug/L)													
Aluminum, total (Al)	10	0	N/A				65	66	74	120	445	2671	2900
Arsenic, total (As)	10	10	>10	0	0		5	5	5	5	5	5	5
Cadmium, total (Cd)	10	10	>0.4	0	0		1	1	1.8	2	2	2	2
Chromium, total (Cr)	10	10	>50	0	0		10	10	21	25	25	25	25
Copper, total (Cu)	10	9	>7	0	0		2	2	2	2	2	5	5
Iron, total (Fe)	10	0	>1000	1	10	73.6	110	112	168	220	590	3221	3500
Lead, total (Pb)	10	10	>25	0	0		10	10	10	10	10	10	10
Mercury, total (Hg)	8	8	>0.012	0	0		0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nickel, total (Ni)	10	10	>88	0	0		10	10	10	10	10	10	10
Zinc, total (Zn)	10	6	>50	0	0		10	10	10	10	11	26	28

Fecal Coliform Screening(#/100mL)

# results:	Geomean	# > 400:	% > 400: %Conf:
50	94.5	6	12

Key:

result: number of observations
 # ND: number of observations reported to be below detection level (non-detect)
 EL: Evaluation Level; applicable numeric or narrative water quality standard or action level
 Results not meeting EL: number and percentages of observations not meeting evaluation level
 %Conf : States the percent statistical confidence that the actual percentage of exceedances is at least 10% (20% for Fecal Coliform)
 Stations with less than 10 results for a given parameter were not evaluated for statistical confidence

Appendix B: Station Box & Whisker Plots

Figure 7. Box Plots of Water Temperature and Dissolved Oxygen in the Little Tennessee River Basin

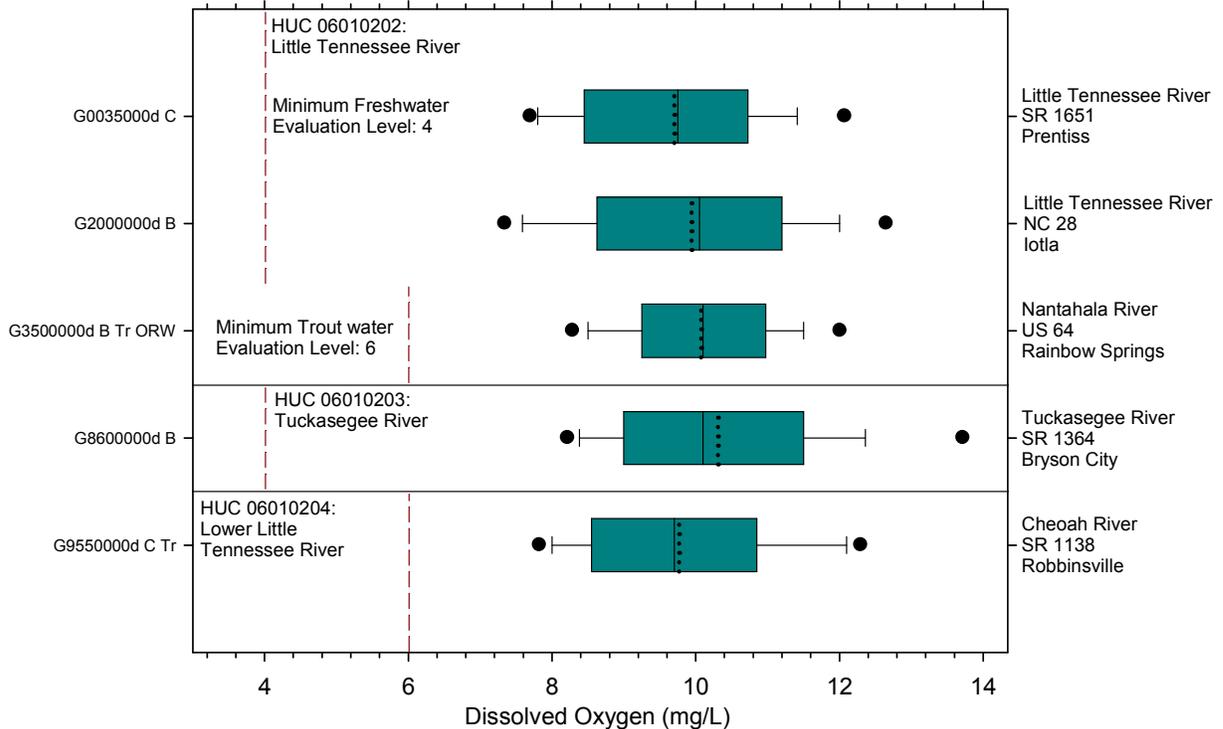
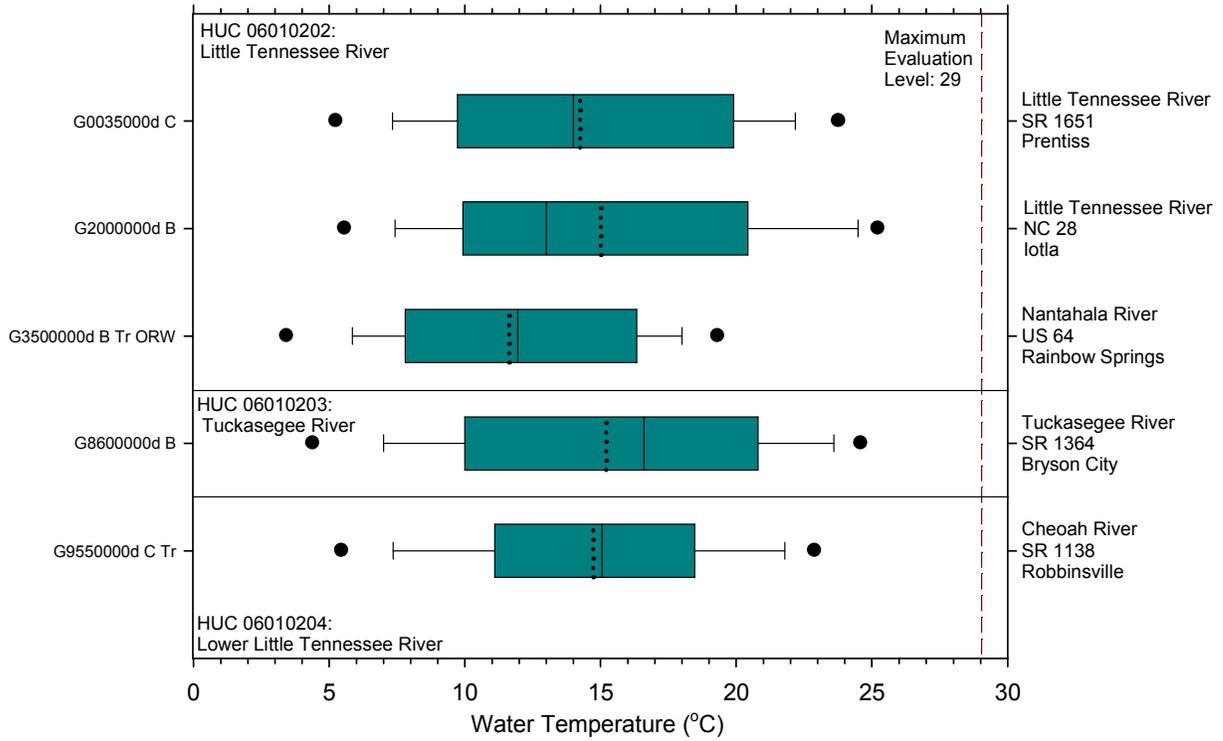


Figure 8. Box Plots of pH and Specific Conductance in the Little Tennessee River Basin

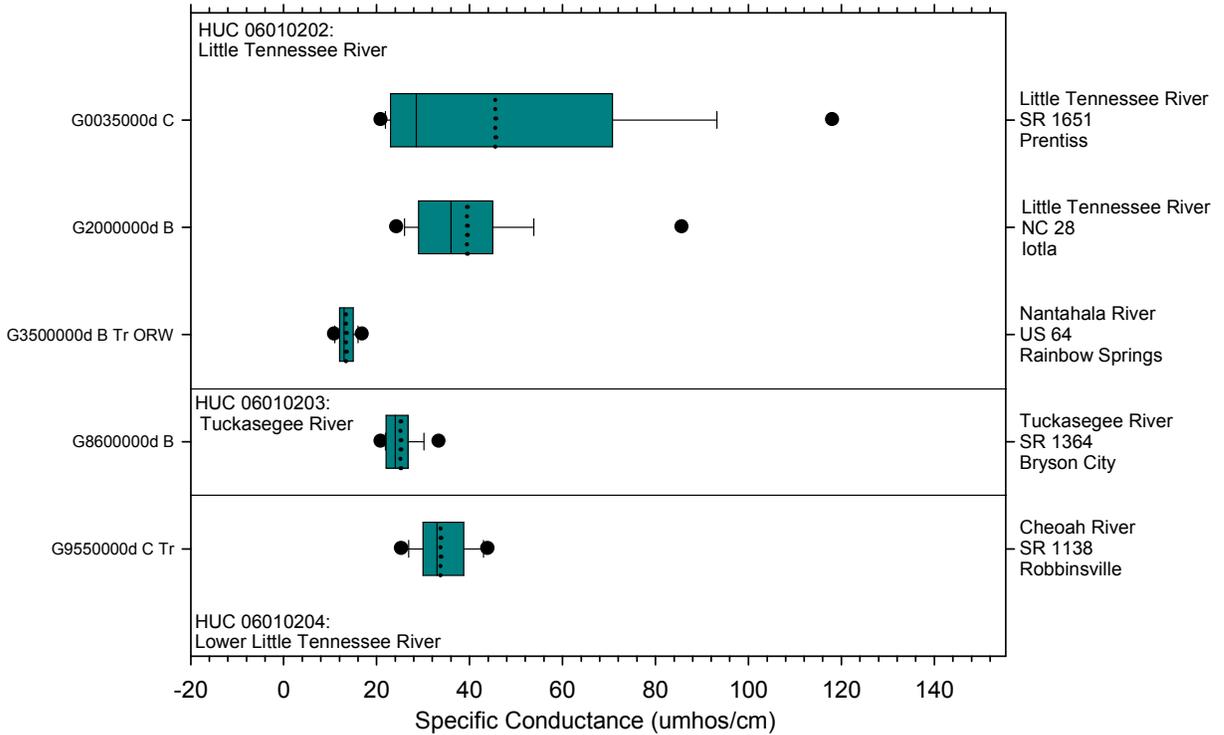
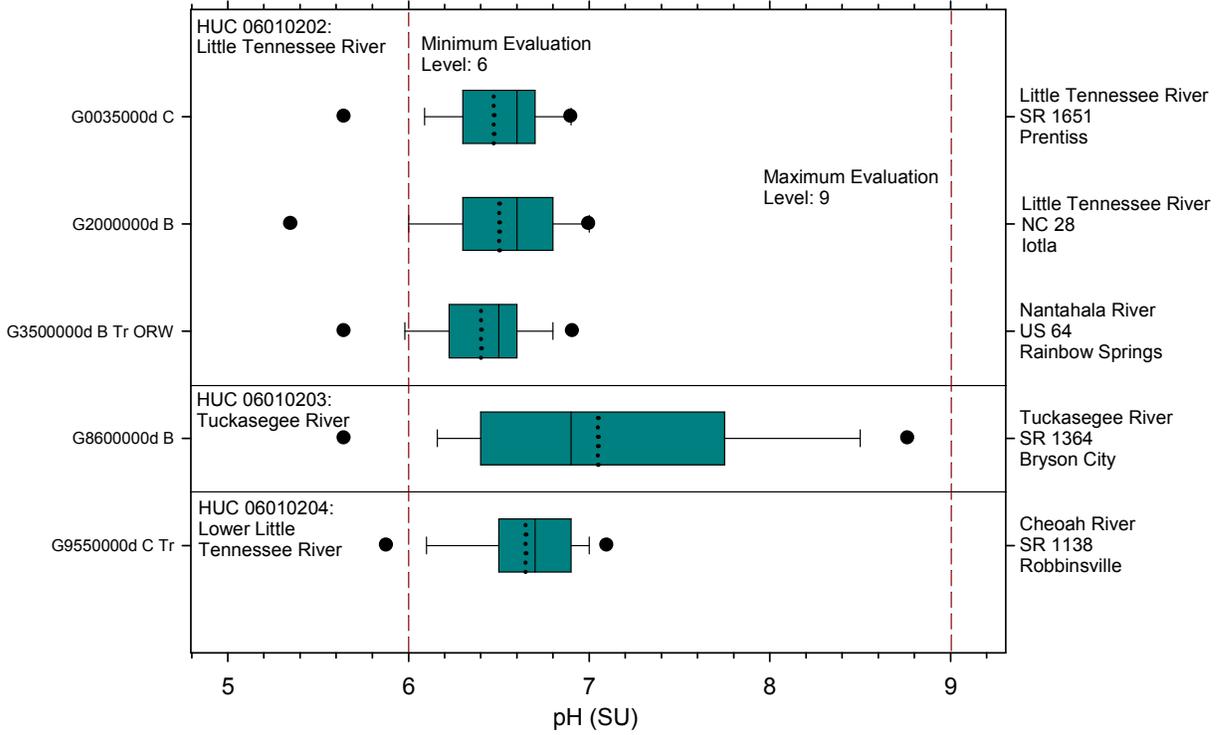


Figure 9. Box Plots of Turbidity and Fecal Coliform in the Little Tennessee River Basin

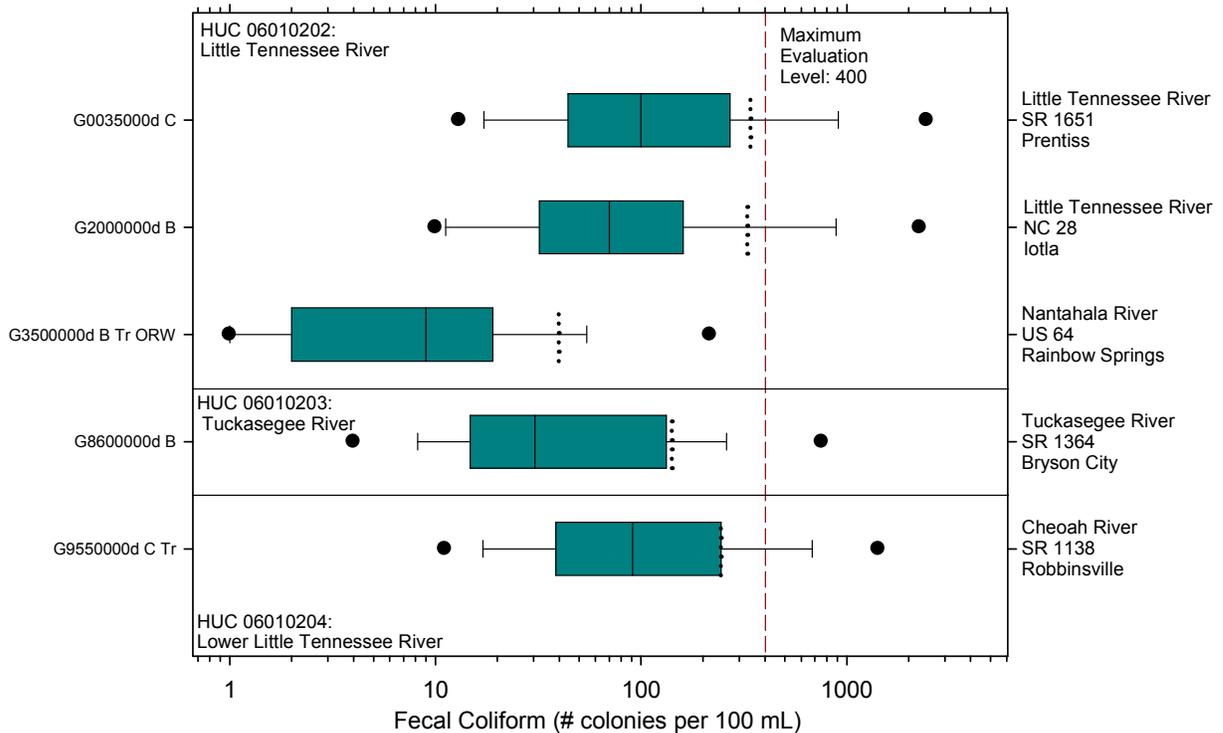
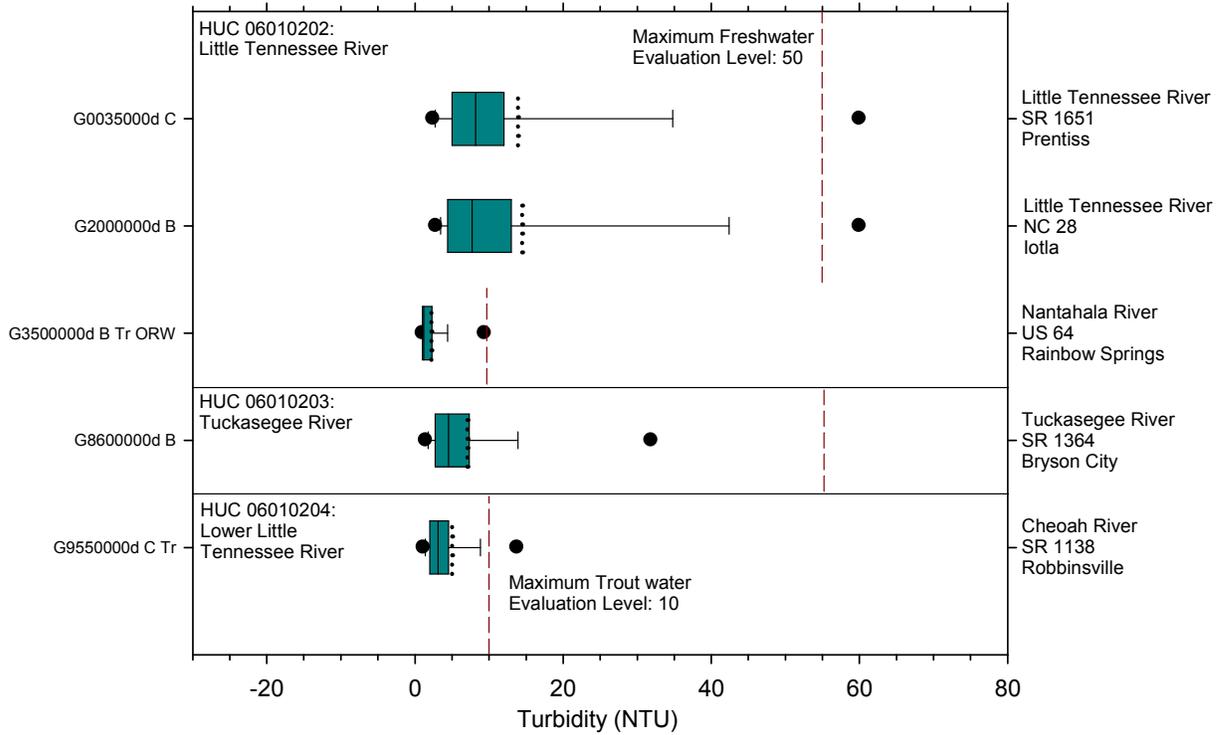


Figure 10. Box Plots of Ammonia and Nitrates/Nitrites in the Little Tennessee River Basin

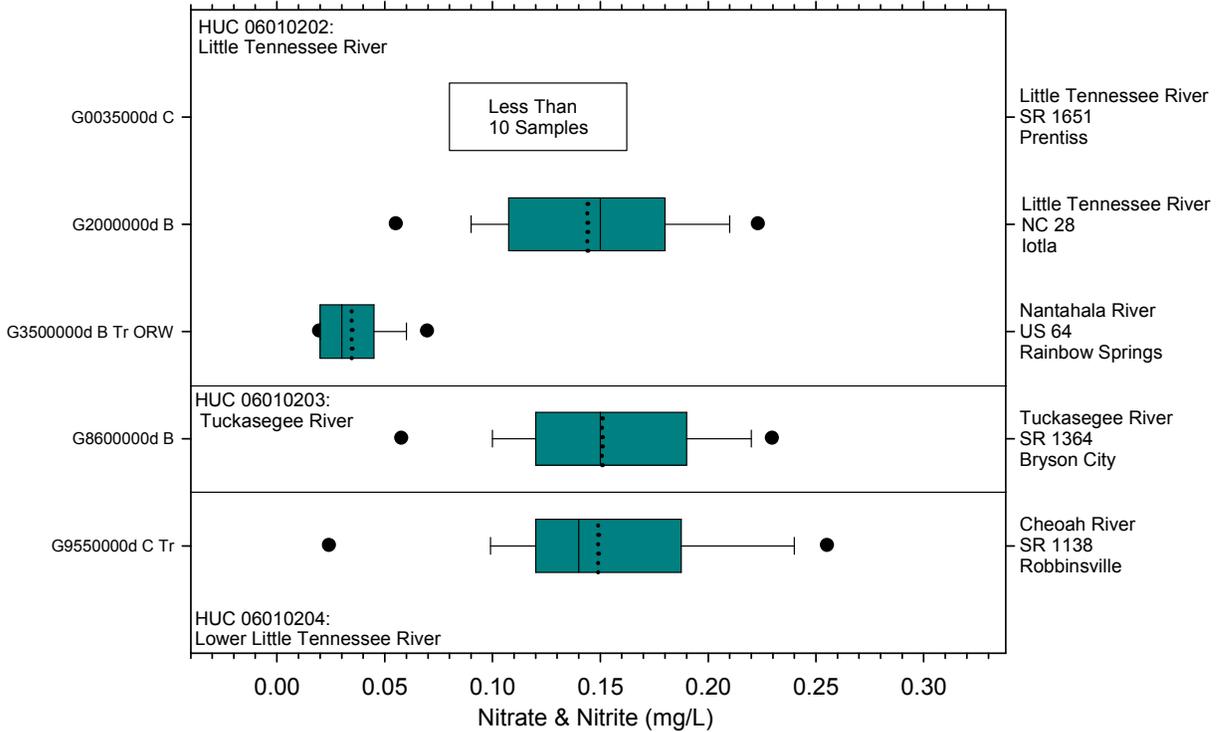
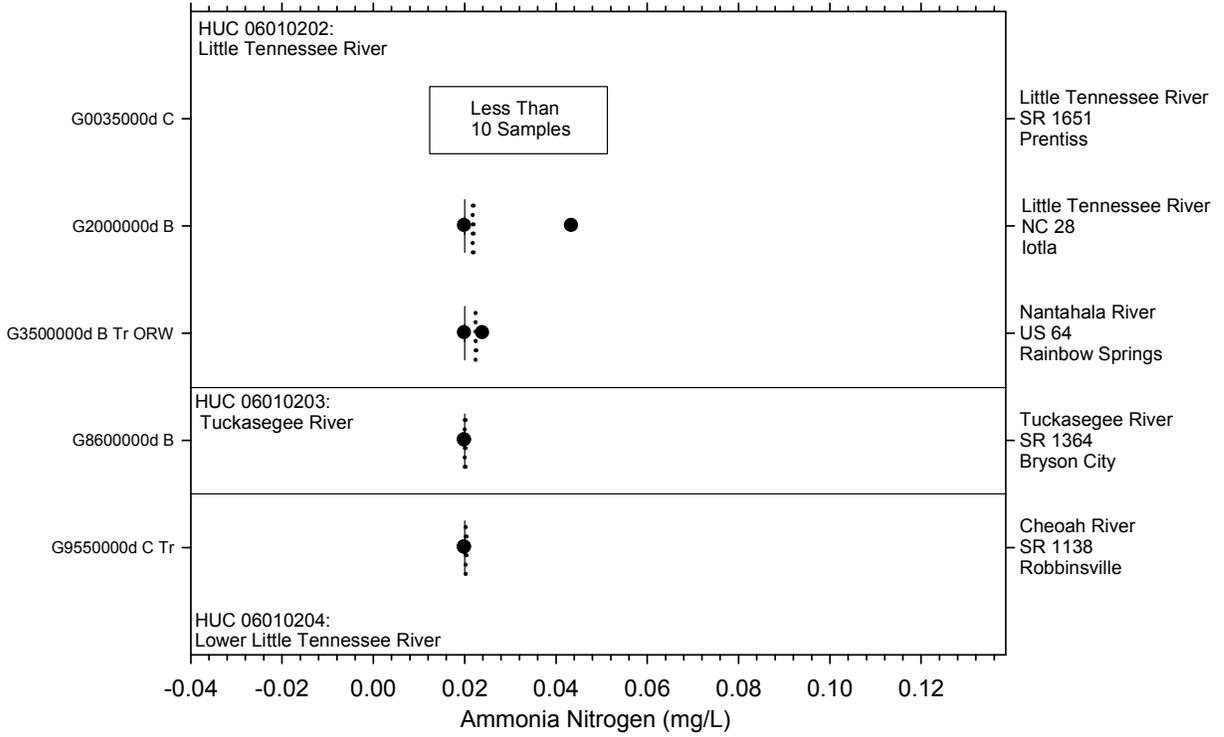
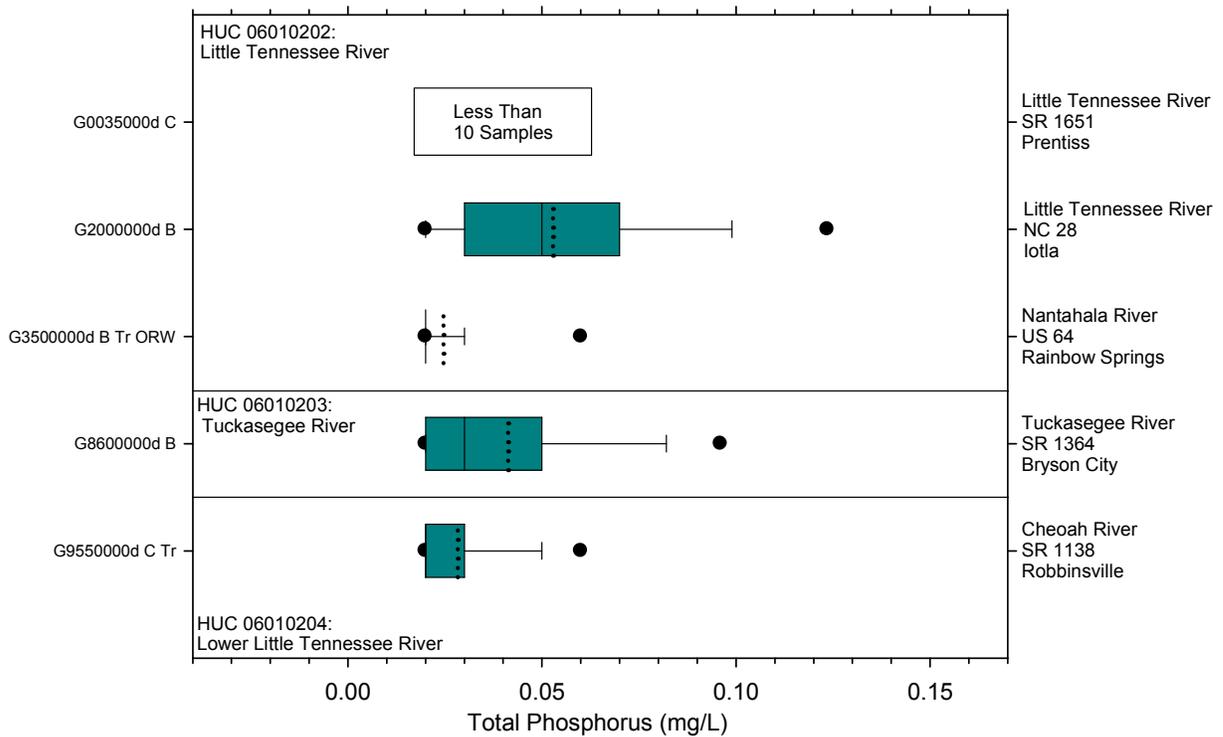
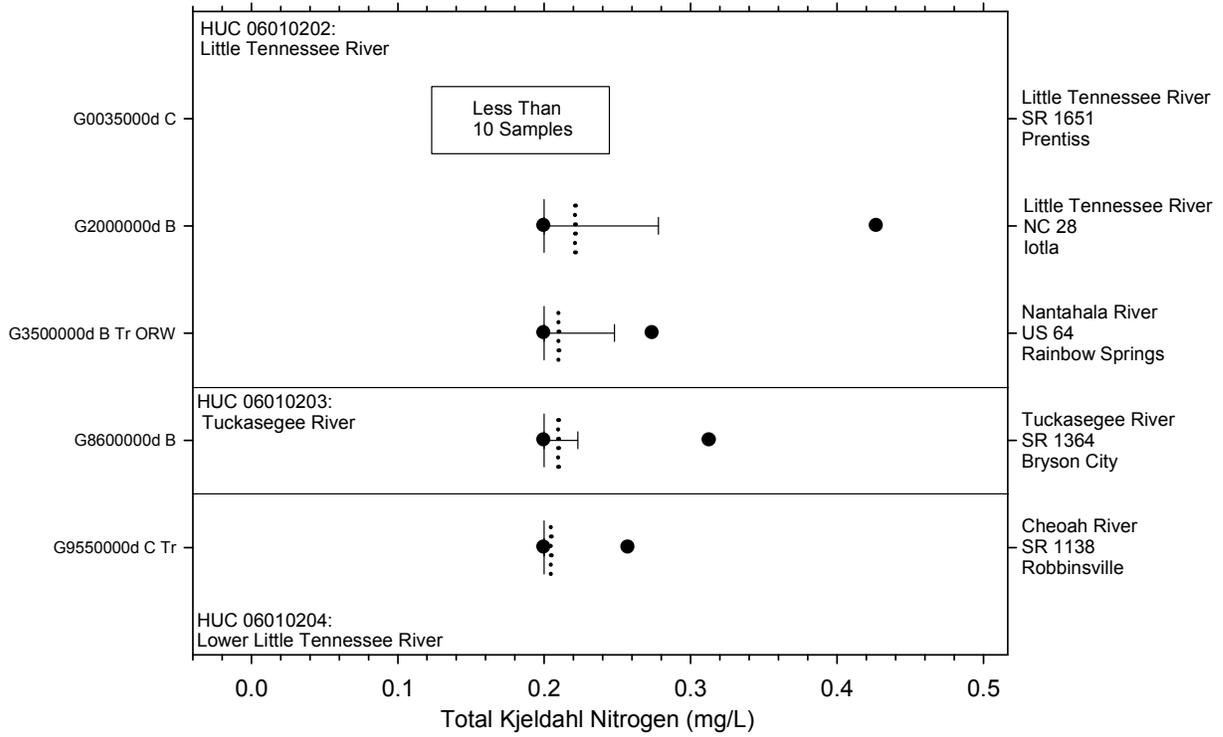


Figure 11. Box Plots of Total Kjeldahl Nitrogen and Total Phosphorus in the Little Tennessee River Basin



Appendix C: References

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