

BASINWIDE ASSESSMENT REPORT

LITTLE TENNESSEE RIVER

NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT AND
NATURAL RESOURCES
Division of Water Quality
Water Quality Section
Environmental Sciences Branch

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EXECUTIVE SUMMARY

This document presents a water quality assessment of the Little Tennessee River basin. Monitoring programs covered within this report include benthic macroinvertebrates, lake assessment, ambient water quality, and aquatic toxicity for the period 1994 - 1999. Studies conducted prior to and including 1994 were previously summarized in NCDEHNR (1996a).

In general, the document is structured such that each subbasin is physically described and an overview of water quality is given at the beginning of each subbasin section. General water quality conditions are presented in an upstream to downstream format. Subbasins within the Little Tennessee River basin are described by a six digit code (040401 - 040404), but are often referred to by their last two digits (e.g. Subbasin 01).

The Little Tennessee River basin is located within the Blue Ridge Province of the Appalachian Mountains of western North Carolina. It encompasses about 1,800 mi² in Swain, Macon, Clay, Graham, Cherokee, and Jackson counties (Figure 1). Much of the land within the basin is federally owned (49%) and in the U.S. Forest Service's Nantahala National Forest (including the Joyce Kilmer/Slick Rock Wilderness Area) or the Great Smoky Mountains National Park (GSMNP). The basin also includes the Cherokee Indian Reservation.

The North Carolina section of the Little Tennessee River is typical of many other mountain rivers. The gradient is relatively steep in most reaches of the river and the substrate is dominated by riffle habitats. The headwater reaches of the Little Tennessee River are located in Georgia. Most tributaries are high gradient streams capable of supporting trout populations in the upper

reaches. Most of the basin is forested. However, lower reaches of many tributary catchments are farmed or developed resulting in the increased potential for nonpoint source problems.

The Little Tennessee River is one of three major tributaries of Fontana Lake. The other two are the Nantahala River and the Tuckasegee River. The Cheoah River, the fourth major tributary of the Little Tennessee River in North Carolina, has its confluence with the river below Fontana Lake.

The Little Tennessee River is critical habitat for three federally listed endangered species: a fish, the Spotfin chub (*Cyprinella monacha*) and two mussels, the Appalachian elktoe (*Alasmidonta raveneliana*) and the Little-wing pearly mussel (*Pegias fabula*). Two other important aquatic species are found in the Little Tennessee River: *Alasmidonta viridis* (Slippershell mussel) and *Fusconaia barnesiana* (Tennessee pigtoe). These two species are found only in a portion of the Little Tennessee River in North Carolina, although more extensive populations are known from the Mississippi drainage or from Tennessee. Both species are considered as endangered in the state.

Upper Little Tennessee River (Subbasin 01)

The upper section of the Little Tennessee River contains approximately 35 river miles from the North Carolina/Georgia state line to the confluence of Burningtown Creek below Franklin. Franklin, and a portion of the Town of Highlands, are the only large urban areas. The Cullasaja River and Cartoogechaye Creek are the major tributaries to this part of Little Tennessee River. Other smaller tributaries include Middle Creek, Coweeta Creek, Cowee Creek and Burningtown Creek.

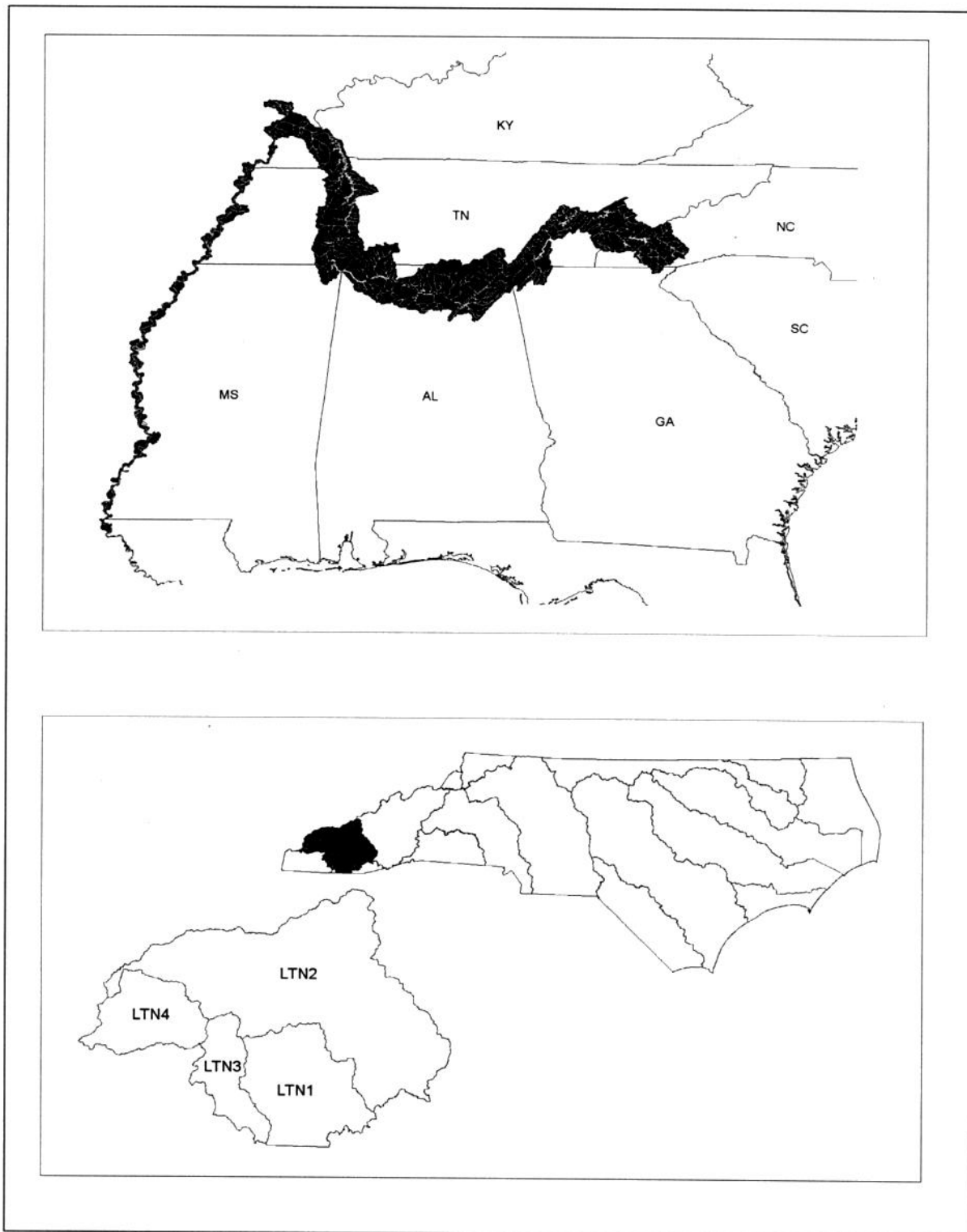


Figure 1. Geographical relationships of the Little Tennessee River and its subbasins to the lower Tennessee River and lower Mississippi River drainages.

This area is within the US Forest Service's Nantahala National Forest and is characterized by many mountain ranges. Most tributaries are high gradient streams capable of supporting trout populations in the upper reaches. The water quality of rivers and streams in this area is generally high. The Little Tennessee River, though, and some of its tributaries become very turbid after rainfalls. Sedimentation is the dominant water quality problem. Sources of sedimentation include agriculture, development, and silviculture.

The Cullasaja River watershed was given special attention in 1999 at the request of the Asheville Regional Office. Four mainstem river sites and seven tributaries were sampled for benthic macroinvertebrates. All Cullasaja River sites downstream of Highlands were Excellent as were Big Creek, Brush Creek, Buck Creek, Ellijay and North Prong Ellijay Creek, and Turtle Pond Creek. Walnut Creek was Good; the Cullasaja River in Highlands was Fair, as was Mill Creek. The Cullasaja River site receives runoff from the Town of Highlands area as well as from golf courses. These tributary sites were all sampled for the first time. Prior data has been collected from the Cullasaja River, and no substantial changes were found in water quality since it was first sampled in 1990. Lake Sequoyah, an impoundment of the upper Cullasaja River, was mesotrophic in 1999.

Water quality problems were found in the Little Tennessee River, especially near the Georgia state line. Nonpoint source runoff may contribute to some of the degradation at the upstream Little Tennessee River site, although point source dischargers in Georgia seem to be a potential source of problems. This site was given a Fair bioclassification in 1999, a decline from the Good-Fair rating found in 1994. The next downstream site at Prentiss was also Good-Fair in 1999. The Little Tennessee River at Iotla is below Franklin and Lake Emory. This site was given a Good-Fair bioclassification in 1999, a rating that has been found since 1983.

Of the six tributary streams sampled for benthic macroinvertebrates during this monitoring cycle, four showed considerable improvement from 1994 ratings. Coweeta Creek and Tellico Creek were both Excellent in 1994 and 1999. Cowee Creek and Iotla Creek improved from Good-Fair to Good, while Burningtown Creek and Cartoogechaye Creek improved from Good to Excellent. Extremely high flows in 1994 prior to sample collection most likely caused the lower 1994 ratings.

Middle Little Tennessee River (Subbasins 02 and 03)

Principal tributaries to the Little Tennessee River in this area are the Oconaluftee River, the Tuckasegee River, Hazel Creek, and Deep Creek. The largest tributary watershed in the Little Tennessee River basin is that of the Tuckasegee River which flows into Fontana Lake. The Nantahala River is another large tributary of Fontana Lake. Fontana Lake is the largest impoundment in this region and is operated by the Tennessee Valley Authority (TVA). Much of its immediate watershed lies within either the Great Smoky Mountains National Park or the Cherokee Indian Reservation. Most streams on the north side of Fontana Lake are in a roadless wilderness region and can be reached only by boat (across the lake) or by hiking.

The area contains some of the most pristine areas and cleanest waters in North Carolina. This portion of the basin also contains some of the most famous trout streams in eastern North America including Hazel Creek, Forney Creek, Deep Creek and Noland Creek. Streams designated High Quality Waters include the headwaters of Alarka Creek, the Tuckasegee River upstream of Tanassee Creek, Caney Fork and tributaries above Mull Creek, most of the Oconaluftee River catchment, and several small streams that were formerly classified for water supply. The Tuckasegee River upstream of Tanassee Creek is classified Outstanding Resource Waters.

The rest of this watershed is included in the Nantahala National Forest, although this does

not preclude some other land uses. Portions of this area are developed and erosion from these areas causes some minor nonpoint source problems. Major municipal areas include Bryson City, Cherokee, and Sylva.

Benthic macroinvertebrate sampling during this monitoring cycle in 1999 found, that overall, water quality was very good. Fifteen of the 20 sites sampled had a bioclassification of Excellent, while the other five sites were Good. Moses Creek, Cullowhee Creek, Tuckasegee River, Oconaluftee River, and Stecoah Creek had a change in bioclassification compared to 1994 from Good to Excellent, but these changes seemed to be related more to extremely high flows in 1994, rather than to any long term change in water quality. More significant improvement in water quality was observed at Scott Creek, where the bioclassification improved from Good-Fair in 1994 to Good in 1999. Declining water quality was observed only at Savannah Creek.

Wolf Creek Reservoir, Bear Creek Reservoir, Cedar Cliff Lake and Thorpe Reservoir were monitored in 1999. All were rated as oligotrophic with no algal blooms or nuisance aquatic plants occurring.

Ambient monitoring data were collected from the Oconaluftee River at Birdtown and the Tuckasegee River at Bryson City. Neither site had any indication of water quality problems. Fecal coliform concentrations have declined over time at both these sites.

The Nantahala River, from its source to the confluence with Roaring Fork, is currently classified as Outstanding Resource Waters. Much of the land adjacent to this reach is privately owned by the Rainbow Springs Corporation. The Nantahala River and most tributaries are high gradient systems capable of supporting wild trout populations. Nantahala Power and Light Company maintains a power generation facility at Nantahala Lake. Flow is diverted to downstream power generators, bypassing a seven mile reach of the river prior to discharging back into the original channel

above the Nantahala Gorge. The regulated reach of the Nantahala River below the powerhouse is very popular for white water rafting and kayaking. Development has increased along the Nantahala Gorge corridor as it relates to this recreational industry.

Overall water quality in the Nantahala River watershed is high. Excellent bioclassifications have been found using benthos data for the river above Nantahala Lake near Rainbow Springs since 1984. Ambient chemistry data from this location demonstrated the lowest variability for total suspended solids, hardness, fecal coliform bacteria, turbidity, nitrite+nitrate as nitrogen, and total phosphorus of all ambient sites in the basin. Medians were low for most parameters, indicating a high frequency of samples with low concentrations for these parameters.

Nantahala Lake is oligotrophic and has been since first monitored in 1981. Benthos samples from the bypass reach of the river below the lake improved from Good in 1993 to Excellent in 1999. Further downstream, in the flow regulated portion of the river, benthos data have resulted in Good bioclassifications in 1994 and 1999, although heavy periphyton growths reduced the abundance of many taxa. Benthos samples of tributary streams in 1999 resulted in an Excellent bioclassification for Queens Creek, and Good bioclassifications for Dicks Creek and Whiteoak Creek. The Dicks Creek rating was an improvement from the Good-Fair bioclassification found in 1993.

Lower Little Tennessee River (Subbasin 04)

The Cheoah River and significant sections of most tributary catchments are within the Nantahala National Forest and are minimally impacted. These tributaries are typically high-gradient streams capable of supporting trout populations. However, lower reaches of some tributaries and corridors along Tulula Creek, Sweetwater Creek, Little Snowbird Creek, Yellow Creek, and the Cheoah River are not in the national forest. Thus, they are more likely to be impacted by land-disturbing

activities. Tulula Creek flows through the Town of Robbinsville, where the stream becomes the Cheoah River at its confluence with Sweetwater Creek. Robbinsville is the only urban area.

The Cheoah River is dammed below Robbinsville to form Santeetlah Lake. Tapoco, Inc. operates the hydroelectric dam to provide hydroelectric power for the Aluminum Company of America (ALCOA). The tailwater reach below the dam is approximately nine river miles above the confluence with the Little Tennessee River.

Good or Excellent bioclassifications have been recorded at all benthic macroinvertebrate monitoring locations in this watershed since 1983. Trout farms and land disturbing activities are the main potential sources of water quality problems.

The 1994 benthos sites had extremely high stream flows immediately prior to sample collection. This may explain the improvement found at 2 of the 3 basin sites sampled in 1999. Tulula Creek was sampled in Robbinsville where nonpoint source runoff is a potential impact, but an Excellent rating was found. Further downstream, the Cheoah River was also Excellent where sampled below the Robbinsville WWTP (0.63 MGD), which discharges to Long Creek, a tributary

of the Cheoah River. An ambient chemistry station on the Cheoah River had slightly higher fecal coliform values in the past five years than earlier, but no other notable values. Snowbird Creek had been Excellent before the 1994 Good rating, and was Excellent again in 1999, supporting the contention that high flows in 1994 may have displaced some taxa.

Monitoring of Cheoah Lake on the Little Tennessee River and Santeetlah Lake on the Cheoah River in 1999 found oligotrophic conditions in the mainstem of both lakes.

Division studies during the 1990s indicated excessive phosphorus loading into the Snowbird Creek and West Buffalo Creek arms of Santeetlah Lake. Bluegreen algal blooms and chlorophyll *a* values greater than 15 µg/l were noted. The cause of the accelerated eutrophication was nearby trout farms. The 1999 study concluded that the Snowbird Creek arm of the lake cannot tolerate additional nutrient contributions. The West Buffalo Creek arm was determined to be impaired and only partly supporting its uses for swimming and biological integrity. A benthos sample from West Buffalo Creek above the lake but below the trout farms gave an Excellent bioclassification. The stream did show some signs of enrichment, however.

Executive Summaries By Program Area

BENTHIC MACROINVERTEBRATES

Bioclassification and Water Quality Changes

Water quality in the basin, as assessed using benthic invertebrates, is generally Good or Excellent. Two hundred seven ratable samples, representing 112 sites, have been collected since 1983. Good or Excellent ratings have been assigned for 77% of these samples (Figure 2).

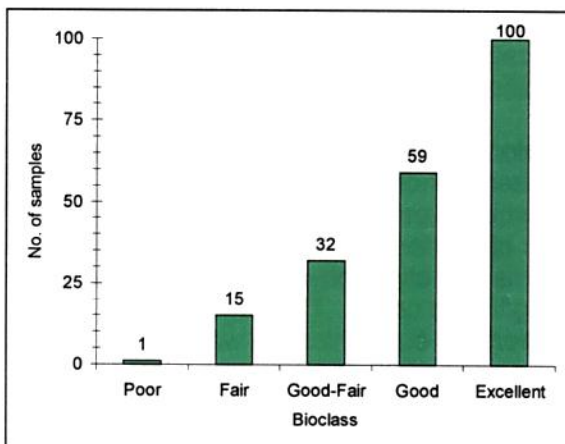


Figure 2. Bioclassifications of 207 samples collected from the Little Tennessee River basin, 1983 - 1999.

In 1999, 34 sites were sampled as part of the basinwide monitoring program. An Excellent or Good rating was given to 91% of these sites (Figure 3).

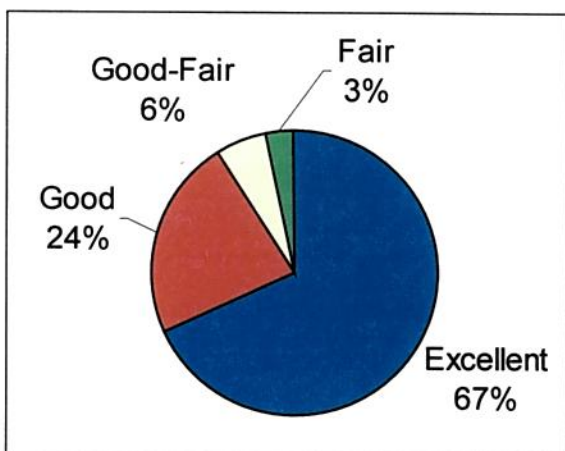


Figure 3. Bioclassifications of 34 basinwide sites in the Little Tennessee River basin, 1999.

Overall, the water quality in the basin has improved slightly since the last monitoring cycle (Figures 4 and 5).

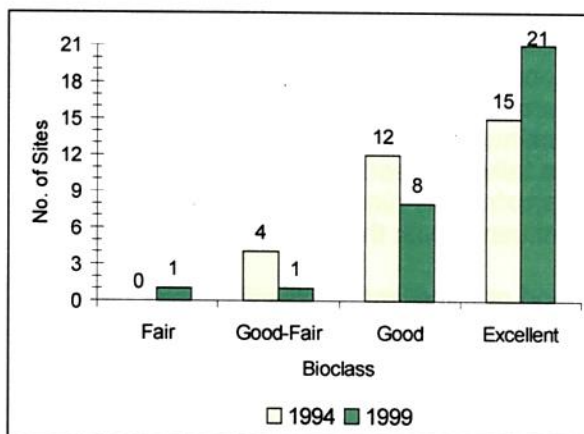


Figure 4. Bioclassifications of the same 31 sites rated in 1994 and 1999 in the Little Tennessee River basin.

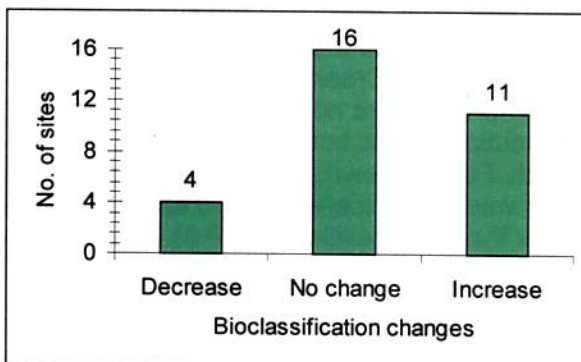


Figure 5. Short-term changes in bioclassifications at 31 sites in the Little Tennessee River basin, 1994 and 1999.

Of the 31 same sites rated in 1994 and 1999, 94% of them were rated Good or Excellent in 1999 in contrast to 87% of the sites in 1994. But, many of these short-term changes were more related to differences in flow rather than actual improvements in water quality between the 1994 and 1999 basinwide monitoring cycles.

One short-term decline in water quality was found at the uppermost site on the Little Tennessee River in Macon County. A decrease in bioclassification was accompanied by a sharp increase in conductivity. This problem seemed to be

associated with an upstream discharger in Georgia.

The distribution of ratings was very similar for the 1999 collections and for all collections made since 1983. This suggested there has been little overall change in water quality within the basin. Individual sites, however, sometimes showed distinct long-term or short-term changes in water quality.

While few problems occurred in the basin, most acute problems (those sites rated Fair) were associated with:

- Nonpoint source runoff from more developed areas. Examples included the Cullasaja River above Mirror Lake and Mill Creek near Highlands.
- High sulfate bearing rock formations. Upper Beech Flats Prong in the Great Smoky Mountains National Park is affected by low pH caused by precipitation coming into contact with the Anakeesta rock formation. This occurs either naturally from rock slides or use of the rock as road fill to maintain US 441 across Newfound Gap.
- Wastewater discharges. This was a major problem only in the upper portion of the Little Tennessee River.

Agricultural runoff may cause less acute problems than point source discharges. Where the only change in stream habitat was from the introduction of sediment, these streams usually received a Good or Good-Fair rating. Many of these streams were also affected by bank erosion and carried heavy sediment loads. This often resulted in the reduction in the number of pools with some streams having fairly uniform riffle and run instream habitat.

Long-term (greater than 5 years of data) changes in bioclassification were evaluated at 13 sites (Figure 6). These data indicated a change in the bioclassifications at 3 of the 13 sites. Like the short-term changes, many of these long-term changes were more related to differences in flow rather than to actual improvements in water quality among the various monitoring cycles. Water quality did not decline at any of these long-term monitoring sites.

Improvements in water quality were related to upgrades or better performing wastewater treatment plants. Examples included Scott Creek below the Town of Sylva's WWTP and the Cheoah River below the Robbinsville WWTP.

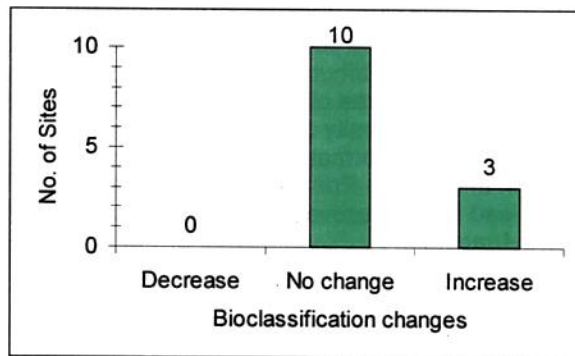


Figure 6. Long-term changes in bioclassifications at 13 sites in the Little Tennessee River basin, 1983 - 1999.

Endangered Benthic Fauna

The Little Tennessee River in Subbasin 02 is critical habitat for two federally listed endangered species of mussels: the Appalachian elk-toe (*Alasmodonta raveneliana*) and the Little-wing pearly mussel (*Pegias fabula*). Other important mussel species in this subbasin include:

- *Alasmodonta viridis* (Slippershell mussel): This species is found only in this portion of the Little Tennessee River in North Carolina. Although more extensive populations are known from the Mississippi River drainage, the species is listed in North Carolina as endangered; and
- *Fusconaia barnesiana* (Tennessee pigtoe): This species is found only in this portion of the Little Tennessee River in North Carolina. Although more extensive populations are known from Tennessee, the species is listed as endangered in North Carolina.

New Species and Distributional Records for the Benthic Invertebrate Fauna

Benthic monitoring in 1999 also recorded several rare taxa from the basin:

- *Baetopus* sp. nov.: The first North American record of this mayfly genus was collected from Panthertown Creek. The specimen represents a new species which will be described by Robert Waltz (Indiana Department of Natural Resources).
- *Heterocloeon* sp. nov.: Another new species of mayfly was collected from the Oconaluftee River and from the lower Cullasaja River. It will also be described by Robert Waltz. Currently, this taxon is only known only from these two locales.
- *Serratella spiculosa*: This rare mayfly had not been collected since it was originally described in 1962. In 1999 it was found in Snowbird Creek and Brush Creek.

- *Agapetus* spp.: Several distinct species of *Agapetus* were collected in the Cullasaja River and its tributaries, although no key exists for larvae of this genus. Dr. David Etnier (University of Tennessee) will be using this information to try to collect adults in the spring. Prior work by Dr. Etnier has lead to the discovery of many new species of *Agapetus*.
- *Micrasema sprulesi*: This species was collected from Little Snowbird Creek. Also present were an unusually large number of the intolerant mayfly, *Rithrogena fuscifrons*.
- *Megaleuctra williamsae* and *Zapada chila*: These rare stoneflies are confined to small, high elevation, mountain streams, and thus, may be missed by normal Division sampling. Both species were found in the headwaters of Beech Flats Prong in October 1995.
- *Cambarus (Jugicambarus) sp. nov.*: This taxon, found in the Oconaluftee River, represents a new species of crayfish. It will be officially described by Dr. John Cooper (North Carolina State Museum of Natural Science).

FISHERIES

Fish Community Assessment

Sixty-eight species have been collected from the Little Tennessee River basin in North Carolina (Menhinick 1991, 1995 (pers. com.)). Special status has been granted to six of them by the United States Department of the Interior, the North Carolina Wildlife Resources Commission, or the North Carolina Natural Heritage Program under the North Carolina State Endangered Species Act (G.S. 113-311 to 113-337 (LeGrand and Hall 1999; Menhinick and Braswell 1997) (Table 1). Additional information on these six species may be found in Menhinick and Braswell (1997).

The North Carolina Index of Biotic Integrity is one of the tools the NCDWQ uses which summarizes all classes of factors such as water and habitat

quality, flow regime, and energy sources which influence the freshwater fish communities of Wadeable streams throughout the state. No stream fish community basinwide monitoring was conducted during 1999 in the Watauga River basin because of recent revisions and a reexamination of the criteria and metrics.

Fish Tissue Contaminants

No fish tissue contaminant monitoring in the basin was conducted by the Division between 1994 and 1999 because there were no significant contaminant issues to be addressed.

As part of the relicensing effort of the Tapoco Hydroelectric Project, Normandeau Associates, under contract with Stone and Webster Engineering Corporation, collected baseline fish tissue data from the three project reservoirs in North Carolina (Lake Cheoah, Lake Santeetlah, and Calderwood Lake) (Normandeau Associates 1999). Common carp, white sucker, channel catfish, largemouth bass, and yellow perch were collected in October 1997 and June 1998. The tissues were analyzed for mercury and polychlorinated biphenyl (PCBs) compounds.

Where mercury was detected, all concentrations were less than the State of North Carolina, the Federal Drug Administration, and the US Environmental Protection Agency consumption criteria. PCBs concentrations were less than the laboratory detection limit at all three reservoirs.

Fish Kills

The Division has systematically monitored and reported on fish kill events across the state since 1996. No fish kills have been reported from the Little Tennessee River basin during this time period. Information on fish kills in other basins may be found on the Division's website (refer to the Glossary).

Table 1. Species of fish listed as endangered, rare, threatened, or of special concern in the Little Tennessee River basin in North Carolina.

Species	Common Name	State or Federal Status	State Rank ¹
<i>Cyprinella monacha</i>	Spotfin chub	Federal - Threatened	S1
<i>Noturus flavus</i>	Stonecat	State - Endangered	S1
<i>Clinostomus funduloides</i> ssp.	Little Tennessee Rosyside dace (Smoky dace)	State - Special Concern	S2
<i>Etheostoma vulneratum</i>	Wounded darter	State - Special Concern	S2
<i>Notropis lutipinnis</i>	Yellowfin shiner	State - Special Concern	S3
<i>Percina squamata</i>	Olive darter	State - Special Concern	S2

¹S1 = critically imperiled in North Carolina because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from North Carolina; S2 = imperiled in North Carolina because of rarity or because of some factor(s) making it very vulnerable to extirpation from North Carolina; S3 = rare or uncommon in North Carolina (LeGrand and Hall 1999).

LAKE ASSESSMENT

Eight lakes in the basin were sampled as part of the Lake Assessment Program (Table 2). Lakes in this basin typically exhibited very good water quality. Six of the eight lakes had exceptional water clarity and low biological productivity resulting in oligotrophic conditions (NCTSI < -2.0) (Figure 7). Nantahala Lake, Wolf Creek Reservoir, Bear Creek Reservoir, Cedar Cliff Lake, Thorpe Reservoir and Lake Cheoah demonstrated excellent to very good water quality.

Two lakes demonstrated water quality conditions which were of concern. Lake Sequoyah near the Town of Highlands was moderately productive (mesotrophic) and had chlorophyll *a* values which were greater than the state water quality standard of 15 µg/l for lakes designated as Trout Waters (Tr). Seven species of algae collected at this lake are known to contribute taste and odor problems in drinking water.

The West Buffalo and Snowbird Creek arms of Santeetlah Lake have been exhibiting symptoms of accelerated eutrophication such as algae blooms and elevated dissolved oxygen saturation levels. In 1993, in response to citizen complaints regarding water quality, a special study was conducted which determined that nutrient loading from upstream trout farms enhanced algal blooms observed on the West Buffalo Creek arm. Voluntary management actions were taken by the trout farms. The Division also instituted a new permitting policy to restrict new or expanding trout farm facilities within the Santeetlah Lake drainage area.

A second special study was conducted from April through October 1999. This study determined that the mainstem of Santeetlah Lake was continuing to support its designated uses. The Snowbird Creek arm, however, was found to be experiencing accelerated eutrophication and cannot tolerate additional nutrient loading. The West Buffalo Creek arm was determined to be impaired and only partially supporting its uses for swimming and biological integrity.

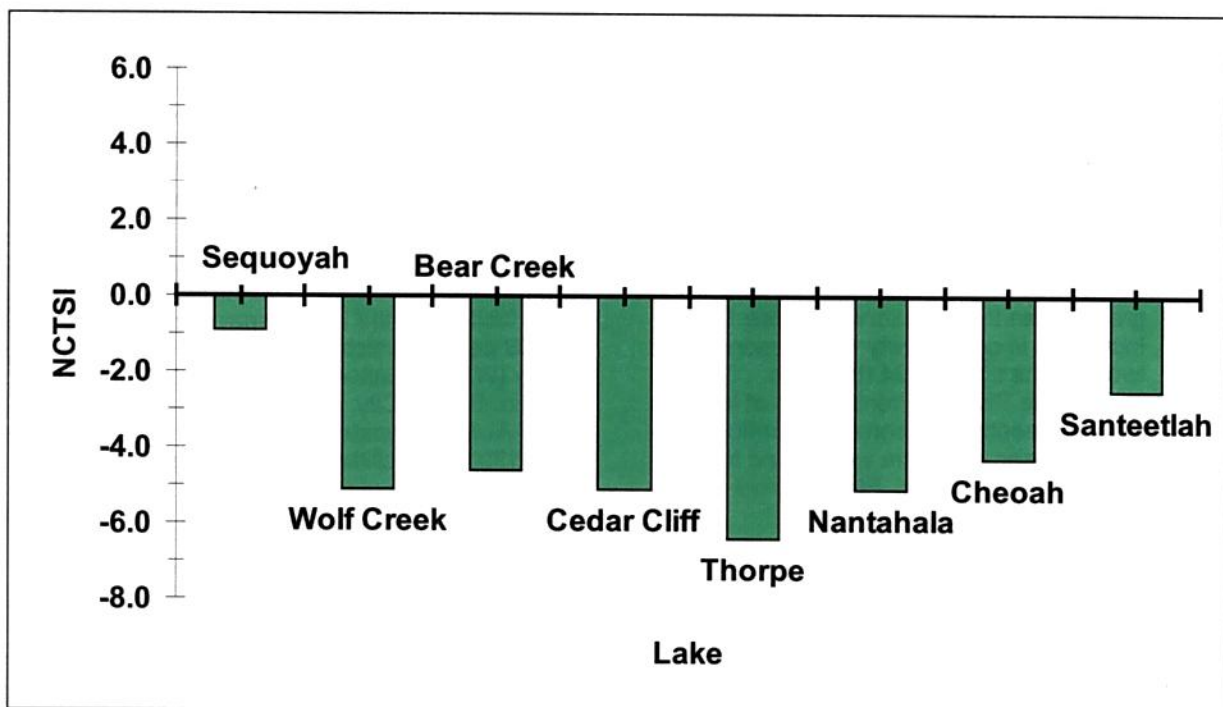


Figure 7. North Carolina Trophic State Index scores for lakes in the Little Tennessee River basin, August 1999.

Table 2. Lakes monitored in the Little Tennessee River basin in 1999.

Subbasin/Lake	County	Classification	Surface Area (Ac)	Mean Depth (ft)	Volume (X 10 ⁶ m ³)	Watershed (mi ²)
01 Lake Sequoyah	Macon	WS-III, Tr, CA	150	7	0.1	14
02 Wolf Creek Reservoir	Jackson	WS-III, B, Tr, HQW	193	89	2.1	40
Bear Creek Reservoir	Jackson	WS-III, B, Tr	475	108	5.6	75
Cedar Cliff Lake	Jackson	WS-III, B, Tr, CA	146	89	7.2	81
Thorpe Reservoir	Jackson	WS-III, B, HQW	1462	76	82.6	37
03 Nantahala Lake	Macon	B, Tr	1606	125	160.0	108
04 Lake Cheoah	Swain/Graham	C, Tr	633	131	297.5	1608
Santeetlah Lake	Graham	B, Tr	2849	56	195.0	176

AMBIENT MONITORING SYSTEM

There are six active ambient water quality monitoring stations located in the Little Tennessee River basin. These stations are sampled monthly for 27 parameters. Important findings during the recent (09/01/1994 to 08/31/1999) monitoring cycle included:

- Dissolved oxygen concentrations were greater than 7.0 mg/l for all stations during this assessment period.
- A period of low pH (some values between 5.5 - 6.5 s.u.) was noted between 1990 and 1995 for all stations. The cause(s) were unknown. Atmospheric deposition was speculated but there was also the possibilities of monitoring personnel error and pH meter equipment variability. Since 1995 pH has increased to values greater than those observed before 1990.
- Increases in conductivity were observed at two stations since 1994 (the Little Tennessee River at Prentiss and at lotla). Measurements were corrected for flow and the increases over time were found to be statistically significant. Flow was not an

explanatory variable for these temporal increases. No explanation has been determined for this change in water quality.

- The geometric mean for fecal coliform bacteria ranged from 1 to 13 colonies/100ml for samples collected during this assessment period. All stations showed a decrease in the geometric mean from the assessment periods before June 1989.
- No temporal patterns were observed for any of the other parameters.
- The only parameters that exceeded water quality standards or action levels for more than 10% of the number of samples collected were copper and iron, and this did not occur at all stations.

AQUATIC TOXICITY MONITORING

Three facilities in the Little Tennessee River have NPDES permits which require whole effluent toxicity (WET) monitoring. These facilities are the Franklin, Bryson City, and Tuckasegee Water and Sewer Authority wastewater treatment plants. Since 1993, all facilities have been operating within a compliance rate of 90-95%.

INTRODUCTION TO PROGRAM METHODS

The Division uses a basinwide approach to water quality management. Activities within the Division, including permitting, monitoring, modeling, nonpoint source assessments, and planning are coordinated and integrated for each of the 17 major river basins within the state. All basins are reassessed every five years, and the Watauga River basin was sampled by the Environmental Sciences Branch in 1994 and 1999.

The Environmental Sciences Branch collects a variety of biological, chemical, and physical data that can be used in a myriad of ways within the basinwide planning program. In some areas there may be adequate data from several program areas to allow a fairly comprehensive analysis of ecological integrity or water quality. In other areas, data may be limited to one program area, such as only benthic macroinvertebrate data or only fisheries data, with no other information available. Such data may or may not be adequate to provide a definitive assessment of water quality, but can provide general indications of water quality. The primary program areas from which data were drawn for this assessment of the Little Tennessee River basin include benthic macroinvertebrates, lake assessment, ambient monitoring, and aquatic toxicity monitoring.

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates, or benthos, are organisms that live in and on the bottom substrates of rivers and streams. These organisms are primarily aquatic insect larvae. The use of benthos data has proven to be a reliable monitoring tool, as benthic macroinvertebrates are sensitive to subtle changes in water quality. Since many taxa in a community have life cycles of six months to one year, the effects of short term pollution (such as a spill) will generally not be overcome until the following generation appears. The benthic community also integrates the effects of a wide array of potential pollutant mixtures.

Sampling methods and criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample from flowing waters based on the number of taxa present in the intolerant groups Ephemeroptera, Plecoptera and Trichoptera (EPT S) (Appendix B1). Likewise, ratings can be assigned with a North Carolina Biotic Index (NCBI). This index summarizes tolerance data for all taxa in each collection. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed

as well by a taxa richness analysis. Different criteria have been developed for different ecoregions (mountains, piedmont and coastal) within North Carolina for freshwater flowing waterbodies.

Bioclassifications listed in this report (Appendix B2) may differ from older reports because evaluation criteria have changed since 1983. Originally, total taxa richness and EPT taxa richness criteria were used, then just EPT taxa richness, and now BI as well as EPT taxa richness criteria are used for flowing freshwater sites. Refinements of the criteria continue to occur as more data are gathered.

LAKE ASSESSMENT

Lakes are valued for the multiple benefits they provide to the public, including recreational boating, fishing, drinking water, and aesthetic enjoyment. Assessments have been made at publicly accessible lakes, at lakes which supply domestic drinking water, and lakes (public or private) where water quality problems have been observed.

Physical field measurements (dissolved oxygen, pH, water temperature, and conductivity) are made with a calibrated HydrolabTM. Readings are taken at the surface of the lake (0.15 meters) and at 1 m increments to the bottom of the lake. Secchi depths are measured at each sampling station with a weighted Secchi disk attached to a rope marked off in centimeters. Surface water samples are collected for chloride, hardness, fecal coliform bacteria, and metals. A LablineTM sampler is used to composite water samples within the photic zone (a depth equal to twice the Secchi depth). Nutrients, chlorophyll *a*, solids, turbidity and phytoplankton are collected at this depth. Nutrients and chlorophyll *a* from the photic zone are used to calculate the North Carolina Trophic State Index score. The LablineTM sampler is also used to collect a grab water samples near the bottom of the lake for nutrients. Water samples are collected and preserved in accordance with protocols specified in (NCDEHNR 1996b).

Data are used to determine the trophic state of each lake, a relative measure of nutrient enrichment and productivity. These determinations are based on information from the most recent summertime sampling (Appendices L1 - L3).

AMBIENT MONITORING SYSTEM

Assessments of water quality can be obtained from information about the biological communities present in a body of water or from field and laboratory measurements of particular water quality parameters. This section summarizes the field and laboratory measures of water quality, typically referred to as ambient water quality measures.

The Ambient Monitoring System is a network of stream, lake, and estuarine stations strategically located for the collection of physical and chemical water quality data. Parametric coverage is tiered 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 appended when justified (Table 3).

Summaries of water quality parameters measured during the five year period (September 1, 1994 – August 31, 1999) are provided (refer to Tables 27 - 33). These tables present the number of samples collected and the number (and proportion) of samples greater than or less than a water quality reference value.

In addition, a description of how the data are distributed is provided using percentiles. Percentiles describe the proportion of observations less than a specific value or concentration. For example, the 50th percentile (also called the median) provides the value (or concentration) of the parameter in which one half (50%) of the observations lie.

The water quality reference value may be a narrative or numeric standard, or an action level as specified in the North Carolina Administrative Code 15A NCAC 2B .0200. Zinc is not included in the summaries for metals because recent (since April 1995) sampling or analyses may have been contaminated with zinc and the data may be unreliable.

In this report, conductivity is synonymous with conductance. It is given in micromhos per centimeter (µmhos/cm) at 25 °C.

AQUATIC TOXICITY MONITORING

Acute and/or chronic toxicity tests are used to determine toxicity of discharges to sensitive aquatic species (usually fathead minnows or the water flea, *Ceriodaphnia dubia*). Results of these tests have been shown by several researchers to be predictive of discharge effects on receiving stream populations.

Table 3. Freshwater parametric coverage for the ambient monitoring system.¹

Parameter	All freshwater	Water Supply
Field		
Dissolved oxygen	x	x
pH	x	x
Conductivity	✓	✓
Temperature	✓	✓
Nutrients		
Total phosphorus	✓	✓
Ammonia as N	✓	✓
Total Kjeldahl as N	✓	✓
Nitrate + nitrite as N	✓	x
Other		
Total suspended solids	✓	.
Total dissolved solids	.	x
Turbidity	x	x
Hardness	✓	x
Chloride	x	x
Bacteria		
Fecal coliform bacteria	x	x
Total coliform bacteria	.	x
Metals		
Aluminum	✓	✓
Arsenic	x	x
Cadmium	x	x
Chromium	x	x
Copper	x	x
Iron	x	x
Lead	x	x
Mercury	x	x
Nickel	x	x
Silver	x	x
Zinc	x	x
Manganese	.	x
Biological		
Chlorophyll <i>a</i> ²	x	x

¹ A check (✓) indicates the parameter is collected; an 'x' indicates the parameter is collected and has a standard or action level.

² Chlorophyll *a* is collected in Nutrient Sensitive Waters (NSW).

Many facilities are required to monitor whole effluent toxicity by their NPDES permit or by administrative letter. Facilities without monitoring requirements may have their effluents evaluated for toxicity by the Division's Aquatic Toxicology Laboratory. If toxicity is detected, the Division may include aquatic toxicity testing upon permit renewal.

The Aquatic Toxicology Unit maintains a compliance summary for all facilities required to perform tests and provides a monthly update of this information to regional offices and Division administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.

LITTLE TENNESSEE RIVER SUBBASIN 02

Description

This subbasin is located in the western portion of the mountain ecoregion (Figure 11). Fontana Lake is the largest impoundment in this region and is operated by the Tennessee Valley Authority. Principal tributaries to the Little Tennessee River are the Oconaluftee River and the Tuckasegee River.

Much of the catchment to the north of the Little Tennessee River is within either the Great Smoky Mountains National Park or the Cherokee Indian Reservation. Most streams on the north side of the lake are in a roadless area and can only be reached by boat or by hiking.

This subbasin contains some of the most famous trout streams in North Carolina, including Hazel

Creek, Forney Creek, Deep Creek, and Noland Creek. Most of the rest of this subbasin is included in the Nantahala National Forest, although this does not preclude other land uses.

The area also contains some of the most pristine and some of the highest quality waters of the state. Portions of Alarka Creek, the Tuckasegee River, Caney Fork, and most of the Oconaluftee River catchment have been supplementally classified HQW. Small streams, formerly classified for water supply, have also been reclassified as HQW: Whiterock Creek, Wolf Creek, Long Branch, Jenkins Branch, Clingman's Creek, Dednan Branch, Twentymile Creek, and Moore Spring Branch. The Tuckasegee River upstream of Tanassee Creek is classified ORW.

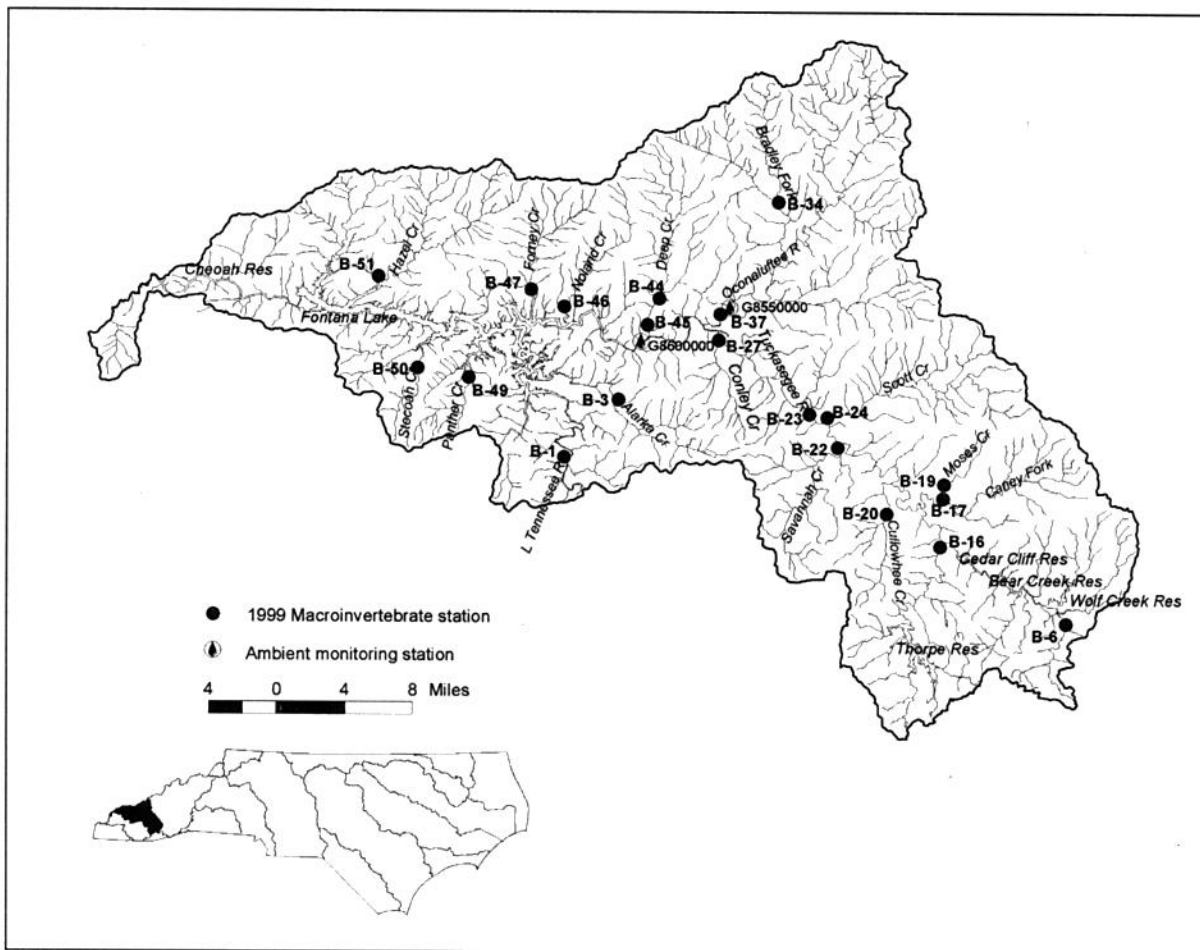


Figure 11. Sampling sites in Subbasin 02 in the Little Tennessee River basin.

The largest towns are Bryson City, Cherokee, and Sylva. There are about 20 NPDES permitted dischargers in this subbasin, but only three have permitted flows greater than 0.5 MGD: Sylva (0.5 MGD to Scott Creek), Dillsboro

(1.5 MGD to the Tuckasegee River), and Bryson City (0.6 MGD to the Tuckasegee River). Only the latter two facilities are required to monitor their effluents' toxicity.

Overview of water quality

Benthic macroinvertebrate data indicated stable water quality at most sites (Table 6). Moses Creek, Cullowhee Creek, Tuckasegee River, Oconaluftee River, and Stecoah Creek had a change in bioclassification from Good to Excellent, but these changes seemed to be related more to differences in flow regimes than to any improvements in water quality.

More significant improvement in water quality was observed at Scott Creek, where the bioclassification improved from Good-Fair in 1994 to Good in 1999. Declining water quality was observed only at Savannah Creek.

The primary problem in this basin is nonpoint source runoff, including inputs of sediment and(or) nutrients. Although much of this subbasin is forested, development is often located along the stream corridor. Both farmland and new residential areas are typically found adjacent to streams, often with inadequate riparian buffer zones. Water quality was not a problem throughout most of this area. But there was evidence of habitat problems: few pools, relatively uniform riffles and runs and an embedded substrate (Table 7). These changes have been shown to have some slight affects on the benthic macroinvertebrates, but are presumed to have greater affects on the fish fauna.

Table 6. Waterbodies monitored in Subbasin 02 in the Little Tennessee River basin for basinwide assessment, 1994 - 1999.¹

Map #	Waterbody	County	Location	1994	1999
B-1	L Tennessee R	Swain	Off SR 1113	Good	Good
B-3	Alarka Cr	Swain	SR 1185	Excellent	Excellent
B-6 ²	Tuckasegee R	Jackson	SR 1140	Excellent	Excellent
B-16	W Fk Tuckasegee R	Jackson	SR 1133	---	Good
B-17	Caney Fk	Jackson	SR 1740	Excellent	Excellent
B-19	Moses Cr	Jackson	SR 1739	Good	Excellent
B-20	Cullowhee Cr	Jackson	SR 1001	Good	Excellent
B-22	Savannah Cr	Jackson	SR 1367	Excellent	Good
B-23 ²	Tuckasegee R	Jackson	Off SR 1377	Excellent	Good
B-24	Scott Cr	Jackson	SR 1556	Good-Fair	Good
B-27	Conley Cr	Swain	SR 1177	Excellent	Excellent
B-34 ²	Bradley Fk	Swain	Off US 441	Excellent ³	Excellent
B-37 ²	Oconaluftee R	Swain	SR 1359	Good	Excellent
B-44	Deep Cr	Swain	Above campground	Excellent	Excellent
B-45	Deep Cr	Swain	SR 1340	Excellent	Excellent
B-46	Noland Cr	Swain	Near mouth	---	Excellent
B-47	Forney Cr	Swain	Near mouth	Excellent	Excellent
B-49	Panther Cr	Graham	SR 1233	Excellent	Excellent
B-50	Stecoah Cr	Graham	SR 1237	Good	Excellent
B-52	Hazel Cr	Swain	Near mouth	Excellent	Excellent
	Wolf Creek Reservoir	Jackson		Mesotrophic ⁴	Oligotrophic
	Bear Creek Reservoir	Jackson		Oligotrophic	Oligotrophic
	Cedar Cliff Lake	Jackson		Oligotrophic ⁴	Oligotrophic
	Thorpe Reservoir	Jackson		Oligotrophic	Oligotrophic

¹ B = benthic macroinvertebrate monitoring sites.

² Data are available prior to 1994, refer to Appendix B2.

³ Data were collected in 1995.

⁴ Data were collected in 1996.

Table 7. Water quality and habitat characteristics of streams in agriculturally and residentially developed watersheds in Subbasin 02 in the Little Tennessee River basin.¹

✓ Elevated conductivity	✓ Embedded substrate (20 - 40%)
✓ Riparian zone breaks	✓ Uniform instream habitat of riffles and runs
✓ Sediment deposition	✓ Bank erosion
✓ Abundant periphyton	✓ Few number of pools
✓ Narrow riparian zone	

¹Note: not all of these characteristics were found at all sites. The table represents a compilation of the habitat degradation across all sites.

Many streams in the Little Tennessee River basin are discussed as having some habitat problems, yet are given Excellent bioclassifications using benthic macroinvertebrate data. There are several reasons for this paradox. For example, undisturbed streams in this region are characterized by having highly intolerant macroinvertebrate species. These taxa have been assigned very low tolerance values, resulting in extremely low biotic index scores for many sites.

Such streams can experience significant degradation (as evidenced by an increase in biotic index values) without exceeding the range used to assign an Excellent rating. As an example, compare the biotic index scores for streams in forested catchments vs. streams in slightly developed areas (Figure 12). There was an increase from 2.8 for forested sites to 3.7 for more developed sites. But both mean scores are within the range expected for an Excellent bioclassification (< 4.0). For this reason, a criteria revision is being considered for the western mountains, including the entire Little Tennessee River basin.

Furthermore, benthic macroinvertebrates are more sensitive to changes in water quality than to changes in habitat. The habitat degradation seen in many Little Tennessee River basin streams is expected to have more of an impact on the fish communities than on the benthic macroinvertebrates, although there has been no recent data to verify this hypothesis. There is, however, abundant literature (e.g., Waters 1995) to show that filling of pools and a more embedded substrate have negative effects on coldwater fisheries.

Based upon the 1999 macroinvertebrate data, overall water quality was very good, with all sites having a bioclassification of Good or Excellent (Table 6). Sites with an Excellent bioclassification fell into two broad groups: streams in largely forested catchments and streams with some agricultural or residential development (Figure 12).

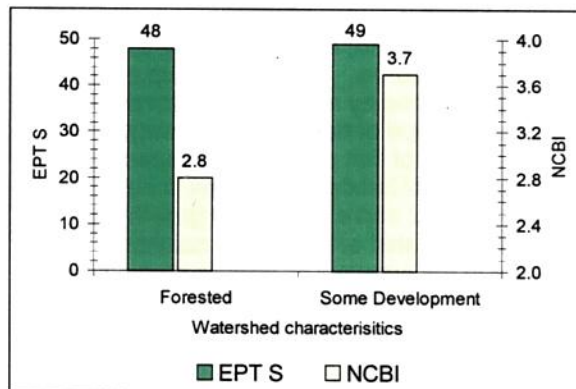


Figure 12-. Mean metric scores for Excellent rated streams in Subbasin 02 in the Little Tennessee River, 1999.

Streams with forested watersheds include the upper Tuckasegee River, Bradley Fork, upper Deep Creek, Noland Creek, Forney Creek, and Hazel Creek. These streams had extremely low conductivity (8 - 12 $\mu\text{mhos/cm}$) and high habitat scores (draft scores = 89 - 96, where maximum score = 100). The only site with a low habitat score (77) was the upper Tuckasegee River. Due to local geological characteristics, streams in the upper Tuckasegee River basin (especially Panthertown Valley) have coastal plain, bog-like characteristics of humic-colored water and sandy substrates.

Most of these sites were sampled during a period of high flow in 1994 and during a period of low flow in 1999. Low flow conditions would be expected to produce slightly higher taxa richness, higher EPT taxa richness, but no significant change in biotic index scores. This was the general pattern observed for reference sites as most sites had an increase of 3 - 5 EPT taxa richness between 1994 and 1999.

Typical residential or agriculturally developed sites included Alarka Creek, Caney Fork, Moses Creek, Conley Creek, Lower Deep Creek, Panther Creek, and Stecoah Creek. These streams generally had conductivity measurements of 20 - 25 $\mu\text{mho/cm}$. The two exceptions in this group were lower Deep Creek (12 $\mu\text{mhos/cm}$ and 100% forested

headwaters area) and Stecoah Creek (40 $\mu\text{mhos/cm}$).

Deep Creek and Panther Creek had fairly good habitat (habitat scores = 82 - 84), but other sites showed slightly lower habitat scores (70 - 80). Alarka Creek, Caney Fork, Moses Creek, Stecoah Creek and Conley Creek showed similar changes in habitat relative to the reference sites: 20 - 40% embedded substrate, infrequent pools and poor riparian buffer zones. This latter group of streams was characterized by relatively uniform riffle-run habitat. This type of habitat change may have a negative effect of fish populations, especially those that require pool habitats. Streams in developed areas often had more periphyton growth than streams in forested areas, with a resultant increase in the numbers of benthic macroinvertebrates.

Taxa richness values were identical for these two types of streams, but a change in biotic index values indicated a slight shift towards more tolerant organisms in the developed catchments. Taxa richness values were below the expectations

for two streams rated as Excellent and having forested catchments: Bradley Fork (a basinwide site) and Panthertown Creek (a special study site). These sites may be slightly stressed by low pH, although there was little chemical data to support this hypothesis.

Four lakes were monitored in this subbasin in 1999: Wolf Creek Reservoir, Bear Creek Reservoir, Cedar Cliff Lake, and Thorpe Reservoir. All were oligotrophic, with no algal blooms or nuisance aquatic plants.

Ambient monitoring data were collected from the Oconaluftee River at Birdtown and the Tuckasegee River at Bryson City. Neither site had any indication of water quality problems. Fecal coliform concentrations have declined over time at both these sites.

Two wastewater treatment plants in this subbasin are required to monitor the toxicity of their effluent. Neither facility had problems meeting its toxicity limits in 1999.

River and Stream Assessment

Stream flow in the Little Tennessee River basin was generally low to normal for June-August 1999. For example, the Little Tennessee River near Prentiss had mean daily flows for this three-month period between 45% and 83% of the long-term mean flows. There were, however, considerable geographic differences in rainfall and flow patterns within this subbasin. The eastern section, as exemplified by the Oconaluftee River near Birdtown, had high flows during July 1999. The mean daily flow for that month was 170% of the long-term mean.

Because the 1999 benthic invertebrate sampling was spread out over much of July and August, samples were collected under a wide variety of flow conditions. The Little Tennessee River at Needmore was sampled at very low flow, while the next upstream site (the Little Tennessee River at lotla) was sampled at high flow and it was almost too deep for normal collections. The majority of monitoring sites were sampled under conditions of low flow and low scour and would be expected to show slight improvements compared to the high flow conditions in 1994. Analysis of changes at reference sites predicted a between sampling period increase in EPT taxa richness of 3 to 5 species.

Little Tennessee River, off SR 1113

The Little Tennessee River at Needmore was the largest site monitored in this basin with a mean width of 70 m. This section of the river received a Good rating for all collections (Table 8 and Figure 13), although the EPT abundance in 1999 (150) was slightly lower as compared with 1994 (185 and 173).

Table 8. Flow and bioclassifications for the Little Tennessee River off SR 1113, Swain County.

Year	Flow	Rating
June 1994	Normal	Good
July 1994	Normal	Good
August 1999	Low	Good

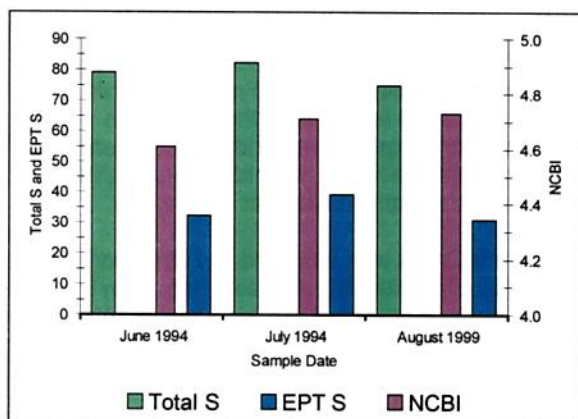


Figure 13. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Little Tennessee River off SR 1113, Swain County.

Water quality data collected in 1999 during the invertebrate monitoring indicated atypical characteristics for a stream in this river basin. Elevated readings were observed for water temperature, conductivity, and pH. The high temperature (28 °C) might have been influenced by the open canopy, while the high pH (9.0) indicated extremely high levels of primary production by river weed and periphyton under the low flow conditions of 1999. Conductivity (100 $\mu\text{mhos/cm}$) exceeded any values recorded from this site prior to 1999 and paralleled an increase observed at all upstream sites (cf. Ambient Chemistry). These changes in some water quality variables may be due to a change in the effluent from an upstream discharger (for example in Georgia).

The elevated temperature and pH conditions observed in 1999 could eliminate many of the coldwater or coolwater species seen in prior samples. The elevated temperature and pH conditions observed in 1999 could eliminate many of the coldwater or coolwater species seen in prior samples. For example, between 2 and 6 species of stoneflies were collected for the two collections in 1994, but only a single specimen of one species was collected in August 1999.

Alarka Creek, SR 1185

Alarka Creek is a medium-sized stream (10 m wide) with a relatively uniform riffle-run habitat. An Excellent bioclassification was assigned in 1994 and 1999. Almost identical EPT taxa richness (48 and 49) and NCBI values (3.7) were recorded in both collections. The substrate was highly embedded (40%) and there were occasional breaks in the riparian zone.

Tuckasegee River, SR 1140

This site, located in Panthertown Valley, was about 10 m wide. Due to local geological characteristics, this portion of the river is naturally sandy (70% sand and gravel) with humic-colored water. Conductivity was very low (8 $\mu\text{mhos/cm}$).

EPT samples in 1994 and 1999 produced an Excellent rating. Seven more EPT taxa were collected in 1999 under low flow conditions than in 1994 under normal flow conditions.

W Fk Tuckasegee River, SR 1133

This site was sampled for the first time in July 1999. It is located downstream of Thorpe Reservoir. This reservoir has a hypolimnetic release, causing the stream to have much colder water in summer months than other nearby streams. The West Fork had a stream temperature of 12 °C in July 1999, vs. 17 - 22 °C for other streams in this area. This situation is similar to that observed in the lower segment of the Nantahala River.

Such a change in the water temperature regime is often associated with a slight decline in diversity. This site received only a Good rating based on EPT taxa richness of 33. The presence of many intolerant species, however, indicated no other significant water quality problems.

Discharge of water from Thorpe Reservoir is used to generate electrical power, with resulting hourly, daily, and seasonal variations in flow. These variations may affect some taxa associated with bank habitats. This site also had many of the habitat problems that are widespread in the Little Tennessee River basin: infrequent pools, relatively uniform riffle and runs, bank erosion, and many breaks in the riparian zone.

Caney Fork, SR 1740

An Excellent rating was assigned to this site in both 1994 and 1999. The biotic index was slightly elevated relative to the reference sites (3.3 and 3.7), although this site had very high EPT taxa richness (52 and 53 taxa).

Caney Fork is virtually identical to the site on Alarka Creek: 10 m wide, uniform riffle-run habitat, few pools, 40% embedded substrate, and many breaks in the riparian zone.

Moses Creek, SR 1737 (SR 1740)

Moses Creek is a small (4 - 5 m wide) tributary of Caney Fork and had similar habitat problems (Table 7). This stream, however, had a higher

gradient, a more closed canopy, and less abundant periphyton than Caney Fork.

The bioclassification at this site changed from Good in 1994 to Excellent in 1999. Three more EPT taxa were collected in 1999 than in 1994. This change was equivalent to that observed at reference sites, thus it was unlikely that the change in bioclassification indicated a significant change in water quality.

Cullowhee Creek, SR 1001

Cullowhee Creek flows through Western Carolina University campus, although the monitoring site was upstream from all urban areas. This portion of the stream is seven meters wide with good boulder and rubble habitat.

The bioclassification for this site changed from Good in 1994 to Excellent in 1999, based on an increase in EPT taxa richness from 32 to 41 (Table 9 and Figure 14). However, there was no significant between-sampling period change in either EPT abundance (150 vs. 153) or EPT biotic index. Lower flow in 1999 probably contributed to the increase in EPT taxa richness.

Table 9. Flow and bioclassifications for Cullowhee Creek, SR 1001, Jackson County.

Year	Flow	Rating
1994	High	Good
1999	Low	Excellent

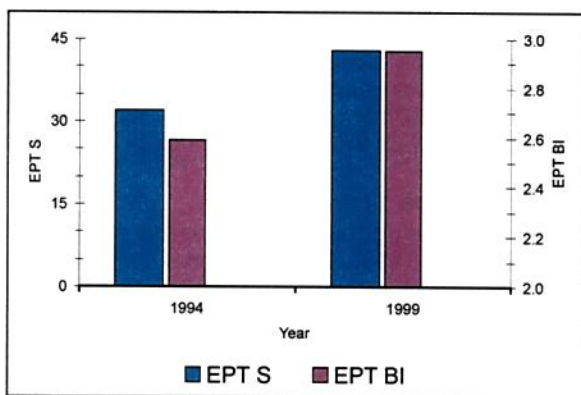


Figure 14. EPT taxa richness (EPT S) and biotic index (EPT BI) for Cullowhee Creek, SR 1001, Jackson County

This site shares some of the habitat problems observed for the other developed catchments (Table 7).

Savannah Creek, SR 1367

Savannah Creek is a medium-sized stream (12 m wide) between Dillsboro and Franklin. While most of the catchment is forested, there is much residential and agricultural land use adjacent to the stream. This site had a low habitat score (58), in part because of altered habitat (Table 7).

Savannah Creek was sampled in 1994 and 1999 under high flow conditions (Table 10). Ten fewer EPT taxa were collected in 1999 than in 1994 (Figure 15), resulting in a bioclassification change from Excellent to Good.

Table 10. Flow and bioclassifications for Savannah Creek, SR 1367, Jackson County.

Year	Flow	Rating
1994	High	Excellent
1999	High	Good

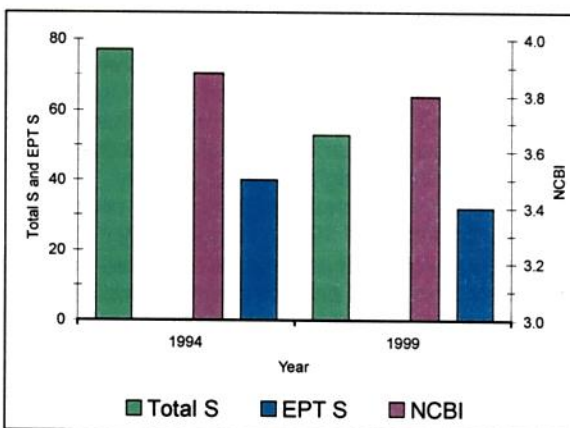


Figure 15. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for Savannah Creek, SR 1367, Jackson County.

There was little change, however, in either EPT abundance or Biotic Index between the two sampling periods. No tolerant community was observed at this site although the low EPT abundance values (EPT N = 138 in 1999 and 136 in 1994) suggested sediment stress to the benthic macroinvertebrate community.

Tuckasegee River, off SR 1377 (SR 1378)

The Tuckasegee River, at Dillsboro, is another large river site, with a mean width of 50 m.

The Dillsboro site had shown a steady improvement in water quality from 1984 to 1994, changing from a Good-Fair rating to an Excellent rating (Table 11). The rating decreased to Good in 1999,

but this sample did not appear to be different from the samples collected in 1988 or 1990 (Figure 16).

Table 11. Flow and bioclassifications for Tuckasegee River, off SR 1377, Jackson County.

Year	Flow	Rating
1984	High	Good-Fair
1986	Low-Normal	Good
1988	Low	Good
1990	Normal	Good
1994	High	Excellent
1999	Variable	Good

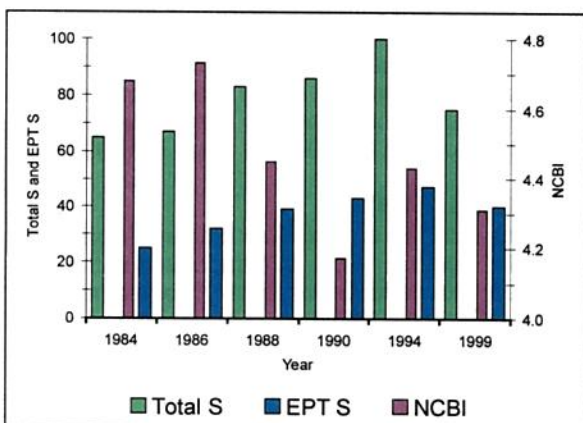


Figure 16. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Tuckasegee River, off SR 1377, Jackson County.

The overall pattern still suggested water quality improvements. The bioclassifications at this site may be expected to vary between Good and Excellent, depending on the amount of scour that precedes the invertebrate collections.

The substrate at this site was 40-50% sand and gravel, and some silt also was observed along the banks. Although the habitat was clearly affected by sediment inputs (habitat score = 69), good rubble and boulder substrate was present, and bank habitats supported a variety of slow-water species. The 1999 samples were collected under high flow conditions, although flow had been low earlier throughout much of the summer.

Scott Creek, SR 1556

Scott Creek is a medium-sized stream (13 m wide), which flows through downtown Dillsboro. Although the land use near the monitoring site is urban, most of the drainage area is agricultural or residential. The stream channel is highly modified within the town as much of the bank is protected

by rip-rap. . The low habitat score (59) reflects the poor riparian zone in Dillsboro, plus a relatively uniform riffle/run habitat.

The monitoring site on Scott Creek is downstream of the Sylva WWTP as well as several other small dischargers. This facility has reported few problems and the town is working on reducing the number of sewer leaks. An increased percentage of Jackson County's wastewater is also being routed to the newer treatment plant which discharges to the Tuckasegee River.

The high biotic index in 1994 indicated dominance by facultative and tolerant taxa, including Chironomidae, Oligochaeta, Simuliidae, Baetidae, and Hydropsychidae. In 1999, many EPT taxa increased in abundance, resulting in a sharp decrease in the biotic index value in contrast to the scores for 1994 (Figure 17). This is the only site in the subbasin where an improvement in bioclassification (Tables 6 and 12) reflected a significant change in water quality.

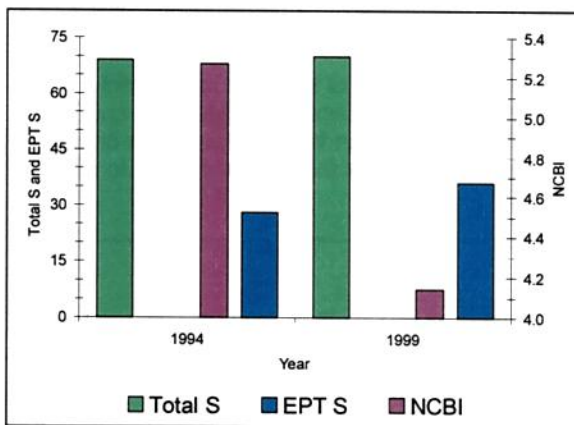


Figure 17. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for Scott Creek, SR 1556, Jackson County.

Table 12. Flow and bioclassifications for Scott Creek, SR 1556, Jackson County.

Year	Flow	Rating
1994	High	Good-Fair
1999	High	Good

Conley Creek, SR 1177

Conley Creek (= Connelly Creek) received an Excellent bioclassification in 1994 and 1999. It is a small stream (six meters wide), with habitat problems typical of developed catchments in this subbasin (Table 7). A silt and periphyton layer was observed over much of the stream bottom, and the stream was turbid at the time of sampling.

Bradley Fork, off US 441

Bradley Fork was sampled above the Great Smoky Mountains National Park's Smokemont campground. This site was about 14 m wide with high quality habitat. Conductivity at the time of the benthic invertebrate sampling was only 12 $\mu\text{mhos/cm}$.

Lower than expected EPT taxa richness was observed in 1999, a pattern that also had occurred in 1994. The very low biotic index values for this site (2.7), however, clearly indicated that this site should have an Excellent rating. It was possible that episodic low pH values affect the species diversity at this site, although the pH at the time of the Division sampling was not unusually low (6.6).

Oconaluftee River, SR 1359

The Oconaluftee River and its tributaries drain the Great Smoky Mountain National Park and the Cherokee Indian Reservation. The lower portion of this stream (near Birdtown) receives heavy recreational use and urban runoff from the Town of Cherokee.

The bioclassification of the river has varied between Good and Excellent (Figure 18 and Table 13). There have been few between-year changes in water quality, other than changes due to high flow.

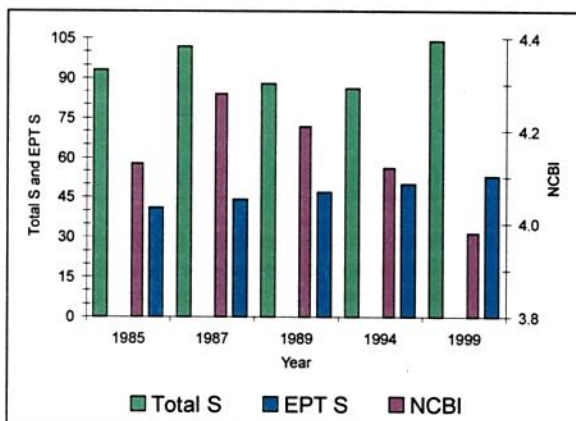


Figure 18. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Oconaluftee River, SR 1359, Swain County.

Table 13. Flow and bioclassifications for the Oconaluftee River, SR 1359, Swain County.

Year	Flow	Rating
1985	Normal	Good
1987	Normal	Excellent
1989	Low	Excellent
1994	High	Good
1999	Variable	Excellent

Deep Creek, above campground

This site on Deep Creek is 13 m wide with high quality instream and riparian habitat. Conductivity at the time of the benthic invertebrate sampling was 12 $\mu\text{mhos/cm}$. Although this part of the stream is within the Great Smoky Mountains National Park, there is a heavy recreational use ("tubing") during the summer. The stream was rated as Excellent in 1994 and again in 1999.

Deep Creek, SR 1340

This site received an Excellent bioclassification in 1994 and again in 1999. In comparison to the upstream site in the Great Smoky Mountains National Park, the EPT taxa richness at this lower site remained high. There was, however, a shift towards more tolerant species.

There were few water quality differences between the two sites on Deep Creek, but there were habitat differences. The lower site at SR 1340 had fewer pools, a more embedded substrate, more breaks in the riparian zone, and much greater periphyton growths than the upstream site.

Noland Creek, near mouth

Noland Creek at this site was about 13 m wide with high quality riparian and instream habitat. This site is accessible only by boat. As expected for a protected watershed in the Great Smoky Mountains National Park, the conductivity at the time of the benthic macroinvertebrate sampling was only 11 $\mu\text{mhos/cm}$. The 1999 sample was the first collection from this site and produced an Excellent rating, based on an EPT taxa richness of 40.

Forney Creek, near mouth

Like Noland Creek, Forney Creek was sampled near its mouth. And as expected for a protected watershed in the Great Smoky Mountains National Park, this site has good habitat and water quality. An Excellent rating was assigned to this site, based on virtually identical results in 1994 and 1999: EPT = 46, and NCBI = 2.5 - 2.7. These biotic index values were among the lowest values recorded in North Carolina.

Panther Creek, SR 1233

Panther Creek was rated as Excellent in 1994 and 1999 with virtually identical results from these two collections. It is a small stream (seven meters wide) with many of the habitat problems associated with agricultural and (or) residential land use in this subbasin (Table 7).

Stecoah Creek, SR 1237

Stecoah Creek is a small stream (five meters wide) located in a developed watershed. As observed in many other streams in this subbasin, a large increase in EPT taxa richness was noted between 1994 and 1999 (Figure 19). This resulted in a change in bioclassification from Good to Excellent (Table 14).

Table 14. Flow and bioclassifications for Stecoah Creek, SR 1237, Graham County.

Year	Flow	Rating
1994	High	Good
1999	Normal (?)	Excellent

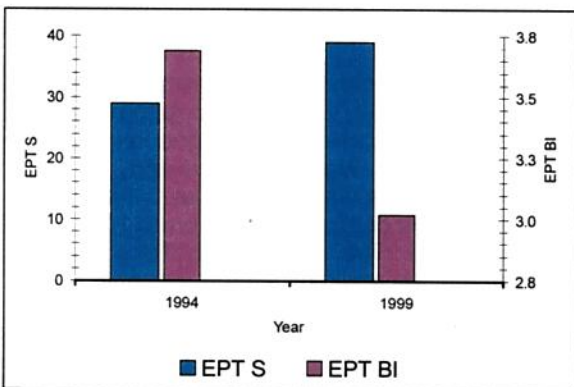


Figure 19. EPT taxa richness (EPT S) and biotic index (EPT BI) for Stecoah Creek, SR1237, Graham County.

There was also a large increase in EPT abundance and a shift towards more intolerant species. Taxa which were rare or absent in 1994, but abundant in 1999, included *Baetis pluto*, *Paraleptophlebia*, *Leuctra*, *Dolophilodes*, and *Psychomyia flava*. This pattern indicated stress under high flow conditions by nonpoint source pollution. It is to be expected that the bioclassification will continue to fluctuate between Good and Excellent, depending on flow conditions.

The substrate was mostly rubble and boulder (only slightly embedded, although much of the stream was a uniform riffle-run habitat with few pools.

Hazel Creek, near mouth

Like Noland Creek and Forney Creek, Hazel Creek was sampled near its mouth. And as expected for a protected watershed in the Great Smoky Mountains National Park, this stream had high quality habitat and very low specific conductivity. The stream has been consistently rated as Excellent.

The biotic index values were virtually identical for 1994 and 1999 (2.9 and 3.0). Nine more EPT taxa were collected under low flow conditions in 1999 in contrast to the high flow conditions in 1994.

SPECIAL STUDIES

Great Smoky Mountains National Park

The National Park Service has initiated several monitoring programs within the Great Smoky Mountains National Park. The water quality in many streams is regularly monitored using techniques almost identical to the Division's macroinvertebrate sampling program.

The National Biological Service has documented low pH problems in some of the streams within the Great Smoky Mountains National Park (Flum, et al. 1996). Data, including almost 2,500 measurements of stream pH, have been collected from 350 monitoring sites. About 5% of the samples were found to have pH values < 5.0, 11% had pH values < 5.5, and 22% had pH values < 6.0. Low pH values were found in two types of streams:

- *Streams in catchments with Anakeesta rock deposits.* This includes Beech Flats Prong and Bradley Fork. A characteristic symptom of this problem is high sulfate concentrations in the Anakeesta rock which produces sulfuric acid as it weathers. Road cuts or landslides in areas of this deposit, or use of fill containing this rock can result in stream pH values < 5.0.
- *Streams above 3500' in old-growth (undisturbed) forest.* The terrestrial systems may become nitrogen saturated after many years of acid precipitation. Eventually, the acid-neutralizing capacity of the catchment is depleted. A characteristic of this problem is high aqueous nitrate concentrations, especially after rainfall. Headwater catchments with low pH values (usually at sites above 4,000' feet) include Raven Fork and several tributaries of Lake Fontana such as Eagle Creek, Forney Creek, and Noland Creek.

Lower elevation sites rarely have records of pH < 6.2, but this may reflect sampling frequency bias.

It is possible that these lower elevation sites may have occasional pH values less than 6.0, but for a period of only a few days.

Tennessee Valley Authority

During April and July 1999, TVA biologists collected data on fish, benthic invertebrates, and habitat characteristics at four sites in the Little Tennessee River basin (unpublished data) (Table 15). The macroinvertebrate data was limited to the number of EPT families with a maximum score

of about 25 families/site. The habitat assessment score had a maximum value of 52.

Overall, results were similar to those from the Division studies. Habitat problems were observed at most sites, but high invertebrate taxa richness also indicated good water quality at most sites. A slight depression in EPT taxa richness was observed at the Little Tennessee River site, but this large river site had a good diversity of fish, including six species of darters, five species of suckers, and nine species of minnows.

Table 15. Biological and habitat data collected by the Tennessee Valley Authority from the Little Tennessee River basin, April and July, 1999. Note: EPT ratings are not equivalent to Division ratings

Stream	Location	County	No. of EPT Families	EPT Rating	No. of Fish Species	No. of Fish	TVA IBI	Habitat Score
Little Tennessee R	NC 28	Macon	15	Good	33	523	56	39
Caney Fk	Off SR1737	Jackson	22	Excellent	15	421	34	39
Cullowhee Cr	Off SR 1001	Jackson	21	Excellent	19	799	40	35
Tuckasegee R	Off SR 1001	Jackson	22	Excellent	11	144	26	44

Lake Assessment

Wolf Creek Reservoir

This small reservoir is on a tributary to the upper Tuckasegee River (Figure 20). Built in 1955, it is owned by the Nantahala Power & Light Company (NP&L). Its watershed is within the Nantahala National Forest near the county borders of Jackson and Transylvania counties.

The reservoir was most recently sampled during the summer of 1999 (Table 16 and Appendices L2 and L3). Mean Secchi depths ranged from 5.9 m in June to 4.2 m in August. Nutrient and chlorophyll *a* concentrations were low. Fecal coliform bacteria concentrations were ≤ 10 colonies/100 ml. The calculated NCTSI scores indicated that the reservoir was oligotrophic.

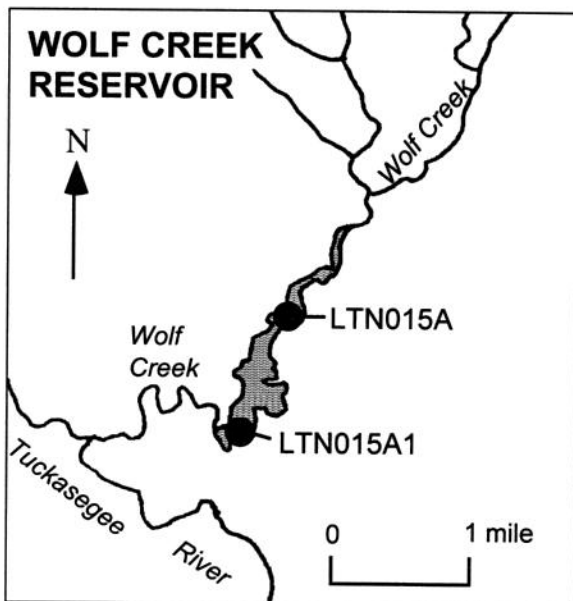


Figure 20. Monitoring sites at Wolf Creek Reservoir, Jackson County.

Previous data was collected from the reservoir in August 1996. Secchi depths were less than those usually observed, ranging from 2.1 to 2.4 m. Total phosphorus concentrations were also greater than those generally observed (0.02 to 0.03 mg/l). Chlorophyll *a* values were low. The NCTSI score (-1.4) rated the lake as mesotrophic. Localized storms a few days earlier within the watershed may have contributed to the decreased transparency and increased nutrient concentrations that were measured later.

Data collected from 1988 through 1999 for the four constituents of the NCTSI were summarized using box and whisker plots (Figure 21). As expected for a mountain reservoir, median Secchi depths and chlorophyll *a* concentrations were greater near the dam as compared with the upper end of the reservoir. By contrast, median total phosphorus and total organic nitrogen were greater at the upper end of the lake than near the dam.

AMBIENT MONITORING SYSTEM

The Division collects ambient water quality information from approximately 421 active monitoring stations statewide. In the Little Tennessee River basin there are seven stations (Figure 35 and Table 25).

Regional flow patterns generally showed greater than normal flows beginning in 1994 to about 1998

(Figure 36). Beginning in 1998, yearly and monthly median flows displayed decreases. The graph depicting flow in the Hiwassee River does not include data for the water year 1998-1999, but the yearly median flow follows the same patterns for the Watauga River and Little Tennessee River.

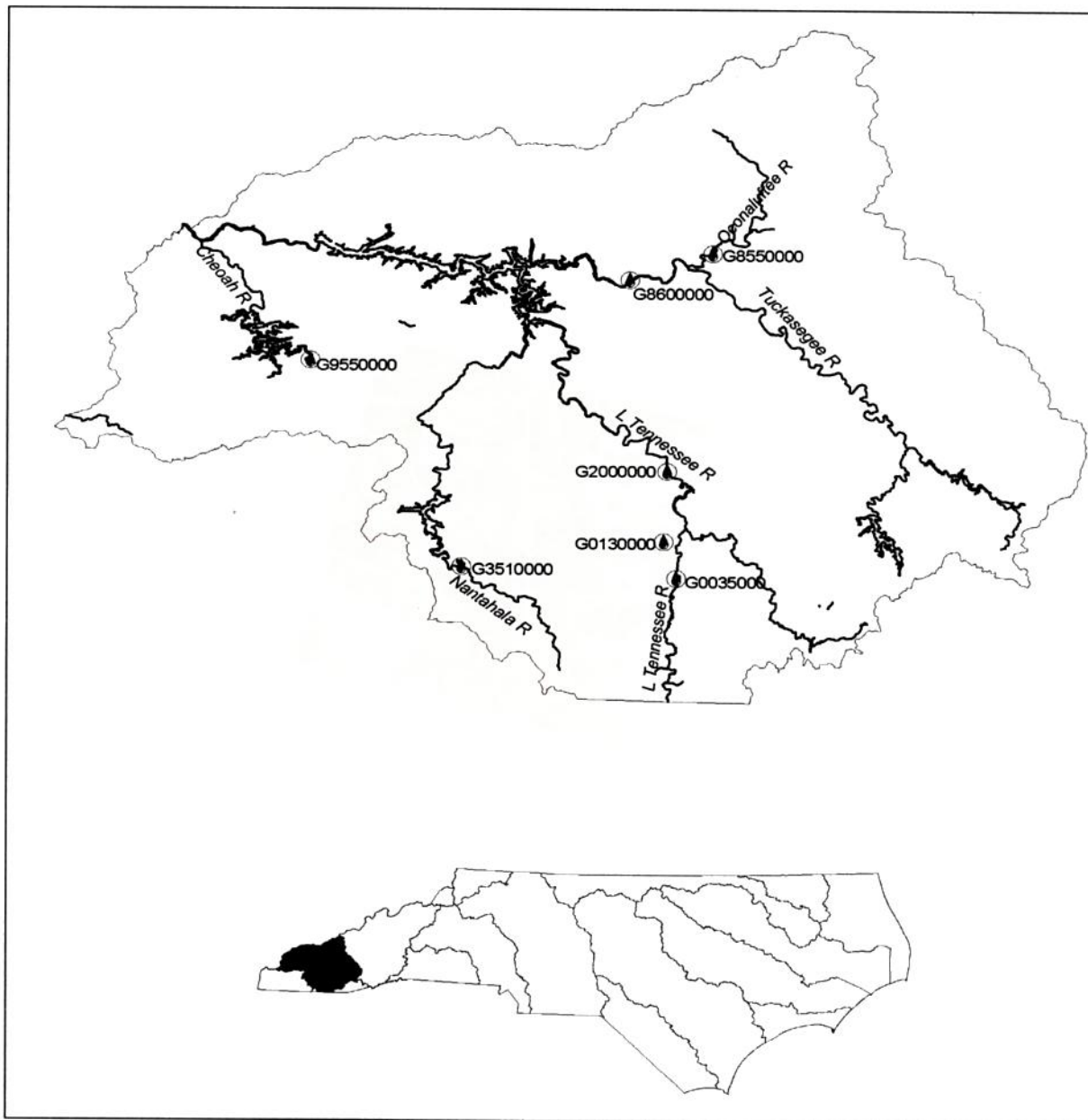


Figure 35. Ambient monitoring sites in the Little Tennessee River basin.

Table 25. Ambient monitoring system stations within the Little Tennessee River basin.

Subbasin	Station code	Station	County	Class
01	G0035000	Little Tennessee River at SR 1651, near Prentiss	Macon	C
	G0130000	Cartoogechaye Creek at SR1152, near Franklin	Macon	B, Tr
	G2000000	Little Tennessee River at NC Hwy 28, at lotla	Macon	C
02	G8550000	Oconaluftee River at SR1359, at Birdtown	Swain	C, Tr
	G8600000	Tuckasegee River at SR 1364, at Bryson City	Swain	C
03	G3510000	Nantahala River, near Rainbow Springs	Macon	B, Tr, ORW
04	G9550000	Cheoah River at SR 1138, at Robbinsville	Graham	C, Tr

The previous basinwide assessment report stated that the most noticeable feature of water chemistry data was a decline in pH beginning in the winter of 1991 and continuing to the fall of 1994 (NCDEHNR 1996). Data collected since 1994 showed pH recovering to historically observed values after 1995 (Figure 37). There was no known reason for the earlier decline in pH, although episodes of acid deposition could have played a role. There was also the possibilities of monitoring personnel error and pH meter equipment variability.

Fecal coliform bacteria concentrations have decreased considerably from samples collected before 1989 and only occasionally have they exceeded the reference level (Table 26).

For the current basin assessment period (09/01/1994 - 08/31/1999), geometric mean concentrations of fecal coliform bacteria were the lowest among the three time periods, except for samples from the Cheoah River. The geometric mean for the Cheoah River has increased very slightly in contrast to the previous five years (11.5 - 13.2). The proportion of samples greater than the reference level also increased very slightly at the Tuckasegee River (two sites) and at the Cheoah River from the previous five years.

The differences between the geometric mean and proportion of samples greater than 200 colonies/100ml may be biased slightly by considerably fewer samples collected during the period 09/01/1989 to 08/31/1994.

Overall, there were no temporal patterns among any of the parameters at any of the stations. Exceptions include pH (discussed previously) and conductivity measured at the Little Tennessee River at Prentiss and lotla. At both of these sites, an increase in conductivity was measured beginning in about 1994 (Figure 38). Flow was not found to be an explanatory variable for these increases.

There were few incidents of any parameter exceeding a water quality standard or action level (Tables 27 - 33). The lowest dissolved oxygen concentration observed among all stations was 7.1 mg/l in the Little Tennessee River at lotla. This concentration was still well above state standards. Copper exceeded the action level of 7 µg/l at all stations, ranging from 7.5% to 20.8% of the total number of samples. Iron exceeded the action level of 1000 µg/l at six stations. However, iron is an element commonly found in soils. The ecological effects of copper and zinc values cannot be inferred without accompanying ecotoxicity data.

Spatial differences in the distribution (percentiles) of several parameters are depicted in groups of box and whisker plots (Figures 39 - 43). Figure 39 explains how to interpret box and whisker plots. These plots provide a graphic representation of the percentiles listed in Tables 27-33 and are useful for depicting spatial differences.

Conductivity was highest and most variable at the Little Tennessee River (at Prentiss and at lotla) (Figure 40)..

The Nantahala River had the lowest variability for total suspended solids, hardness, fecal coliform bacteria, turbidity, nitrite+nitrate as nitrogen, and total phosphorus (Figures 41 - 43). Medians were low for most parameters, indicating a high frequency of samples with low concentrations for these parameters. The river at this station is supplementally classified as Outstanding Resource Waters.

Hardness appeared to vary the most among the stations, although medians were low, ranging from 4 to 10 mg/l (Figure 41). Geological differences in the watersheds may influence the concentrations of hardness.

Table 26. Summary of fecal coliform bacteria collections from the Little Tennessee River basin, 1968-1999¹.

Site	First Sample	Last Sample	N ²	Geometric Mean	N > 200	% > 200
L. Tennessee R. at Prentiss	04/29/1981	06/22/1989	72	274.0	45	62.5
	09/06/1989	08/29/1994	14	18.7	2	14.3
	09/28/1994	08/26/1999	49	11.5	4	8.2
L. Tennessee R. at Iotla	07/29/1968	08/24/1989	150	254.8	84	56.0
	09/06/1989	08/29/1994	17	24.4	2	11.8
	09/28/1994	08/26/1999	49	14.4	4	8.2
Cartoogechaye Cr	08/23/1971	08/24/1989	42	120.3	18	42.9
	09/06/1989	08/29/1994	20	23.1	3	15.0
	09/28/1994	08/26/1999	49	13.7	2	4.1
Nantahala R.	04/29/1981	08/24/1989	94	13.4	2	2.1
	09/06/1989	08/29/1994	48	2.3	0	0.0
	09/28/1994	08/26/1999	48	1.2	0	0.0
Oconaluftee R.	01/31/1985	08/24/1989	36	75.4	9	25.0
	09/06/1989	08/04/1994	17	4.0	0	0.0
	09/20/1994	08/04/1999	50	3.2	1	2.0
Tuckasegee R.	08/13/1974	08/24/1989	139	294.3	91	65.5
	09/06/1989	08/04/1994	15	7.9	1	6.7
	09/20/1994	08/04/1999	50	6.6	4	8.0
Cheoah R.	04/2/1974	06/15/1989	142	278.6	78	54.9
	09/06/1989	08/04/1994	17	11.5	0	0.0
	09/20/1994	08/04/1999	50	13.2	2	4.0

¹ Row in bold face represents the summary for the current basin assessment period (9/1/1994 to 8/31/1999).

² N = Number of samples; N > 200 = number of samples > 200 colonies/100ml; % > 200 = proportion (%) of samples > 200 colonies/100 ml.

Table 30. Summary of water quality parameters collected from the Oconaluftee River (Station G8550000; Class C Tr) during the period 09/01/1994 to 08/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref.	Min.	Max	Percentiles				
								10	25	50	75	90
Field												
Temperature (°C)	56	.	.	.	.	2	22	5	9	14	18	20
Conductivity	56	.	.	.	.	13	37	17	18	20	22	23
Dissolved Oxygen	56	.	6	0	.	8.3	13.8	8.5	9.1	10.2	11.2	11.8
pH (s.u.)	56	.	6-9	0	.	6.3	8.8	6.7	6.9	7.2	7.4	7.9
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	50	4	.	.	.	1	130	1	2	3	6	13
Hardness	50	0	.	.	.	1	12	2	4	5	6	8
Chloride	0	0	230	.	.	.	.	.	.	.	.	.
Turbidity (NTU)	50	6	50	1	2.0	1.0	150.0	1.0	1.4	2.2	4.0	6.5
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	50	15	200	1	2.0	1	210	1	1	2	8	24
Nutrients												
NH ₃ as N	60	14	.	.	.	0.01	0.12	0.01	0.01	0.03	0.06	0.09
TKN as N	60	3	.	.	.	0.1	1.0	0.1	0.1	0.2	0.2	0.3
NO ₂ +NO ₃ as N	60	0	.	.	.	0.08	1.40	0.14	0.18	0.23	0.27	0.32
Total Phosphorus	60	8	.	.	.	0.01	0.21	0.01	0.01	0.03	0.04	0.06
Metals (total)												
Arsenic	56	56	50	0	.	10	10	10	10	10	10	10
Cadmium	56	56	0.4	N/A	.	2	2	2	2	2	2	2
Chromium	56	56	50	0	.	25	25	25	25	25	25	25
Copper	56	27	7	6	10.7	2	19	2.0	2.0	2.0	3.0	7.4
Iron	56	0	1000	4	7.1	51	5600	76	98	160	255	377
Lead	56	53	25	0	.	10	20	10	10	10	10	10
Manganese	1	1	200	.	.	10	10	.	.	10	.	.
Nickel	56	56	88	0	.	10	10	10	10	10	10	10
Aluminum	56	3	.	.	.	50	6200	66	105	135	205	367
Mercury	56	56	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N Total number of samples.
N < RL Number of samples less than the Division analytical reporting level (RL).
Ref Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref Number of samples greater than (or less than) the reference.
% > Ref Proportion (%) of samples greater than the reference.
Min Minimum.
Max Maximum.
N/A Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

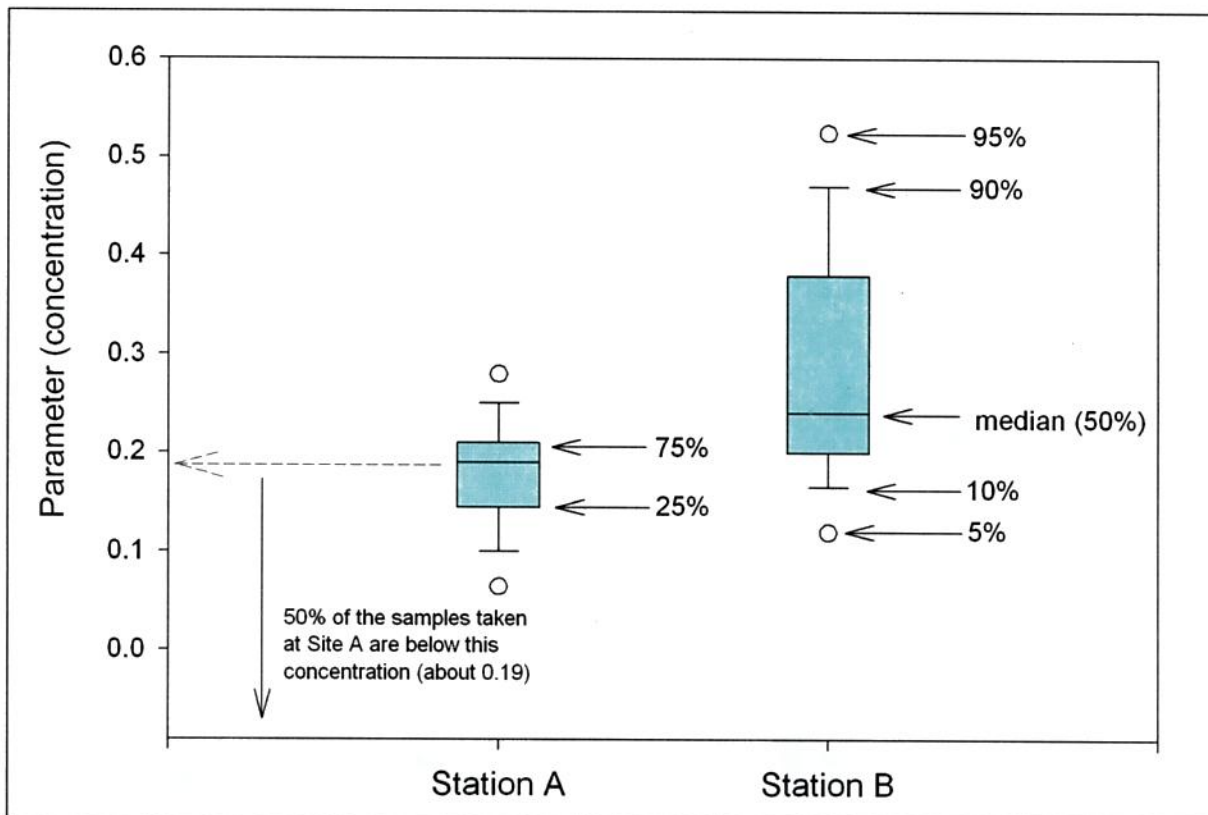


Figure 39. Explanation of box plots. Box plots (or box and whisker plots) show the distribution of measurements of a parameter. Here the distribution of measurements of a hypothetical parameter are compared between Station A and Station B. The percentage of measurements at or below a particular concentration are indicated on the figure. Note that the median and variation of measurements taken at Station B are greater than the median of Station A.

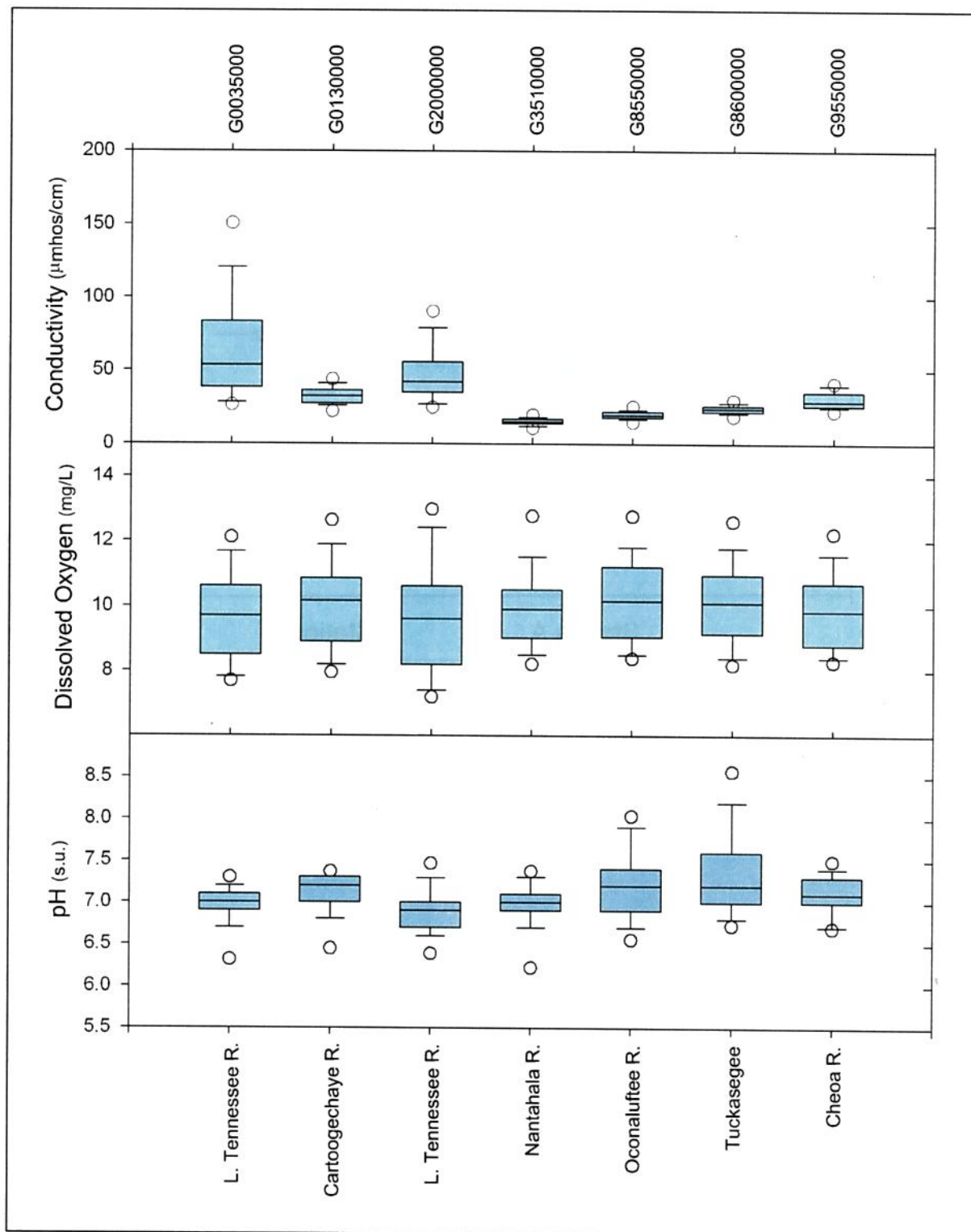


Figure 40. Box plots of conductivity, dissolved oxygen, and pH in the Little Tennessee River basin, 1980 - 1999.

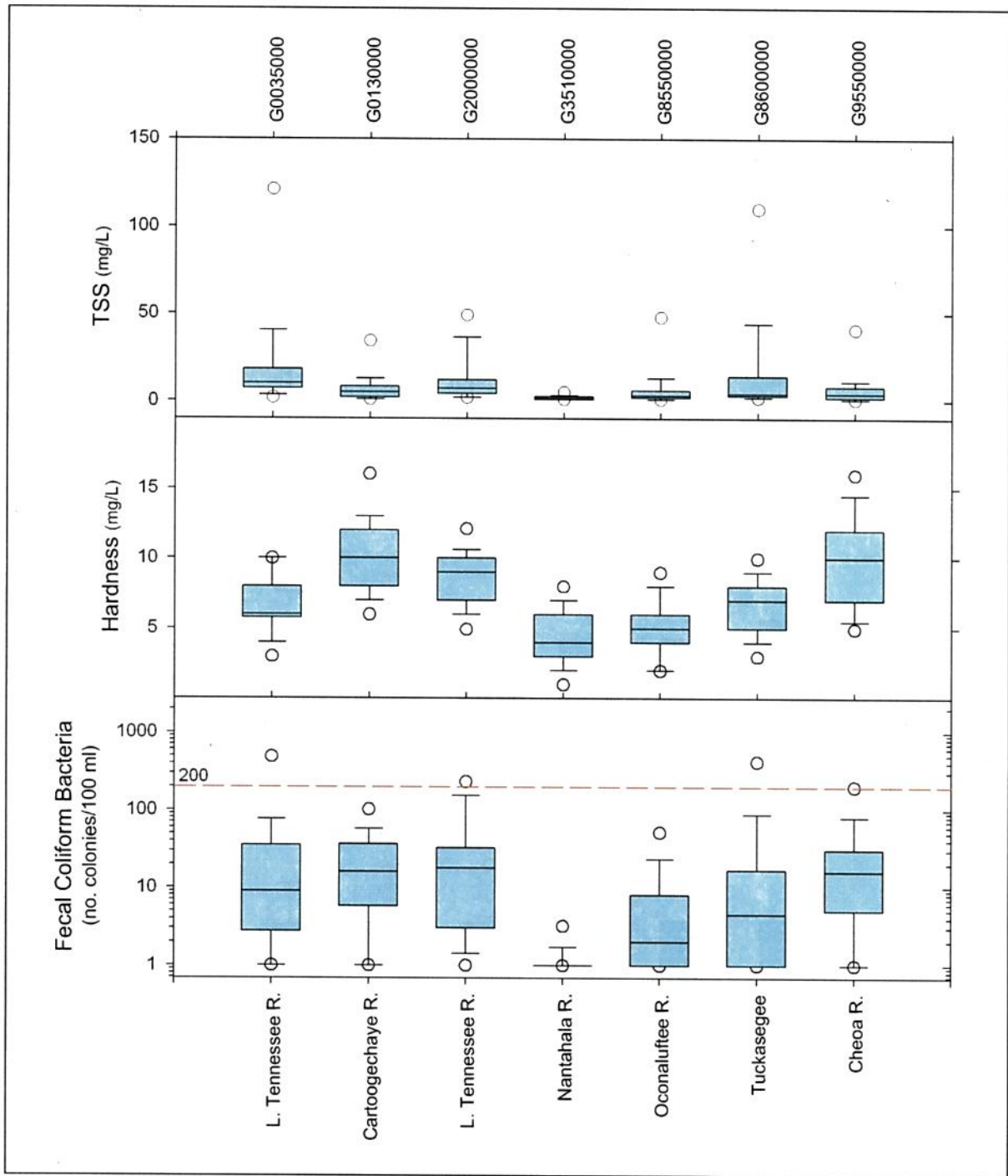


Figure 41. Box plots of total suspended solids (TSS), hardness, and fecal coliform bacteria in the Little Tennessee River basin, 1980 - 1999. Dashed line at 200 colonies/100 ml represents a reference level.

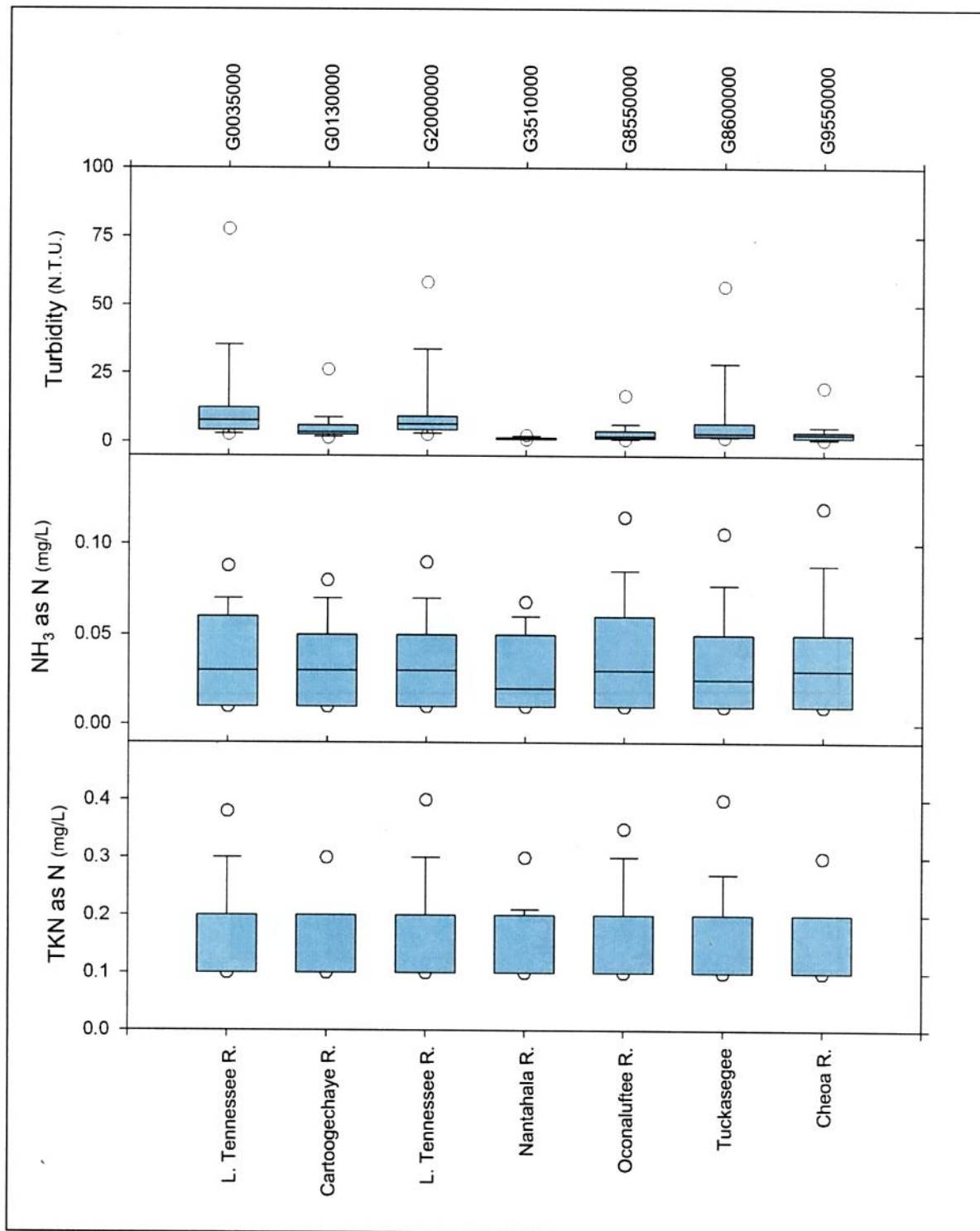


Figure 42. Box plots of turbidity, ammonia (NH₃ nitrogen), and total Kjeldahl nitrogen (TKN) in the Little Tennessee River basin, 1980 - 1999.

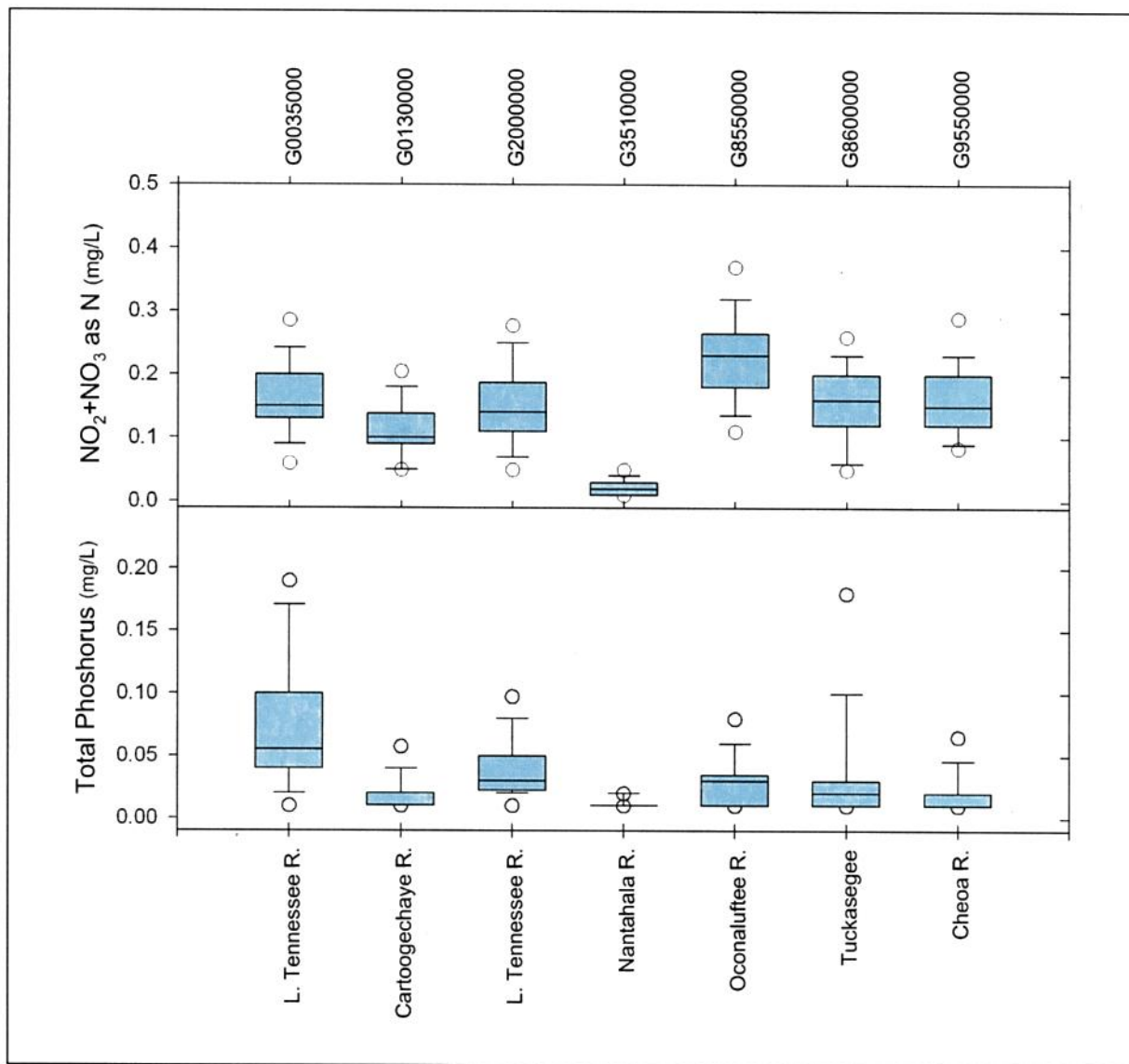


Figure 43. Box plots of nitrite + nitrate ($\text{NO}_2 + \text{NO}_3$) as nitrogen and total phosphorus in the Little Tennessee River basin, 1980 - 1999.

AQUATIC TOXICITY MONITORING

Three facilities in the Little Tennessee River basin have NPDES permits which require whole effluent toxicity (WET) monitoring. These facilities are the Franklin, Bryson City, and Tuckasegee W&SA wastewater treatment plants (Figure 44 and Table 34). All three facilities also have a WET permit limit.

The number of facilities monitoring for whole effluent toxicity has increased from one in 1987 (first year that whole effluent toxicity limits were written into permits in North Carolina) to three by 1992 (Figure 45). The compliance rate of these three facilities has been greater than 96% since 1990 (Figure 45).

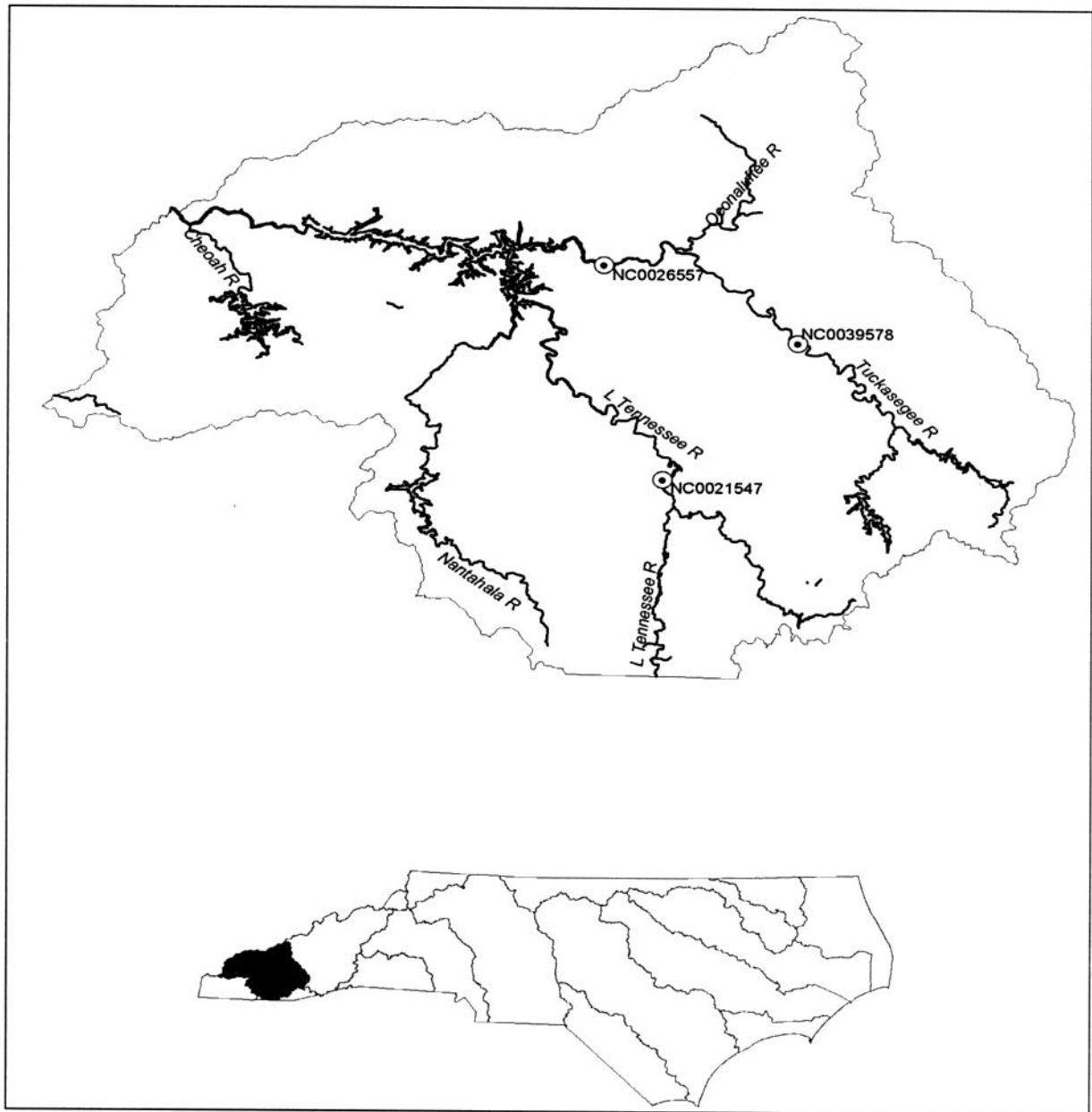


Figure 44. Location of facilities in the Little Tennessee River basin required to perform whole effluent toxicity testing.

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GLOSSARY

7Q10	A value which represents the lowest average flow for a seven day period that will recur on a ten year frequency. This value is applicable at any point on a stream. 7Q10 flow (in cfs) is used to allocate the discharge of toxic substances to streams.
Bioclass	Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups (EPT) and the Biotic Index value.
cfs	Cubic feet per second, generally the unit in which stream flow is measured.
CHL <i>a</i>	Chlorophyll <i>a</i> .
Division	The North Carolina Division of Water Quality.
D.O.	Dissolved Oxygen.
Ecoregion	An area of relatively homogeneous environmental conditions, usually defined by elevation, geology, and soil type. Examples include mountains, piedmont, coastal plain, sandhills, and slate belt.
EPT	The insect orders (Ephemeroptera, Plecoptera, Trichoptera); as a whole, the most intolerant insects present in the benthic community.
EPT N	The abundance of Ephemeroptera, Plecoptera, Trichoptera insects present, using values of 1 for Rare, 3 for Common and 10 for Abundant.
EPT S	Taxa richness of the insect orders Ephemeroptera, Plecoptera and Trichoptera. Higher taxa richness values are associated with better water quality.
HQW	High Quality Waters.
IWC	Instream Waste Concentration. The percentage of a stream comprised of an effluent calculated using permitted flow of the effluent and 7Q10 of the receiving stream.
Major Discharger	Greater than or equal to one million gallons per day discharge (≥ 1 MGD).
MGD	Million Gallons per Day, generally the unit in which effluent discharge flow is measured.
Minor Discharger	Less than one million gallons per day discharge (< 1 MGD).
NPDES	National Pollutant Discharge Elimination System.
NCBI (EPT BI)	North Carolina Biotic Index, EPT Biotic Index. A summary measure of the tolerance values of organisms found in the sample, relative to their abundance. Sometimes noted as the NCBI or EPT BI.
NCIBI	North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community.
NSW	Nutrient Sensitive Waters.
NTU	Nephelometric Turbidity Unit.

GLOSSARY (continued)

ORW	Outstanding Resource Waters.
Parametric Coverage	A listing of parameters measured and reported.
SOC	A consent order between an NPDES permittee and the Environmental Management Commission that specifically modifies compliance responsibility of the permittee, requiring that specified actions are taken to resolve non-compliance with permit limits.
Total S (or S)	The number of different taxa present in a benthic macroinvertebrate sample.
UT	Unnamed tributary.
WWTP	Wastewater treatment plant.
Web Sites	Basinwide planning -- http://h2o.enr.state.nc.us/basinwide/basinwide/default.html Biological monitoring -- http://www.esb.enr.state.nc.us/bau.html Fish kills -- http://www.esb.enr.state.nc.us/fishkill/fishkill00.html North Carolina Administrative Code that relates to the Division of Water Quality and water quality protection -- http://h2o.enr.state.nc.us/rules/ruleindex.html

Appendix B1.**Benthic macroinvertebrate sampling and criteria for freshwater Wadeable and flowing waters.**

Benthic macroinvertebrates can be collected using two sampling procedures. The Division's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (NCDEHNR 1997b).

An abbreviated method (4-sample EPT) includes one kick-net sample, one bank sweep, one leaf pack sample, and visual collections from large rocks and logs. Only EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification. "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution. Higher EPT taxa richness values usually indicate better water quality.

The purpose of these collections is to inventory the aquatic fauna and produce an indication of relative abundance for each taxon. Organisms are classified as Rare (1-2 specimens), Common (3-9 specimens), or Abundant (≥ 10 specimens).

Several data-analysis summaries (metrics) can be produced to detect water quality problems (Table B1).

Table B1. Benthos classification criteria for flowing water systems in the mountain ecoregion.

Metric	Sample type	Bioclass	Score
EPT S	10-sample Qualitative	Excellent	> 41
		Good	32 - 41
		Good-Fair	22 - 31
		Fair	12 - 21
		Poor	0 - 11
	4-sample EPT	Excellent	> 35
		Good	28 - 35
		Good-Fair	19 - 27
		Fair	11 - 18
		Poor	0 - 10
Biotic Index (range 0 - 10)	10-sample Qualitative	Excellent	< 4.05
		Good	4.06 - 4.88
		Good-Fair	4.89 - 5.74
		Fair	5.75 - 7.00
		Poor	> 7.00

These metrics are based on the idea that unstressed streams and rivers have many invertebrate

taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index.

EPT taxa richness (EPT S) is used with criteria to assign water quality ratings (bioclassifications). Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI). Tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions.

Water quality ratings assigned with the biotic index numbers are combined with EPT taxa richness ratings to produce a final bioclassification, using criteria for Mountain streams. EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. If the EPT taxa richness rating and the biotic index differ by one bioclassification, the EPT abundance value is used to determine the final site rating.

The expected EPT taxa richness values are lower in small high-quality mountain streams (< 4 m wide or with a drainage area < 3.5 mi²). For these small mountain streams, an adjustment to the EPT taxa richness values is made prior to applying taxa richness criteria.

EPT taxa richness and biotic index values also can be affected by seasonal changes. Criteria for assigning bioclassification are based on summer sampling: June-September. For samples collected outside summer, EPT taxa richness can be adjusted by subtracting out winter/spring Plecoptera or other adjustment based on resampling of summer site. The biotic index values also are seasonally adjusted for samples outside the summer season.

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis.

Flow Measurement

Changes in the benthic macroinvertebrate community are often used to help assess between-year changes in water quality. Some between-year changes in the macroinvertebrates, however, may be due largely to changes in flow. High flow years magnify the potential effects of nonpoint source runoff, leading to scour, substrate instability, and reduced periphyton. Low flow years may accentuate the effect of point source dischargers by providing less dilution of wastes. For these reasons, all between-year changes in the biological communities are considered in light of flow conditions (high, low, or normal) for one month prior to the sampling date. Daily flow information is obtained from the closest available USGS monitoring site and compared to the long-term mean flows. High flow is defined as a mean flow > 140% of the long-term mean for that time period, usually July or August. Low flow is defined

as a mean flow < 60% of the long-term mean, while normal flow is 60-140% of the mean. While broad scale regional patterns are often observed, there may be large geographical variation within the state, and large variation within a single summer period.

Habitat Evaluation

The Division has developed a habitat assessment form to better evaluate the physical habitat of a stream. The habitat score has a potential range of 1-100, based on evaluation of channel modification, amount of instream habitat, type of bottom substrate, pool variety, bank stability, light penetration, and riparian zone width. Higher numbers suggest better habitat quality, but no criteria have been developed to assign impairment ratings.

Appendix B2.

Benthic macroinvertebrate data collected in the Little Tennessee River basin, 1983 - 1999. Current basinwide monitoring sites have the Map No. bolded.

Subbasin/Stream	Location	County	Map No.	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class ¹
01								
L Tennessee R	SR 1629	Macon	B-1	2-(1)	08/99	60/14	6.23/4.74	F
					08/94	69/27	5.27/4.41	G-F
L Tennessee R	SR 1651	Macon	B-2	2-(1)	10/99	62/29	4.41/3.48	G-F
					08/87	64/20	5.63/4.74	G-F
					08/85	52/18	5.53/4.77	F
					08/83	66/21	5.94/4.64	F
L Tennessee R	NC 28	Macon	B-3	2-(1)	08/99	86/32	5.33/3.75	G-F
					07/94	57/27	5.02/4.27	G
					08/87	75/28	5.49/4.44	G-F
					06/86	72/26	5.70/4.51	G-F
					08/85	64/26	5.18/4.26	G-F
					08/84	64/28	4.92/4.17	G-F
					08/83	73/30	5.28/4.12	G-F
Middle Cr	SR 1635	Macon	B-4	2-(8)	08/99	-/25	-/4.15	G-F
Coweeta Cr	SR 1114	Macon	B-5	2-10	08/99	-/39	-/3.01	E
					07/94	-/39	-/2.89	E
Cartoogechaye Cr	SR 1307	Macon	B-6	2-19-(1)	06/96	84/45	3.21/2.70	E
Cartoogechaye Cr (downstream)	SR 1307	Macon	B-7	2-19-(1)	06/96	77/36	3.93/2.83	G
Cartoogechaye Cr	SR 1146	Macon	B-8	2-19-(1)	08/99	-/41	-/3.18	E
					07/94	-/30	-/3.29	G
Cartoogechaye Cr	SR 1152	Macon	B-9	2-19-(10.5)	08/88	62/16	5.31/4.44	G-F
Cullasaja R (above Mirror Lake)	US 64	Macon	B-10	2-21-(0.5)	06/99	47/14	5.70/4.97	F
					10/96	-/18	-/4.82	F
					10/91	-/9	-/5.59	P
					12/90	-/14	-/4.87	F
Mill Cr (above old WWTP)		Macon	3-11	2-21-3	10/91	36/12	5.32/4.41	F
					12/90	-/15	-/4.25	F
Mill Cr (below old WWTP)		Macon	B-12	2-21-3	06/99	44/15	4.53/3.69	F
					10/91	50/12	5.49/3.90	F
					12/90	-/17	-/3.14	F
Cullasaja R (below Lake Sequoyah)	off US 64	Macon	B-13	2-21-(5.5)	10/96	-/20	-/4.12	G-F
					07/94	70/27	5.10/3.76	G-F
					10/91	-/20	-/4.02	G-F
					12/90	-/30	-/3.38	G-F
Cullasaja R (at Jackson Hole)	off US 64	Macon	B-14	2-21-(5.5)	06/99	-/49	-/2.70	E
Cullasaja R	SR 1678	Macon	B-15	2-21-(5.5)	06/99	90/50	3.71/2.86	E
					10/96	86/45	3.57/2.60	E
					07/94	85/42	4.01/3.23	E
					10/91	95/48	3.74/3.08	E
					12/90	-/37	-/2.71	G
Cullasaja R	US 64/SR 1524	Macon	B-16	2-21-(5.5)	10/96	-/37	-/2.47	G
					10/91	-/35	-/3.33	G
					12/90	-/28	-/3.17	G-F
Cullasaja R	US 64/SR 1668	Macon	B-17	2-21-(5.5)	08/99	99/51	3.95/3.34	E
Big Cr (above Highlands WTP)		Macon	B-18	2-21-51-1-(4)	06/99	-/41	-/2.04	E
Turtle Pond Cr	SR 1620	Macon	B-19	2-21-8	06/99	-/42	-/1.90	E
Brush Cr (near mouth)	near US 64	Macon	B-20	2-21-13	06/99	-/47	-/2.09	E
Buck Cr	NC 28	Macon	B-21	2-21-15	06/99	-/38	-/2.11	E
Walnut Cr	SR 1533	Macon	B-22	2-21-17	06/99	-/34	-/2.03	G
Elijay Cr	SR 1524	Macon	B-23	2-23-23	06/99	-/40	-/3.20	E
N Pr Elijay Cr	SR 1001	Macon	B-24	2-21-23-2	06/99	-/39	-/2.01	E
Crawford Br (at Franklin Memorial Pk)		Macon	B-25	2-22	06/99	-/24	-/3.66	NR
Crawford Br (at E Main St, Franklin)		Macon	B-26	2-22	06/99	33/7	7.50/4.70	NR
Iotla Cr	SR 1372	Macon	B-27	2-27	08/99	-/35	-/3.80	G
					07/94	-/21	-/4.25	G-F
Cowee Cr	NC 28	Macon	B-28	2-29	08/99	-/35	-/3.06	G
					07/94	-/24	-/3.32	G-F
Burningtown Cr	SR 1371	Macon	B-29	2-38	08/99	-/39	-/3.19	E
					07/94	-/30	-/2.72	G
Tellico CR	SR 1367	Macon	B-30	2-40	08/99	108/54	3.57/2.61	E
					07/94	84/43	3.46/2.69	E

Appendix B2 (continued).

Subbasin/Stream	Location	County	Map No. ¹	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class ¹
02								
Little Tennessee R	off SR 1113	Swain	B-1	2-(1)	08/99	75/31	4.73/3.67	G
					07/94	82/39	4.71/4.15	G
					06/94	79/32	4.61/3.98	G
Alarka Cr	SR 1140	Swain	B-2	2-69-(2.5)	11/88	59/37	2.33/1.63	E
Alarka Cr	SR 1185	Swain	B-3	2-69-(2.5)	08/99	86/51	3.66/3.11	E
					07/94	91/48	3.69/3.08	E
Bearmeat Br	Near SR 1140	Swain	B-4	2-69-3	11/88	-/24	-/1.71	G
Tuckasegee R (below Greenland Cr)		Jackson	B-5	2-79-(0.5)	06/88	99/51	3.85/2.80	E
Tuckasegee R	SR 1140	Jackson	B-6	2-79-(0.5)	07/99	-/46	-/1.95	E
					09/94	-/39	-/2.42	E
					09/89	101/47	3.59/1.97	E
UT Panthertown Creek		Jackson	B-7	2-79-1	06/99	-/26	-/1.25	E
Panthertown Creek		Jackson	B-8	2-79-1	06/99	-/28	-/1.72	G
Hurricane Cr	SR 1145	Jackson	B-9	2-79-23-2	12/91	-/45	-/1.66	E
					09/89	-/39	-/2.06	E
Cedar Cr	SR 1120	Jackson	B-10	2-79-23-3	09/89	89/40	4.36/2.92	G
Grassy Camp Cr (headwaters)		Jackson	B-11	2-79-23-4-1	08/84	52/21	4.27/2.04	G-F
Grassy Camp Cr	SR 1145	Jackson	B-12	2-79-23-4-1	09/89	-/27	-/2.03	G-F
UT Shortoff Cr	SR 1150	Jackson	B-13	2-79-23-4-1-1	08/84	54/27	2.50/1.18	E
Mill Cr	SR 1145	Jackson	B-14	2-79-23-5	09/89	-/28	-/2.08	G
Pine Cr	SR 1145	Jackson	B-15	2-79-23-6	09/89	87/36	4.34/2.96	G
W Fk Tuckasegee R	SR 1133	Jackson	B-16	2-79-23-(7)	07/99	-/35	-/2.98	G
Caney Fk	SR 1740	Jackson	B-17	2-79-28-(2.5)	07/99	97/53	3.68/3.03	E
					07/94	93/56	3.25/2.68	E
Mull Cr	SR 1737	Jackson	B-18	2-79-28-3	07/94	-/29	-/1.45	G
Moses Cr	SR 1739	Jackson	B-19	2-79-28-8	07/99	-/37	-/1.91	E
Moses Cr	SR 1740	Jackson	B-20	2-79-28-8	07/94	-/33	-/2.47	G
Cullowhee Cr	SR 1001	Jackson	B-21	2-79-31	07/99	-/43	-/2.95	E
					08/94	-/32	-/2.59	G
Whiterock Cr (near school)		Jackson	B-22	2-79-31-1-(2)	12/91	-/31	-/1.64	E
Savannah Cr	SR 1367	Jackson	B-23	2-79-36	07/99	53/32	3.80/3.48	G
					07/94	77/40	3.88/3.22	E
Tuckasegee R	SR 1378 (at end)	Jackson	B-24	2-79-(38)	07/99	75/40	4.31/3.81	G
Tuckasegee R	off SR 1377	Jackson	B-25		07/94	101/48	4.43/3.41	E
					08/90	86/43	4.17/3.32	G
					08/88	83/39	4.45/3.15	G
					07/86	67/32	4.73/3.53	G
					08/84	65/25	4.68/3.77	G-F
Scott Cr	SR 1556	Jackson	B-26	2-79-39	07/99	70/36	4.14/3.22	G
					07/94	69/28	5.27/3.91	G-F
Fisher Cr (above WTP)	SR 1447	Jackson	B-27	2-79-39-11-(1)	04/87	-/24	-/2.50	G*
Fisher Cr (below WTP)	SR 1447	Jackson	B-28	2-79-39-11-(2)	04/87	-/24	-/2.49	G*
Conley Cr	SR 1177	Swain	B-29	2-79-52	07/99	-/44	-/3.17	E
					07/94	94/42	3.62/3.10	E
Beech Flats Pr (headwaters, above)	US 441	Swain	B-30	2-79-55-2	10/95	39/26	1.46/0.85	E*
Beech Flats Pr (below)	US 441	Swain	B-31	2-79-55-2	10/95	16/7	3.08/0.37	F*
Beech Flats Pr	US 441	Swain	B-32	2-79-55-2	09/94	-/22	-/1.35	G-F
Beech Flats Pr (above Kephart Pr)		Swain	B-33	2-79-55-2	10/95	69/41	1.90/1.17	E
Kephart Pr (near mouth)		Swain	B-34	2-79-55-3	10/95	63/42	1.92/1.26	E
Oconaluftee R (below Bradley Fk)	US 441	Swain	B-35	2-79-55-(11)	03/89	86/48	2.39/1.65	E
Bradley Fk (at Smokemont)	off US 441	Swain	B-36	2-79-55-12-(11)	07/99	67/39	2.67/1.87	E
					10/95	69/42	1.94/1.24	E
					09/94	-/31	-/1.24	G
					03/89	-/45	-/1.68	E
Mingus Cr	US 441	Swain	B-37	2-79-55-16-(2)	03/89	-/41	-/2.06	E
Oconaluftee R (below Raven Fk)	US 441	Swain	B-38	2-79-55-(16.5)	03/89	-/42	-/2.29	E
Oconaluftee R (at Birdtown)	SR 1359	Swain	B-39	2-79-55-(16.5)	07/99	104/53	3.98/3.28	E
					07/94	86/46	4.12/3.12	G
					07/89	88/47	4.21/3.33	E
					03/89	93/50	3.74/2.83	E
					08/87	102/44	4.28/3.04	E
					08/85	93/41	4.13/2.95	G

Appendix B2 (continued).

Subbasin/Stream	Location	County	Map No. ¹	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class ¹
Raven Fk (above trout farm)	USFS Road	Swain	B-40	2-79-55-17-(13.5)	03/89	-/43	-/1.48	E
Raven Fk (below Cherokee trout farm)		Swain	B-41	2-79-55-17-(15)	03/89	-/43	-/2.28	E
Raven Fk (below Straight Fk)		Swain	B-42	2-79-55-17-(15)	03/89	-/43	-/2.49	E
Raven Fk (below Sequoyah Church)		Swain	B-43	2-79-55-17-(15)	03/89	-/41	-/2.40	G
Straight Fk (below hatchery)		Swain	B-44	2-79-55-17-16-(20.5)	03/89	-/47	-/1.92	E
Soco Cr (near mouth)	old US 441	Swain	B-45	2-79-55-21	03/89	83/41	3.39/2.71	E
Deep Cr (above campground)		Swain	B-46	2-79-63-(16)	08/99	-/47	-/2.66	E
					07/94	-/41	-/2.27	E
Deep Cr	SR 1340	Swain	B-47	2-79-63-(21)	08/99	-/45	-/3.07	E
					07/94	88/50	3.17/2.42	E
Noland Cr (near mouth)		Swain	B-48	2-90	08/99	-/40	-/1.97	E
Forney Cr (near mouth)		Swain	B-49	2-97	08/99	81/46	2.66/1.68	E
					07/94	79/46	2.49/1.60	E
Bear Cr (near mouth)		Swain	B-50	2-97-17	07/94	71/44	2.19/1.43	E
Panther Cr	SR 1233	Swain	B-51	2-115	08/99	-/39	-/2.24	E
					07/94	-/37	-/1.86	E
Stecoah Cr	SR 1237	Swain	B-52	2-130	08/99	-/39	-/3.02	E
					07/94	-/29	-/3.69	G
Hazel Cr (near mouth)		Swain	B-53	2-146-(19)	08/99	106/56	2.95/1.96	E
					07/94	96/47	2.86/1.94	E
03								
Nantahala R (near Rainbow Springs)	USFSR 437	Macon	B-1	2-57-(0.5)	08/99	100/49	3.43/2.45	E
					07/94	77/48	2.68/2.22	E
					11/93	80/46	3.12/2.31	E
					07/91	94/54	2.45/1.65	E
					08/90	98/53	3.04/2.36	E
					08/88	98/49	3.46/2.67	E
					07/86	106/48	3.67/2.53	E
					08/84	106/45	3.78/2.16	E
Nantahala R	off SR 1401	Macon	B-2	2-57-(22.5)	11/93	-/33	-/3.07	G
Nantahala R	USFSR 308	Macon	B-3	2-57-(22.5)	08/99	-/41	-/2.41	E
					11/93	72/37	3.70/3.17	G
Nantahala R	SR 1310	Macon	B-4	2-57-(22.5)	11/93	66/39	4.19/3.12	G
Nantahala R	US 19/74	Swain	B-5	2-57-(22.5)	08/99	-/35	-/2.29	G
					07/94	71/36	3.67/2.19	G
					11/93	65/32	4.06/1.92	G
					07/86	68/27	4.68/2.77	G
					08/84	60/22	5.39/3.06	G-F
Bryson Br	USFSR 437	Macon	B-6	2-57-18	10/98	47/27	2.56/1.76	G
					09/95	59/33	2.44/1.70	E
Roaring Fk	USFSR 437	Macon	B-7	2-57-22	10/98	41/27	2.16/1.75	G
					09/95	57/31	2.48/1.68	E
Nantahala R, US 19/74, Swain	US 19/74	Swain	B-8	2-57-(22.5)	11/93	54/24	3.85/2.12	G-F
Jarrett Cr	USFSR 437	Macon	B-9	2-57-27	09/95	-/35	-/1.51	G
Big Choga Cr	USFSR 440	Macon	B-10	2-57-32	09/95	-/30	-/1.40	E
Wine Spring Cr	SR 1310	Macon	B-11	2-57-39	09/95	-/21	-/1.31	G-F
Dick's Cr	off SR 1401	Macon	B-12	2-57-42	08/99	-/34	-/1.93	G
					11/93	-/26	-/2.70	G-F
Whiteoak Cr (above trout farm)	off USFS Road 711	Macon	B-13	2-57-45	08/90	84/47	2.50/1.79	E
					05/90	83/48	2.50/1.52	E
					01/90	78/46	2.10/1.41	E
					11/88	59/34	2.32/1.63	E
Whiteoak Cr (below trout farm)	SR 1397	Macon	B-14	2-57-45	08/90	60/20	5.90/2.58	F
					05/90	79/35	4.06/1.92	G-F
					01/90	83/39	3.92/2.26	G-F
					11/88	41/10	6.16/1.63	F
Whiteoak Cr	SR 1423	Macon	B-15	2-57-45	08/90	94/31	4.32/2.14	G
					05/90	1044/46	3.31/1.86	G
					01/90	77/37	3.61/2.35	G-F

Appendix B2 (continued).

Subbasin/Stream	Location	County	Map No. ¹	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class ¹
Whiteoak Cr (above dam)	off SR 1310	Macon	B-16	2-57-45	08/99	-/31	-/2.14	G
					11/93	-/33	-/2.40	G
					08/90	78/26	4.07/1.91	G
					05/90	96/44	3.32/1.85	G
					11/88	-/33	-/2.50	G
Cold Spring Cr	USFS R 711	Macon	B-17	2-57-45-8	01/90	-/41	-/1.80	G
Queens Cr	SR 1412	Macon	B-18	2-57-51	08/99	-/29	-/1.38	E
					11/93	-/27	-/1.56	E
Silvermine Cr	SR 1103	Swain	B-19	2-57-55	11/93	-/22	-/2.77	G-F
04								
Tulula Cr	SR 1275	Graham	B-1	2-190-2-(0.5)	08/99	85/40	4.08/3.24	G
					07/94	78/34	3.76/2.97	G
Bear Cr	SR 1201	Graham	B-2	2-190-2-1	07/94	64/34	3.53/2.60	E
Cheoah R	SR 1138	Graham	B-3	2-190-2-(3.5)	07/89	80/39	3.88/3.07	E
					07/89	-/38	-/2.91	E
					08/87	97/40	4.77/3.45	G
					08/85	74/34	4.74/3.49	G
					08/83	81/32	4.56/3.31	G
Cheoah R	off US 129	Graham	B-4	2/190-(3.5)	07/94	73/32	4.01/3.42	G
Cheoah R	off SR 1138	Graham	B-5	2-190-(3.5)	08/99	88/48	3.48/2.84	E
Snowbird Cr	SR 1120	Graham	B-6	2-190-9-(0.5)	08/99	-/52	-/2.60	E
					06/90	-/49	-/1.66	E
Snowbird Cr	SR 1119	Graham	B-7	2-190-9-(15.5)	07/94	-/33	-/1.97	G
					06/90	-/47	-/2.08	E
L Snowbird Cr	SR 1115	Graham	B-8	2-190-9-17	08/99	-/39	-/1.41	E
W Buffalo Cr	Off SR 1123	Graham	B-9		06/90	83/40	2.95/1.79	E
W Buffalo Cr	SR 1123	Graham	B-10	2-190-12	08/99	-/39	-/2.54	E
					06/90	-/43	-/2.05	E
Hooper Mill Cr	Near SR 1123	Graham	B-11	2-190-12-3	06/90	85/49	2.24/1.69	E

¹ E = Excellent, G = Good, G-F = Good-Fair, F = Fair, P = Poor, and NR = Not Rated.

*Small stream criteria