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

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OVERVIEW OF THE WATER QUALITY OF THE CAPE FEAR RIVER BASIN

Basin Description

The Cape Fear River Basin is the largest river basin in the state, covering 9,149 square miles in 24 counties (Figure 1). There is an estimated 6,300 miles of streams and rivers in the basin confined to the Piedmont and Coastal Plain ecoregions. These ecoregions are further subdivided into Southern Outer Piedmont, Northern Inner and Outer Piedmont, Carolina Slate Belt, and Triassic Basin in the Piedmont. The Coastal Plain contains the Sand Hills, Rolling Coastal Plain, Carolina Flatwoods, and the Southeast and Mid-Atlantic Floodplains and Low Terraces subecoregions. The Cape Fear River is formed by the confluence of the Deep and Haw Rivers at the Chatham/Lee County line. B. Everett Jordan Reservoir is the largest impoundment in the basin. Several large tributaries join the river as it flows towards the Atlantic Ocean near Southport: Upper and (Lower) Little Rivers, Rockfish Creek, Black River, South River and the Northeast Cape Fear River.

The basin is characterized by highly urban and industrialized areas around the cities of Greensboro, High Point, Burlington, Chapel Hill, and Durham in the upper part of the watershed and around Fayetteville and Wilmington in the middle and lower part. Fort Bragg Military Reservation occupies a large area in the middle of the basin. As might be expected in such a populous area, water quality in the basin has been affected by the impacts of numerous dischargers and nonpoint source runoff.

The basinwide monitoring in 2003 was significantly hampered by continuous high flows at many of the biological sampling sites. Many sites simply could not be sampled. Those that were sampled, have results complicated by the extreme drought in 2002, where many rivers and streams dried up that have never been known before to dry up. There was nothing typical about the present 5 year basin cycle (1999 - 2003), and this must always be kept in mind when using the data presented in this report.

Haw River Drainage (Subbasins 01 – 04)

The Haw River originates in the Northern Inner Piedmont ecoregion near Oak Ridge in Guilford County and drains 1,526 square miles. The most upstream tributaries of the Haw River are Troublesome and Little Troublesome Creeks. The combination of agricultural land use and highly erodible soils produces widespread nonpoint source problems in the upper Haw River and Troublesome Creek watersheds. Several Haw River sites could not be sampled in 2003, but a Good-Fair benthos rating was given to the Haw River near Altamahaw. This site fluctuates between Fair and Good-Fair. Substantial improvements in the fish community were documented in Little Troublesome Creek after a discharge was relocated to the Haw River. However, the fish and benthic communities in Little Troublesome Creek continued to be impacted by urban runoff and numerous other nonpoint sources (Figure 2). Lake Hunt and Reidsville Lake, in the Troublesome Creek watershed, were evaluated as eutrophic in 2003.

As the Haw River continues downstream, Reedy Fork and its two major tributaries, North and South Buffalo Creeks, join it. There are several major dischargers in the area; the largest of these are Greensboro's T. Z. Osborne South Buffalo Creek WWTP (40 MGD) and the Greensboro North Buffalo Creek WWTP (16 MGD). These two facilities have been monitored by water chemistry samples at ambient sites, self-monitoring toxicity data, and collections of fish and benthic macroinvertebrates. The segments of North and South Buffalo Creeks below the two dischargers constitute two of the worst water quality problems in the state. Conductivity values were elevated in these streams (the median value in North Buffalo Creek was 370 µmhos/cm and 636 µmhos/cm in South Buffalo Creek from 1998 through 2003). Nutrient concentrations were high and there were elevated concentrations of total copper. Fish and macroinvertebrate sampling have shown Poor water quality below these discharges. Upstream biological collections have also shown Poor water quality due to urban stormwater runoff.

The upper site on Reedy Fork maintained its Good-Fair benthos rating, although residential areas are encroaching into the watershed as the City of Greensboro expands. A downstream site on Reedy Fork declined to Fair in 2003. Horsepen Creek is an example of a stream which has declined over time as a result of urban growth. This site declined from Good-Fair in 1986 to Poor in 2003. Lakes Higgins, Brandt, and Townsend are in the upper section of Reedy Fork and were evaluated as eutrophic in 2003.

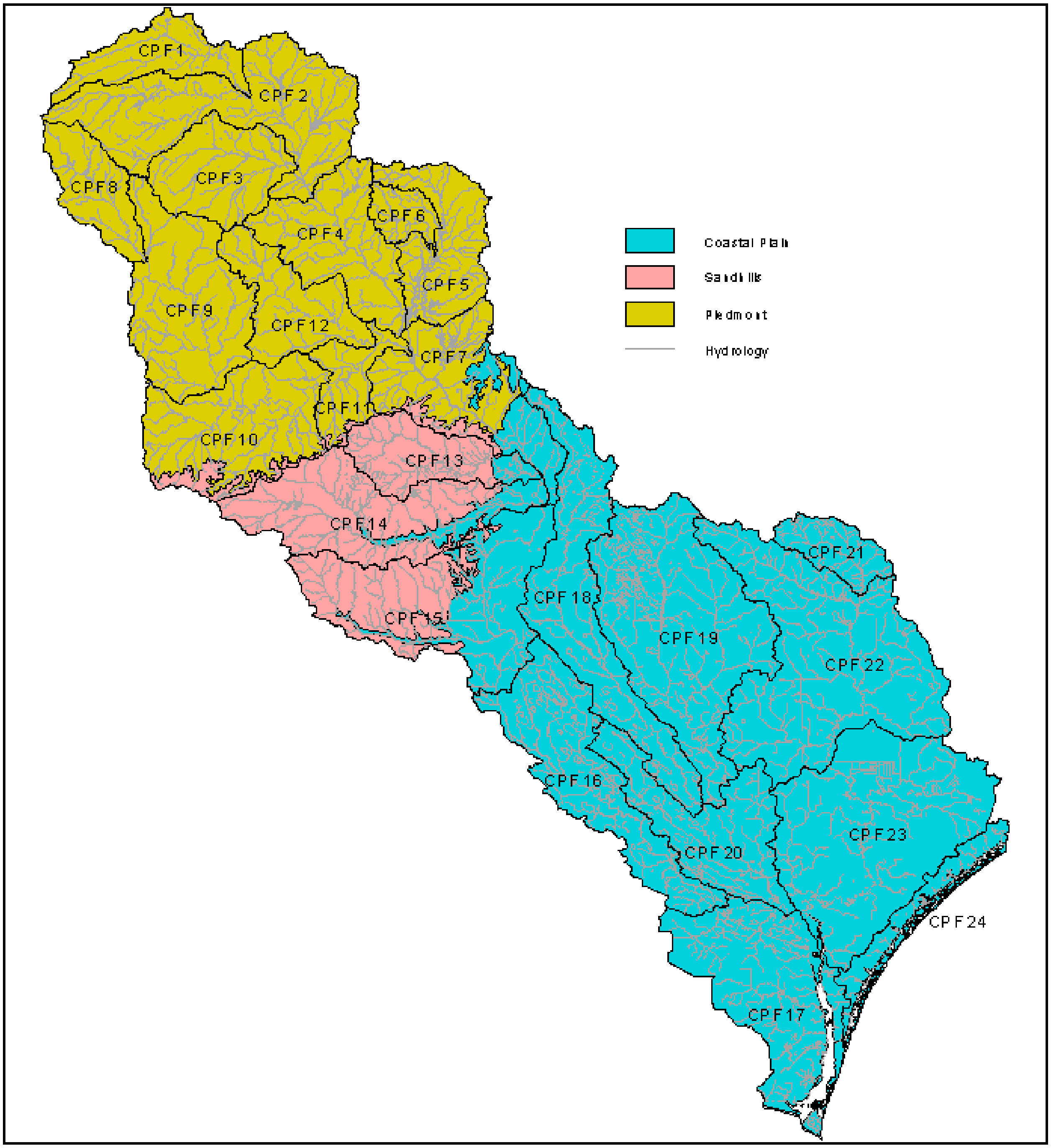


Figure 1. **Physiographic regions and subbasins of the Cape Fear River basin.**

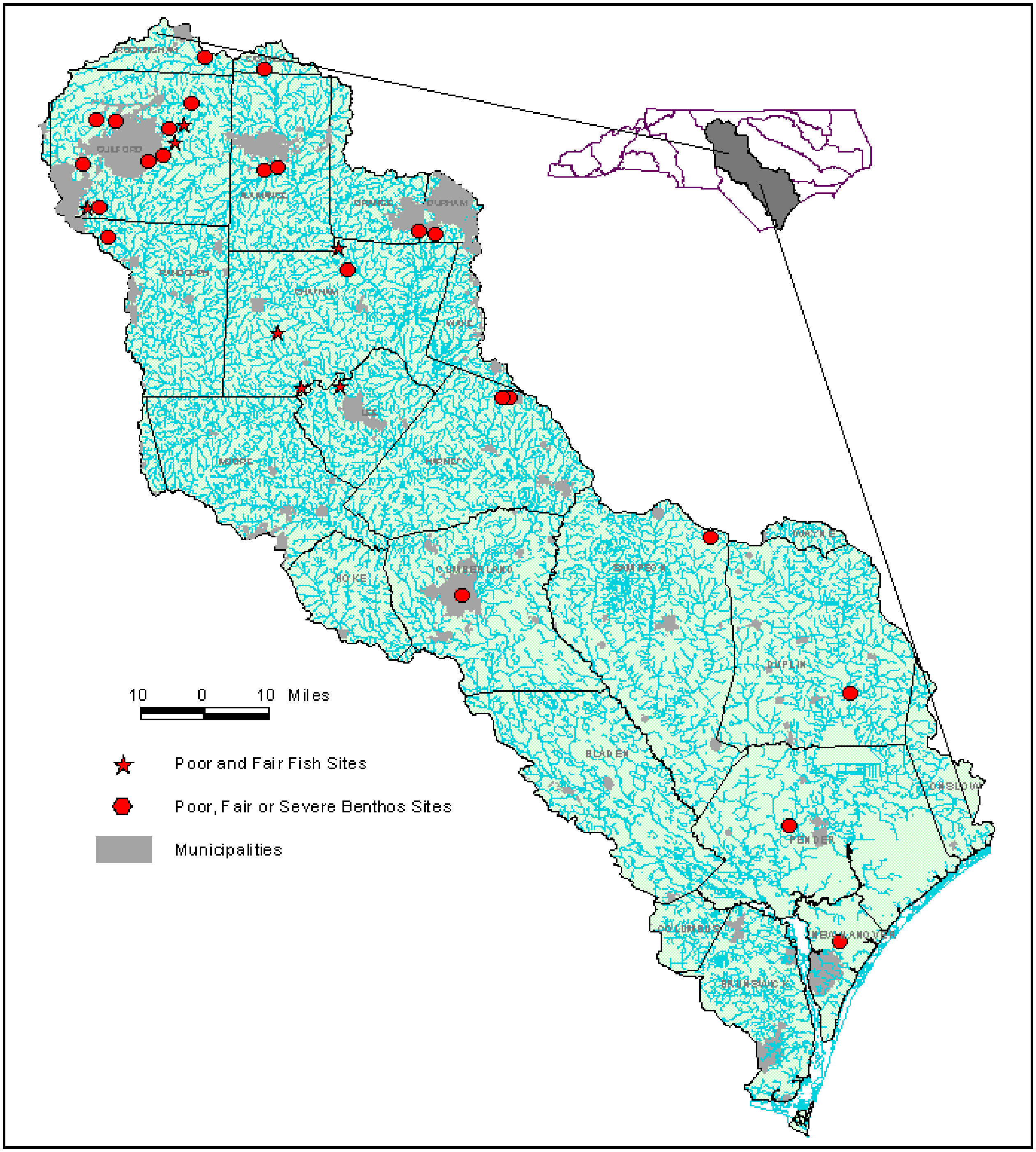


Figure 2. **Fish community and benthic macroinvertebrate assessment sites rated Fair, Poor, or Severe in the Cape Fear River basin, 2003. Stars = fish sites and circles = benthic macroinvertebrate sites.**

Haw, Jordan, and Stony Creeks had Good or Good-Fair benthos ratings in the past despite having degraded habitats and being affected by agricultural runoff. Haw Creek, which rated Good in 1998, declined to Good-Fair in 2003, but flow extremes may have played a role in this change. The fish communities in Stony and Jordan Creeks rated Good-Fair.

The Alamance Creek watershed is in the Burlington-Graham area. Benthos ratings in 2003 were either Fair (Big Alamance and Little Alamance Creeks) or Good-Fair (Stinking Quarter Creek). Little Alamance Creek rated Poor in 1998. Big Alamance and Stinking Quarter Creeks ratings declined from 1998. It was difficult to determine whether the declines could be attributed to lasting effects from the 2002 drought or increased nonpoint source inputs in 2003 from high rainfall. Fish community ratings varied from Excellent (South Prong Stinking Quarter Creek) to Good (North Prong Stinking Quarter Creek and Little Alamance Creek) (Figure 3) to Good-Fair (Big Alamance and Little Alamance Creeks). Burlington Reservoir, Lake Burlington, Lake McIntosh, and Graham-Mebane Reservoir were eutrophic in 2003.

The lower reach of the Haw River, above its confluence with B. Everett Jordan Reservoir, is approximately 25 river miles in length and contains many small to medium sized tributaries. Many of these tributaries are located within the Carolina Slate Belt ecoregion and were severely impacted by the 2002 drought, and had not recovered in 2003. Comparing 2003 to 1998 data for the few sites sampled, the benthic communities in Cane, Dry, and Pokeberry Creeks may be declining and certainly warrant future sampling in this rapidly growing area. Fish community analyses from this area ranged from Poor to Excellent. The Poor rating at Collins Creek was attributed to drought-induced declines in fish numbers and diversity. Terrells Creek appeared to have recovered from the drought and rated Excellent. Ferrells and Robson Creeks rated Good, although the fish community in Robeson Creek indicated elevated nutrient concentrations. Cane Creek Reservoir and Pittsboro Lake, on Robeson Creek, were evaluated as eutrophic in 2003.

Benthic data from the Haw River indicated that water quality conditions improved downstream near the Haw River arm of Jordan Lake at US 64 (Good in 1998 and 2002) compared to upstream reaches near Saxapahaw (Good-Fair in 1998 and 2002). Water chemistry data indicated generally good water quality with few violations of water quality criteria.

B. Everett Jordan Reservoir and Tributaries (Subbasins 05 - 06)

Intensive monitoring and research of the 14,300 acre B. Everett Jordan Reservoir (Jordan Lake) has been performed by many scientists since the reservoir was filled in 1981. The multi-purpose reservoir was created for flood control, fish and wildlife habitat, recreation, and water supply. It is now being used for water supply by the cities of Cary and Apex. The Haw River makes up 70 to 90 percent of the annual flow into the reservoir with an average retention time of five days. The New Hope Arm has an average retention time of 418 days. Jordan Lake is about five miles in length on the Haw River arm and 17 miles long on the New Hope Creek arm.

It is one of the most eutrophic reservoirs in the state. Severe subsurface algal blooms were dominated by filamentous bluegreen species in August 2003.

Other tributaries to Jordan Lake, besides the Haw River, include Northeast, New Hope, White Oak, and Morgan Creeks. These streams drain the highly urbanized areas of Chapel Hill and Durham and are affected by point and nonpoint sources of pollution. These streams are also in the Triassic basin and can have very low flows. Such low flows made evaluation by benthos not possible in 2003 for White Oak Creek. New Hope Creek was given a Good-Fair fish community rating and a Fair benthos rating at downstream sites. An upstream benthos site showed Good-Fair water quality.

Upstream reaches of Morgan Creek stopped flowing in 2003 and a study indicated that the benthos did not return to pre-drought conditions until October 2003, when 22 EPT taxa were collected. Only two EPT taxa had been found when the stream resumed flowing when the drought ended in 2002. University Lake on Morgan Creek was hypereutrophic in 2003. Water quality conditions degrade as streams flow through the suburban and urban sections of Chapel Hill. Fair benthos and Poor fish ratings were given to the lower reach of Morgan Creek below the Orange Water and Sewer Authority's Mason Farm WWTP.

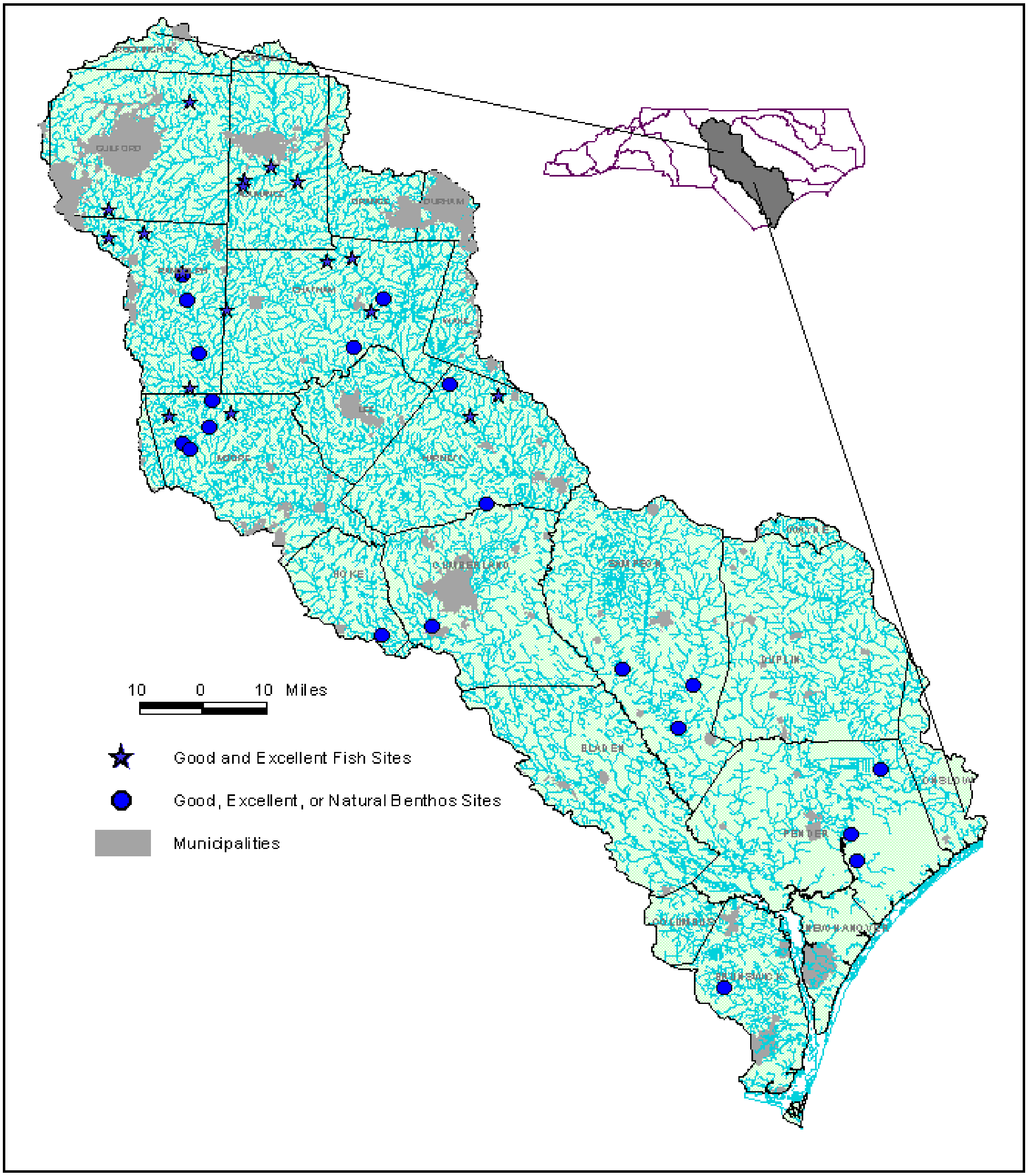


Figure 3. **Fish community and benthic macroinvertebrate assessment sites rated Good, Excellent, or Natural in the Cape Fear River basin, 2003. Stars = fish sites and circles = benthic macroinvertebrate sites.**

Deep River Drainage (Subbasins 08 - 11)
Mainstem
The Deep River originates in eastern Forsyth County. Draining an area of approximately 1,442 square miles, it flows about 116 miles to its confluence with the Haw River. The Fall Line, separating the Piedmont from the Coastal Plain ecoregions, lies at this confluence. The Deep River is impounded by more than 16 small dams between High Point and its confluence. These reservoirs slow the river's velocity and limit the system's assimilative capacity. The average slope along the entire river from the High Point dam to its mouth is about 5 feet per mile. The fall is rapid down to the mouth of McLendons Creek, where it begins to flatten out. The watershed terrain changes from hilly and rolling in Randolph and Guilford counties to flat or gently rolling in Moore and Lee counties with some swampy areas. The river generally has high banks and few large flood plains.

Its headwaters, the East and West Forks of the Deep River, are affected by nonpoint source runoff, small dischargers, and by low summer flows. But, there is a contrast between the East Fork Deep River (urban/residential) and the West Fork Deep River (agricultural). Macroinvertebrate data clearly showed more severe water quality problems in the East Fork (Fair) than in the West Fork (Good-Fair) in 2003, as it did in 1998. A TMDL stressor study in the East Fork Deep River watershed found only one small stream that was not degraded.

High Point Lake (fed by the East and West Forks Deep River) and Oak Hollow Lake (on the West Fork Deep River) have significant and chronic water quality problems. The reservoirs suffer from many problems related to cultural eutrophication – taste and odor problems related to planktonic algal blooms, problems related to bluegreen algal mats along the shoreline and in shallow water, and dissolved oxygen, and aesthetic problems. The algal blooms resulted in exceedances of water quality standards for chlorophyll *a*, dissolved oxygen, and pH.

Urban areas in the Deep River watershed include High Point, Randleman, Ramseur, Asheboro, and Sanford. Municipal wastewater treatment plants in these cities discharge either directly or indirectly to the Deep River, and their effluents may make up the majority of the flow during low flow periods. Water quality has improved since 1983 and these improvements have been related to upgrades at several of the wastewater treatment plants. A Deep River site at Randleman has consistently been Good-Fair since 1988 based on benthos data. Local governments formed the Piedmont Triad Regional Water Authority (PTRWA) in 1986 with plans to construct Randleman Lake for a drinking water supply. On August 7, 2001 construction on the Randleman Lake Dam officially began.

Benthos samples from the Deep River at Ramseur edged into the Good range in 2003, compared to Good-Fair since 1986. The benthic community was not significantly different though. Benthos data from a Deep River location in Moore County have consistently indicated an Excellent bioclassification, as was true in 2003. Most of the Deep River in Moore County (from Grassy Creek to NC 42 near Carbonton) is classified as HQW. Ambient water quality samples are collected from the Deep River at High Falls and the Deep River at Carbonton. Slow moving reaches of the river, including the Carbonton impoundment, are severely impacted by nutrient loading from upstream sources.

Deep River Tributaries
The City of High Point's Eastside WWTP is permitted to discharge 16 MGD to Richland Creek, just above its confluence with the Deep River. The fish community rated Richland Creek above the WWTP Fair and the benthic community rated the creek Fair below the WWTP in 2003.

A TMDL stressor study in the Hickory Creek watershed resulted in Fair and Good-Fair ratings, but the fish community in Hickory Creek was rated Good. Muddy Creek was given a Fair benthos rating, but this small stream may have dried up during the drought. The fish community in Muddy Creek has fluctuated between Good and Fair. The fish community in Bull Run was rated Good-Fair.

Hasketts Creek is the next major downstream tributary and receives the discharge from the Asheboro WWTP. A TMDL stressor study found Poor and Fair water quality throughout the watershed, not just below the WWTP. The stream receives urban runoff from the City of Asheboro.

Benthos surveys conducted in tributary catchments from the Town of Ramseur to Moore County noted Good bioclassifications in 2003 at Sandy and Richland Creeks. Brush Creek was sampled at two locations for benthic macroinvertebrates and fish. An upstream site was rated Good based upon its fish community, while a site further downstream decreased one bioclassification from Good in 1998 to Good-Fair in 2003 based on its benthic macroinvertebrates. Fork Creek is a new fish community regional reference site that was rated Good. Evidence of extreme high flows in the previous six months and the 2002 drought may have prevented an Excellent rating.

Sandy Creek Reservoir serves as the major water supply for the Town of Ramseur and was classified as eutrophic in 2003. Blooms of diatoms and bluegreen algae were prevalent during the summer and caused high chlorophyll *a* concentrations that exceeded the water quality standard. These blooms were also the source of drinking water taste and odor problems. Dissolved oxygen saturation levels were also elevated and exceeded the water quality standard. Carthage City Lake, the water source for the Town of Carthage, progressed from oligotrophy in June to eutrophy in August.

Water quality in upper Cotton Creek is impacted by the discharge from the Town of Star's WWTP (0.6 MGD). Ongoing and continuing effluent toxicity problems in the Town of Star, mostly due to salts from textile waste, have prompted the town to explore sewer regionalization with the Towns of Bisco and Troy to resolve this issue. An engineering analysis was underway as of April 2004. The bioclassification in Cabin Creek improved to Good at the Mill Creek confluence (fish and benthos). Wet , Bear, and Mill Creeks also had Good benthos or fish ratings. Buffalo Creek (Subbasin 10) was rated as Good Fair, but it was not rated in the past possibly due to its ephemeral qualities. The NCIBI was Good for Buffalo Creek at the same site. The NCIBI ratings for Cabin and Indian Creeks decreased from Excellent to Good and Fair respectively. Cabin Creek should recover from the effects of highly fluctuating flows soon. However, Indian Creek, a former reference site, suffered serious effects from extensive logging operations and subsequent scouring effects from high flows in 2003.

The Triassic basin streams, Little Buffalo and Georges Creeks, will not be rated for benthos until better criteria are derived for such streams. The fish community rating at Buffalo Creek (Subbasin 11) improved from Poor to Fair but the number of fish collected at this site has progressively declined since 1993.

Rocky River (Subbasin 12)

The Rocky River, a major tributary of the Deep River, is approximately 35 river miles in length. It is located mainly within Chatham County. Land use within its watershed is primarily agriculture, dairy production, and forest. This watershed is also in the Carolina Slate Belt. Siler City is the only urban area. The Rocky River Reservoir is an impoundment of the Rocky River high in its watershed that provides water supply for Siler City. Monitoring results in 2003 characterized the reservoir as hypereutrophic.

Benthos bioclassifications from locations on the mainstem of the Rocky River in 2003 indicated that upstream reaches were either not rated due to ongoing drought effects (at US 64), were Good-Fair (at SR 2170), or Good (at US 15-501, near the confluence with the Deep River). A fish sample from above the reservoir had a Fair NCIBI. Several reaches of the lower Rocky River have been designated Critical Habitat for the Cape Fear Shiner by the US Fish and Wildlife Service.

Special surveys on Loves Creek have been conducted to assess the effects of Siler City's WWTP. Though a TMDL stressor study suggested that some impairment of Loves Creek could be attributed to the facility, the primary sources of impairment lay upstream of the WWTP. Declines from Good to Good-Fair in Harlands Creek (benthos) and Bear Creek (fish) were likely due to delayed recovery from the 2002 drought, despite higher flows prior to sampling. Tick Creek was given a Fair NCIBI rating, but a Good-Fair benthos rating. This may be a result of fish taking longer to recover from the drought at this site than the benthos.

Cape Fear River Drainage
Mainstem and Minor Tributaries (Subbasins 07 and parts of 15 - 17)

The mainstem Cape Fear River originates near the Fall Line and then flows 170 miles through the Coastal Plain to the Atlantic Ocean. The stream gradient is higher down to the City of Fayetteville, than beyond where it then begins to flatten out. The flat terrain of the Coastal Plain results in many tributary swamp systems. The drainage area of the mainstem Cape Fear River is about 6,065 square miles. At its mouth the Cape Fear empties into the Atlantic Ocean near the Town of Southport and much of this estuarine area has salinities high enough for the waters to be classified as shellfish waters (SA).

Benthos ratings for the Cape Fear River at the Town of Lillington had been consistently Good since 1983, until the 2002 drought. A sharp decrease in the number of intolerant taxa, from the 30's to only 12, were noted immediately after the drought. In January 2003, this value had increased to 20, but further recovery could not be documented due to high flows during the remainder of 2003.

DWQ investigated the frequency and magnitude of algal blooms in the Cape Fear River during the summer drought of 2002 with collections above Buckhorn Dam (in Subbasin 07) and at Tarheel, Elizabethtown, and Kelly. The most severe blooms occurred at the Buckhorn site with the magnitude of blooms declining further downstream. This was the first record of blooms in this portion of the river, which is in agreement with the high pH data at ambient sites during the summer of 2002.

The Avents and Hector Creeks watersheds are near or are part of Raven Rock State Park. These two streams, along with nearby Parkers Creek, generally had Good or Excellent benthic macroinvertebrate and fish communities and are classified as High Quality Waters. The fish community in Avents Creek had yet to recover form the 2002 drought.

The benthos and fish communities in lower Kenneth Creek responded differently to the upstream discharge from the Town of Fuquay-Varina's wastewater treatment plant. The discharge seemed to be impacting the benthic community but not the fish community. The benthic macroinvertebrates rated the stream Poor; the fish community rated the stream Good. Further studies will need to be done on upper Neills Creek to determine if the decline in the benthic community from Good-Fair in 1998 to Poor in 2003 was due to drought or to a toxic spill.

Tributary streams in the Coastal Plain near the Town of Elizabethtown that were sampled for benthos include Harrison, Ellis, Turnbull, and Browns Creeks. The very low pH of these streams (4.0 - 4.3 s.u. in 2003) limited the diversity of these streams and most were rated Good-Fair.

Harris Lake, a 4,150 acre impoundment of Buckhorn Creek, is classified as eutrophic, a classification it had received in prior monitoring cycles. There were occasional exceedances of the chlorophyll *a* water quality standard and the reservoir was infested with *Hydrilla*. Grass carp have been stocked to help manage the nuisance macrophyte's growth.

Salters and Jones Lakes are Carolina Bay Lakes receiving almost no overland inputs of water, relying on precipitation and groundwater for recharge. Both lakes are located in state forests and are therefore protected and undeveloped. They are classified as dystrophic, indicating tannic waters and low productivity due to natural causes. White Lake, also a Carolina Bay Lake, has been classified as oligotrophic.

Sand Hills (Subbasins 13 - 15)
The first major watershed in the Sand Hills is that of the Upper Little River in Harnett and Lee counties. It has a drainage area of 220 square miles and enters the Cape Fear River below the Town of Lillington. High flows allowed only one benthos collection of the Upper Little River in the upper watershed. In 2003 it retained the Good-Fair rating it had received in 1998.

The (Lower) Little River watershed is much larger (500 square miles) and is largely rural, but lower reaches flow through or near the Town of Spring Lake and the City of Fayetteville. The (Lower) Little River from the headwaters to Crane Creek has been designated as High Quality Waters. Only an upper site was sampled during the drought study and the drought caused a decline from Excellent to Good-Fair. Recovery could not be documented due to high flows in 2003. A special study on Little Crane Creek concluded that the stream was not impaired. Nicks Creek is a headwater tributary that declined from Good in 1998 to Good-Fair in 2003 using benthos data. Anderson Creek improved from Good-Fair to Good.

Eight streams were sampled in the Sand Hills for fish community assessments. However, criteria have not been developed for rating these communities. Based upon high instream, riparian, and watershed characteristics, sites on James, Flat, and Muddy Creeks were qualified as new regional reference sites.

The Old Town Reservoir is an impoundment of Mill Creek and is mainly used for recreation. Water clarity was considered good and concentrations of chlorophyll *a*, metals, and nutrients were within water quality standards throughout 2003. The reservoir was considered mesotrophic in June and July and eutrophic in August. Mill Creek was given an Excellent benthos bioclassification during an HQW study in 1998.

Rockfish Creek is another large tributary with a drainage area of 310 square miles whose confluence with the Cape Fear River is below the City of Fayetteville. An upper benthos site on Rockfish Creek is below the Town of Raeford's WWTP and benthos bioclassifications improved from Good-Fair in 1990 to Good in 1993 - 2003. The downstream Rockfish Creek site has been consistently rated Excellent, using benthos data, since 1983. This site could not be sampled in 2003 due to high flows during the summer. Little Rockfish Creek was sampled above its confluence with Rockfish Creek. Even though its watershed is urban and agricultural, benthos ratings (1993 - 2003) were Good. Hope Mills Lake on Little Rockfish Creek suffered a catastrophic dam failure in May 2003 which drained the lake.

The Good or Excellent ratings in Rockfish Creek contrasted sharply with the Poor or Fair bioclassifications assigned to sites in the Cross Creek catchment. This highly urbanized area in downtown Fayetteville was sampled at six sites in August 2003 as part of a TMDL stressor study. Typical urban impacts were found. Four impoundments on Little Cross Creek: Bonnie Doone, Kornbow, Mintz Pond and Glenville Lakes, serve as primary or backup water supplies for Fayetteville. All were eutrophic or mesotrophic in 2003, which suggest increased enrichment since last sampled in 1998.

South and Black Rivers (Subbasins 18 - 20)
Naming of the Black and South Rivers can cause confusion when discussing sampling sites and water quality information. The South River actually is called the Black River in its headwaters near the Town of Dunn, then becomes the South River until its confluence with the Black River, where the combined flow is named the Black River to its confluence with the Cape Fear River. These rivers have been described as among the most beautiful and least disturbed of North Carolina's Coastal Plain rivers. Both are slow moving, meandering, sand- bottomed, blackwater rivers, with extensive swampy floodplains dominated by bald cypress and gum trees. The South River has a drainage area of about 500 square miles, while the Black River drainage is much larger (1,560 square miles). The South River below Big Swamp was designated ORW in 1994.

A benthos site on the South River near the Town of Parkersburg had been rated Good or Excellent since 1985, but it was severely impacted by the 2002 drought. Mercury in fish tissue continued to be found in the South River. Bay Tree Lake, a dystrophic Carolina bay, continued to have low concentrations of chlorophyll *a* and nutrients in 2003.

Great Coharie and Six Runs Creeks merge to form the Black River. Land adjacent to the Black River is primarily undisturbed forest and swamp; the Town of Clinton is the largest municipality in the watershed. The Black River from its source to the Cape Fear River and Six Runs Creek below Quewhiffle Swamp were reclassified as ORW in 1994. These reclassifications were based on Excellent biological and physical/chemical data, as well as the rivers' recreational and ecological significance. The Black River's benthic macroinvertebrate rating has returned to Excellent after the desnagging of the river following Hurricane Fran (1996) and the 2002 drought. Little Coharie Creek has shown improvement from Good-Fair in 1993 and 1998 to Good in 2003. Six Runs Creek was Excellent in 1993, but Good in 1998 and 2003.

Though the Black River does continue to flow throughout the year, other large tributaries such as Colly and Moores Creeks have periods of no flow. Benthos samples collected in winter using swamp stream methods indicated Moderate stress for an upstream site on Moores Creek.

Singletary Lake is a dystrophic system that appeared to have become more enriched in 2003 compared to prior data. Changes include reduced water clarity, higher chlorophyll *a* concentrations and reports of expanding areas of algae and alligator weed.

Northeast Cape Fear River Watershed (Subbasins 21 - 23)
The last downstream major tributary of the Cape Fear River is the Northeast Cape Fear River, which originates near the Town of Mt. Olive in southern Wayne and northern Duplin counties. Its drainage area is about 1,750 square miles. Chemical monitoring of the Northeast Cape Fear River below Mt. Olive showed high chlorophyll *a* concentrations near Mt. Olive. Low dissolved oxygen concentrations were frequently detected from ambient sites in the lower reaches of the river, especially during the summer or following large storms. In particular, low dissolved oxygen

concentrations after Hurricanes Fran and Bonnie contributed to large fish kills. High flows prevented any biological sampling in 2003, but prior benthos data indicated Good to Excellent water quality in the middle portion of the river with the section of the between Muddy and Rockfish Creeks classified as HQW.

Based upon benthic macroinvertebrate data, Limestone Creek declined from Excellent in 1993 to Good-Fair in 1998 and 2003. A spill of chicken waste caused a Poor rating in 1995. Stockinghead Creek remained Good-Fair; Muddy Creek was Fair; and Rockfish Creek improved from Fair to Good-Fair at sites above and below the Town of Wallace's WWTP.

Lower watershed tributary streams are often limited by low pH, especially those in the Holly Shelter Creek area. Two of these were rated as Natural in 2003 (Merricks and Lillington Creeks), and Angola Creek was Good. Some streams have shown a temporary impact after hurricanes. A Moderate stress rating was given to Holly Shelter and Cypress Creeks. Severe stress was noted at Long Creek in Pender County and Smith Creek outside Wilmington. Both are channelized streams with tolerant benthic fauna.

Coastal and Estuarine Area (Subbasins 17 and 24)

Large portions of this area have been classified as ORW, including Turkey, Cedar Snag, Butler, and Howe Creeks and Howard, Long Point, Green, and Nixon Channels. ORW areas also include portions of Stump, Middle, and Masonboro Sounds, Everett Bay, and the Intracoastal Waterway.

DWQ and NPDES coalition monitoring was conducted at 28 ambient water chemistry sites. These data showed low summer dissolved oxygen concentrations in the estuarine portion of the Cape Fear River. Concentrations less than 4.0 mg/L regularly occurred from Indian Creek to Channel Marker 35. The lower mainstem of the Cape Fear River can be very turbid and have elevated concentrations of inorganic nutrients and fecal coliform bacteria after rains. Algal blooms and low dissolved oxygen concentrations occurred during low rainfall periods when the river water was less turbid. Impacts from hurricanes were also associated with low dissolved oxygen levels.

Rapid urbanization and the increasing runoff that accompanies development can pose problems in this area. Problems in Bradley Creek, whose watershed drains the City of Wilmington, have been confirmed in greater detail by UNC-Wilmington studies.

Benthos sampling indicated a Good-Fair bioclassification for Livingston Creek in 1998 and 2003. Hood and Barnards Creeks were given Moderate stress ratings; high flows in 2003 may have contributed to their decline compared to ratings in 1998. Lewis Swamp has a primarily forested watershed and was rated Natural in 1998 and 2003. Hewletts Creek was sampled in a residential area and was given a Moderate stress rating.

Greenfield Lake, in downtown Wilmington is very eutrophic with extensive growths of aquatic plants. Boiling Springs Lake is a dystrophic lake that has recently experienced problems with sinkholes formed by acidic waters dissolving the underlying limestone.

EXECUTIVE SUMMARIES BY PROGRAM AREA

The water quality of the Cape Fear River basin was evaluated for the period 1999 through 2003. The previous evaluation covered the period 1993 through 1998. Assessments conducted by the North Carolina Division of Water Quality included ambient chemistry, benthic macroinvertebrates, fish community, fish tissue contaminants, fish kills, lakes, and whole effluent toxicity testing. External data were also examined. The purpose of this report is to summarize the 2003 monitoring efforts for each of the waterbodies sampled in the basin during the past five years, especially during 2003, and to document any trends over the past 10 years, 1993 – 2003.

FISHERIES

Fish Community Assessment

In 2003, 55 sites were sampled from late April to late October; a majority of these sites were within the Piedmont and Sand Hills. Only one stream could be sampled in the Coastal Plain due to persistent high flows throughout 2003. As in 1998, the most commonly collected species in 2003 in the Piedmont was the redbreast sunfish (collected at all 38 sites); the most abundant species were the bluehead chub and the redbreast sunfish (~30 percent of all the fish collected were of these two species). In the Sand Hills, the most commonly collected species were the American eel, pirate perch, tessellated darter, redbreast sunfish, dusky shiner, and bluegill.

All streams in the Piedmont were evaluated using the North Carolina Index of Biotic Integrity (NCIBI) (Appendices 7 and 8); streams in the Coastal Plain or Sand Hills were not rated because metrics ands criteria have yet to be developed. The Piedmont ratings ranged from Poor to Excellent (Figure 4) with the scores ranging from 26 to 56. Based upon the fish community ratings, degraded streams (bioclassifications of Fair or Poor) included South Buffalo, North Buffalo, Richland, Collins, Indian, Tick, and Big Buffalo Creeks. The fish communities in Collins, Indian, and Tick Creeks may have yet to recover from the 2002 drought and while given an NCIBI rating should not be given a Use Support rating.

Of the 25 Piedmont sites sampled for basinwide assessments in 2003 and 1998/1999, 4 sites had scores that did not change, 11 sites had scores that increased, and 10 sites had scores that decreased between years. The range in the difference in the scores between 2003 and 1998/1999 was ± 20 points (Figure 5). Almost one-half of the sites in 2003 had scores that were different by only ± 4 points from the scores received in 1998/1999.

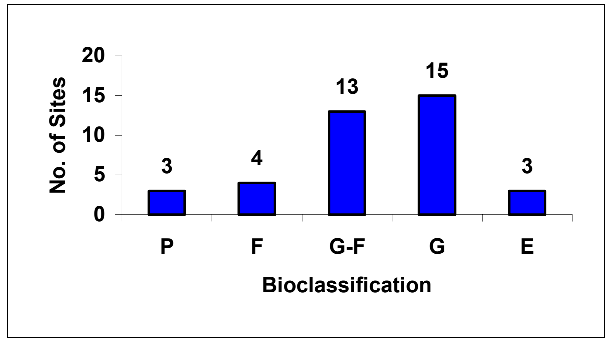


Figure 4. Bioclassifications of 38 fish community basinwide sites in the Piedmont portion of the Cape Fear River basin, 2003. Abbreviations are: P = Poor, F = Fair, G-F = Good-Fair, G = Good, and E = Excellent.

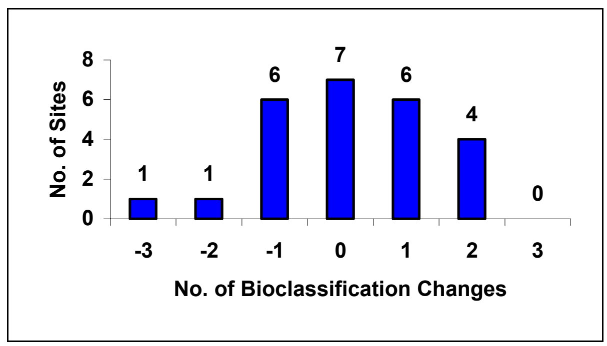


Figure 6. Bioclassification rating changes between 1998/1999 and 2003 at 25 fish community sites in the Piedmont portion of the Cape Fear River basin.

The bioclassifications did not change at 7 sites, increased at 10 sites, and decreased 1 or more bioclassifications at 8 sites (Figures 5 and 6). Relocation of a wastewater treatment plant discharge resulted in improvements at Little Troublesome Creek. Closure of the Cone Mills Textile Plant which had discharged into North Buffalo (off 16th Street and US 29) Creek also resulted in improvements in the fish community.

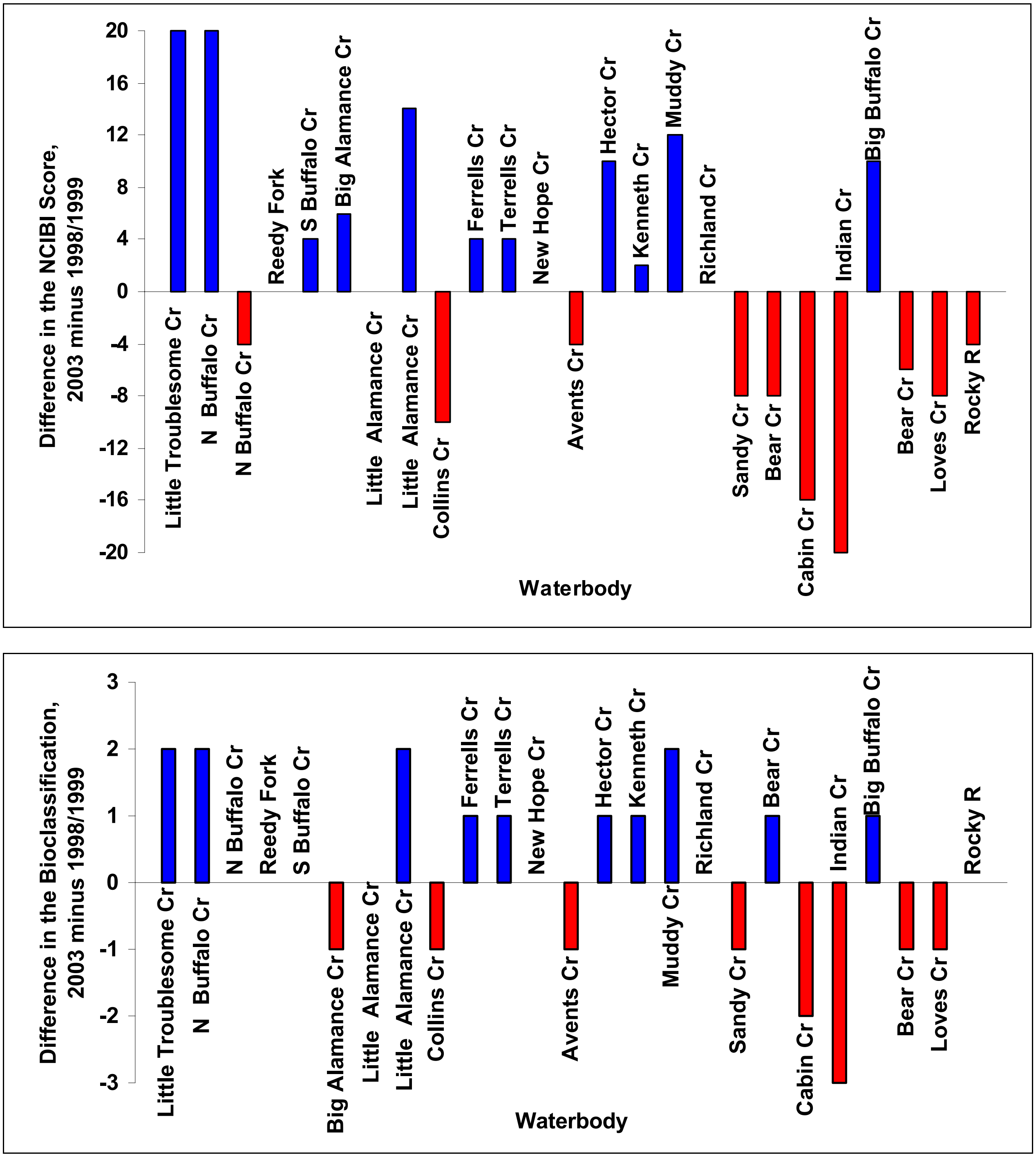


Figure 5. **A comparison of the NCIBI scores (top) and the bioclassifications (bottom)at 25 rateable fish community sites in the Piedmont portion of the Cape Fear River basin between 1998/1999 and 2003. For waterbodies (e.g. Reedy Fork or Little Alamance Creek) with neither a red or blue vertical bar, the difference between years in the NCIBI score or the bioclassification was zero.**

Other slight improvements may have been due to less nonpoint source and urban impacts during the 2002 drought. Many of the decreases in the scores and ratings, especially in streams within the Carolina Slate Belt ecoregion, were attributable to the fish community still recovering from the 2002 drought and/or the flash floods of early summer 2003. Fish communities still affected by the drought had reduced species diversity and abundance, the fish were generally small, and few species were represented by multiple age classes. Four of the six regional reference sites which were sampled in 2003 declined from the ratings received in 1998 or 1994. These declines were also due to hydrological and meteorological events occurring during the past several years.

Although the Sand Hills streams could not be rated, most of the communities, even though sampled for the first time in 2003, seemed to be characteristic of unimpacted and fully functioning streams.

Ninety four fish community samples with associated habitat evaluations have been collected throughout the basin since 1998. These data showed that as instream and riparian habitat deteriorated, so did the fish community ratings (Figure 7). In 2003, with a few exceptions, fish communities rated Excellent and Good were found in streams with moderate to high quality habitats. Sites rated Excellent (NCIBI Score ≥ 54) had the highest quality habitats; the median habitat score for Excellent rated streams was 79 (Figure 7).

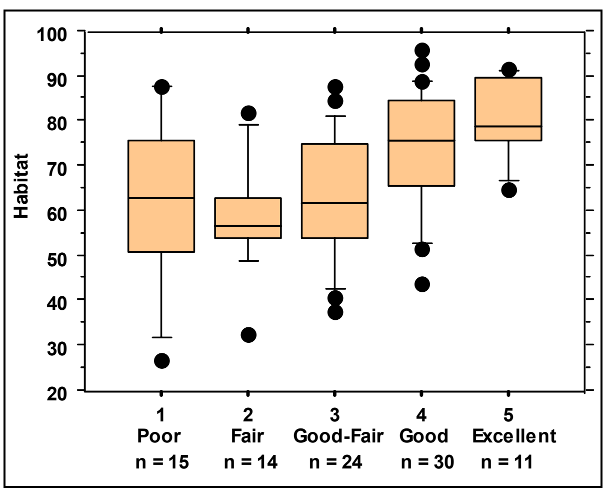


Figure 7. Relationships between habitat scores and NCIBI ratings in the Cape Fear River basin, 1998 - 2003.

Fish Tissue Contaminants
Fish tissue was sampled for metals contaminants at 12 stations within the basin from 1999 to 2003. All fish were collected from the Coastal Plain in Subbasins 16 - 23 as part of DWQ's eastern North Carolina mercury surveys. Three hundred eight individual samples were analyzed. Total mercury concentrations exceeded the North Carolina criteria and US EPA's screening value (0.4 ppm) in 62 percent of the samples. Concentrations also exceeded the US Food and Drug Administration criteria limit of 1.0 ppm in 16 percent of the samples. All other metals were non-detectable or at levels below limits specified in Appendix 16.

Currently there are no waterbody-specific fish consumption advisories posted in the basin. However there is one basinwide advisory:

- *Women of childbearing age (15 - 44 years), pregnant women, nursing women, and children under 15 are advised not to eat shark, swordfish, tilefish, or king mackerel; or blackfish (bowfin), largemouth bass, or jack fish (chain pickerel) caught in North Carolina waters south and east of Interstate 85. These fish are often high in mercury. They are advised to eat up to two meals per week of other fish.*
- *Other women, men, and children 15 years and older are advised to eat no more than one meal per week of shark, swordfish, tilefish, or king mackerel; or blackfish (bowfin), largemouth bass, or jack fish (chain pickerel) caught in North Carolina waters south and east of Interstate 85. These fish are often high in mercury. They are advised to eat up to four meals per week of other fish.*

Additional information on consumption advisories in North Carolina may be found at: http://www.schs.state.nc.us/epi/fish/current.html.

Fish Kills
The NC DWQ has systematically monitored and reported on fish kill events across the state since 1996 (http://www.esb.enr.state.nc.us/). Investigators reported 43 incidents which killed more than one million fish in the basin from 1999 to 2003. All kills, except one, were reported from freshwaters and were generally evenly dispersed throughout the basin. Kills were attributed to low dissolved oxygen, algal blooms, temperature stress, and spills of toxic substances. The largest kill occurred as a result of bycatch from a fishing operation in the Atlantic Ocean off Yaupon Beach (Brunswick County) and involved an estimated one

million menhaden. About one-half of the events investigated in the basin could not be attributed to an obvious cause.

Yearly kills reported decreased during the monitoring period from 14 events in 1999 to just three reports in 2003. The decrease has not been associated with any improvements in water quality throughout the basin.

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates have been collected at 842 sites in the basin since 1983. In 2003, more sites (n = 47) were rated Good-Fair than any other bioclassification and totaled 30 percent of all sites rated (Figure 8). Only 18 percent of the sites rated Good, Excellent, or Natural; 29 percent of the sites rated Poor, Fair, or Severely stressed.

Nine subbasins (e.g., 01 - 05, 08, 09, 12, and 13) had high percentages of streams rated Fair (Table 1). In addition, Subbasins 02, 03, and 09 also had high percentages of streams rated Poor. These subbasins contain catchments that are dominated by urban and suburban areas of Reidsville, Greensboro, Burlington, Graham, Mebane, Pittsboro, Durham, Research Triangle Park, Greensboro, High Point, Asheboro, Ramseur, Siler City, and Sanford. The large amount of impervious surfaces combined with point (e.g., WWTPs) and nonpoint sources of pollution all contributed to these low bioclassifications.

All of these subbasins, other than Subbasins 05 and 13, are located in the Carolina Slate Belt ecoregion and are characterized by low summer flows. Moreover, Subbasin 05 is located in the Triassic Basin ecoregion and has zero flow for most, if not all of the summer and is also characterized by very poor instream habitat. These factors, combined with the effects of urbanization and drought, contributed to the lower bioclassifications in these subbasins.

Conversely, Subbasins 07, 09, 10, 14, 19, and 23 had the greatest percentages of Good and Excellent ratings. Subbasins 07 and 14 are located in the Sand Hills ecoregion and are characterized by year-round flow. Landuse in these two subbasins is mostly rural, agricultural, and forested instead of urbanized. Although Subbasins 09 and 10 are located in the Carolina Slate Belt, these subbasins have landuse which are mostly composed of rural residences, agriculture, and forest. Even though Subbasin 09 had a high percentage of Poor and Fair ratings, most of these bioclassifications were associated with urbanized areas near Asheboro. The Good and Excellent ratings were obtained from streams whose catchments were mostly rural, agricultural, and forest in composition.

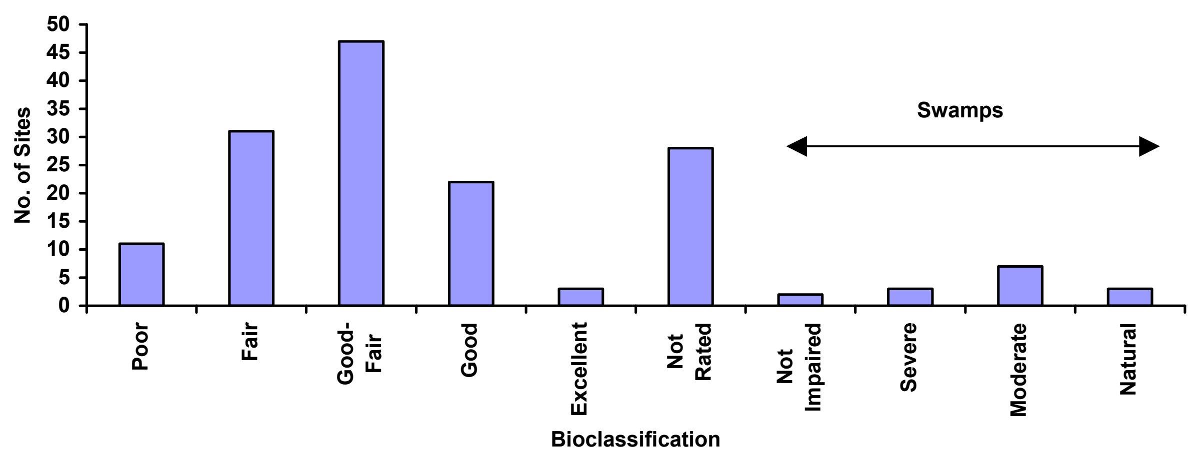


Figure 8. **Distribution of bioclassifications for 157 benthic invertebrate samples collected in the Cape Fear River basin in 2003.**

Table 1. Percent distribution of bioclassifications by subbasin for all rateable benthic macroinvertebrate sites in the Cape Fear River Basin, 2003.

	Bioclassifications									
Subbasin	**Poor**	**Fair**	**Good-Fair**	**Good**	**Excellent**	**Not Rated**	**Not Impaired**	**Severe**	**Moderate**	**Natural**
01		50	50							
02	25	25	33			17				
03	38	38	12			12				
04		27	64			9				
05		20	20			60				
06		17	33	17		33				
07	14	7	7	37	14	14	7			
08		47	47				6			
09	31	22	8	31	8					
10			33	67						
11						100				
12		23	23	8		46				
13		50	50							
14			67	17		16				
15		18	27	18		37				
16			75						25	
17			25						50	25
18										
19				75		25				
20									100	
21										
22		14	58			14		14		
23				12		13		25	25	25
24									100	

Long-term data was associated with 36 sites in the basin (Table 2); 26 sites had stable water quality, 5 sites had declining water quality, and 5 sites had improving water quality. Reedy Fork declined from Good-Fair (two samples) to Fair. This decline was likely due to very low flows resulting from the variable discharges from Lake Townsend during the 2002 drought. Stony Creek declined from Good (two samples) to Not Rated. This site lost roughly one-half of its EPT diversity in 2003 and the BI increased significantly. The decline in rating was largely the result of extremely low flows during 2002 although changes in upstream landuse could not be ruled out as a contributing factor in this site's decline.

Big Alamance Creek declined from Good-Fair (two samples) to Fair. This decline was likely the combined effects of drought and the increased nonpoint inputs during the very wet year of 2003. However, landuse changes in the catchment could also be a contributing factor in the decline. Dry Creek had been rated Poor, Good, and Good-Fair. In 2003 this site declined slightly to Fair which may be the result of the effects of the 2002 drought and the increased nonpoint pollution inputs from the wet year observed in 2003. Neill's Creek had a substantial decline in bioclassification from Good-Fair (two samples) to Poor. The decline could not be attributed to drought alone as other nearby streams showed no such impacts. Given the drastic decline, the most likely explanations was a toxicant spill or that this stream dried up completely during 2002.

Little Troublesome Creek improved from Poor (two samples) to Fair (last three samples). This modest improvement was due to the relocation of the Town of Reidsville's WWTP to the Haw River. The Deep River has shown steady improvement ever since initial samples in 1983 and 1985 were rated Fair. From 1986 to 1996 the site was rated Good-Fair; in 2003 it was rated Good. The improved ratings were attributed to upgrades at the numerous WWTPs located upstream.

Improved ratings were also noted from Anderson, Little Coharie, and Angola Creeks. While specific reasons for these improvements were not readily apparent, many of these sites regularly experience low flow conditions. It was possible that the high flows in the lower basin a result of the very wet year in 2003 may have improved ordinarily low dissolved oxygen concentrations and increased the amount of instream habitat suitable for invertebrate colonization. However, use of BMPs in the catchment cannot be ruled out. Continued monitoring at these sties will help determine if improvements are due to anthropogenic intervention (i.e., BMPs) or are rather the result of natural inter-annual variation.

Table 2. **Trends in bioclassification at basinwide sites in the Cape Fear River basin, 1983 - 2004. Full Scale and EPT samples: E (Excellent), G (Good), G-F (Good-Fair), F (Fair), and P (Poor). Swamp samples: N (Natural), M (Moderate), and S (Severe). Other samples: Not Impaired (NI), Not Rated (NR). Blank = no sample. Stable = → = stable, improving = ↑, and declining = ↓.**

			Year															
Subbasin/Waterbody	**County**	**Location**	**83**	**85**	**86**	**87**	**88**	**89**	**90**	**93**	**96**	**97**	**98**	**00**	**01**	**02**	**03**	**Overall**
01																		
Haw R	Alamance	NC 87				G-F			F	G-F			F				G-F	→
L Troublesome Cr	Rockingham	SR 2600								P			P	F	F		F	↑
02																		
S Buffalo Cr	Guilford	US 70					P			F			P				F	→
Horsepen Cr	Guilford	US 220								F			F	F	NR		P	→
Reedy Fk	Guilford	SR 2728								G-F			G-F				F	↓
Stony Cr	Caswell	SR 1100								G			G				NR	↓
Haw Cr	Alamance	SR 2158											G				G-F	→
03																		
L Alamance Cr	Alamance	SR 2309		F									P				F	→
Big Alamance Cr	Alamance	NC 49								G-F			G-F				F	↓
Stinking Quarter Cr	Alamance	SR 1136								G-F			G				G-F	→
04																		
Marys Cr	Alamance	SR 2174											F				G-F	→
Cane Cr	Orange	SR 1114								G-F			G				G-F	→
Dry Cr	Chatham	SR 1520			P					G			G-F				F	↓
Pokeberry Cr	Chatham	SR 1711		G-F	G					G-F			G				G-F	→
06																		
Morgan Cr	Orange	NC 54		G						G	G		E				G	→
07																		
Neills Cr	Harnett	SR 1441								G-F			G-F				P	↓
08																		
Richland Cr	Guilford	SR 1145	F	P	P	P	P			F			P				F	→
09																		
Deep R	Randolph	SR 2615	F	F	G-F	G-F		G-F		G-F			G-F				G	↑
Sandy Cr	Randolph	SR 2481					G	G		G			E		E	G	G	→
Richland Cr	Randolph	SR 2873								G			E				G	→
Brush Cr	Randolph	NC 22/42	G										G				G-F	→
10																		
Mill Cr	Moore	SR 1275								G			G-F				G	→
Buffalo Cr	Moore	NC 22								NR			NR				G-F	→
12																		
Rocky R	Chatham	US 64						F		F		G-F	G-F				NR	→
Harlands Cr	Chatham	NC 902							G-F				G				G-F	→
14																		
Anderson Cr	Harnett	SR 2031								G-F			G-F	G			G	↑
Nicks Cr	Moore	NC 22								G			G				G-F	→
Lower L River	Moore	SR 2023					E		E	E			E			G-F	G-F	→
16																		
Turnbull Cr	Bladen	SR 1511											G				G-F	→
17																		
Hood Cr	Brunswick	US 74/76											N				M	→
19																		→
Black R	Sampson	NC 411		E			E			E			E				E	→
L Coharie Cr	Sampson	SR 1214								G-F			G-F				G	↑
22																		
L Rockfish Cr	Duplin	SR 1165								G-F			F				G-F	→
23																		
Angola Cr	Pender	NC 53								NR			NR				G	↑
Lillington Cr	Pender	SR 1520										M					N	→

LAKE ASSESSMENT

In 2003, 33 lakes in the basin were monitored as part of the Lakes Assessment program. Each lake was sampled three times during the summer. There were a variety of water quality concerns documented during this time period:

- The summer of 2003 had significantly more precipitation than the previous summer. Precipitation from June 1 to August 31, 2003 ranged from 15 to 25 inches (http://water.dnr.state.sc.us/climate/sercc/index.html). This rainfall resulted in an increase in nonpoint source nutrient and sediment runoff.
- Algal blooms were recorded at 50 sites during 2003. The frequency of blooms increased throughout the summer (13 in June, 17 in July, and 20 in August). One-third of the lakes experienced blooms, seven of which had blooms that persisted

throughout the monitoring period. Blooms ranged from a single species, such as *Chrysochromulina sp.*, to diverse assemblages of bluegreens, greens, and diatoms. One-third of the blooms were dominated by filamentous bluegreen algae. Not only do bluegreen algae discolor the water and cause taste and odor problems but some strains produce toxins.

- Cabin Lake, a recreational reservoir in Duplin County, was sampled for the first time in 2003. It is classified as a dystrophic lake. Dystrophic lakes are acidic and "tea-colored" rich in organic matter in the form of suspended plant colloids and larger plant fragments. Such lakes usually have low productivity and few water quality problems. However, nutrient concentrations were elevated and late in the summer chlorophyll *a* concentrations were greater than the water quality standard of 40 µg/L.
- University Lake was hypereutrophic in June from elevated nutrient and chlorophyll a concentrations. This reservoir had been classified as eutrophic since 1990. Heavy rain within the watershed in June may have increased nonpoint source runoff which increased photic zone nutrients and productivity.
- Pittsboro and Greenfield Lakes are on the impaired waterbodies list due to excessive aquatic macrophytes. In 2003, parrot feather (*Myriophyllum aquaticum*) was observed in Pittsboro Lake. These plants form dense mats blocking water flow and creating unsuitable conditions for fish. Greenfield Lake is impaired due excessive growths of duckweed (*Lemna* sp.), watermeal (*Wolffia* sp.), and Brazilian elodea (*Egeria densa*). These plants along with floating mats of filamentous algae and alligator weed (*Alternanthera* sp.) make boating in this urban lake difficult.
- Basinwide, lakes located south and east of I-85 have been placed under a fish consumption advisory by the Department of Health and Human Resources due to high levels of mercury in several species of fish (http://www.schs.state.nc.us/epi/fish/current.html).

PHYTOPLANKTON MONITORING

Algal Blooms

Algal blooms can occur throughout the year in response to favorable environmental conditions, such as an abundance of nutrients (eutrophication). Some bloom-forming taxa, such as diatoms, prefer the cooler waters of the winter months while others, such as the dinoflagellates, are tolerant of a wider range of environmental conditions and can bloom during any season. The majority of observed blooms occurred in the hot, long days of summer -- conditions which favor greens, bluegreens, and dinoflagellates (Appendix 23).

Algae and Fish Kills

Algal assemblages can have adverse effects on fish health when the normal processes of photosynthesis, respiration, and decomposition become extreme. During photosynthesis, algae produce oxygen, thus increasing the concentration of dissolved oxygen (DO). Concentrations of DO greater than 140 percent of saturation can be acutely fatal to fish. Conversely, during algal respiration or decomposition, concentrations decrease. This may cause fish and other aquatic organisms to suffocate. Small lakes and ponds are particularly susceptible to such fluctuations, especially when these systems are eutrophic.

AMBIENT MONITORING

Chemical and physical measurements were obtained from 173 stations located throughout the basin by DWQ and three NPDES discharger monitoring coalitions. All data were collected between September 1, 1998 and August 31, 2003.

All results were compared to water quality standards to determine if more that 10 percent of the results violated the appropriate standard. When more than 10 percent of the results violated the standard, a binomial statistical test was employed to determine if there was sufficient confidence to conclude the likelihood of a exceedance was significant. This criterion applied to all parameters with a water quality standard or action level, except fecal coliform bacteria in which case a 20 percent exceedance threshold was used.

Stations with statistically significant exceedances were frequent for fecal coliform bacteria (n = 30 sites), copper (n = 31), dissolved oxygen (< 5.0 mg/L, n = 19), and pH (n = 20). Many of these exceedances were at stations whose watersheds included urban areas. Four out of the five monitoring stations in water supply watersheds had statistically significant exceedances for nitrite+nitrate nitrogen.

Upstream to downstream patterns in water quality were depicted graphically using box and whisker plots for the Haw, Deep, Northeast Cape Fear, and Cape Fear Rivers and Rockfish Creek. Upstream to downstream patterns in water quality showed the influences of urban areas for the Haw and Deep Rivers.

AQUATIC TOXICITY MONITORING

One hundred nineteen facility permits in the basin currently require whole effluent toxicity (WET) monitoring. Ninety four facility permits have a WET limit; the other 25 facility permits specify monitoring with no limit. Since 1999 the compliance rate for those facilities with a limit has stabilized at approximately 90 to 95 percent. Eleven facilities have had difficulty meeting their toxicity limits or targets (Table 3).

Table 3. Facilities that have had difficulty meeting toxicity limits or targets in the Cape Fear River basin 1998 – 2003.

Subbasin	Facility
02	BP Oil Company
05	Brenntag Southeast, Inc.
06	UNC-Chapel Hill Power Plant
07	Dynea USA, Inc.
10	Town of Star's WWTP
17	Archer Daniels Midland Co.
	Leland Industrial Park WWTP
21	Mt. Olive Pickle Co.
22	Charles F. Cates & Sons
	Guilford Mill
	Town of Rose Hill's WWTP
24	Town of Holly Ridge's WWTP

INTRODUCTION TO PROGRAM METHODS

The North Carolina Division of Water Quality (DWQ) uses a basinwide approach to water quality management (http://h2o.enr.state.nc.us/basinwide/). Activities within the DWQ, including monitoring, permitting, modeling, nonpoint source assessments, and planning are coordinated and integrated for each of the 17 major river basins within the state. All basins are assessed every five years and the Cape Fear River basin was last sampled by the Environmental Sciences Branch in 1998 (NCDENR 1999, http://www.esb.enr.state.nc.us/bar.html).

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 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 the assessment of the Cape Fear River basin include benthic macroinvertebrates, fish community, fish kills, fish contaminants, lake assessment, ambient monitoring, and aquatic toxicity monitoring.

QUALITY ASSURANCE

Laboratory measurements play a key role in the assessment and protection of water quality. Laboratory analyses are needed to identify problems and to monitor the effectiveness of management strategies to abate these problems. The relative accuracy and precision of laboratory data must be considered as part of any data interpretation or analysis of trends and use support. Absolute certainty in laboratory measurements can never be achieved. However, it is the goal of quality assurance and quality control efforts to quantify an acceptable amount of uncertainty. The evaluation of data quality is thus a relative determination. What is high quality for one situation could be unacceptable in another.

The DWQ's Chemistry Laboratory has recently established rigorous internal quality assurance evaluations. These evaluations may have significant implications on interpretation of historical data and how new data are generated and reviewed. DWQ will continue to work on ensuring the quality of water analyses in North Carolina. It is obviously beneficial to generate the highest quality information to apply a statistical level of significance to water quality observations. In addition to quantification limits, lower limits of detection, method detection limits, and instrumentation detection limits must be evaluated on a continuing basis to ensure sound data and information. Because each of these detection limits can represent different levels of confidence, water quality evaluations may change from time to time based on improved laboratory instruments, analytical methods, and improved quality assurance and quality control applications.

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. Because 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 stressors.

Sampling methods and criteria (Appendix 17) have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample from flowing fresh waters based on the number of taxa (EPT S) present in the intolerant groups Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), and the value of the North Carolina Biotic Index (NCBI or BI). This index summarizes tolerance data for all taxa in each collection. These bioclassifications primarily reflect the influence of chemical pollutants. 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 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. Swamp streams are rated Natural, Moderate or Severe.

Bioclassifications listed in this report (Appendix 18) may differ from older reports because evaluation criteria have changed since 1983. Originally, Total S and EPT S criteria were used, then just EPT S, and now NCBI and EPT S criteria are used for flowing freshwater sites. Refinements of the criteria continue to occur as more data are gathered.

FISHERIES

Fish Community Structure

The NCIBI is a modification of the Index of Biotic Integrity initially proposed by Karr (1981) and Karr, *et al*. (1986) (Appendix 8). The IBI method was developed for assessing a stream's biological integrity by examining the structure and health of its fish community. The scores derived from this index are a measure of the ecological health of the waterbody and may not directly correlate to water quality. For example, a stream with excellent water quality, but with poor or fair fish habitat, would not be rated excellent with this index. However, in many instances, a stream which rated excellent on the NCIBI should be expected to have excellent water quality.

The Index of Biological Integrity incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition. The NCIBI summarizes the effects of all classes of factors influencing aquatic faunal communities (water quality, energy source, habitat quality, flow regime, and biotic interactions). While any change in a fish community can be caused by many factors, certain aspects of the community are generally more responsive to specific influences. Species composition measurements reflect habitat quality effects. Information on trophic composition reflects the effect of biotic interactions and energy supply. Fish abundance and condition information indicate additional water quality effects. It should be noted, however, that these responses may overlap. For example, a change in fish abundance may be due to decreased energy supply or a decline in habitat quality, not necessarily a change in water quality.

Fish Kills

Fish kills investigation protocols were established in 1996 to investigate, report, and track fish kill events throughout the state. Fish kill and fish health data collected by trained NCDWQ and other resource agency personnel are recorded on a standardized form. Fish kill investigation forms and supplemental information are compiled in a database where the data can be managed and retrieved for use in reporting to concerned parties. Additional information on fish kills may be found at: http://www.esb.enr.state.nc.us/.

Fish Tissue

Because fish spend their entire lives in the aquatic environment, they incorporate chemicals from this environment into their body tissues. Contamination of aquatic resources have been documented for heavy metals, pesticides, and other complex organic compounds. Once these contaminants reach surface waters, they may be available for bioaccumulation, either directly or through aquatic food webs, and may accumulate in fish and shellfish tissues. Results from fish tissue monitoring can serve as an important indicator of further contamination of sediments and surface water.

Since 1991, fish tissue surveys have been conducted as part of the Basinwide Assessment Program. Fish tissue were sampled for metals and organic contaminants throughout the year's scheduled basins with the intent of assessing as many waterbodies as possible. While this included efforts to assess suspected "trouble spots" in a basin, significant time and resources were spent in gathering data from areas where few fish tissue contaminants were historically detected. Review of data after the first round of basin assessments were completed revealed that, except for mercury, there were no widespread fish contaminant issues in the state that warranted basinwide-style investigations.

In 1999, the scope of fish tissue surveys were revised and shifted from basinwide assessments to areas where contaminants exist or are suspected. This shift has resulted in less basinwide coverage, but has focused resources on known contaminant issues within a basin.

All fish samples were collected according to standard operating procedures (NCDENR 2001). Analysis results are used as indicators for human health concerns, fish and wildlife health concerns, and the presence and concentrations of various chemicals in the ecosystem (Appendices 15 and 16)

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 at lakes (public or private) where water quality problems have been observed (Appendix 21).

PHYTOPLANKTON MONITORING

The NCDWQ analyzes algal samples to document blooms, to investigate the causes of fish kills, and to identify unusual or suspicious problematic growths of algae. Most samples are collected as part of the ambient monitoring system.

AMBIENT MONITORING SYSTEM

Assessments of water quality can be obtained from information about the fish and benthic invertebrate communities present in a body of water or from chemical measurements of particular water quality parameters. 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 determined by freshwater or saltwater waterbody classification and corresponding water quality standards. Under this arrangement, core parameters are based on Class C waters with additional parameters appended when justified (Table 4).

Water quality data were evaluated for the previous five year period. Some stations have little or no data for several parameters. However, for the purpose of standardization, data summaries for each station include all parameters may be found at:
http://www.esb.enr.state.nc.us/Basinwide/CPFSummaries_20040406/StationsBySubbasin_edit.htm.

Data collected from September 01, 1998 to August 30, 2003 were displayed in box plots. Box plots provide measures of central tendency and variation (Figure 9).

Table 4. Freshwater parametric coverage for the ambient monitoring system.[1]

Parameter	All freshwater	Water Supply
Dissolved oxygen (s)	✔	✔
pH (s)	✔	✔
Specific conductance	✔	✔
Temperature (s)	✔	✔
Total phosphorus	✔	✔
Ammonia as N	✔	✔
Total Kjeldahl as N	✔	✔
Nitrate+nitrite as N (s)	✔	✔
Total suspended solids	✔	✔
Turbidity (s)	✔	✔
Fecal coliform bacteria (s)	✔	✔
Aluminum	✔	✔
Arsenic (s)	✔	✔
Cadmium (s)	✔	✔
Chromium, total (s)	✔	✔
Copper, total (s)	✔	✔
Iron (s)	✔	✔
Lead (s)	✔	✔
Mercury (s)	✔	✔
Nickel (s)	✔	✔
Zinc (s)	✔	✔
Manganese (s)	---	✔
Chlorophyll *a*[2] (s)	✔	✔

[1]A check (✔) indicates the parameter is collected and an 's' indicates the parameter has a standard or action level.
[2]Chlorophyll *a* is collected in Nutrient Sensitive Waters (NSW).

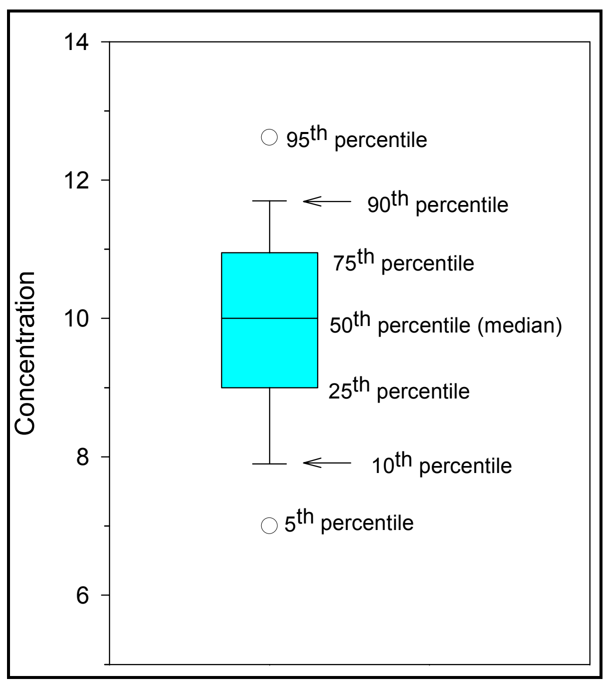


Figure 9. Explanation of box and whisker charts.

The water quality reference value may be an ecological evaluation level, a narrative or numeric standard, or an action level as specified in (NCAC 2002) (Table 5). Zinc is included in the summaries for metals but recent (since April 1995) sampling or laboratory analyses may have been contaminated and the data may be unreliable.
In this report, conductivity is synonymous with specific conductance. It is reported 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.

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 DWQ's Aquatic Toxicology Laboratory. If toxicity is detected, DWQ may include aquatic toxicity testing upon permit renewal.

DWQ's 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 WQ administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.

Table 5. Selected water quality standards for parameters sampled as part of the ambient monitoring system.[1]

Parameter (µg/L, unless noted)	Standards for All Freshwater			Standards to Support Additional Uses		
	Aquatic Life	Human Health	Water Supply Classifications	Trout Water	HQW	Swamp Waters
Arsenic	50					
Cadmium	2.0			0.4		
Chloride	230,000[2]		250,000			
Chlorophyll *a*, corrected	40[3]			15[3]		
Chromium, total	50					
Coliform, total (MFTCC/100 ml)[4]			50[3] (WS-I only)			
Coliform, fecal (MFFCC/100 ml)[5]		200[3]				
Copper, total	7[2]					
Dissolved oxygen (mg/L)	5.0[6,7]			6.0		[3, 7]
Hardness, total (mg/L)			100			
Iron (mg/L)	1[2]					
Lead	25[3]					
Manganese			200			
Mercury	0.012					
Nickel	88		25			
Nitrate nitrogen			10,000			
pH (units)	6.0 - 9.0[3, 7]					[3, 7]
Selenium	5					
Solids, total dissolved (mg/L)			500			
Solids, total suspended (mg/L)					10 Trout, 20 other[8]	
Turbidity (NTU)	50, 25[3]			10[3]		
Zinc	50[2]					

[1]Standards apply to all classifications. For the protection of water supply and supplemental classifications, standards listed under Standards to Support Additional Uses should be used unless standards for aquatic life or human health are listed and are more stringent. Standards are the same for all water supply classifications (Administrative Code 15A NCAC 2B 0200, eff. April 1, 2001).
[2]Action level.
[3]Refer to 2B.0211 for narrative description of limits.
[4]Membrane filter total coliform count per 100 ml of sample.
[5]Membrane filter fecal coliform count per 100 ml of sample.
[6]An instantaneous reading may be as low as 4.0 mg/L, but the daily average must be 5.0 mg/L or more.
[7]Designated swamp waters may have a dissolved oxygen less than 5.0 mg/L and a pH as low as 4.3, if due to natural conditions.
[8]For effluent limits only, refer to 2B.0224(1)(b)(ii).

Parameter (µg/L, unless noted)	Standards for All Saltwater			Standards To Support Additional Uses	
	Aquatic Life	Human Health[1]	Class SA[2]	HQW	Swamp Waters
Arsenic	50				
Cadmium	5.0				
Chlorophyll *a*	40[3]				
Chromium, total	20				
Coliform, fecal (MFFCC/100ml)[4]		200[3]	14[3]		
Copper, total	3[5]				
Dissolved oxygen (mg/L)	5.0[9]			6.0	[3, 6]
Lead	25[3]				
Mercury	0.025				
Nickel	8.3				
pH (units)	6.8 - 8.5[6]				[3, 6]
Selenium	71				
Silver	0.1[5]				
Solids, total suspended (mg/L)				10 PNA[7], 20 other[8]	
Turbidity (NTU)	25[3]				
Zinc	86[5]				

[1]Standards are based on consumption of fish only unless dermal contact studies are available, see 2B.0208 for equation.
[2]Class SA = shellfishing waters, see 2B.0101 for description.
[3]See 2B.0220 for narrative description of limits.
[4]MFFCC/100ml means membrane filter fecal coliform count per 100 ml of sample.
[5]Values represent action levels as specified in 2B.0220.
[6]Designated swamp waters may have a dissolved oxygen less than 5.0 mg/L and a pH as low as 4.3 s.u., if due to natural conditions.
[7]PNA = Primary Nursery Areas.
[8]For effluent limits only, see 2B.0224.
[9]Swamp waters, poorly flushed tidally influenced streams, or embayments, or estuarine bottom waters may have lower values if caused by natural conditions.

CAPE FEAR RIVER SUBBASIN 01

Description

This subbasin is located primarily in the Northern Inner Piedmont with the upper Haw River watershed included in the Southern Outer Piedmont (Griffith *et al*. 2002). The Northern Inner Piedmont has higher elevations, more rugged topography, and more monadnocks (isolated hills of resistant bedrock) than other areas of the Piedmont. The Southern Outer Piedmont ecoregion is characterized by lower elevations, less relief, and less precipitation.

Included in this subbasin are the headwaters of the Haw River and the Troublesome Creek watershed (Figure 10). These headwaters tend to be slow flowing with little assimilative capacity. Streams in the northern and western portion of the subbasin (i.e., the upper Haw River, upper Troublesome Creek, and Little Troublesome Creek) tend to be very sandy while streams or reaches in the southeast portion of the subbasin are rocky (lower Troublesome Creek and lower Haw River).

Almost two-thirds of the subbasin is in pasture or forest (Table 6). The largest urban area is near the Town of Reidsville. There are 12 permitted dischargers in this subbasin, mostly near the Town of Reidsville. Many of these facilities are very small (less than 0.05 MGD); the largest dischargers are the Town of Reidsville's WWTP (7.5 MGD) and Glen Raven Mills (0.15 MGD), both discharging into the Haw River.

Table 6. Land use in Subbasin 01. Based upon CGIA coverage 1993 - 1995 (total area = 189 square miles (NCDENR 2000).

Land use	Percent
Water	2
Cultivated crop	7
Pasture	31
Urban	2
Forest	59

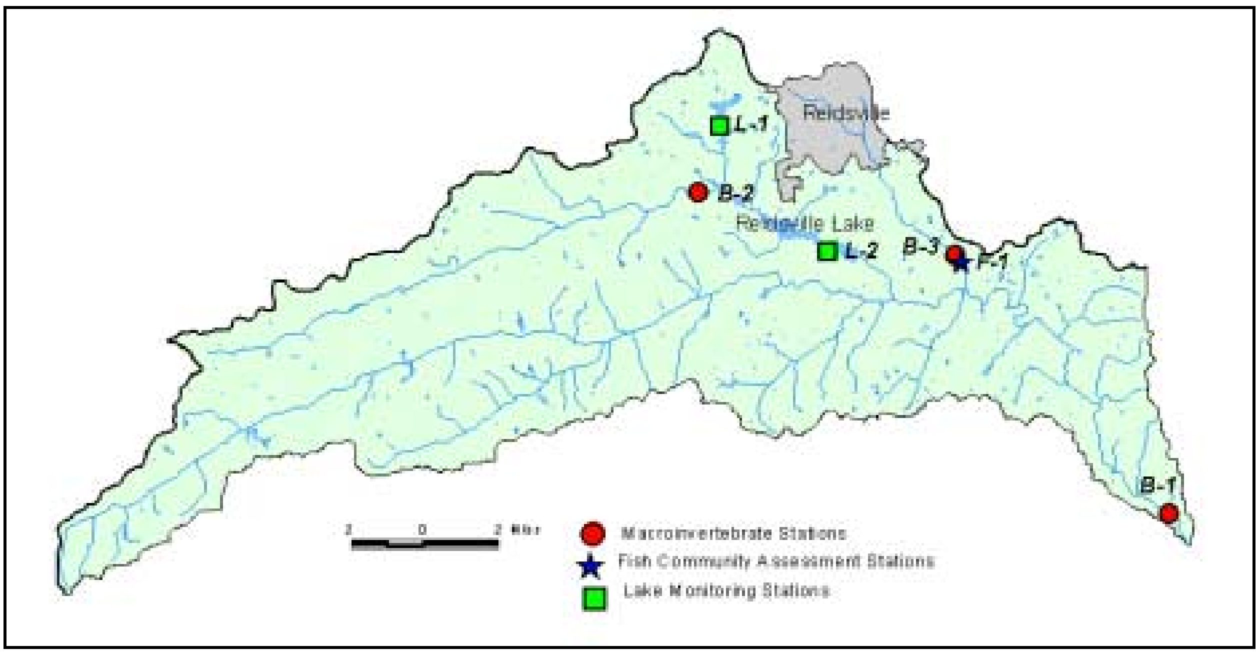


Figure 10. Sampling sites in Subbasin 01 in the Cape Fear River basin. Monitoring sites are listed in Table 7.

Overview of Water Quality

Widespread agriculture and highly erodible soils produced nonpoint source problems in the Haw River and Troublesome Creek catchments, which may have been exacerbated by the high rainfall in 2003. Since 1993, many sites were rated Good-Fair using benthic macroinvertebrate data, but Fair conditions were recorded often, including the upper site on the Haw River. Low flow in this segment of the river may influence these ratings. The Haw River at NC 87, the only Haw River site sampled in 2003, has fluctuated between Good-Fair and Fair since 1985. In 2003, the site was rated Good-Fair (Table 7). High flows prevented sampling at three river basinwide sites. Troublesome Creek was rated Good-Fair in 1998 and 2002 and data indicated water quality and habitat conditions typical for sandy streams in the upper basin.

In November 1998, the Town of Reidsville's WWTP relocated its discharge from Little Troublesome Creek to the Haw River to achieve greater dilution. Biological sampling in Little Troublesome Creek prior to the relocation clearly indicated stress from the discharge (organic loading and toxic conditions) and resulted in Poor ratings. Benthic data collected after the relocation, including the 2003 sample, produced Fair ratings.

The Haw River at NC 150 could not be sampled in 2003 because of high flow. This site is located downstream of the new discharge, which was not in operation until after the 1998 report was completed (NCDENR 1999). However, the sample collected at NC 150 in 1998 did not indicate that Little Troublesome Creek was having a negative impact on the benthic community in the Haw River.

Substantial improvements in the fish community were documented in Little Troublesome Creek after the discharge was relocated to the Haw River. However, the fish and benthic communities in Little Troublesome Creek continued to be impacted by urban runoff and numerous other nonpoint sources.

Lake Hunt has been sampled by DWQ since 1981. The lake is now used for recreational purposes, but served as the Town of Reidsville's primary water supply until 1979, when Reidsville Lake was built. Data collected in 2003 indicated elevated dissolved oxygen and chlorophyll *a* concentrations. Nutrient concentrations ranged from moderate to elevated. These characteristics indicated increased algal productivity and the lake was classified as eutrophic. In previous years, the lake had been classified as mesotrophic or oligotrophic.

Reidsville Lake is located on Troublesome Creek just outside of the City of Reidsville. Like Lake Hunt, 2003 data showed elevated dissolved oxygen and chlorophyll a concentrations. Metals and turbidity levels were greater than in previous years. The reservoir was classified as eutrophic in 2003, but was mesotrophic to borderline eutrophic in the past. These two reservoirs may have been influenced by high rainfall and nonpoint runoff during 2003.

There are five ambient monitoring sites located in this subbasin: Haw River at SR 2109 near Oak Ridge, Haw River at US 29A near Benaja, Little Troublesome Creek at SR 2600 near Reidsville, Haw River at NC 87 near Altamahaw, and the Haw River at SR 1561 near Altamahaw. In addition, the Upper Cape Fear River Basin Association, a monitoring coalition of NPDES dischargers, also samples three sites (two on the Haw River and one on Troublesome Creek) in the subbasin. Nutrients and conductivity values were lower in the Haw River in this subbasin than further downstream, reflecting the less developed watershed in the upper reaches of the river. Several sites on the upper Haw River and in Troublesome Creek had low dissolved oxygen concentrations. Low flow conditions at these sites created low dissolved oxygen environments. Elevated copper concentrations were documented at the Haw River near Benaja.

Three facilities in the subbasin maintain NPDES permits with requirements to conduct Whole Effluent Toxicity (WET) testing. The City of Reidsville incurred more than four WET NPDES permit limit violations between January 1998 and November 2003. Follow-up monthly testing indicated that effluent toxicity had been reduced to acceptable levels during the quarterly testing period.

Table 7. **Waterbodies monitored in Subbasin 01 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.**

Map #[1]	Waterbody	County	Location	1998	2003
B1	Haw River	Alamance	NC 87	Fair	Good-Fair
B2	Troublesome Cr	Rockingham	SR 2422	Good-Fair	Good-Fair[2]
B3	Little Troublesome Cr	Rockingham	SR 2600	Poor	Fair
F1	Little Troublesome Cr	Rockingham	SR 2600	Fair/Poor	Good-Fair
L1	Lake Hunt	Rockingham			
L2	Reidsville Lake	Rockingham			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake monitoring sites.
[2]sampled in 2002.

River and Stream Assessment

Benthic macroinvertebrate samples were not collected from three sites on the Haw River due to continuous high flows during the sampling season: at SR 2109, at US 29 Business, and at NC 150 (Appendix 1). These sites will be monitored during the 2008 basinwide cycle. Troublesome Creek was sampled in 2002 for a TMDL stressor study, so it was not sampled again in 2003.

Habitat characteristics and examples of high and low quality habitats at fish community sites in the basin are presented in Appendix 2.

Haw River, NC 87

This site is located a short distance below a run-of-the-river dam. This segment of the river is 15-20 meters wide and the drainage area is 189 square miles. The substrate is comprised mostly of boulders and bedrock. There were infrequent pools, eroding stream banks, and breaks in the riparian zone; the habitat score was 69.

Upstream view of Haw River at NC 87, Alamance County.

The benthic bioclassifications have fluctuated between Good-Fair and Fair (Table 8). In 1998, the decrease from Good-Fair to Fair was partly attributed to low flow. Several declines in taxa reported in 1998 were also observed in 2003. These included: *Acroneuria abnormis*, *Polycentropus*, and *Triaenodes ignitus*. Taxa that increased in abundance in 2003 included *Heterocloeon* sp., *Tricorythodes*, *Nectopsyche exquisita*, and elmid beetles.

Table 8. **Macroinvertebrate data from the Haw River at NC 87, Alamance County, 1987 - 2003.**

Year	EPT S	EPT N	NCBI	Flow	Rating
2003	15	82	6.3	High	Good-Fair
1998	17	56	6.7	Low	Fair
1993	22	117	5.9	Normal	Good-Fair
1990	12	65	7.1	Low	Fair
1987	14	74	6.4	Low	Good-Fair

Although rated Good-Fair in 2003, the EPT S and the EPT N were not as high as in 1993 (the previous Good-Fair rating). In addition, the EPT BI was 5.14 in 1993 and 5.40 in 2003. These numbers indicated a less-solid Good-Fair rating in 2003 than in 1993. However, high rainfall during the 2003 sampling period would increase the amount of nonpoint runoff and could have had an adverse affect by increasing the EPT BI and lowering the EPT S and EPT N. The chironomid assemblage continued to indicate toxic stress and nutrient enrichment.

Troublesome Creek, SR 2422

This site is a benthic macroinvertebrate basinwide site but was sampled in 2002 for a Wetlands Restoration Program study (Biological Assessment Unit Memorandum B- 021114). It was not sampled during the summer basinwide monitoring period.

The site is located near an old dam, and while the sampling reach contained a substrate with a good, rocky mix, the substrate above and below the reach was predominately sand. The habitat was scored 86. The stream width is about five meters and the drainage area is approximately 31 square miles.

Downstream view of Troublesome Creek at SR 2422, Rockingham County.

This site was rated Good-Fair in 2002, as it was in 1993 and 1998. The 2002 seasonally corrected EPT S was slightly higher than in 1998 (18 *vs*. 14). In 2002, all of the larger benthic organisms, especially *Acroneuria abnormis* and *Corydalus cornutus*, had black (manganese) deposits completely encrusting their exoskeletons and there was an abundance of sponge on the underside of rocks (both conditions indicating low dissolved oxygen concentrations). No odonates were collected in 2002, which was unusual because odonates are tolerant of low dissolved oxygen and were collected at other Troublesome Creek sites. Only four EPT taxa were abundant and three of those were winter taxa.

Little Troublesome Creek, SR 2600

This site on Little Troublesome Creek is located in the transition area between the Northern Inner and Southern Outer Piedmont. The monitoring site is about one mile above the stream's confluence with the Haw River. The stream drains southeastern Rockingham County, including the Town of Reidsville. At this location, the creek is about seven meters wide with a drainage area of 12 square miles. The habitat characteristics are of very low quality (Appendix 2).

Upstream view of Little Troublesome Creek at SR 2600, Rockingham County.

Until November 1998, the town's WWTP discharged to Little Troublesome Creek about three miles upstream of the monitoring site. The discharge caused severe water quality problems downstream from organic loading and toxic conditions. In November 1998, the effluent was relocated to the Haw River.

Relocating the discharge has resulted in improvements in the stream. For example, in April and October 1998 the conductivity was 236 and 549 µmhos/cm; in April 2003 it was 112 µmhos/cm (Appendix 14).

The benthic macroinvertebrate community also improved from Poor to Fair, but continued to be impacted. The benthic community was indicative of occasional low dissolved oxygen and low velocity (*Argia, Calopteryx, Hyalella azteca,* and *Physella*), rather than toxicity. The 2003 EPT sample was rated Fair, and was similar to a sample collected in 2001.

Substantial improvements in the fish community were documented after the discharge was relocated (Table 9).

Table 9. Comparisons of fish community variables at Little Troublesome Creek at SR 2600, Rockingham County, October 1998 and April 2003.

Variable[1]	Sample Period October 1998	April 2003
No. species	9	13
No. fish	50	214
No. species of darters	0	1
Tolerants (%)	38	18
Omni.+herb. (%)	52	32
Pisci. (%)	0	3.7
Multiple ages (%)	22	64
NCIBI score	24	44
NCIBI rating	Poor	Good-Fair

[1]variables showing little or no change are not listed.

The aquatic communities continued to be influenced by urban runoff and numerous other nonpoint sources, including agriculture. The flat, swampy nature of the stream below the town compounds the stress of low dissolved oxygen and low velocity. Relocating the largest point source discharge improved water quality, but nonpoint impacts continue to adversely affect the biological integrity of the stream.

SPECIAL STUDIES

Troublesome Creek

Benthic macroinvertebrate sampling for a Wetlands Restoration Program study concluded that Troublesome Creek had Good-Fair water quality throughout its length (Biological Assessment Unit Memorandum 021114). The benthos community did not suggest toxic impacts nor nutrient enrichment problems. In addition, there was no conclusive evidence suggesting that agricultural sediment was a problem in the watershed. Macroinvertebrate data indicated water quality and habitat conditions that seemed to be typical for sandy streams in the upper Cape Fear River Basin. The benthic fauna was only slightly more degraded than that found in a nearby reference stream.

Little Troublesome Creek

The Watershed Assessment and Restoration Project Program conducted an extensive assessment of the Little Troublesome Creek watershed in 2000 and 2001 (Biological Assessment Unit Memorandum B-020510, NCDENR 2002). Data collection included benthic macroinvertebrate sampling; assessment of stream habitat, morphology, and riparian zone condition; water chemistry and toxicity sampling; bed sediment chemistry and toxicity analysis; and watershed landuse characterization, conditions, and pollution sources.

The most probable causes and sources of impairment in the watershed were widespread habitat degradation manifested by extensive sedimentation and bank instability. These conditions were exacerbated by channelization and changes in watershed hydrology following increased development in the upper watershed. Organic loading and nutrients as well as toxicity from nonpoint sources, including development associated with the City of Reidsville were also important stressors to the benthic community. Little Troublesome Creek was impacted for its entire length. Prior to the relocation of the Town of Reidsville WWTP discharge to the Haw River, the benthic fauna indicated Poor conditions below the outfall. However, macroinvertebrate sampling always documented Fair conditions above the outfall, indicating that nonpoint sources negatively impacted the stream prior to mixing with the WWTP discharge.

ADDITIONAL DATA

Haw River Assembly

The Haw River Assembly coordinates a volunteer monitoring network that collects data from over 50 sites within the Haw River watershed. Volunteers note temperature, pH, field observations, and collect benthic macroinvertebrates. The macroinvertebrates are evaluated using the Izak Walton League analysis method. For further information, contact The Haw River Assembly, PO Box 187, Bynum, NC 17228, riverwatch@hawriver.org.

Lake Assessment

Lake Hunt

Lake Hunt is a recreational impoundment on an unnamed tributary to Troublesome Creek (Figure 11). The lake was the Town of Reidsville's primary water supply from 1956 to 1979 when Reidsville Lake was built. The boat launch area (Figure 12) is privately owned and public access is restricted. Prior to 2003, this lake had been sampled 14 times by DWQ.

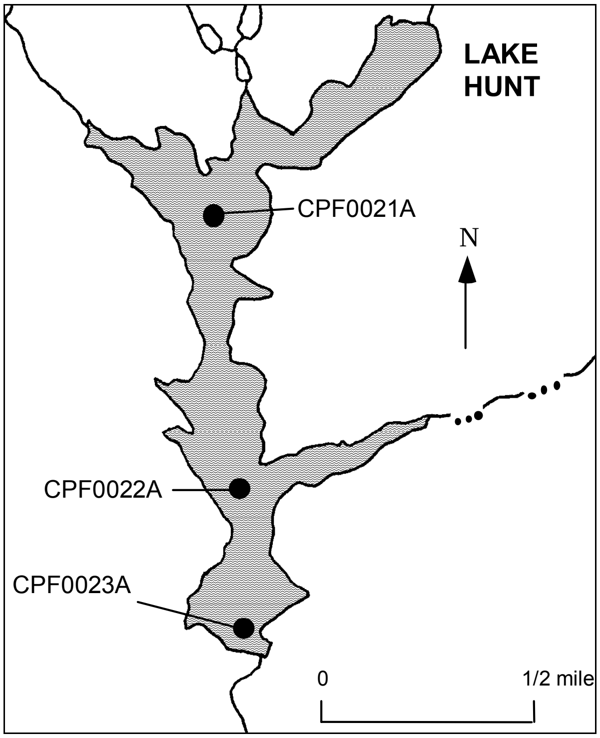


Figure 11. Sampling sites at Lake Hunt, Rockingham County.

Figure 12. Boat launch area at Lake Hunt, Rockingham County.

The reservoir was most recently monitored in 2003. Secchi depths were similar to those observed during past years. Surface dissolved oxygen values were elevated at all sites indicating increased algal productivity. This was further supported by elevated chlorophyll *a* concentrations (Appendix 22). In August the chlorophyll *a* concentration at Station CPF021A (42 µg/L) was greater than the water quality standard of 40 µg/L. A phytoplankton sample indicated a diverse assemblage with no apparent dominance of any particular species or group. Problematic species were noted in the sample such as filamentous bluegreens (*Anabaenopsis raciborskii* and *Aphanizomenon flos-aquae*). These algae can cause taste and odor problems in drinking water supplies.

Nutrient concentrations (total phosphorus, total Kjeldahl nitrogen, and total organic nitrogen) generally ranged from moderate to elevated, and these concentrations were sufficient to support algal growth within the lake. Nutrient and chlorophyll *a* concentrations in 2003 were the greatest observed at all sites since the reservoir was first monitored in 1981. Frequent summer rainfall events within the watershed in 2003 may have contributed to an increase in nonpoint source nutrient inputs which resulted in these findings.

Concentrations of metals in surface waters were less than water quality standards with the exception of iron in June, which was 70 percent greater than the water quality standard of 1,000 µg/L. The reservoir was classified as eutrophic in 2003 based on the calculated NCTSI scores. In previous sampling years (1981 to 1993), the reservoir was classified as mesotrophic or oligotrophic.

Reidsville Lake

Reidsville Lake is a water supply reservoir located on Troublesome Creek just outside of, and owned by, the City of Reidsville (Figure 13). The topography of the immediate watershed is characterized by rolling hills and land use is mainly row crop and pastures along with residential and commercial development. Rockingham County has limited activities in the watershed with strict zoning laws; the reservoir has a 100 foot buffer with a 50 foot buffer on all tributary streams. A city park with a boat launch area is located off of SR 2435 (Figure 14). Prior to 2003, this lake was sampled seven times by DWQ.

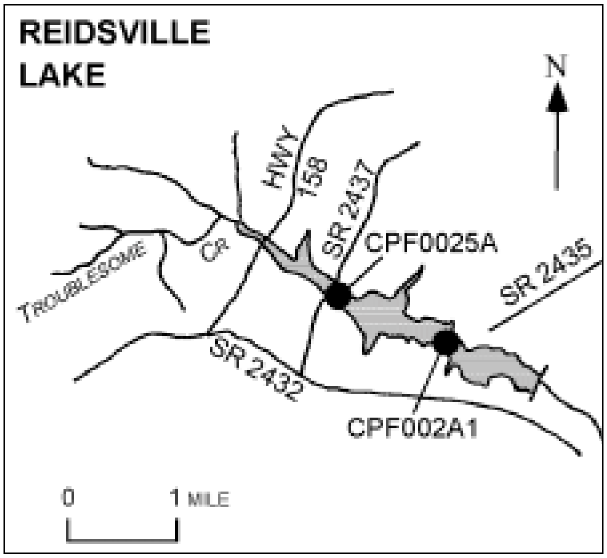


Figure 13. **Sampling sites at Reidsville Lake, Rockingham County.**

Figure 14. **Boat docks at Reidsville Lake, Rockingham County.**

The reservoir was most recently sampled in 2003. Surface percent dissolved oxygen saturation was elevated. These values ranged from 110 to 116 percent and were greater than those values previously observed for this lake (Appendix 22). Nutrient concentrations were also greater than those previously observed and may have been the result of increased nonpoint source contributions due to the frequent rainfall during the summer. In 1998, lake nutrient concentrations were also observed to be influenced by nonpoint source runoff. The increase of nonpoint source nutrients from summer rainfall events may have contributed to the reservoir's eutrophic conditions in July.

In response to the availability of nutrients in 2003, chlorophyll a concentrations for July and August were greater than the water quality standard of 40 µg/L. Phytoplankton analyses indicated diverse assemblages in July, however a good portion of the sample consisted of *Chrysochromulina sp*. In August, a diverse community was present and included the filamentous bluegreen algae *Aphanizomenon* and *Anabaena*. *Chrysochromulina sp*. and the filamentous blue green species are known to cause taste and odor problems in drinking water supplies.

Turbidity values were greater in 2003 than in previous years and may have been due to an increase in suspended sediments. Concentrations of metals in the surface waters were less than the water quality standards with the exception of iron in June, which was 50 percent greater than the water quality action level of 1,000 µg/L. Iron-rich sediments suspended in the water column as a result of a recent rain event may have contributed to this result.

The reservoir was classified as eutrophic in 2003 based on the calculated NCTSI scores. From 1981 to 1993 the reservoir was classified as mesotrophic to borderline eutrophic.

CAPE FEAR RIVER SUBBASIN 02

Description

This subbasin is located primarily in the Southern Outer Piedmont ecoregion which is characterized by lower elevations, less relief, and less precipitation than more western Piedmont areas (Griffith *et al*. 2002). Most of the Reedy Fork watershed is in the Northern Inner Piedmont ecoregion. The streams in this subbasin, all tributaries to the Haw River, include Reedy Fork and Stony, North Buffalo and South Buffalo Creeks (Figure 15). Stony and Jordan Creeks are classified as High Quality Waters.

There are 32 NPDES permitted dischargers in this subbasin with a total permitted flow of 60 MGD. Six of these dischargers have a permitted flow greater than 1.0 MGD:

- City of Greensboro's Lake Townsend WTP discharging 1.5 MGD into Reedy Fork;
- City of Mebane's WWTP discharging 2.5 MGD into Moadams Creek;
- City of Graham's WWTP discharging 3.5 MGD into the Haw River;
- City of Greensboro's North Buffalo Creek WWTP discharging 16 MGD into North Buffalo Creek;
- City of Greensboro's T. Z. Osborne's WWTP discharging 24 MGD into South Buffalo Creek; and
- City of Burlington's Eastside WWTP discharging 12 MGD into the Haw River.

This subbasin includes the City of Greensboro metropolitan area. The most recent landuse coverage (1993-1995) showed more than 80 percent of the subbasin forested or in pasture(Table 10). However, due to urban growth throughout the subbasin these landuse types have probably decreased as the percentage of urban landuse has increased. Such changing land uses practices will likely adversely affect stream water quality near the metropolitan areas.

Table 10. Land use in Subbasin 02. Based upon CGIA coverage 1993 - 1995 (total area = 562 square miles (NCDENR 2000).

Land use	Percent
Water	3
Cultivated crop	2
Pasture	28
Urban	9
Forest	59

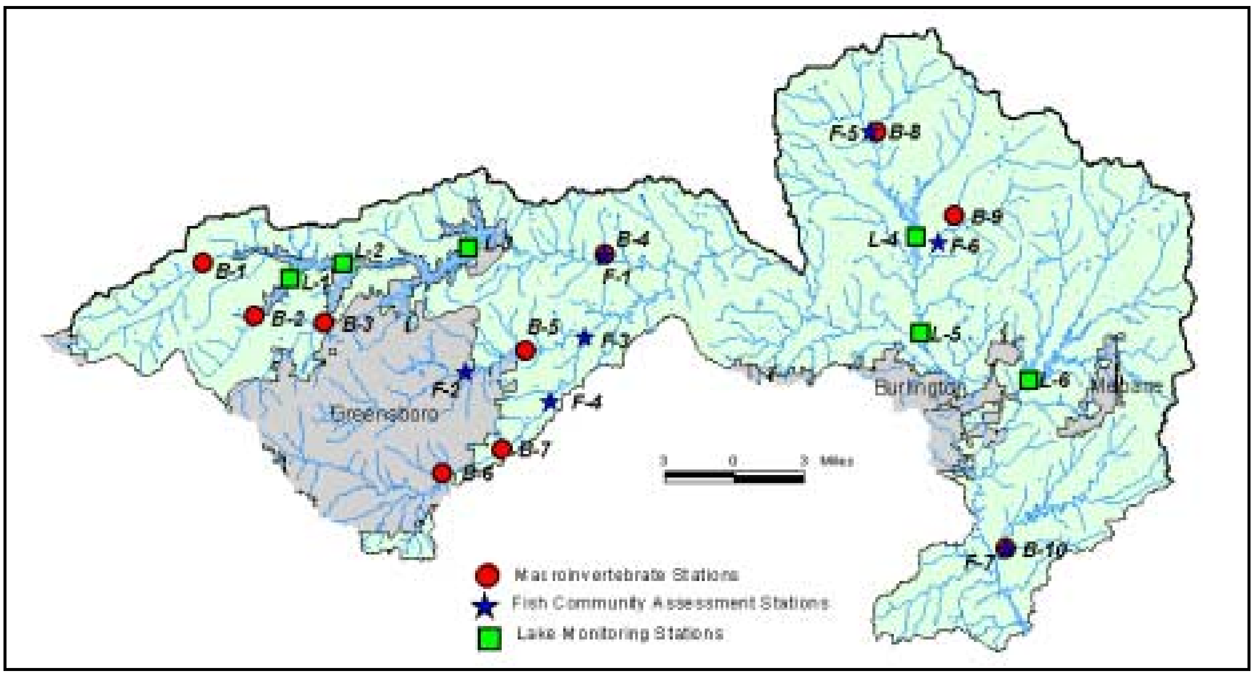


Figure 15. Sampling sites in Subbasin 02 in the Cape Fear River basin. Monitoring sites are listed in Table 11.

Overview of Water Quality

Point source dischargers and nonpoint source runoff from agricultural and urban areas contributed to the Fair to Poor macroinvertebrate bioclassifications found in many streams in this subbasin (Table 11). The upper Reedy Fork site maintained a Good-Fair rating, although residential areas are encroaching into the watershed as the City of Greensboro expands. The Reedy Fork site at SR 2136 declined to Fair in 2003, losing numerous EPT taxa from 1998. Horsepen Creek is an example of a stream declining over time as a result of the City of Greensboro's growth. This site declined from Good-Fair in 1986 to Poor in 2003. Monitoring sites downstream of the City of Greensboro's WWTPs (North and South Buffalo Creeks) were again rated Poor in 2003. These two sites have consistently rated Poor since sampling commenced in 1985.

Urban runoff from rapidly growing areas around Greensboro, Burlington, and Mebane has severe impacts (resulting in Poor or Fair ratings) on the water quality of headwater streams in this subbasin. Streams potentially affected by agricultural runoff and substantial habitat degradation such as in Haw , Jordan, and Stony Creeks had Good or Good-Fair ratings in the past. Haw Creek, which rated Good in 1998 declined to Good-Fair in 2003. It was difficult to determine whether the decline was attributed to the 2002 drought or from the adverse effects of development and nonpoint source runoff in a high rainfall year such as 2003.

Similar to benthic data, fish community data indicated water and habitat concerns associated with increasing urban landuse and nonpoint sources, in addition to point source issues. Based upon the fish community ratings, degraded streams (bioclassifications of Fair or Poor) included North and South Buffalo Creeks. Closure of the Cone Mills Textile Plant, which had discharged into N. Buffalo Creek (off 16th Street and US 29) in the upper part of the watershed, resulted in improvements in the fish community. The fish communities in Stony and Jordan Creeks rated Good-Fair. There are no NPDES permitted facilities in these watersheds; agricultural nonpoint sources of pollution and habitat degradation (severe bank erosion and sandy, embedded substrate) are currently the main concerns.

Three reservoirs (Lakes Higgins, Brandt, and Townsend) on Reedy Fork serve as water supply sources for the City of Greensboro and support recreational activities. In 2003 all three reservoirs showed elevated nutrient and chlorophyll *a* concentrations, although chlorophyll concentrations did not exceed the water quality standard. Based on three sampling events during the summer, the reservoirs were mostly classified as eutrophic.

Lake Burlington and Burlington Reservoir serve as the primary and auxiliary water supplies for the City of Burlington. Both reservoirs were eutrophic in 2003 and experienced elevated nutrients and decreased water clarity from previous samplings. During 2003, Burlington Reservoir also experienced several algal blooms.

Graham-Mebane Reservoir is the water supply for the Towns of Mebane, Graham, Green Level, and Haw River. Secchi depths were less than one meter in 2003 and suspended solids colored the water brown. Nutrients and chlorophyll a concentrations were elevated during 2003 and the reservoir was classified as eutrophic.

In this subbasin there are six ambient water quality monitoring sites and the Upper Cape Fear River Basin Association samples an additional 11 sites. Downstream of Burlington, Graham, and Mebane elevated conductivity and nutrient values were common. The median conductivity value at the Haw River at Haw River was 282 µmhos/cm. Numerous instances of elevated metals (copper and zinc) were detected from North and South Buffalo Creeks, the Haw River at Haw River, and Moadams Creek. Additionally, elevated fecal coliform concentrations were noted at these sites and along Reedy Fork, Town Branch, and Moadams Creek. The segments of North and South Buffalo Creeks below the City of Greensboro's WWTP dischargers constitute some of the worst water quality problems in the state. Conductivity values, nutrients, and copper concentrations were chronically elevated in these streams.

Fourteen facilities in this subbasin maintain NPDES permits with requirements to conduct Whole Effluent Toxicity testing. BP Oil Company WWTP, the City of Burlington South WWTP, and the City of Greensboro North Buffalo Creek WWTP incurred four or more WET NPDES Permit limit violations between January 1998 and November 2003. Follow-up monthly testing indicated that effluent toxicity had been reduced to acceptable levels during the quarterly testing period for the City of Burlington and Greensboro WWTPs. BP Oil Company operated a groundwater remediation system located in Guilford County and began Toxicity Reduction Evaluation work in 1999. The system was shut down in December 2002 to determine an acceptable discharge/treatment option.

Table 11. Waterbodies monitored in Subbasin 02 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Reedy Fork	Guilford	SR 2128	Good-Fair	Good-Fair
B-2	Brush Cr	Guilford	SR 2136	Fair	Fair
B-3	Horsepen Cr	Guilford	US 220	Fair	Poor
B-4	Reedy Fork	Guilford	SR 2728	Good-Fair	Fair
B-5	N. Buffalo Cr	Guilford	SR 2832	Poor	Poor
B-6	S Buffalo Cr	Guilford	US 70	Poor	Fair
B-7	S Buffalo Cr	Guilford	SR 2821	Poor	Poor
B-8	Stony Cr	Caswell	SR 1100	Good	Not Rated
B-9	Jordan Cr	Alamance	SR 1002	Good-Fair	Good-Fair
B-10	Haw Cr	Alamance	SR 2158	Good	Good-Fair
F-1	Reedy Fork	Guilford	SR 2728	Good/Good	Good
F-2	North Buffalo Cr	Guilford	off 16th Street & US 29	Poor (1999)	Good-Fair
F-3	North Buffalo Cr	Guilford	SR 2770	Poor	Poor
F-4	South Buffalo Cr	Guilford	US 70	Poor	Poor
F-5	Stony Cr	Caswell	SR 1104	---	Good-Fair
F-6	Jordan Cr	Alamance	SR 1754	---	Good-Fair
F-7	Haw Cr	Alamance	SR 2158	---	Good
L-1	Lake Higgins	Guilford			
L-2	Lake Brandt	Guilford			
L-3	Lake Townsend	Guilford			
L-4	Burlington Res.	Alamance			
L-5	Lake Burlington	Alamance			
L-6	Graham-Mebane Res.	Alamance			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake assessment sites.

River and Stream Assessment

Benthic macroinvertebrate samples were not collected from the Haw River at NC 54 or from Reedy Fork at NC 87 due to continuous high flows during the sampling season (Appendix 1). These sites will be monitored in the 2008 basinwide cycle. Habitat characteristics and examples of high quality and low quality habitats at fish community sites in the basin are presented in Appendix 2.

Reedy Fork, SR 2128

The headwaters of Reedy Fork are located in an agricultural area, although the proportion of residential landuse is increasing as the City of Greensboro expands. The stream is about six to eight meters wide and the watershed drainage area is 20.5 square miles. The stream bottom is entirely coarse, shifting sand. Erosion produces a relatively uniform sandy-run habitat with few riffles or pools and eroding banks; the habitat score was 54.

Reedy Fork at SR 2128, Guilford County.

Most benthic macroinvertebrates were associated with snag and leaf pack habitats. In spite of the poor habitat, the benthic macroinvertebrates rated the stream as Good-Fair. Over six collections (1986 - 2003) this site has been rated either Good-Fair. In 2002 the EPT S (15) and EPT N (54) were lower than in any previous sampling. However, intolerant *Pteronarcys*, *Paragnetina fumosa*, *Eccoptura xanthenes*, and *Neoperla* were still collected.

Brush Creek, SR 2136
Brush Creek is a small stream, approximately four meters wide with a drainage area of seven square miles. The creek originates under the Piedmont Triad International Airport, is then impounded to create a retention pond, flows through residential areas, and then several golf courses above this site. Habitat was similar to that of upper Reedy Fork (SR 2128) -- nearly all sand with no riffles or pools; the habitat score was 43. However, unlike Reedy Fork, this site had water quality problems.

Brush Creek at SR 2136, Guilford County.

Based upon benthic macroinvertebrates, the site was rated Fair in 1998 and 2003. The intolerant stonefly taxa that were collected at the Reedy Fork site were absent at this site. The 2003 sample resulted in seven EPT taxa and a BI of 6.83. Pollution tolerant filter-feeders (*Hydropsyche betteni* and *Cheumatopsyche*) and midges indicating organic inputs (*Polypedilum illinoense* and *Conchapelopia)* dominated the community.

Horsepen Creek, US 220
Horsepen Creek is a small sandy stream, five meters wide, originating in an industrial area of Greensboro and flowing through suburban residential and commercial areas before reaching Lake Brandt. The site, above Lake Brandt, has a drainage area of 16 square miles. The poor sandy habitat and severely eroded banks are reflected in the habitat score of 57.

Horsepen Creek at US 220, Guilford County.

This site declined from Good-Fair to Fair between 1986 and 1993, coincident with increased development in the watershed. It was also rated Fair in 1998 and 2001. The 2003 sample was rated Poor, although the decline in rating was due to the loss of one taxa from the 1998 sample (7 *vs*. 6 EPT S). Since 1986, this stream has clearly declined as the result of increasing urban development.

Reedy Fork, SR 2728
This site on Reedy Fork is located in the transition area between the Northern Inner and Southern Outer Piedmont. This portion of Reedy Fork is upstream of all major dischargers, but it may be influenced by releases of water from Lake Townsend, especially during drought conditions. The monitoring site is about seven miles below the reservoir. The stream width is approximately 10 - 15 meters and the drainage area is 125 square miles. The habitat was score 72 and 61 in 2003

Reedy Fork at SR 2728, Guilford County.

North Buffalo Creek off 16th Street and US 29, Guilford County.

During benthic sampling in 2003, the water was swift and deeper than in previous years as a result of recent rainfall. The rating declined from Good-Fair in 1993 and 1998 to Fair in 2003. EPT S significantly declined from 18 in 1998 to 8 in 2003. Stoneflies have never been an integral part of this community; tolerant and moderately tolerant mayflies and caddisflies had comprised the community in past collections. However, in 2003, many of these taxa (*Baetis flavistriga*, *B. pluto*, *Tricorythodes*, *Polycentropus*, and *Triaenodes ignitus*) declined or disappeared.

The fish community has been sampled four times and has consistently been rated Good. In June 2003, seven fewer species were collected than in October 1998 but the number of species was comparable to the number collected in November 1993 and April 1998. The species absent in 2003 were rosyside dace, whitefin shiner, mountain redbelly dace, creek chub, speckled killifish, flat bullhead, and redear sunfish. Except for the absence of the whitefin shiner, there were no changes in the dominant species between 1998 and 2003.

North Buffalo Creek, off 16th Street and US 29

This site, in the upper part of the watershed, drains the northern part of the City of Greensboro but still retains high quality stream and riparian habitats (Appendix 2). The stream used to receive the treated discharge (1.25 MGD) from the Cone Mills textile facility, but the facility ceased discharging on June 30, 2001. On April 21, 1999, the water was black from dye wastes and the conductivity was 911 µmhos/cm; on April 22, 2003 the conductivity was 228 and the water was slightly turbid but no longer black.

Substantial improvements in the fish community within almost two years of ceasing the discharge were documented at this site (Table 12.)

Table 12. Comparisons of fish community variables at North Buffalo Creek off 16th St. and US 29, Guilford County, April 1999 and April 2003.

Variable[1]	Sampling Period	
	April 1999	April 2003
No. species	9	11
No. fish	105	244
No. species of darters	0	1
No. species of suckers	0	2
Tolerants (%)	90	68
Omni.+herb. (%)	3	26
Insect. (%)	97	74
Pisci. (%)	0	3.7
Multiple ages (%)	44	64
NCIBI score	22	42
NCIBI rating	Poor	Good-Fair

[1]variables showing little or no change are not listed.

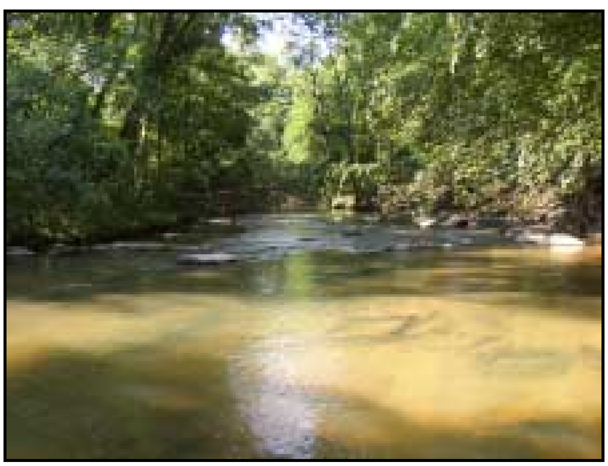
North Buffalo Creek, SR 2832

This site is 12 - 16 meters wide and has a drainage area of 37.1 square miles. The substrate is mostly sand with the remainder comprised of boulder, rubble, and gravel. There were good riffle areas near the bridge with profuse growths of attached algae. In 2003, the habitat score was 69.

North Buffalo Creek at SR 2832, Guilford County.

Since 1985 all benthic macroinvertebrate samples have rated this site as Poor. The EPT S was very low (1 - 4) in all of the samples. Certain taxa (*Cricotopus bicinctus*, *Conchapelopia* group, *Rheocricotopus robacki*, *Rheotanytarsus,* and *Limnodrilus hoffmeisteri*) indicated organic loading and instream toxicity. The tolerant filter feeding caddisflies *Hydropsyche betteni* and *Cheumatopsyche* were the dominant EPT taxa in 2003.

North Buffalo Creek, SR 2770
This site is approximately 8.5 miles below the City of Greensboro's North Buffalo Creek WWTP and the odor of treated effluent is still prevalent. The watershed is rural.



North Buffalo Creek at SR 2770, Guilford County.

The fish community has been assessed during every basin cycle and has consistently been rated Poor. There are few fish, darters are absent as are intolerant species, and there is an abundance of bluehead chubs and redbreast sunfish – all indicative of a nutrient enriched and degraded stream.

South Buffalo Creek, US 70
The watershed of this site on South Buffalo Creek includes the southeastern part of the City of Greensboro and the I-40 corridor. The stream is an urban stream with urban problems (e.g., elevated conductivity, tires, urban debris, *etc*.) (Appendix 2). The stream is a uniform sandy run with evidence of massive sediment inputs; turbidity fluctuates greatly depending upon the flow. It is also subject to the effects of urban runoff and several small dischargers. The stream width is about 12 meters and the drainage area is 28.1 square miles. Undercut banks and root mats were the most developed habitats for the benthos.

South Buffalo Creek at US 70, Guilford County.

The benthic bioclassification has been Fair or Poor since 1988; in 2003 it was again rated Fair. The 2003 sample included EPT taxa and chironomids that are tolerant of nutrient enrichment and sedimentation.

The fish community has been assessed during every basin cycle and has consistently been rated Poor. The community is dominated by tolerant eastern mosquitofish and redbreast sunfish; 95 percent of all the fish are tolerant, and the community had the fewest species of any site in the Piedmont (n = 7).

South Buffalo Creek, SR 2821
This site on South Buffalo Creek has much better habitat and greater flow (due to the 40 MGD discharge from the City of Greensboro's WWTP discharge) than the site at US 70. The drainage

area is 43.5 square miles. One large rocky riffle area was present in the sampling reach and woody debris and leaf packs were common. Moss and abundant periphyton covered the rocks; the habitat score was 75. The conductivity was very high (776 µmhos/cm).

South Buffalo Creek at SR 2821, Guilford County.

Since 1985 all benthic macroinvertebrate samples have rated this site as Poor. The 2003 sample was actually an improvement over the 1998 sample which was collected after a spill at the WWTP. EPT taxa were largely absent in 1998, with only a single specimen of *Hydropsyche betteni* collected. In 2003, three of the four EPT taxa collected were abundant.

Stony Creek, SR 1104

This stream drains southern Caswell County and is a tributary to Lake Burlington. The fish community was previously sampled in 1994, however, habitat assessments were not made at that time. In 2003 at this crossing, the instream, riparian, and watershed characteristics qualified the site as a new regional reference site (Appendix 2). There was evidence of erosion from previous storm events including bank blowouts and large woody debris in the channel.

Stony Creek at SR 1104, Caswell County.

In 1994 the fish community was rated Excellent, but in 2003 it was rated only Good-Fair. A decrease in the number of species, the number of fish, the number of species with multiple ages, an abundance of small fish, and the lack of larger fish were all indicative that this community continued to be affected by the 2002 drought.

Stony Creek, SR 1100

At this site, Stony Creek is about six meters wide and has a drainage area of 23.9 square miles. Habitat concerns included infrequent riffles, severe bank erosion, and an embedded, sandy substrate; the habitat score was 63. The amount of sand has seemingly increased since 1993. Areas with a rocky substrate and greater flow velocities than quiescent areas previously had a diverse EPT fauna. This was not the case in 2003. The habitat has declined, only one small riffle was found, and the rest of the stream was very slow moving.

Typical habitat of Stony Creek at SR 1100, Caswell County.

Atypical riffle in Stony Creek at SR 1100, Caswell County.

Past benthic samples rated the site Good. The severe drought of 2002 greatly impacted this stream, for this reason the site was Not Rated in 2003. The EPT S declined from 21 in 1998 to 11 in 2003 and the BI increased from 5.4 to 6.3. These metrics indicated a significant decline in the community.

The conductivity was slightly greater in Stony Creek (123 µmhos/cm) than in comparable streams in the subbasin 02 (such as Reedy Fork, Haw Creek, and Jordan Creek with rural and agricultural settings). The median conductivity value for these streams in 2003 was 97 µmhos/cm. The high rainfall and increased nonpoint source input in 2003 may have contributed to the lowered EPT S and increased EPT BI. The site should be declined from future basinwide assessments because the small riffle at this site was atypical of this reach of the stream.

Jordan Creek, SR 1002

This stream had an average width of six meters and a drainage area of 13.8 square miles. The habitat scored 49 because of the many habitat problems (infrequent riffles, infrequent pools, sandy substrate, and severely eroding banks).

Jordan Creek at SR 1002, Alamance County.

Severe bank erosion, Jordan Creek at SR 1002, Alamance County.

Despite habitat problems, the benthic community has always been rated Good-Fair. Taxa collected have been a mix of intolerant and tolerant taxa. *Ephoron leukon*, an intolerant mayfly, was abundant in 1998, but was not found in 2003. *Paraleptophlebia,* an intolerant mayfly, was abundant and collected for the first time in 2003.

Jordan Creek, SR 1754

This stream is a tributary to Stony Creek below Lake Burlington and drains primarily rural, northern Alamance County. However, the stream suffers from substantial bank erosion and habitat degradation (Appendix 2). The 2003 site was relocated approximately 1.5 miles beyond the 1993 site (at SR 1002) to capture more of the watershed (i.e., 13.8 *vs*. 24.1 square miles); it had not been sampled since 1993. The SR 1002 site is within the NC Natural Heritage Program's 76 acre Jordan Creek Alluvial Forest (Coomans, 2002).

Jordan Creek at SR 1754, Alamance County.

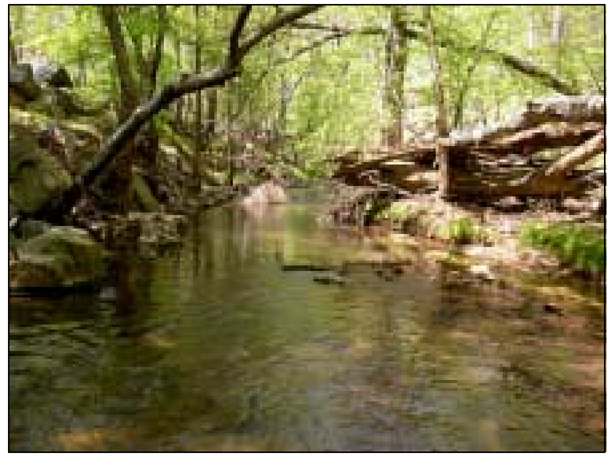
The fish community was rated Good-Fair in 1993 and 2003. Few fish were collected (only 73) and the number of species declined from 17 in 1993 to 12 in 2003. The stream may have gone dry during the 2002 drought and the fish community may not have yet completely recovered.

Haw Creek, SR 2158

Haw Creek borders the Carolina Slate Belt and the Southern Outer Piedmont and drains eastern Alamance and western Orange counties. There is one small NPDES dischargers (0.007 MGD) located in its headwaters.

Haw Creek was sampled for the first time for fish community assessment in 2003. At this crossing, the instream and riparian characteristics would have qualified the site as a new regional reference site (Appendix 2). However, watershed characteristics such as having I-85 dissect its headwaters and NC 54 dissect the lower part of the watershed precluded designating the site as a regional reference site.

The fish community was rated Good and there was a high level of species diversity (22) including seven species of sunfish and five species of catfish. The dominant species were the crescent shiner, spottail shiner, and redbreast sunfish.



Haw Creek at SR 2158, Alamance County.

The benthic macroinvertebrates rated the sites as Good-Fair, a rating it had also received in 1993. It had been rated Good in 1998. The benthic community seemed to be affected by nonpoint runoff because the bioclassification improves in low flow years (1998) and declines in years with high rainfall (2003). There was a noticeable loss of Trichoptera taxa from 1998 to 2003 (12 *vs*. 5). The 2003 sample barely rated Good-Fair (EPT S = 14). A combination of increasing development in this subbasin and nonpoint source runoff seemed to be adversely affecting the benthic community.

SPECIAL STUDIES

Brush Creek TMDL Development

Two sites were sampled for benthic macroinvertebrates in the Brush Creek watershed during June 2003. The upper site on Brush Creek indicated a degraded community and the lower site produced a Fair rating. The study concluded that the most likely causes of stress to the communities were from toxic nonpoint source runoff, sedimentation, and lack of instream habitats. The most likely sources of these stressors were the change in hydrology to the stream due to the high level of impervious surface in the watershed and the lack of adequate riparian zone buffers to filter and reduce runoff (Biological Assessment Unit Memorandum B-030812).

Horsepen Creek Watershed Assessment and Restoration Project

An extensive watershed investigation was conducted on the Horsepen Creek watershed in 2001 and 2002. Data collection included benthic macroinvertebrate sampling; assessment of stream habitat, morphology, and riparian zone condition; water chemistry and toxicity sampling;

bed sediment chemistry and toxicity analysis; and watershed landuse characterization, conditions, and pollution sources.

Macroinvertebrate data indicated that the watershed was severely impacted. The study concluded that the most probable causes and sources of impairment in the watershed were toxicity from nonpoint sources, habitat degradation and scour due to changes in hydrology following increased development, organic enrichment, and sedimentation (Biological Assessment Unit Memorandum B-021112, NCDENR 2003b).

Varnals Creek High Quality Waters Supplemental Classification Survey
Two sites were sampled for benthic macroinvertebrates on Varnals Creek in September 2000. The upper site was rated Good and the lower site Fair. These ratings precluded the watershed from qualifying as HQWs; an Excellent rating based on biological and physical/chemical characteristics is required (Biological Assessment Unit Memorandum B-010316).

Impact of the Town of Mebane's WWTP
At the request of the Planning Branch, a study of the water quality problems in the Moadams Creek catchment was conducted in November 1999. Results of the macroinvertebrate sampling were complicated by Hurricane Floyd (which occurred in September 1999), low flow in the upper reaches of Moadams Creek, urban runoff, the effects of impoundments, and the lack of prior data. Sampling indicated inputs of organic particulates downstream of the WWTP discharge and water quality problems in Back Creek. No ratings were assigned to any of the sites (Biological Assessment Unit Memorandum B-991203).

ADDITIONAL DATA

The City of Greensboro's Fish Community and Benthic Macroinvertebrate Studies
In 1999, the Staff of the City of Greensboro's Stormwater Services Division conducted an assessment of the fish communities of several streams in the Greensboro area in Guilford County (Anon. 2000) (Table 13). The assessment followed NC DWQ's Standard Operating Procedures for stream fish community assessment (NCDENR 1999, superceded by NCDENR 2001) and thus the data can be used for use support purposes. The collecting effort on April 21, 1999 was assisted by NC DWQ's Biological Assessment Unit Staff.

Table 13. Streams monitored in the Greensboro area for fish community assessment, 1999.

Waterbody	Location	Date	NCIBI	Rating
Brush Cr	SR 3820	09/24/99	46	Good
Horsepen Cr	US 220	10/27/99	42	Good-Fair
Reedy Fk	SR 2128	09/20/99	34	Fair
N Buffalo Cr	SR 2628	10/27/99	28	Poor
N Buffalo Cr	SR 1400	09/20/99	32	Poor
N Buffalo Cr	off 16th St & US 29	04/21/99	22	Poor
S Buffalo Cr	off SR 3300	04/21/99	36	Fair
S Buffalo Cr	US 70	04/21/99	22	Poor

Staff also collect benthic macroinvertebrate data from many streams within the South Buffalo and North Buffalo watersheds, numerous water supply watershed, and from reference streams. The assessments follow NC DWQ's Standard Operating Procedures for benthic macroinvertebrates (NCDENR 2001b) and utilizes DWQ-certified laboratories for taxonomic identification. Similar to DWQ data, the City of Greensboro data indicated impacted water quality conditions in South and North Buffalo Creeks.

Haw River Assembly
The Haw River Assembly coordinates a volunteer monitoring network that collects data from over 50 sites within the Haw River watershed. Volunteers note temperature, pH, field observations, and collect benthic macroinvertebrates. The macroinvertebrates are evaluated using the Izak Walton League analysis method. For further information, contact The Haw River Assembly, PO Box 187, Bynum, NC 17228, riverwatch@hawriver.org.

Lake Assessment

Three reservoirs on Reedy Fork were sampled in this subbasin (Figure 16). Each reservoir is used by the City of Greensboro as a water supply and support recreational activities such as fishing and canoeing. Each reservoir was sampled at two or three locations (upper, middle, and lower).

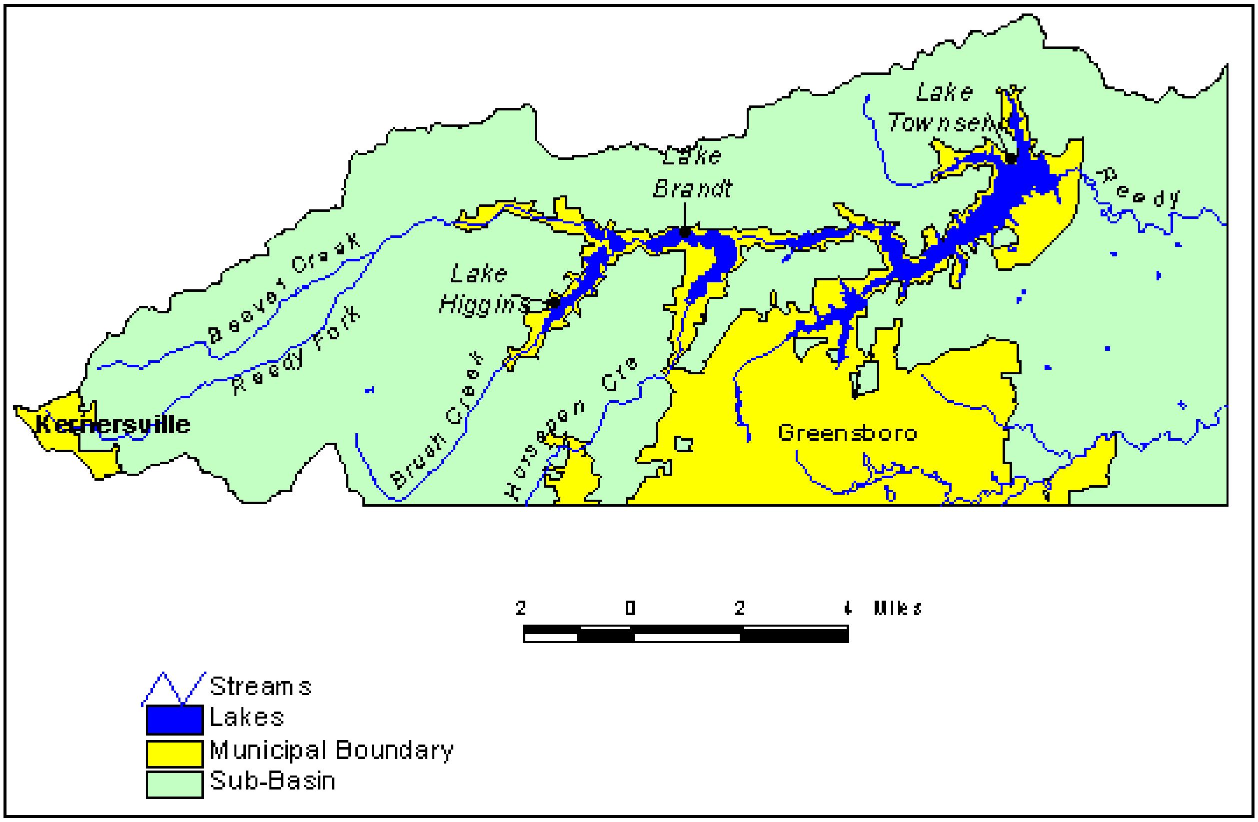


Figure 16. **Reservoirs on Reedy Fork sampled as part of the Cape Fear River basin monitoring program.**

Lake Higgins
The shoreline of Lake Higgins is mostly forested land with a few private homes set back from the lakeshore. The immediate watershed is a mix of agriculture and residential development (Figure 17). During the height of the drought of 2002, the reservoir was completely drained to provide adequate water for Lakes Brandt and Townsend. Prior to 2003, the reservoir had been sampled five times by DWQ.

Figure 17. **Park office at Lake Higgins, Guilford County.**

The reservoir was most recently monitored in 2003. Total phosphorus values in August (0.05 mg/L) were the highest ever measured since the reservoir was first monitored in 1990 (Appendix 22). Total Kjeldahl nitrogen and total organic nitrogen concentrations were also elevated. This increase in nutrients may have been due to frequent rainfall within the watershed resulting in a greater nonpoint source input of nutrients. In response to the elevated availability of nutrients, algal biomass (as estimated by chlorophyll *a* concentrations) was also the greater in August than in June and July. However, the concentrations were not greater than the water quality standard. Metals concentrations in surface waters were also less than the water quality standards.

Based on the calculated NCTSI scores, the reservoir was classified as eutrophic in June and August and mesotrophic in July. The reservoir was classified as eutrophic in 1990 and mesotrophic in 1993.

In 2003, 15 acres of the lake were infested with water primrose, *Ludwigia hexapetala*, and were treated with herbicides by the Division of Water Resources.

Lake Brandt

The shoreline of Lake Brandt is forested (Figure 18) and the watershed consists of a mix of residential developments, pastures, row crop fields and scattered small businesses. Prior to 2003, the reservoir had sampled seven times by DWQ.

Figure 18. Canada Geese on Lake Brandt, Guilford County.

The lake was most recently monitored in 2003. Total phosphorus concentrations ranged from moderate to elevated; nitrogen concentrations ranged from low to elevated; and chlorophyll *a* concentrations were moderate. Concentrations of metals in the surface waters were less than the water quality standards. Based on the calculated NCTSI scores, the reservoir was classified as eutrophic in 2003, a rating documented in previous years.

Lake Townsend

Lake Townsend is the furthest downstream lake used by Greensboro as a water supply. Although mean retention time of this reservoir is not known, it takes an estimated seven to eight months for water to travel from Lake Higgins to the dam at Lake Townsend. The reservoir's immediate shoreline consists of forested areas and a golf course (Figure 19) The immediate watershed is a mix of urban and residential development, pastures, and row crops. Prior to 2003, the reservoir had sampled five times by DWQ.

Figure 19. Golf course at Lake Townsend, Guilford County.

This reservoir was most recently monitored in 2003. Total phosphorus concentrations were greatest at the upper most station (CPFLT4), with the highest concentration (0.09 mg/L) observed in August (Appendix 22). Total Kjeldahl nitrogen and total organic nitrogen concentrations in 2003 were also greatest at Station CPFLT4 in August, suggesting that the frequent rainfall events during the summer may have increased nonpoint source nutrient contributions to the reservoir.

Chlorophyll a concentrations were greatest in August at all sites in response to the availability of these nutrients. None of the concentrations were greater than the water quality standard of 40 µg/L.

Concentrations of metals in the surface waters were less than the water quality standards. The reservoir was classified as eutrophic in 2003 based on the calculated NCTSI scores, a rating documented in previous years.

Burlington Reservoir

Burlington Reservoir is an auxiliary water supply reservoir for the City of Burlington. The reservoir is located at the confluence of Stony and Toms Creeks in Alamance County (Figure 20). The immediate watershed area consists primarily of forested and agricultural land. The reservoir was sampled seven times by DWQ prior to 2003.

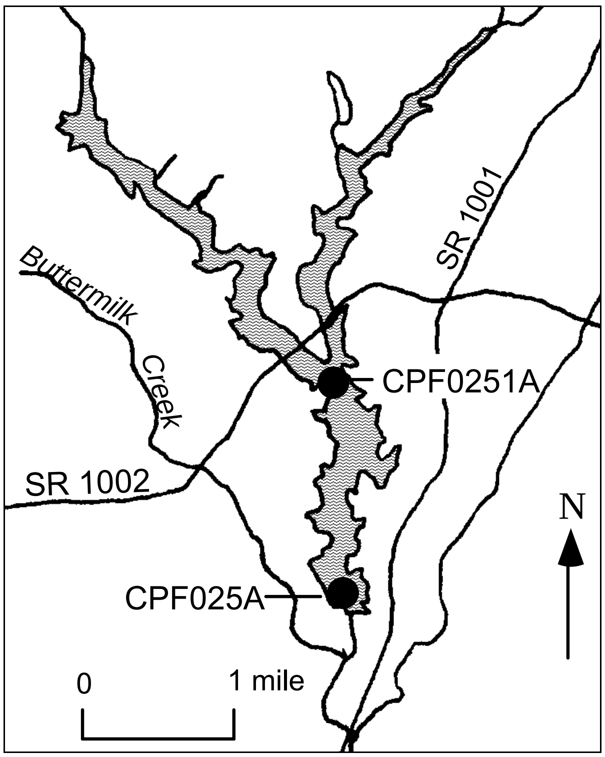


Figure 20. Sampling sites at Burlington Reservoir, Alamance County.

The reservoir was most recently monitored in 2003. Frequent rainfall within the watershed may have contributed to Secchi depths in July and August that were lower than any previously recorded (Appendix 22). Solids were also greater in 2003 than in previous sampling years. Nutrient concentrations were elevated at both sites.

In response to the availability of nutrients, algae growth increased as evidenced by elevated chlorophyll *a* concentrations. Chlorophyll *a* concentrations at Station CPF0251A in June and August (45 and 52 µg/L, respectively) were greater than the water quality standard of 40 µg/L. The July algal bloom was dominated by *Chrysochromulina* sp. In August, the bloom was of the filamentous bluegreen *Anabaenopsis raciborskii*. These taxa cause taste and odor problems in drinking water supplies.

Concentrations of metals in the surface waters were less than the water quality standards. The reservoir was classified as eutrophic in 2003 based on the calculated NCTSI scores, a rating documented in previous years.

Lake Burlington

Lake Burlington, an impoundment of Stony Creek downstream of Burlington Reservoir (Figures 21 and 22), is the primary water supply reservoir for the City of Burlington. The immediate watershed is characterized by rolling hills and agriculture is the most common landuse. The reservoir was sampled five times by DWQ prior to 2003.

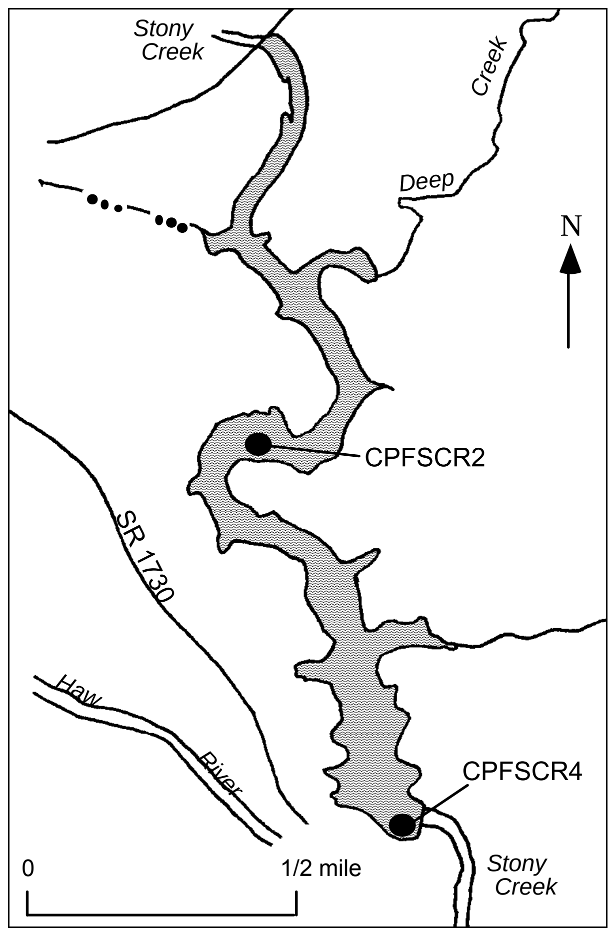


Figure 21. Sampling sites at Lake Burlington, Alamance County.

Figure 22. Lake Burlington at the dam, Alamance County.

The reservoir was most recently monitored in 2003. Secchi depths were consistently less than one meter at both sites, suggesting poor water clarity. The water was brown from suspended sediments. Total phosphorus concentrations in July and August 2003 were greater than those previously observed. During the summer, total Kjeldahl nitrogen and total nitrogen were also greater than those values previously observed. Despite the availability of these nutrients, chlorophyll a concentrations were not greater than the water quality standard of 40 µg/L.

Concentrations of metals in the surface waters were less than the water quality standards with the exception of iron which was slightly greater than the water quality action level of 1,000 µg/L. Suspended iron-rich sediments in the water column due to frequent rain events may have contributed to these elevated values.

The reservoir was classified as eutrophic in 2003 based on the calculated NCTSI scores, a rating documented in previous years.

Graham-Mebane Reservoir

This reservoir serves the water supply needs for the Towns of Graham, Mebane, Green Level, and Haw River. The reservoir is 11 years old. The reservoir is an impoundment of Quaker and Back Creeks (Figure 23) and encompasses the old Quaker Creek Reservoir. The immediate shoreline is primarily forested except for a few houses, a school, and some farmland (Figure 24). Prior to 2003, this reservoir has been monitored four times by DWQ.

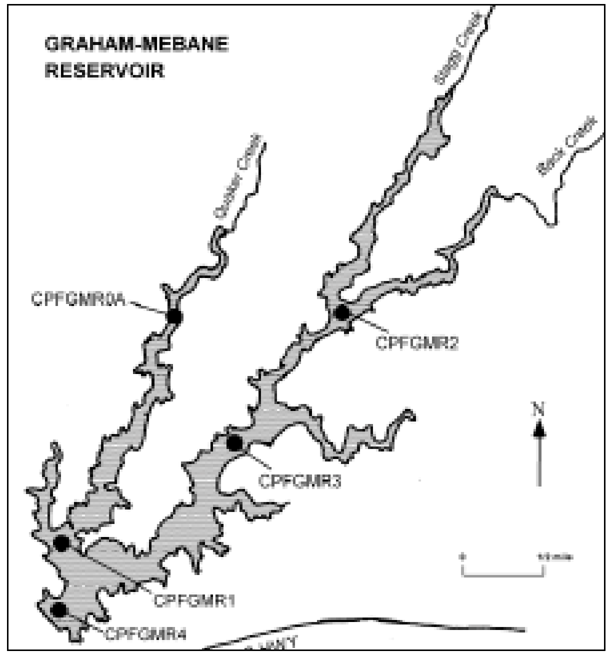


Figure 23. Sampling sites at Graham-Mebane Reservoir, Alamance County.

Figure 24. Graham-Mebane Reservoir, Alamance County.

The reservoir was most recently sampled in 2003. As had been observed in previous years, Secchi depths in 2003 were consistently less than one meter (Appendix 22). The water was brown from suspended sediments. Nitrogen concentrations in were greater than those previously measured and generally ranged from moderate to elevated. Total phosphorus concentrations were also elevated.

These nutrients may have supported an increase in algal growth as indicated by chlorophyll *a* concentrations which ranged from moderate to elevated. In July and August, chlorophyll *a* concentrations at Stations CPFGMR1, CPFGMR3, and CPFGMR4 were greater than the water quality standard of 40 µg/L. These elevated concentrations were attributed to algal blooms consisting of *Gonyostomum* sp. (Appendix 23). This taxon is indicative of eutrophic conditions and can form nuisance blooms in the summer (Wehr and Sheath 2003).

Despite the increased algal productivity, surface percent dissolved oxygen saturation were only elevated at Station CPFGMR2 in August (124 percent). Concentrations of metals in the surface waters were within water quality standards. The reservoir was classified as eutrophic in 2003 based on the calculated NCTSI scores, a rating documented in previous years.

CAPE FEAR RIVER SUBBASIN 03

Description

This subbasin is located wholly within the Southern Outer Piedmont (Griffith *et al*. 2002).and contains the I-40/I-85 corridor between the cities of Burlington and Greensboro (Figure 25). The subbasin is comprised of tributaries to the Haw River -- Big Alamance, Little Alamance, and Stinking Quarter Creeks. [Note: the “Little Alamance Creek” in the headwaters of this subbasin should not be confused with “Little Alamance Creek” that drains the Burlington area.]

There are six NPDES permitted dischargers in this subbasin; only the City of Burlington’s Southside WWTP (12 MGD into Big Alamance Creek) discharges more than more than 0.5 MGD.

The most recent landuse coverage (1993-1995) (Table 14) showed more than 90 percent of the subbasin forested or in pasture. However, due to urban growth throughout the subbasin these landuse types have probably decreased as the percentage of urban landuse has increased.

Table 14. Land use in Subbasin 03. Based upon CGIA coverage 1993 - 1995 (total area = 262 square miles (NCDENR 2000).

Land use	Percent
Water	< 1
Cultivated crop	2
Pasture	32
Urban	6
Forest	59

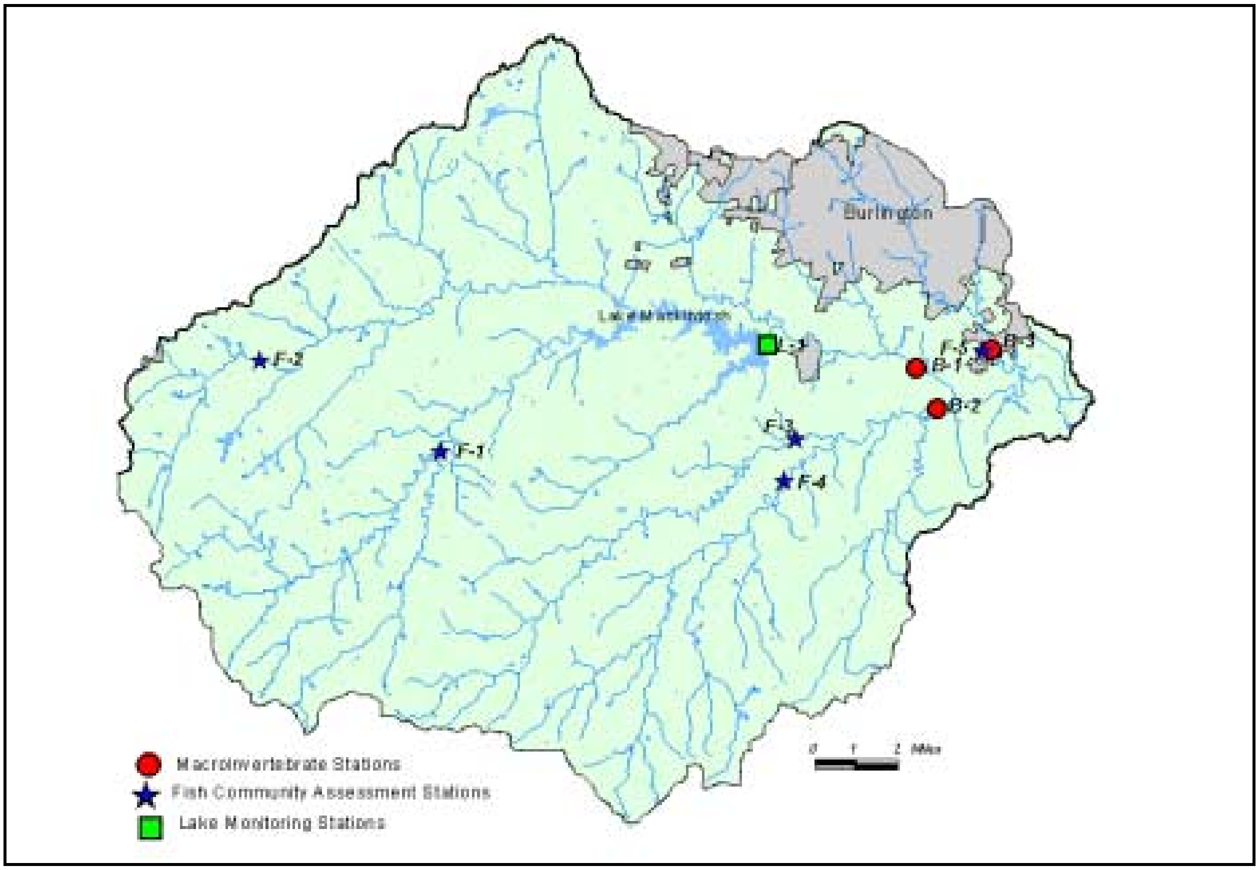


Figure 25. Sampling sites in Subbasin 03 in the Cape Fear River basin. Monitoring sites are listed in Table 15.

Overview of Water Quality

Benthic macroinvertebrate sampling was conducted on three tributaries to the Haw River: Big Alamance, Stinking Quarter, and Little Alamance Creeks (Table 15). Erosion from agricultural land appeared to cause large sediment inputs into the streams and benthos ratings have been quite variable within this subbasin. In addition, the streams are impacted by urban and agricultural nonpoint sources. Ratings in 2003 ranged from Fair (Big Alamance Creek and Little Alamance Creek) to Good-Fair (Stinking Quarter Creek). Little Alamance Creek was rated Poor in 1998, so the 2003 rating was an improvement. Big Alamance and Stinking Quarter Creeks ratings declined from 1998. It was difficult to determine whether the declines could be attributed to lasting effects from the 2002 drought or increased nonpoint source inputs in 2003 from high rainfall.

Fish community sampling was conducted at five sites in this subbasin. There were no NPDES permitted facilities in the watersheds of Big Alamance, South Prong Stinking Quarter, or Little Alamance Creeks where fish community assessment were performed. Ratings ranged from Excellent to Good-Fair. The 2002 drought conditions continued to adversely affect the fish community of Big Alamance Creek.

Lake MacIntosh is a water supply reservoir for the City of Burlington. In 2003, the reservoir demonstrated low water clarity, elevated turbidity, dissolved oxygen, and nutrient levels, and stratification with dissolved oxygen levels at hypoxic levels at depths of three meters from the surface. In addition, chlorophyll *a* concentrations were greater than the water quality standard. Lake MacIntosh was classified as eutrophic in 2003.

There are two DWQ ambient monitoring sites in the subbasin: Alamance Creek at Swepsonville and Lake MacIntosh near Whitsett. The Upper Cape Fear River Basin Association also monitors Alamance Creek and a site on Big Alamance Creek near Swepsonville. DWQ ambient data indicated elevated copper concentrations at Alamance Creek.

There were no facilities in this subbasin that are required by their NPDES permit to conduct Whole Effluent Toxicity testing.

Table 15. Waterbodies monitored in Subbasin 03 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Big Alamance Cr	Alamance	NC 49	Good-Fair	Fair
B-2	Stinking Quarter Cr	Alamance	SR 1136	Good	Fair/Good-Fair
B-3	Little Alamance Cr	Alamance	SR 2309	Poor	Fair
F-1	Big Alamance Cr	Guilford	SR 3088	Good	Good-Fair
F-2	Little Alamance Cr	Guilford	SR 3039	Good-Fair	Good-Fair
F-3	North Prong Stinking Quarter Cr	Alamance	SR 1113	---	Good
F-4	South Prong Stinking Quarter Cr	Alamance	SR 1117	---	Excellent
F-5	Little Alamance Cr	Alamance	SR 2309	Fair	Good
L-1	Lake Mackintosh	Guilford, Alamance			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake monitoring site.

Habitat characteristics and examples of high quality and low quality habitats at fish community sites in the basin are presented in Appendix 2.

Big Alamance Creek, SR 3088
Big Alamance Creek drains southeastern and eastern Guilford County. The creek's headwaters are dissected by the US 421 corridor.

Big Alamance at SR 3088, Alamance County.

The fish community in this stream has suffered from the effects of the droughts of late 1998, 1999, and 2002. During this time, the community has declined from Good to Fair. In 2003 the community was rated Good-Fair. A decrease in many of the metrics such as in the number of species, the number of species of darters and sunfish, the total number of fish, the number of species with multiple ages, and an abundance of small fish with the concomitant lack of larger fish, were all indicative that this community continued to be affected by the 2002 drought.

Big Alamance Creek, NC 49
The creek at this site is about 10 to 12 meters wide and has a drainage area of 242 square miles. The substrate is nearly all sand, so most taxa were found on snag habitats. The prolific stream bottom periphyton growths observed in 1998 were not abundant in 2003. Nonpoint source problems from agricultural and urban areas continued to affect the stream. The channel is entrenched, there is a lack of riffles and pools, the banks are severely eroded, and the substrate is uniform sand. The habitat score was 44.

Big Alamance at NC 49, Alamance County.

This site declined to Fair in 2003; it was rated Good-Fair in 1993 and 1998. It is unclear whether the Fair rating could be attributed to lasting effects from the 2002 drought, high water and increased nonpoint source input in 2003, or increased development within the watershed. The 1998 sample occurred during a time of very low flow, unlike the 2003 sample. The decline in EPT S from 1998 to 2003 was mostly due to decreases in Baetidae taxa.

Little Alamance Creek, SR 3039
The watershed of Little Alamance Creek drains a triangular area south and east of I-85, US 421, and NC 22. There is one NPDES permitted discharger (0.01 MGD) in the watershed above the monitoring site. The monitoring site was located underneath overpasses of I-840 (City of Greensboro bypass). Despite the highway construction between 1998 and 2003, the sinuosity of the stream was maintained and there was no detrimental effect on the fish community. The community continued to be rated Good-Fair.

Upstream view of Little Alamance Creek at SR 3039, Guilford County.

North Prong Stinking Quarter Creek, SR 1113
North Prong Stinking Quarter Creek was sampled for the first time for fish community assessment in 2003. Its watershed drains southeastern Guilford and western Alamance counties. There is one small (0.0045 MGD) NPDES permitted discharger in the headwaters, discharging to an unnamed tributary.

North Prong Stinking Quarter Creek at SR 1113, Alamance County.

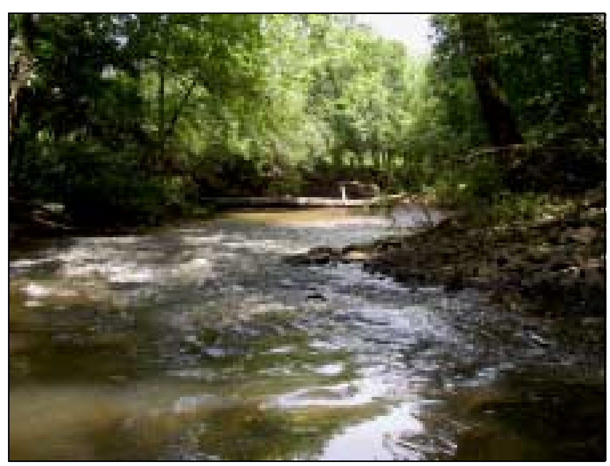
The fish community was rated a low Good (NCIBI = 46). No intolerant species or piscivores were collected. The dominant species was the green sunfish.

South Prong Stinking Quarter Creek, SR 1117
South Prong Stinking Quarter Creek was sampled for the first time for fish community assessment in 2003. Its watershed drains the extreme southeastern corner of Guilford and western Alamance counties. At this crossing, the instream and riparian characteristics would have qualified the site as a new regional reference site (Appendix 2). However, watershed characteristics such as a suboptimal percentage of the watershed being forested precluded designating it as a regional reference site.

South Prong Stinking Quarter Creek at SR 1117, Alamance County.

Never-the-less, the fish community was rated a low Excellent (NCIBI = 54). The dominant species was the Crescent shiner; a introduced species now found in the part of the basin in Subbasins 01 - 03.

Stinking Quarter Creek, SR 1136
This stream is similar in size and habitat to Big Alamance Creek, although Stinking Quarter Creek has better instream habitats (infrequent riffles of gravel, cobble, and some boulder) than Big Alamance Creek. The creek is 11 to 13 meters wide and the drainage area is 81 square miles. The habitat score was 74.

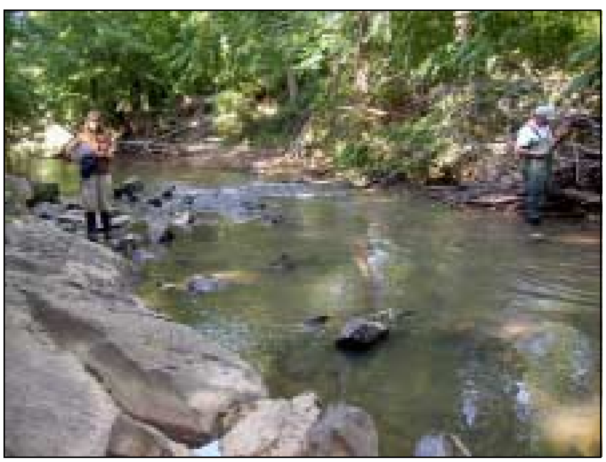


Stinking Quarter Creek at SR 1136, Alamance County.

The site was rated Fair in July 2003. This site has varied between Good-Fair (1993) and Good (1998), depending on flow. The slightly greater EPT S in 1998 (23) compared to 1993 (16) was associated with lower flow and, therefore, lower amounts of nonpoint source runoff. The 2003 sample was collected during a period of high rainfall and the lower EPT S (13) could have been influenced by increased nonpoint source runoff. A second sample , collected in November 2003, had a EPT S of 17 and was rated Good-Fair.

Little Alamance Creek, SR 2309

Little Alamance Creek drains the towns of Burlington and Graham and the I-85/I-40 and US 70 corridors. The monitoring site is about 2¼ miles above its confluence with Alamance Creek. Although there are no NPDES permitted facilities above the site, the elevated conductivity (~155 - 185 µmhos/cm) during the three fish community monitoring cycles suggested some urban runoff. The site still retains moderate quality stream and riparian habitats (Appendix 2).



Upstream view of Little Alamance Creek at SR 2309, Alamance County showing rocky substrate.

Despite its watershed size (14.8 square miles), the fish community was not negatively affected by the 2002 drought. On the contrary, the lack of urban, nonpoint source runoff may have benefited the community. The diverse and balanced community was rated Good in 2003, the same rating it received 10 years earlier. It had been rated only Fair in 1998.

The 2003 benthic sample was rated Fair. Five EPT taxa were collected including *Stenonema modestum*. *Stenacron interpunctatum* was abundant in the previous two collections, but was absent in 2003. Midges were the most common organisms in 2003. Past samples have rated this site Poor (1998) and Fair (1993).

SPECIAL STUDIES

Fish Community Temporal Variability

The fish community in Big Alamance Creek at SR 3088, Guilford County, was sampled in April, June, and October 1999 to determine the temporal variability of the NCIBI during NC DWQ's traditional monitoring period. The community was rated Good in April, no sample could be collected in June due to a prolonged drought, and Fair in October following a prolonged drought and Hurricane Floyd-induced floods. At other sites in the study, it was determined that seasonality was not an important factor to consider when using the NCIBI to assess the fish community of a stream (Biological Assessment Unit Memorandum F-000922).

Little Alamance Creek TMDL Study

A TMDL stressor identification study was conducted on the Little Alamance Creek watershed in June 2003 to determine the sources of impairment. The study concluded that the stream is a typical urban stream greatly affected by urban runoff. This is indicated by the elevated conductivity measurements throughout the watershed and the generally poor water quality as demonstrated by the benthic fauna. In addition, hydrologic changes due to channelization, riparian removal, and large amounts of impervious surface further degrade the stream (Biological Assessment Unit Memorandum B-031103).

ADDITIONAL DATA

The Haw River Assembly coordinates a volunteer monitoring network that collects data from over 50 sites within the Haw River watershed. Volunteers note temperature, pH, field observations, and collect benthic macroinvertebrates. The macroinvertebrates are evaluated using the Izak Walton League analysis method. For further information, contact The Haw River Assembly, PO Box 187, Bynum, NC 17228 (919) 967-2500, riverwatch@hawriver.org.

Lake Assessment

Lake Mackintosh

Lake Mackintosh, an impoundment of Big Alamance Creek, is a 10 year old water supply reservoir for the City of Burlington (Figures 26 and 27). The lake is used for secondary recreation. The surrounding land is comprised of pastures and farmland with a few houses. The reservoir has been sampled 11 times by DWQ prior to 2003.

Figure 26. Lake Mackintosh, Guilford and Alamance counties.

The reservoir was most recently monitored in 2003. Secchi depths ranged from 0.1 to 1 meter (Appendix 22.) Turbidity at Station CPF038F in June was almost six times greater than the water quality standard (25 NTU) and may have been due to recent rainfall within the watershed. Surface percent dissolved oxygen was elevated at Station CPF038G in 2003 (range = 111 to 126 percent). The reservoir was strongly stratified in July and August, with dissolved oxygen values dropping to hypoxic levels (near 0 mg/L) at a depth of approximately three meters from the surface at Stations CPF038J, CPF038L and CPF038N (greater than 50 percent of the water column at each station).

Extremely high total phosphorus concentrations (0.09 – 0.18 mg/L) were measured in the Little Alamance Creek Arm in 2003. The highest concentrations of total Kjeldahl nitrogen (1.7 mg/L) and ammonia (0.93 mg/L) were observed at Station CPF038H in August. Total Kjeldahl nitrogen concentrations were elevated in Big Alamance Creek and Little Alamance Creek arms, suggesting that both creeks are contributing significant amounts of nutrients to the reservoir.

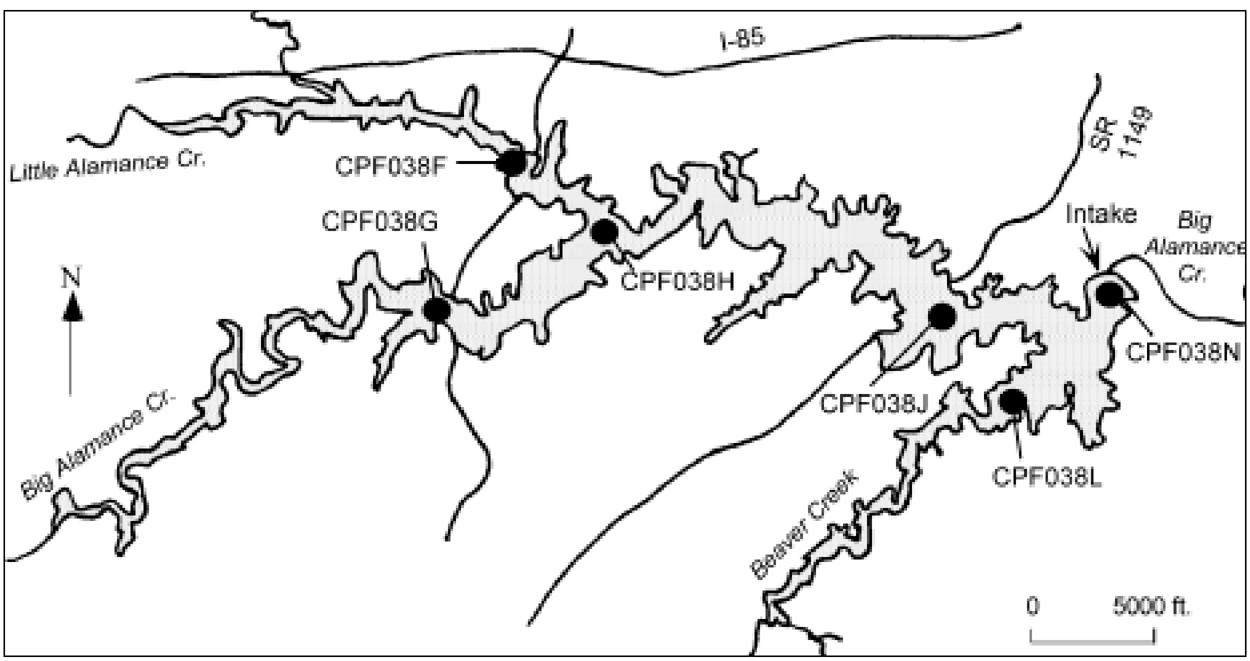


Figure 27. Sampling sites at Lake Mackintosh, Alamance and Guilford counties.

The presence of these nutrients may have contributed to chlorophyll *a* concentrations greater than the water quality standard of 40 µg/L at Station CPF038G in June (51 µg/L) and in August (65 µg/L). Phytoplankton analyses indicated very diverse assemblages especially in July 2003. Mild blooms of green and bluegreen algae were found in June and July at the Station CPF038N. In August, the assemblages became dominated by the small filamentous bluegreen algae *Lyngbya* sp. Moderate to severe blooms were found in August. Blue greens such as *Lyngbya* sp. are indicators of eutrophic conditions and cause taste and odor problems in drinking water supplies (Wehr and Sheath 2003).

Concentrations of metals in the surface waters were less than the water quality standards. Based on the calculated NCTSI scores, the reservoir was classified as eutrophic in 2003; a rating which it had received in 1993.

CAPE FEAR RIVER SUBBASIN 04

Description

This subbasin is located wholly in the Carolina Slate Belt (Griffith *et al*. 2002) and contains the lower 25 miles of the Haw River from Marys Creek to the Haw River Arm of Jordan Reservoir (Figure 28). There are five NPDES permitted dischargers with only the Town of Pittsboro's WWTP (0.75 MGD into Robeson Creek) discharging more than more than 0.5 MGD.

The most recent landuse coverage (Table 16) showed more than 70 percent of the subbasin remains forested. However, due to urban growth throughout the subbasin this landuse type along with pasture lands have probably decreased as the percentage of urban landuse has increased.

Table 16. Land use in Subbasin 04. Based upon CGIA coverage 1993 - 1995 (total area = 331 square miles (NCDENR 2000).

Land use	Percent
Water	2
Cultivated crop	3
Pasture	22
Urban	< 1
Forest	73

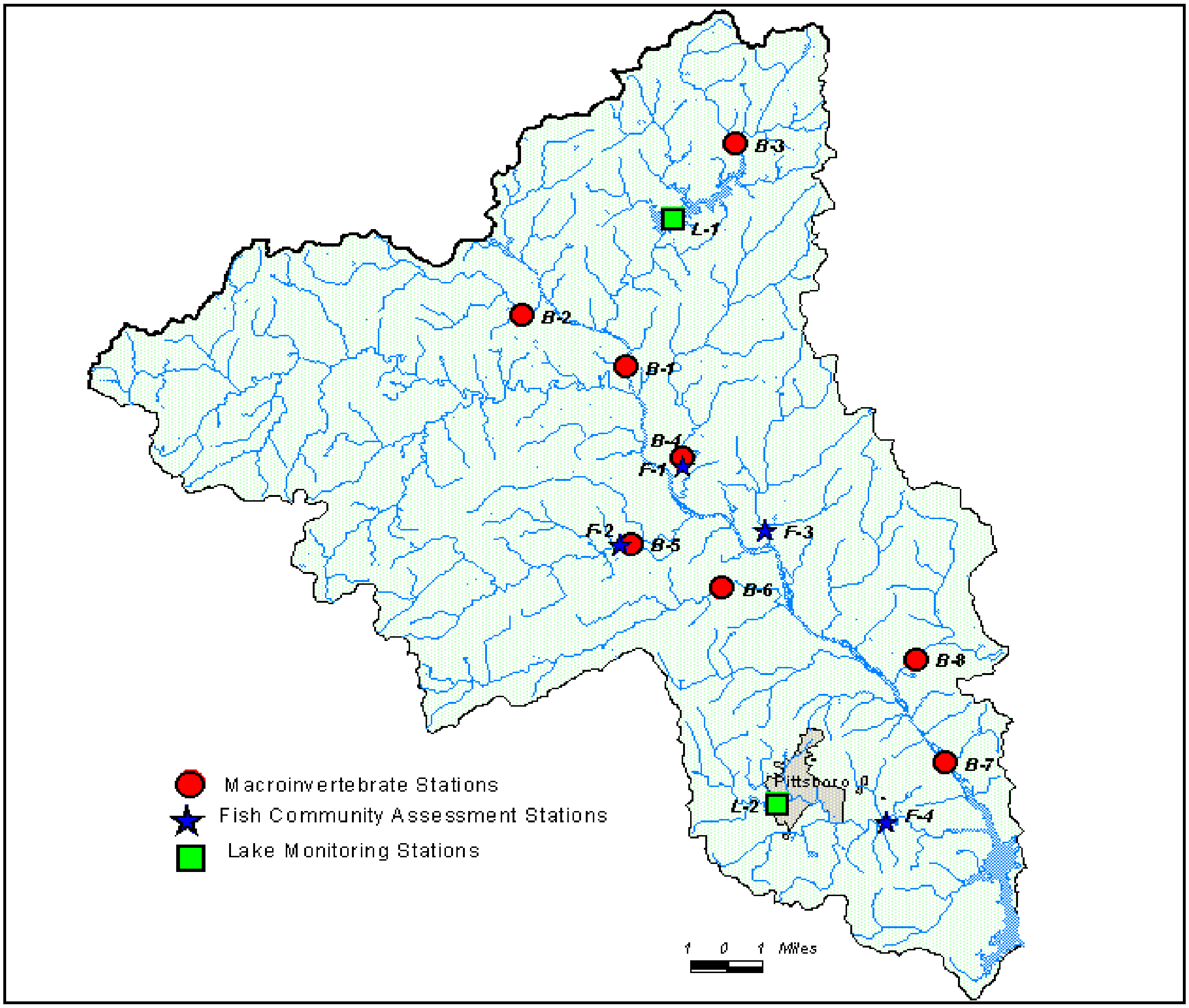


Figure 28. Sampling sites in Subbasin 04 in the Cape Fear River basin. Monitoring sites are listed in Table 17.

Overview of Water Quality

Benthic macroinvertebrate data have been collected from two sites on the Haw River since 1984; including basinwide surveys and a drought study in 2002 (Table 17). These data indicated that water quality conditions in 1998 and 2002 improved downstream near the Haw River arm of Jordan Lake (Good) compared to upstream reaches near Saxapahaw (Good-Fair). Water quality conditions of tributaries in the Carolina Slate Belt ecoregion are sometimes more effectively assessed during winter months rather than during low-flow summer conditions. The benthic communities in Cane, Dry, and Pokeberry Creeks may be declining and certainly warrant future sampling in this rapidly developing area.

Fish community analyses of four tributary streams in this subbasin ranged from Poor to Excellent. The Poor rating at Collins Creek was attributed to drought-induced declines in fish numbers and diversity. Terrells Creek appeared to have recovered from the drought and rated Excellent. Ferrells and Robson Creeks rated Good, although some characteristics of the fish community in Robeson Creek indicated elevated nutrients.

Cane Creek Reservoir is a water supply reservoir for the Town of Chapel Hill. In 2003 concentrations of nutrients ranged from moderate to elevated and chlorophyll *a* concentrations were elevated during summer sampling. Bluegreen algal blooms also occurred throughout the summer. Although greater than normal rainfall may have increased nonpoint source nutrients, the reservoir was again rated eutrophic.

Pittsboro Lake is a small impoundment of Robeson Creek and was rated eutrophic in 2003. It is on the 303(d) list of impaired surface waters because of excessive aquatic weeds. Parrot feather, a highly invasive submerged macrophyte, has been observed in the reservoir. Chlorophyll *a* concentrations were elevated and algal blooms occurred throughout the summer.

Ambient water quality data were collected from four locations in this subbasin: Haw River at Saxapahaw, Haw River near Saxapahaw, Haw River near Bynum, and Robeson Creek at SR 1943. The Upper Cape Fear River Basin Association also monitors three sites; two on the Haw River and one on Robeson Creek. These data have indicated generally good water quality, with few violations in water quality criteria. DWQ data indicated elevated zinc concentrations at the Haw River at Saxapahaw and association data showed elevated chlorophyll *a* concentrations in Robeson Creek.

Only one facility, the Town of Pittsboro's WWTP, is required to by their NPDES permit to conduct Whole Effluent Toxicity Testing. During the assessment period the facility was meeting its compliance requirements.

Table 17. Waterbodies monitored in Subbasin 04 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Haw R	Alamance	SR 1005	Good-Fair (s)[2]	Good-Fair[3]
B-2	Marys Cr	Alamance	SR 2174	Fair (w)	Good-Fair (s)
B-3	Cane Cr	Orange	SR 1114	Good & Excellent (w)/Good (s)	Good-Fair (s)
B-4	Collins Cr	Chatham	SR 1539	Good-Fair (w)	Good-Fair (s)
B-5	Terrells Cr	Chatham	NC 87	Good-Fair (s)	Fair (s)/Good-Fair (f)
B-6	Dry Cr	Chatham	SR 1520	Good-Fair (w)	Fair (s and f)
B-7	Haw R	Chatham	US 64	Good (s)	Good[3]
B-8	Pokeberry Cr	Chatham	SR 1711	Good (w)	Good-Fair (w and s)
F-1	Collins Cr	Chatham	SR 1539	Fair	Poor
F-2	Terrells Cr	Chatham	NC 87	Good	Excellent
F-3	Ferrells Cr	Chatham	SR 1525	Good-Fair	Good
F-4	Robeson	Chatham	off SR 1943	---	Good
L-1	Cane Creek Res	Orange			
L-2	Pittsboro Lake	Chatham			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake assessment sites.
[2]w = winter; s = summer; f = fall.
[3]data collected in 2002.

Typical streams in this ecoregion have very rocky substrates and high quality instream and riparian habitats (Figure 29 and Appendix 2). However, many of the tributary streams are prone to extremely low flow conditions during the summer.

Figure 29. Terrells Creek at NC 87, Chatham County -- a typical stream in the Carolina Slate Belt in Subbasin 04.

Due to high summer flows (Appendix 1), the Haw River at SR 1005 and at US 62 could be not sampled. However, these two locations were sampled as part of the in 2002 drought impact study. These two sites should be sampled during the next round of basinwide monitoring in 2008.

Haw River, SR 1005

This site is below the urban areas of Burlington and Graham. Elevated conductivity values (median = 292 µmhos/cm, maximum = 2,320 µmhos/cm, September 1998 - September 2001) have been recorded during low flow conditions. The river is 40 to 50 meters wide and large bedrock runs dominate the substrate. The drainage area at this site is 1,042 square miles. Some sedimentation is evident in pool and backwater areas and there is minimal shading due to the stream width. The habitat score was 56.

Haw River at SR 1005, Alamance County.

The site has consistently been rated Good-Fair regardless of flow, even after the droughts of 1998 and 2002. The exotic Asiatic clam, *Corbicula fluminea,* was extremely abundant at this site.

Marys Creek, SR 2174

Marys Creek is approximately seven meters wide. The mixed substrate was moderately embedded and pools were filled with unstable, coarse sand. Riffles were as wide as the stream, but were infrequent in the sampling reach. The wide riparian zone and stable stream banks helped produce a habitat score of 76. The 12 square mile drainage area is mostly forested with some pastureland.

Marys Creek at SR 2174, Alamance County.

This site was sampled for the first time in February 1998 and was rated Fair. Subsequent samples (October 2000 and July 2003) were rated Good-

Fair. This site was sampled in March 2003 to help assess drought impacts on Carolina Slate Belt streams. By then it had not recovered from the drought; flow dependent taxa were absent or rare, and mostly winter taxa were collected. By July 2003 the stream had recovered.

Cane Creek, SR 1114

This site is above Cane Creek Reservoir and is approximately seven meters wide. The 7.5 square mile watershed is primarily forested, but contains large tracts of pasture and cultivated crops. The habitat score of 86 reflected a rocky substrate, good instream habitat, stable stream banks, and a wide riparian zone.

Cane Creek at SR 1114, Orange County.

All winter samples have been rated Good or Excellent; a July 1998 sample was rated Good rating. Two samples collected in July and August 2003 were rated Good-Fair. It was difficult to determine if the decline between 1998 and 2003 was a result of drought impacts or a true decline in water quality. The EPT S declined from 27 in July 1998 to 18 in August 2003. The 2003 sample contained more tolerant Baetidae taxa and *Hydropsyche betteni,* a tolerant filter feeder, was abundant. Intolerant taxa, such as *Ceraclea ancylus, C. maculata*, *Polycentropus* sp, *Triaenodes injusta,* and *T. ignitus*, were absent in 2003 although they were collected in 1998. Based on these data, it seemed that the fauna experienced a true decline from 1998 to 2003.

Collins Creek, SR 1539

Collins Creek drains rural northern Chatham County east of the Haw River and southwest Orange County. The monitoring site is about 0.5 mile above its confluence with the Haw River. The stream is approximately eight meters wide and the drainage area is 19.4 square miles. The catchment is primarily forested with rural residential areas. There are frequent riffles and pools, fairly stable stream banks, adequate shading, and a wide riparian zone (Appendix 2). However, prolific growths of algae suggested nutrient enrichment. There is one small (0.04 MGD) NPDES permitted discharger in the stream's headwaters.

Collins Creek at SR 1539, Chatham County.

The fish community was still impacted by the drought of 2002. There were the fewest fish (n = 56) and the second fewest number of total species (n = 8) of any site in the Piedmont portion of the basin in 2003 (Appendix 9). The community was rated Poor in 2003 and Fair in 1998. Drought-induced declines were noted in the number of species, number of fish, number of species of darters, and the number of species with multiple ages. The percentage of tolerant fish, primarily Redbreast sunfish, increased from 11 to 59 percent.

Benthic macroinvertebrates were first sampled from this site in 1986 and rated the stream Poor. A winter sample in 1998 and a summer sample in July 2003 were rated Good-Fair. It is unknown why only four EPT S were collected in 1986 and why this site improved to Good-Fair for the subsequent samples. Future monitoring of this site is certainly warranted as the watershed is located in a rapidly growing area in southwestern Orange and northern Chatham counties.

Terrells Creek, NC 87

Terrells Creek drains rural northern Chatham County west of the Haw River and a small sliver of southeastern Alamance County. The monitoring site is about 11 meters wide and about 2.6 miles above its confluence with the Haw River. The instream and riparian habitats are of high quality (Appendix 2). The drainage are of the stream is 20.9 square miles. There are no NPDES permitted discharger in its watershed.

Terrells Creek at NC 87, Chatham County.

The watersheds of Collins and Terrells Creek are of similar size (~ 20 square miles). But unlike Collins Creek, the fish community in Terrells Creek had mostly recovered from the 2002 drought-induced low flows (Table 18). The number of fish, especially the number of bluehead chubs, and the number of species of suckers had still not yet rebounded to values observed in 1998. The community was rated Good during the 1990s and Excellent in 2003.

Table 18. Comparisons of fish community variables at Collins and Terrells Creeks, Chatham County, May 2003.

	Waterbody	
Variable	Collins Creek	Terrells Creek
No. species	8	16
No. fish	56	176
No. species darters	0	3
No. of intolerants	0	1
Tolerants (%)	59	12
Omni.+herb. (%)	16	18
Insect. (%)	84	80
Pisci. (%)	0	1.7
Multiple ages (%)	38	50
NCIBI score	28	56
NCIBI rating	Poor	Excellent

Benthic samples have been collected from this site in 1993 (winter), 1998 (summer), and 2003 (summer and fall). The 1998 sample was rated Good-Fair (EPT S = 15) and the 1993 winter sample was rated Good (EPT S = 25). Very low flow conditions were recorded during 1998 and the data suggested that seasonal differences in flow and habitat characteristics might have accounted for the lower rating.

The 2003 summer sample was rated Fair (EPT S = 12). It was unclear whether drought conditions continued to affect the benthic community, thus a fall sample was conducted. The November 2003 sample was rated Good-Fair, which was only one taxa greater than Fair (EPT S = 14). In November the water appeared milky and gray. Leeches, amphipods, and isopods were abundant and there was freshwater sponges on the underside of rocks, all indicating possible low dissolved oxygen concentrations.

One noticeable difference between the summer 1998 sample and the two 2003 samples was in the decrease in Trichoptera taxa (*Ceraclea ancylus*, *Neophylax oligus*, and *Triaenodes injustus*). As expected in Carolina Slate Belt streams, summer sampling has produced lower bioclassifications (fluctuating between Fair and Good-Fair), while winter sampling has produced higher ratings (Good).

Ferrells Creek, SR 1525

Ferrells Creek drains rural, southwestern Orange and northern Chatham counties east of the Haw River. There is one small (0.0016 MGD) NPDES permitted discharger in the stream's headwaters on an unnamed tributary about five miles above the monitoring site. The monitoring site was approximately 0.5 mile above its confluence with the Haw River.

Ferrells Creek at SR 1525, Chatham County.

Similar to Terrells Creek this site was not negatively affected by the 2002 drought. In 2003 the fish community was rated Good; it was rated Good-Fair in 1998. The trophic structure was more balanced than it was in 1998 because an unusually large school of the insectivorous whitefin shiner which were collected in 1998 and which had possibly migrated upstream from the Haw River were not collected in 2003. Five fewer species were collected in 2003 than in 1998, but the community continued to be diverse with 22 species known from the site.

Robeson Creek, off SR 1943
Robeson Creek, a tributary to the Haw Creek Arm of Jordan Reservoir, was sampled for the first time for fish community assessment in 2003. The creek's watershed includes the Town of Pittsboro, and major road corridors such as US 64, US 64 Bypass, US 15/501, and NC 902. The monitoring site is approximately 3.5 miles below the town's 0.75 MGD WWTP which also provided continuous flow in the stream during the 2002 drought. There are frequent riffles and pools, fairly stable stream banks, adequate shading, and a wide riparian zone (Appendix 2). However, prolific growths of algae suggested nutrient enrichment.

Robeson Creek off SR 1943, Chatham County.

The fish community was rated Good. However, reflecting some nutrient inputs and enhancement, the omnivorous bluehead chub was the dominant species and more fish were collected at this site than at any other site in the Piedmont portion of the basin in 2003. Blackspot disease, another indicator of nutrient enrichment, was prevalent on many white shiners and spottail shiners.

Dry Creek, SR 1520
This site on Dry Creek is approximately eight meters wide and has a substrate composed of boulder/rubble riffle areas and very sandy runs. Many of the pools have filled in with sediment. Though the riffles were infrequent and there was not an abundance of habitat such as snags, leafpacks, and root mats, the habitat still scored 78 due to a wide riparian zone, ample shading and fairly stable banks. The drainage area is approximately 18 square miles.

Dry Creek at SR 1520, Chatham County.

Samples collected in July and November 2003 contained an abundance of leeches, amphipods, and isopods and there was freshwater sponge on the underside of rocks, all indicating possible low dissolved oxygen concentrations.

Basinwide sampling was conducted at this site during winter in 1993 (Good) and 1998 (Good-Fair). Data collected in 1986 rated the site as Poor. Sampling events in 2003 (July and November) rated the site Fair. Like many Carolina Slate Belt streams that become dry during low rainfall periods, winter sampling seemed to yield a higher rating than summer or fall sampling. However, ratings have varied considerably at this site and future sampling and watershed land use investigations are warranted.

Haw River, US 64
Data from this location represents water quality conditions in the Haw River prior to flowing into the Haw River Arm of Jordan Reservoir. Samples were collected most recently in October 2002 as part of the 2002 drought impact study. The substrate was boulders and cobble, the banks were stable, and the riparian zones were wide.

The habitat score was 78. The drainage area of the Haw River at this site is 1,296 square miles.

Haw River at US 64, Chatham County.

This site has been rated Good since 1985 and EPT S has ranged from 23 to 28 taxa. The 2002 sample rated Good and the EPT S was 23. These data suggested that water quality conditions of the river at this location have been stable. Water quality improved at this site compared to upstream monitoring sites at Saxapahaw and Graham even though conductivity values remain elevated (506 µmhos/cm in 2002 and 356 µmhos/cm in 1998).

Pokeberry Creek, SR 1711

Pokeberry Creek has a mostly sandy substrate, suggesting upstream land disturbance and sedimentation. The drainage area of this seven meter wide stream is approximately 13 square miles. The catchment appears mostly forested, although severe bank erosion was noted.

Pokeberry Creek at SR 1711, Chatham County.

Winter surveys were conducted in 1993 (Good-Fair), 1998 (Good), and 2003 (Good-Fair). The EPT BI decreased between 1993 and 1998 indicating a more intolerant benthic community. Unlike other Carolina Slate Belt streams that were sampled in winter 2003, Pokeberry Creek appeared to have recovered from drought conditions because flow dependant taxa were abundant. The winter EPT S and EPT BI were similar to the winter 1993 sample. Another benthic sample was collected in July 2003; it was also rated Good-Fair.

SPECIAL STUDIES

Marys Creek

Marys Creek was sampled in October 2000 because it was on the 303 (d) impaired streams list. The listing was based on a 1998 benthic macroinvertebrate sample. The site was sampled and the watershed evaluated for possible inclusion in a Watershed Assessment and Restoration Project study. The 2000 sample was rated Good-Fair (almost in the Good range) and had relatively intolerant taxa. It was recommended that Marys Creek be removed from the 303 (d) list based on the new data (Biological Assessment Unit Memorandum B-001218b).

Robeson Creek Watershed

Benthic sampling was conducted in Robeson, Turkey, Camp, and UT Camp Creeks in conjunction with DWQ's Intensive Survey Unit's water quality surveys in January and September 2001. The discharge from the Townsend Foods facility was adversely affecting the community in Turkey and Camp Creeks, and ultimately, the middle reaches of Robeson Creek. Elevated total phosphorus concentrations below the WWTP and from runoff from Townsend Foods, also showed an adverse impact in Robeson Creek. The benthic community above the WWTP was severely stressed, mostly due to habitat degradation and hydrologic factors (Biological Assessment Unit Memoranda B-010216 and B-011120).

Additional Data

The Haw River Assembly coordinates a volunteer monitoring network that collects data from over 50 sites within the Haw River watershed. Volunteers note temperature, pH, field observations, and collect benthic macroinvertebrates. The macroinvertebrates are evaluated using the Izak Walton League analysis method. For further information, contact The Haw River Assembly, PO Box 187, Bynum, NC 17228, riverwatch@hawriver.org.

Lake Assessment

Cane Creek Reservoir

Cane Creek Reservoir, an impoundment of Cane and Turkey Creeks (Figures 30 and 31), is a 14 year old water supply reservoir for the City of Chapel Hill. The maximum depth is approximately 54 feet. The majority of the watershed is forested with some agriculture. The reservoir has been sampled eight times by DWQ prior to 2003

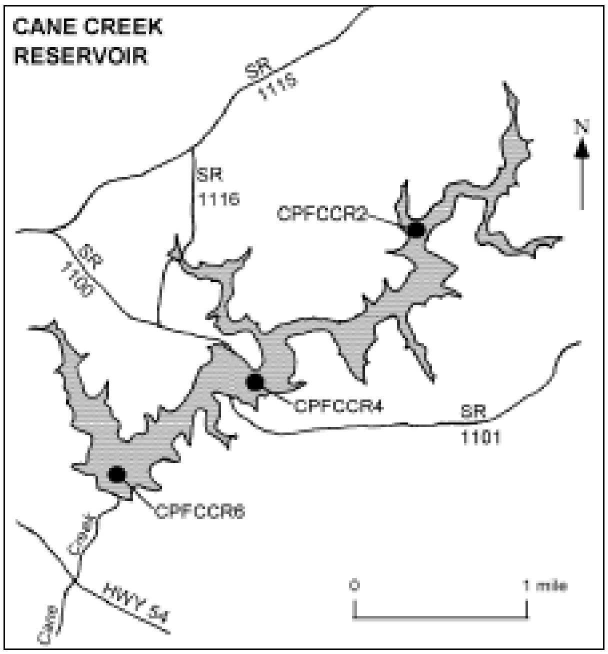


Figure 30. Sampling sites at Cane Creek Reservoir, Orange County.

Figure 31. Dam at Cane Creek Reservoir, Orange County.

The reservoir was most recently monitored in 2003. Secchi depths were at or greater than one meter. Frequent rainfall in 2003 may have increased nonpoint source nutrients. Concentrations of total phosphorus, total Kjeldahl nitrogen, and total nitrogen ranged from moderate to elevated and were greater than those concentrations previously observed (Appendix 22).

In response to the availability of these nutrients and the water clarity, chlorophyll *a* concentrations were generally greater than the water quality standard of 40 µg/L in July and August (Appendix 22). Bluegreen algal blooms (primarily of *Aphanizomenon flos-aquae*) occurred throughout the summer. This species causes taste and odor problems in drinking water supplies (Wehr and Sheath 2003).

Concentrations of metals in the surface waters were within water quality standards. Based on the calculated NCTSI scores, the reservoir was eutrophic throughout 2003; a classification it had received in 1990 and 1993.

Pittsboro Lake

Pittsboro Lake is a small impoundment of Robeson Creek (Figure 32). The reservoir was originally a system of two separate ponds connected by a canal. Hurricane Floyd in September 1999 destroyed the canal, resulting in the formation of a single, shallow waterbody. The maximum depth is seven feet. The drainage area is composed of forested, urban, and agricultural areas (Figure 33). This lake has been sampled six times prior to 2003 by DWQ.

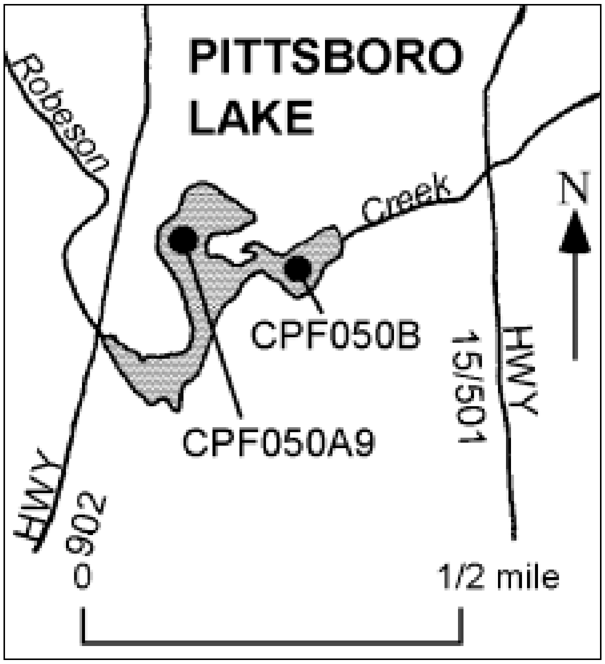


Figure 32. Sampling sites at Pittsboro Lake, Chatham County.

Figure 33. Looking upstream from the boat launch area at Pittsboro Lake, Chatham County.

The reservoir was most recently monitored in 2003. It was classified as eutrophic throughout the period. Chlorophyll *a* concentrations at Station CPF050A9 were consistently greater than the water quality standard of 40 µg/L (Appendix 22) and were the greatest concentrations ever measured by DWQ for the reservoir. Mild to severe algal blooms occurred throughout the period at Station CPF050A9. The blooms were dominated by *Chrysochromulina* sp., an indicator of eutrophic conditions and which can cause taste and odor problems in drinking water supplies (Wehr and Sheath 2003). No blooms occurred at the other station due to the large amounts of aquatic macrophytes and less open water found at the site.

Parrot feather, *Myriophyllum aquaticum*, has been found in the reservoir. The submerged macrophyte is highly invasive and forms dense growths providing excellent habitat for mosquitoes. It is difficult to eradicate and is inedible to Grass carp. Excessive macrophyte growths were also noted in 1998.

Iron concentrations were almost twice the water quality action level of 1,000 µg/L (Appendix 22). High iron-content soils within the watershed may have contributed to these observed values.

This reservoir is on the 303(d) list of impaired surface waters because of the excessive growths of aquatic weeds (NCDENR 2003a). In 2000, the Town of Pittsboro (owners of the dam) had considered breaching the dam and restoring Robeson Creek and its riparian buffer back to their natural conditions. This restoration project has been delayed pending improvement of the local economy.

CAPE FEAR RIVER SUBBASIN 05

Description

This subbasin is located primarily in the Triassic Basins except for the headwaters of New Hope Creek which are in the Carolina Slate Belt (Griffith *et al*. 2002). All streams are tributaries to Jordan Reservoir (Figure 34). The $7Q_{10}$ values are zero for all but the largest catchments and the streams tend to be turbid with clay or sand bottoms and slow moving.

The most recent landuse coverage showed almost 80 percent of the subbasin forested (Table 19). However due to accelerated urban growth away from the cities of Durham, Chapel Hill, Cary, Apex, and Morrisville and the Research Triangle Park, the amount of lands in pasture and forest have probably decreased as the percentage of urban landuse has increased.

Table 19. Land use in Subbasin 05. Based upon CGIA coverage 1993 - 1995 (total area = 269 square miles (NCDENR 2000).

Land use	Percent
Water	8
Cultivated crop	1
Pasture	7
Urban	6
Forest	78

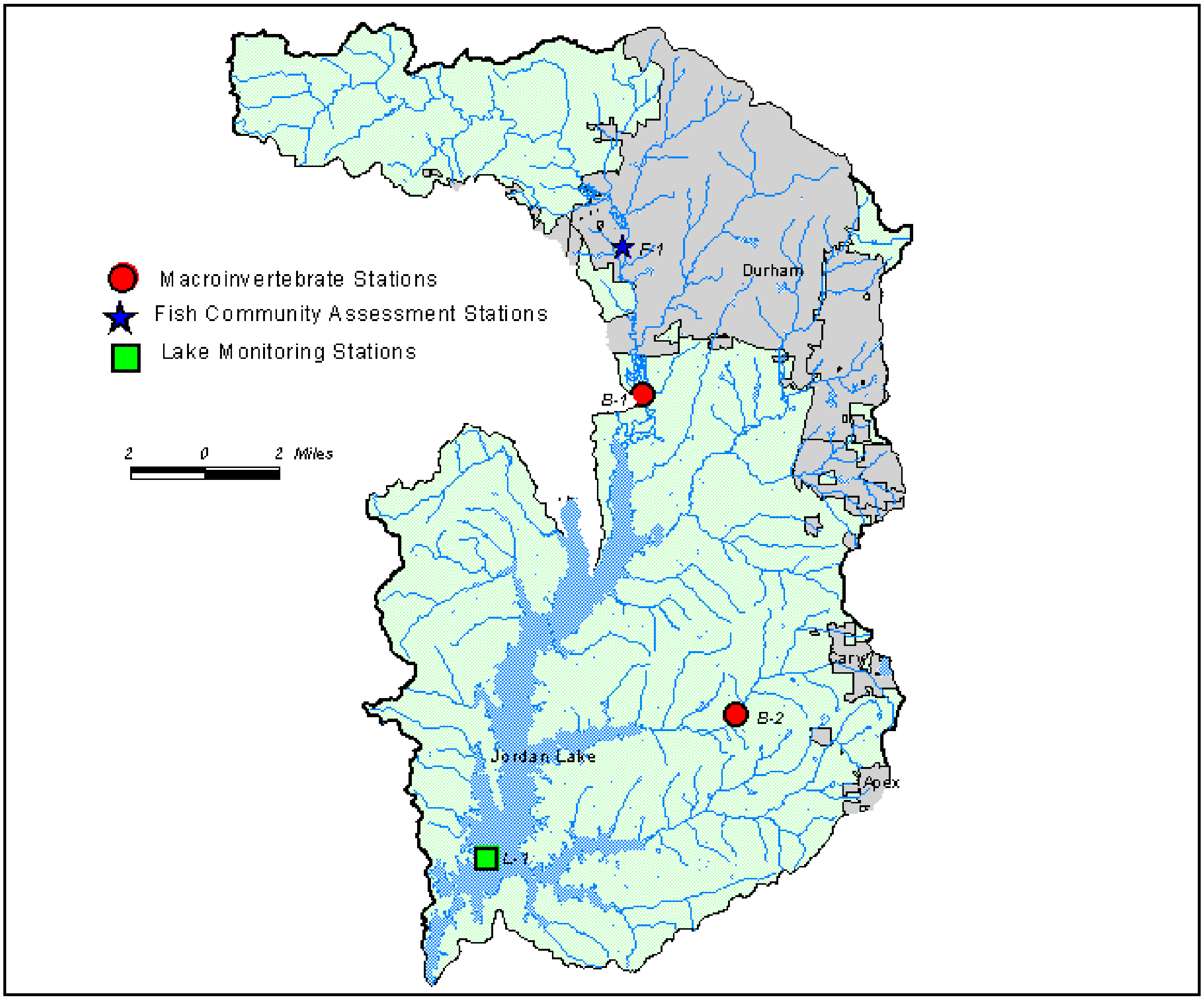


Figure 34. Sampling sites in Subbasin 05 in the Cape Fear River basin. Monitoring sites are listed in Table 20.

There are 11 NPDES permitted dischargers in the subbasin and two of these facilities have permitted flow greater than 1 MGD:

- The City of Durham's South WWTP discharging 20 MDG into New Hope Creek; and
- Durham County's Triangle WWTP discharging 6 MGD to Northeast Creek.

Overview of Water Quality

Three stations within this subbasin were regularly monitored for fish community structure or benthic macroinvertebrates (Table 20). Fish data from New Hope Creek produced a rating of Good-Fair in 1998 and 2003. Fish were characterized as diverse but with few individuals. Benthic macroinvertebrate data collected from New Hope Creek produced a rating of Fair in 1998 and 2003. Macroinvertebrates were monitored in White Oak Creek during 1998 and 2003, but this Triassic Basin stream cannot be rated.

Jordan Lake was monitored during 2003 and was classified as eutrophic, a classification it has received since 1982. Algal blooms were observed throughout the summer. Severe blooms were dominated by filamentous bluegreen species and occurred in August.

Ambient chemistry data were collected at six sites in this subbasin. Statistically significant instances of low dissolved oxygen (< 5.0 mg/L) were measured at New Hope, Third Fork, and Northeast Creeks. Significant elevations in nutrient concentrations (> 10 mg/L) were also measured at two locations on Northeast Creek. Significant elevations above the standard for fecal coliform bacteria were also observed at Third Fork and Northeast Creeks during the monitoring period.

Table 20. Waterbodies monitored in Subbasin 05 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	New Hope Cr	Durham	SR 1107	Fair	Fair
B-2	White Oak Cr	Wake	SR 1603	Not Rated	Not Rated
F-1	New Hope Cr	Durham	SR 2220	Good-Fair	Good-Fair
L-1	Jordan Reservoir	Chatham			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L= lake assessment site.

River and Stream Assessment

Habitat characteristics and examples of high quality and low quality habitats at fish community sites in the basin are presented in Appendix 2.

New Hope Creek, SR 2220

New Hope Creek drains western Durham and eastern Orange counties including the western area of the City of Durham and the US 15/501 and I-40 commercial corridors. The urbanized nature of its watershed contributes household debris such as plastic beverage containers, treated lumber, and tires to the stream. There is one small (0.012 MGD) NPDES permitted discharger in the watershed above the monitoring site.

A typical, turbid and slow moving stream in the Triassic Basins, New Hope Creek, SR 2220, Durham County.

The fish community was rated Good-Fair in 1998 and 2003. Although still diverse, the community is characterized as having few fish, no intolerant species, a high percentage of tolerant fish, and no real dominant species.

New Hope Creek, SR 1107

This site on New Hope Creek is located below the City of Durham's South Water Reclamation Facility. The stream, with a drainage area of 43 square miles, was about eight meters wide with a substrate composed almost entirely of silt and clay. No riffles or pools were present, and most habitat was limited to the margins and woody debris. The banks were steep and eroding, however, the riparian zone was intact and provided good shading to the stream. The habitat score was 43.

New Hope Creek at SR 1107, Durham County.

This sites has been sampled twice; in 1985 it was rated Poor. A basinwide sample in 1998 had 10 EPT S and was rated Fair. In 2003, the site was again rated Fair. Six EPT S were collected with *Stenonema modestum* the dominant species. *Cheumatopsyche* and *Baetis intercalaris* were also abundant. EPT N was nearly identical to 1998 (37 and 36, respectively). The BI was 6.64 compared to 6.79 in 1998. These values suggested that overall water quality has not changed at this site.

White Oak Creek, SR 1603

Benthic macroinvertebrate data have been collected from White Oak Creek in winter during the last three basinwide cycles. At this site the creek is about five meters wide and has a substrate composed of coarse, shifting sand -- typical of Triassic Basin streams. Overbank deposition of sand was apparent following high flows just prior to sampling in 2003.

White Oak Creek at SR 1603, Wake County.

This stream cannot be rated because it stops flowing during most of the summer and dried up completely for several months in 2002. EPT S in March 2003 (five taxa) was only one-half of that found in 1998. This was likely a result of the 2002 drought.

SPECIAL STUDIES

New Hope Creek, SR 1730.

This headwater site, located within the Carolina Slate Belt, was sampled in June 2003 as a joint effort between DWQ and the City of Durham's Public Works Storm Water Services Division. Monitoring was conducted for training and sampling and laboratory analysis comparisons (Biological Assessment Unit Memorandum B-031023). This site was rated Good-Fair.

B. Everett Jordan Reservoir

B. Everett Jordan Reservoir (Jordan Lake) is an impoundment of the Haw River, New Hope Creek, and Morgan Creek (Figure 35). It was created by the US COE for flood control. The reservoir is used extensively for primary and secondary recreational activities. It is also a water supply reservoir for several municipalities.

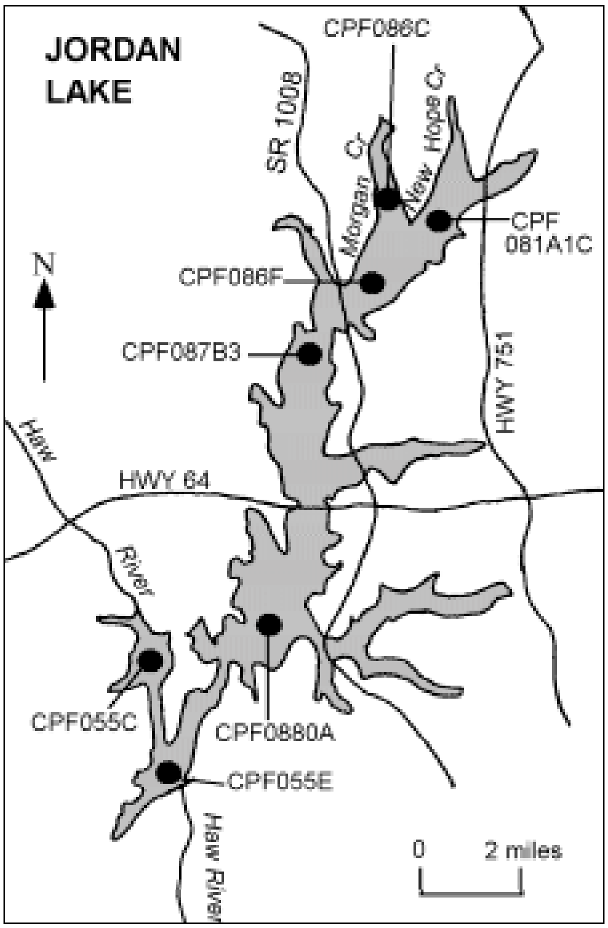


Figure 35. Sampling sites at Jordan Lake, Chatham County.

The Haw River accounts for as much as 90 percent of the annual inflow to the reservoir. The Haw River Arm has an average hydraulic retention time of five days. The New Hope Creek Arm has an average hydraulic retention time of 418 days. Maximum depth of Jordan Lake is approximately 66 feet. Land uses in the immediate watershed include forest (Figure 36), agriculture, and urban centers with much of the area undergoing development by the cities of Cary, Apex, Durham, and Chapel Hill. There are many NPDES permitted faculties within its watershed which begins west of Greensboro and north of Reidsville.

Figure 36. Jordan Lake, Chatham County.

The reservoir was most recently monitored in 2003. Secchi depths were generally less than one meter and were similar to those previously observed. Chlorophyll *a* concentrations in 5 of 7 of sites in August were greater than the water quality standard of 40 µg/L (Appendix 22). Despite this, surface dissolved oxygen values were not elevated and were slightly less than 5mg/L at Stations CPF086F and CPF0880A. These were the lowest concentrations measured since 1996.

Surface dissolved oxygen concentrations and pH values were elevated at Stations CPF055C and CPF055E in July, suggesting increased algal productivity. However, chlorophyll *a* concentrations were not greater than the water quality standard. Algal blooms occurring throughout the summer. The blooms were most severe in August and were dominated by the filamentous bluegreen *Oscillatoria*. Two of the most common algae, *Chrysochromulina* sp and *Oscillatoria geminata* are indicators of eutrophication. These species also cause taste and odor problems in drinking water supplies (Wehr and Sheath 2003).

Concentrations of metals in the surface waters were within water quality standards with the exception of iron. At Station CPF055C in June, the iron concentration was 40 percent greater than the water quality action level of 1000 µg/L. The elevated concentration may have been due to heavy rainfall within the watershed prior to sampling which suspended iron-rich sediment in the Haw River Arm. The reservoir was classified as eutrophic throughout 2003 based on the calculated NCTSI scores; a classification it has received since 1982.

Monitoring activities also occurred between 1999 and 2001 in support of data collection for a model to determine the appropriate management strategies for improving water quality in the reservoir. Secchi depths were generally less than one meter and nutrient and chlorophyll *a* concentrations were similar to those previously observed. Rather than summer peaks in algal productivity, the highest chlorophyll *a* concentrations generally occurred from August through November. During the summer these concentrations tended to be lower.

CAPE FEAR RIVER SUBBASIN 06

Description

Subbasin 06 is the smallest subbasin within the entire river basin; it is only 75 square miles (Figure 37). This subbasin is located primarily in the Carolina Slate Belt with small portions of lower Little and Morgan Creeks in the Triassic Basins.

Typical streams in the Carolina Slate Belt ecoregion have very rocky substrates (Figure 38). Small streams in this subbasin typically stop flowing during low-flow periods due to the lack of groundwater recharge. Slate Belt streams with watersheds of 18 square miles or less have zero $7Q_{10}$ flows during summer low-flow periods (USGS 1993).

Figure 38. Bolin Creek at NC 86, Orange County -- a typical stream in the Carolina Slate Belt in Subbasin 06.

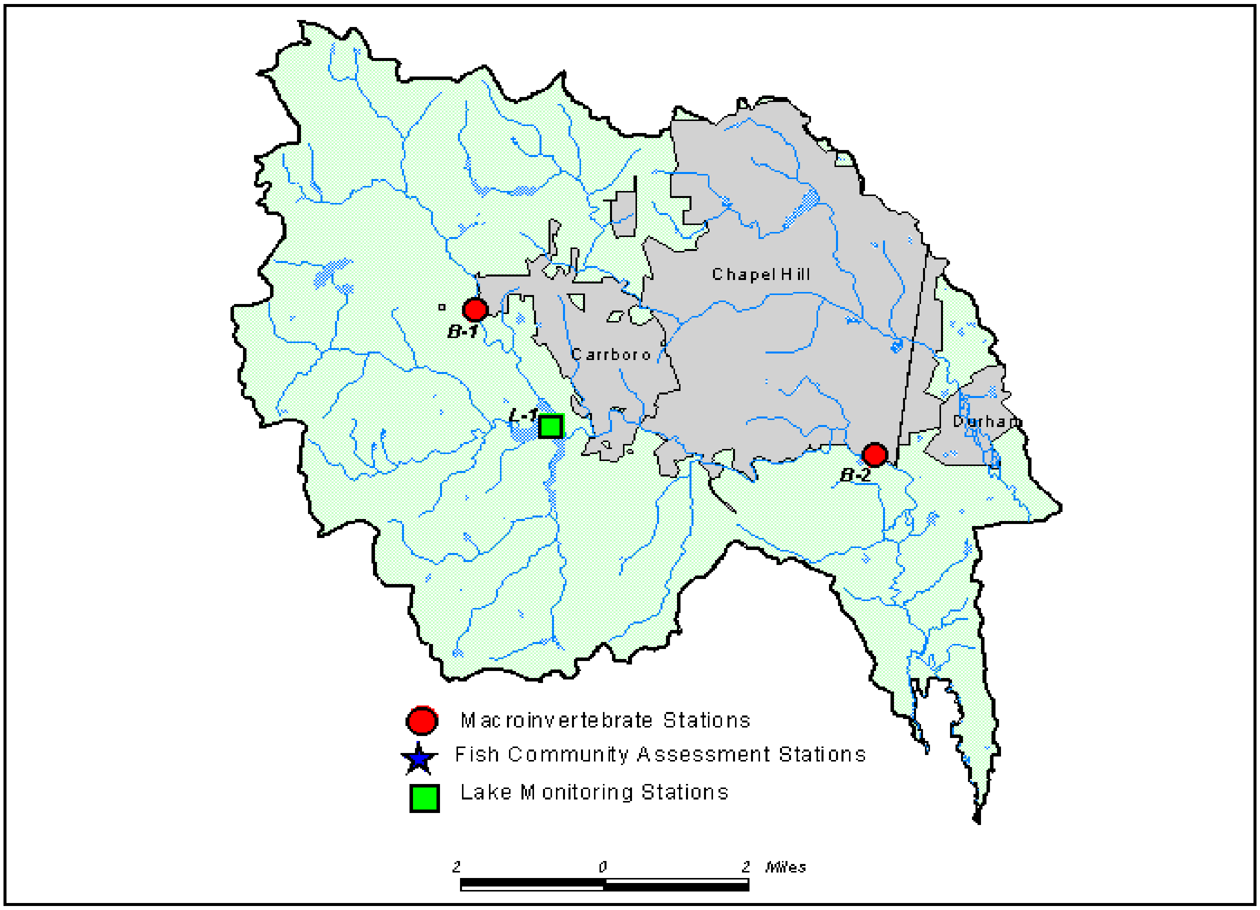


Figure 37. Sampling sites in Subbasin 06 in the Cape Fear River basin. Monitoring sites are listed in Table 22.

The most recent landuse coverage showed more than 80 percent of the subbasin forested (Table 21). However due to accelerated urban growth especially around the Cities of Carrboro, Chapel Hill, and Durham, the amount of forested lands has probably decreased as the percentage of urban landuse has increased.

There are four NPDES permitted dischargers in the subbasin with only the Orange Water and Sewer Authority's (OWASA) Mason Farm WWTP (12 MGD into Morgan Creek) discharging more than more than 0.5 MGD.

Table 21. Land use in Subbasin 06. Based upon CGIA coverage 1993 - 1995 (total area = 75 square miles (NCDENR 2000).

Land use	Percent
Water	1
Cultivated crop	1
Pasture	9
Urban	5
Forest	84

Overview of Water Quality

Morgan Creek was monitored for benthic macroinvertebrates below the OWASA's WWTP. Data collected at SR 1726 and SR 1900 produced ratings of Fair during 1998 and 2003 (Table 22). An additional study of macroinvertebrate recovery after the 2002 drought was conducted in Morgan Creek at NC 54. During 2003 the stream had recovered from Good-Fair to Good (22 EPT S). Only two EPT S had been found when the stream resumed flowing when the drought ended in 2002.

Fish community structure was monitored in Morgan Creek off SR 1900 during 1998 and 1999 as part of a repeatability study of impaired sites. Results from both years rated the stream Poor with the community generally lacking in species of darters, suckers, and intolerant species.

University Lake, an impoundment of Morgan Creek, was classified as hypereutrophic in 2003 with elevated nutrient and chlorophyll a concentrations. Ambient chemistry data were collected from Morgan Creek near Farrington. Only manganese showed statistically significant elevations (> 220mg/L) for the monitoring period.

Table 22. Waterbodies monitored in Subbasin 06 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Morgan Cr	Orange	NC 54	Excellent	Good
B-2	Morgan Cr	Orange	off SR 1900	---	Fair
L-1	University Lake	Orange			

[1]B = benthic macroinvertebrate monitoring sites; L = lake monitoring site.

River and Stream Assessment

Morgan Creek, NC 54

The benthic macroinvertebrates in Morgan Creek at NC 54 were sampled numerous times as part of an ongoing study of the impact from the 2002 drought. This stream had dried up completely during the peak of the drought. In May and July, the community was rated Good-Fair. As of October 2003, the stream had recovered to Good. The final results of this drought study will be presented in a future report.

Morgan Creek at NC 54, Orange County.

Morgan Creek, off SR 1900
The historical benthic macroinvertebrate basinwide site at SR 1726 was too deep for safe access in 2003, so collections were taken upstream of SR 1726 and below the OWASA's Mason Farm WWTP. This site is not recommended as a future sampling location because access is by permission only from the North Carolina Botanical Garden.

At this site the creek here is about 12 meters wide with a sand and gravel substrate; the drainage area is 39 square miles. The stream flows over a concrete ford, with areas of slow flow above and below the road crossing. With the WWTP upstream, there was a smell of sewage and the water was turbid. The habitat score of 51 reflects an absence of pools and riffles. The banks were only slightly eroded and the riparian zone was largely intact, providing a complete canopy over the stream. Instream habitat was largely limited to the margins and woody debris. There were a few rocks and chunks of concrete used as rip-rap.

Morgan Creek off SR 1900, Orange County.

The SR 1726 site had been sampled seven times previously. All ratings were Poor or Fair. The last three samples, from 1990, 1993, and 1998, were rated Fair. The site below OWASA has also been rated Poor or Fair the five times it has been sampled.

The 2003 collection was very similar to the 1998 results from the two upstream locations. Although there were some differences in composition, the Total S was nearly identical for all three collections. Nine EPT S were collected in 2003, compared to eleven for both 1998 samples. The BI was also very similar ranging from 6.63 - 6.78. The site was again rated Fair. Hydropsychid caddisflies and blackflies were the most abundant taxa; chironomids were the most diverse group with 17 taxa present. No stoneflies were collected at this site or at any of the previous SR 1726 samples. *Perlesta* was common below OWASA in 1998.

SPECIAL STUDIES

Fish Community Repeatability at Impaired Sites

Morgan Creek off SR 1900, Orange County, was sampled in 1999 to determine the multi-year temporal repeatability of the NCIBI at sites with known impaired water quality (NC DWQ unpublished data). Sampled at the entrance to UNC's Mason Farm, the stream drains the Town of Carrboro and the southern and eastern part of the City of Chapel Hill. The monitoring site is below the Orange Water and Sewer Authority's Mason Farm WWTP. The conductivities in 1998 and 1999 were 320 and 219 µmhos/cm, respectively and were elevated due to the WWTP discharge. The instream habitats were lacking in riffles and the substrate was entirely sand.

In 1998 and 1999, the fish community was rated Poor (NCIBI = 36 and 38, respectively). The community was diverse and abundant, but generally lacking in species of darters, suckers, and intolerant species. There was an abundance of tolerant fish, especially redbreast sunfish, and few of the species were represented by multiple age groups. If improvements to the discharge or if stream restoration activities occur, the site may once again become a basinwide monitoring site in 2008.

Bolin Creek Watershed Assessment and Restoration Project

Three sites along Bolin Creek, Orange County, were assessed at the request of the Watershed Assessment and Restoration Project Unit. This request was part of a larger study on the effects of urbanization on the benthic and fish communities of the Little Creek watershed. Approximately one mile of Bolin Creek (from US 501 Business to Little Creek) was on the 2000 303 (d) list. These waters are biologically impaired, based upon benthic macroinvertebrate data, due to "sediment" transported by urban runoff and storm sewers (NCDENR 2000).

The three sites were rated either Good-Fair or Good; only the lowermost site (off SR 1750) showed low levels of impairment. Considering the stream as a whole, the three communities showed high levels of total species and sunfish diversity and of total fish abundance, expected levels of tolerant fish and trophic relationships, and high levels of successful reproduction by most species. There was a low level of diversity by darters and intolerant species were absent from all sites. The lowermost site had a high percentage of diseased fish, primarily bluegill. The fish exhibited "popeye" symptoms (exophthalmos) which can be caused by several types of bacterial and viral infections and by gas supersaturation (Biological Assessment Unit Memorandum F-011113).

Impact of the 2002 Drought

The benthic macroinvertebrates in Morgan Creek at NC 54 (Orange County) were sampled numerous times as part of an ongoing study of the impact from the 2002 drought. The final results of that study will be presented in a future report. In May and July, the community was rated Good-Fair. As of October 2003, the stream had recovered to Good (Biological Assessment Unit, unpublished data).

Lake Assessment

University Lake

University Lake, an impoundment of Morgan Creek (Figure 39), is a water supply reservoir for the City of Chapel Hill. Nearly three quarters of the watershed is forested along with agriculture and urban development (Figure 40). Prior to 2003, the reservoir had been sampled five times by DWQ.

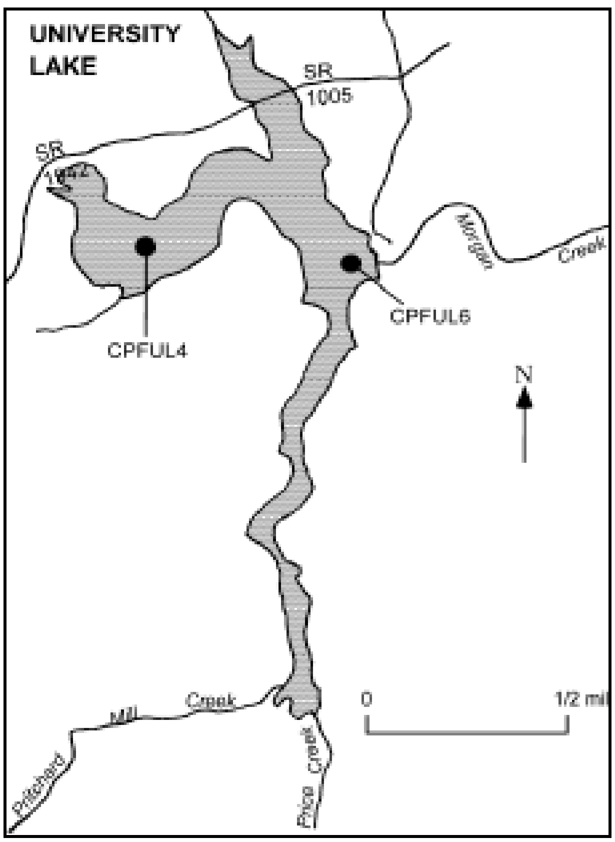


Figure 39. Sampling sites at University Lake, Orange County.

Figure 40. University Lake, Orange County.

The reservoir was most recently sampled in 2003. The reservoir was classified as hypereutrophic (June) and eutrophic (July and August) with elevated nutrient and chlorophyll *a* concentrations (Appendix 22). Similar classifications were derived in previous years. During the 2003 summer, 5 of 6 chlorophyll *a* concentrations were greater than the water quality standard of 40 µg/L (Appendix 22). Surface percent dissolved oxygen concentrations (~ 120 percent) were greater than the water quality standard of 110 percent.

Mild to severe algal blooms occurred throughout the summer. The blooms in June and July were dominated by the unicellular flagellate *Chrysochromulina* sp. Mild blooms of the noxious filamentous bluegreen algae, *Aphanizomenon flos-aquae*, were also recorded in July. In August, the assemblage shifted to the small filamentous bluegreen *Lyngbya* sp. These algae are indicators of eutrophic conditions and cause taste and odor problems in drinking water supplies. Bluegreen algae blooms were also observed in 1998

Rainfall within the watershed prior to sampling in June may have increased nonpoint source runoff and nutrient contributions, resulting in the highly productive conditions observed. Concentrations of metals in the surface waters were within water quality standards with the exception of iron. In June, iron concentrations (1,200 µg/L) were greater than the water quality action level of 1,000 µg/L.

CAPE FEAR RIVER SUBBASIN 07

Description

This subbasin contains the lowermost reach of the Haw River (below Jordan Reservoir and before it joins the Deep River to form the Cape Fear River) and approximately 25 miles of the Cape Fear River from near the confluence of Lick Creek in Lee County to near Buies Creek in Harnett County (Figure 41). Portions of the subbasin are in three ecoregions:

- the headwaters of Kenneth Creek near the Town of Fuquay-Varina and Buies Creek are in the Rolling Coastal Plain;
- the northwest corner of the subbasin is in the Triassic Basins, and
- Parkers, Avents, Hector, and lower Kenneth Creeks are in isolated fingers of the Northern Outer Piedmont. Parkers, Avents, and Hector Creeks in Raven Rock State Park, along the north side of the Cape Fear River, are High Quality Waters.

The most recent landuse coverage showed more than 70 percent of the subbasin forested (Table 23). However due to accelerated urban growth especially around the Towns of Holly Springs, Fuquay-Varina, and Sanford the amount of lands in pasture, cultivated drops, and forest have probably decreased as the percentage of urban landuse has increased.

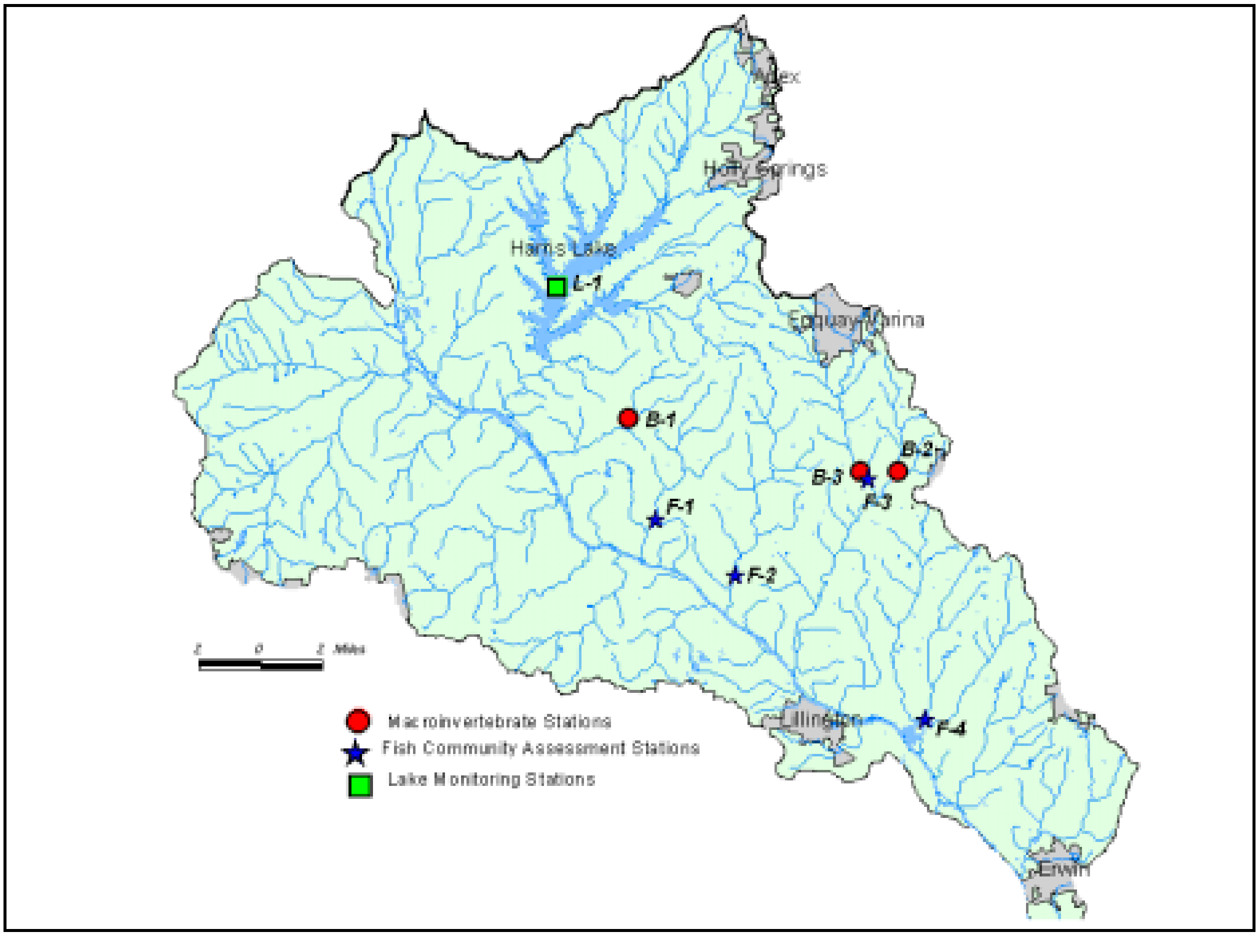


Figure 41. Sampling sites in Subbasin 07 in the Cape Fear River basin. Monitoring sites are listed in Table 24.

Table 23. Land use in Subbasin 07. Based upon CGIA coverage 1993 - 1995 (total area = 415 square miles (NCDENR 2000).

Land use	Percent
Water	3
Cultivated crop	21
Pasture	5
Urban	2
Forest	70

There are 21 NPDES permitted dischargers in the subbasin with 10 of these facilities having a permitted flow greater than 0.5 MGD:

- Harnett County Public Utilities' Buies Creek WWTP discharging 0.5 MDG into the Cape Fear River;
- the Town of Angier's WWTP discharging 0.5 MDG into the Cape Fear River;
- Harnett County Public Utilities' North Harnett Regional WWTP discharging 0.6 MDG into the Cape Fear River;
- the Town of Fuquay-Varina's Kenneth Creek WWTP discharging 1.2 MDG into the Kenneth Creek;
- the Town of Erwin's WWTP discharging 1.2 MGD into the Cape Fear River;
- the Town of Holly Springs' WWTP discharging 1.5 MDG into Utley Creek;
- the Town of Dunn's WTP discharging 2 MGD into Juniper Creek;
- Swift Textiles (Erwin Mills) discharging 2.5 MGD into the Cape Fear River;
- The Town of Dunn's WWTP discharging 3 MGD into the Cape Fear River; and
- Progress Energy's Cape Fear Steam Electric Power Plant discharging 10 MDG into the Cape Fear River.

Overview of Water Quality

In this subbasin, there were 3 sites that were monitored for benthic macroinvertebrates, 4 sites for fish community assessments, 1 reservoir, 13 ambient and coalition monitoring sites, and 10 facilities that performed Whole Effluent Toxicity testing (Table 24, in part). Two or more of the monitoring programs were conducted at several of the sites.

There are no NPDES permitted dischargers in the watersheds of Avents, Hector, or Buies Creeks where fish community assessments were performed. The Avents and Hector Creeks watersheds are near or are part of Raven Rock State Park. These two streams, along with nearby Parkers Creek, generally had Good or Excellent benthic macroinvertebrate and fish communities. The fish community in Avents Creek had yet to recover form the 2002 drought.

The aquatic communities in lower Kenneth Creek responded differently to the upstream wastewater treatment plant discharge. The discharge seemed to be impacting the benthic community but not the fish community. The benthic macroinvertebrates rated the stream Poor; the fish community rated the stream Good. Further studies will need to be done on upper Neills Creek to determine if the decline in the benthic macroinvertebrate community in 2003 was due to drought or to a toxic spill.

Harris Lake is classified as eutrophic, a classification it had received in prior monitoring cycles. There were occasional exceedances of the chlorophyll *a* water quality standard and the reservoir was infested with *Hydrilla*. Grass carp have been stocked to help manage the nuisance macrophytes growth.

Statistically significant water quality standard exceedances were documented for dissolved oxygen at East Buies and Lick Creeks. All mainstem sites on the Haw and Cape Fear Rivers had dissolved oxygen concentrations, fecal coliform concentrations, and turbidity measurements well within the water quality standards. Even though the benthic macroinvertebrate community rated Kenneth Creek Poor, no water quality violations were documented at this site.

Prior to 2003, 199 of the 215 toxicity tests, performed at the 13 NPDES permitted facilities, passed (~ 93 percent passing rate). Since 2003, 50 of the 52 tests have passed (~ 96 percent passing rate). The only facility that had difficulty in passing the tests was DYNEA USA, Inc, a facility that discharges to the Haw River. The failures were due to operational problems associated with its activated sludge system. The system was fixed and the facility has had no noncompliances since March 2001.

Table 24. **Waterbodies monitored in Subbasin 07 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.**

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Parkers Creek	Harnett	SR 1405	Good	Good
B-2	Neills Creek	Harnett	SR 1441	Good-Fair	Poor
B-3	Kenneth Cr	Harnett	SR 1441	Poor	Poor
F-1	Avents Cr	Harnett	SR 1418	Good	Good-Fair
F-2	Hector Cr	Harnett	SR 1412	Good	Excellent
F-3	Kenneth Cr	Harnett	SR 1441	Good-Fair	Good
F-4	Buies Cr	Harnett	off SR 1519	---	Not Rated
L-1	Harris Lake	Wake			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites, L = lake monitoring site.

River and Stream Assessment

Habitat characteristics and examples of high quality and low quality habitats at fish community sites in the basin are presented in Appendix 2. Instream and riparian habitats are of exceptionally high quality at Avents, Hector, and Buies Creeks.

Parkers Creek, SR 1405
This benthic macroinvertebrate site was the only site sampled in the subbasin in April 2003. The drainage area at this site is 3.8 square miles. Sample collection followed a thunderstorm the night before. The stream, though not high, was bright orange from suspended clays; the conductivity was 109 µmhos/cm. This site had a habitat score of only 63 and there was massive bank failure in one spot.

Parkers Creek at SR 1450, Harnett County.

All samples collected from this site since 1993, including 2003, have been rated Good, regardless of season (spring and summer). A site further downstream was rated Excellent in 1988. Despite the extremely turbid water in 2003, EPT S (26) was very similar to that found in 1993 (25 and 27), but greater than the values found in 1998 (19 and 20). There were 16 mayfly taxa here and only three stonefly taxa, and they were all rare. The high number of baetid mayflies and the thick *Periphyton* suggested nutrients could become a problem at this location. Signs along SR 1405 were advertising a new subdivision, which may be the source of the sediments seen after a thunderstorm.

Between years, the community structure was similar. Though intolerant taxa such as *Acroneuria abnormis* have declined from Abundant to Rare, and a few tolerant taxa, such *Caenis* have become abundant. One unusual finding was the complete absence of the ubiquitous hydropsychid, *Cheumatopsyche*, which was abundant in all prior samples. The other hydropsychid collected previously, *Hydropsyche betteni*, did not change in abundance. These changes are slight as seen by the continued high (Good) bioclassification for this HQW stream. However, if the sediment inputs, as observed by the extreme turbidity in April, continue to occur, this slight shift towards tolerant organisms may become greater.

Avents Creek, SR 1418
Avents Creek, in the northwest corner of Harnett County, is a fish community regional reference site on the edge of Raven Rock State Park. The monitoring site is approximately 1.2 miles above its confluence with the Cape Fear River and above a waterfall which functions as a natural barrier to upstream fish migration and recolonization except under extremely high flows.

Avents Creek at SR 1418, Harnett County.

The fish community appeared to still be recovering from the 2002 drought. It was rated Good in 1998 but declined slightly to Good-Fair in 2003 (NCIBI = 48 and 44, respectively). The numbers of white shiner and tessellated darters declined substantially, whereas the dominance of bluehead chub increased between 1998 and 2003.

Hector Creek, SR 1412
The Hector Creek watershed is adjacent to that of Avents Creek and like Avents Creek, it is a fish community regional reference site. The site is approximately 1.7 miles above its confluence with the Cape Fear River.

Hector Creek at SR 1412, Harnett County.

The community was rated Good in 1998 and Excellent in 2003 (NCIBI = 46 and 56, respectively). The site is very species rich, 26 species are known from the site. Between the two sampling periods there was an slight increase in the diversity of darters, suckers, and intolerant species.

Neills Creek, SR 1441
This site on Neills Creek is just above the confluence with Kenneth Creek. This upstream segment includes parts of the Towns of Fuquay-Varina and Angier in its watershed, and also contains the small Fuquay-Angier airfield. The stream width was five meters and the drainage area was 4.0 square miles. The stream had a very unusual substrate composed of nearly equal parts rubble, gravel and sand that was embedded, dense, and hard-packed. There was no severe erosion, riffles were frequent, pools were abundant; and the total habitat score was 79. The water was tannin stained and the conductivity was 64 µmhos/cm. Adjacent land use was forest, pasture for horses, and rural residences.

Neills Creek at SR 1441, Harnett County.

In 2003 the site was rated Poor; the site had been rated Good-Fair in 1993 and 1998. In 2003 only six EPT S were collected (Figure 42); 4 of the 6 were winter stoneflies, leaving a seasonally corrected EPT S of two. No mayflies were collected and the only caddisfly was a single specimen of *Ironoquia punctatissima,* an intermittent stream indicator. The winter stonefly, *Clioperla clio*, was very abundant. Because this stonefly has fast seasonal growth and can survive in intermittent streams, it is possible that this site dried up during the 2002 drought.

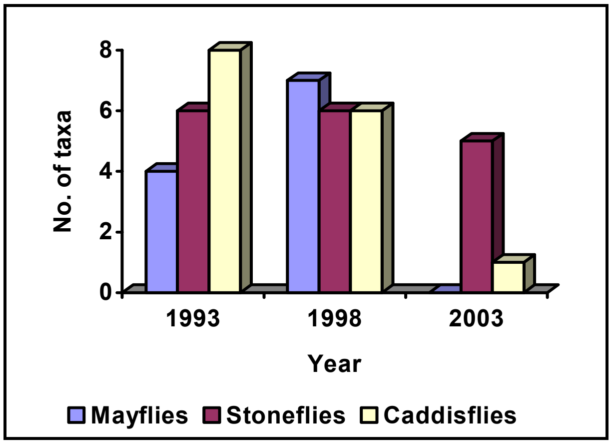


Figure 42. EPT diversity in Neills Creek at SR 1441, Harnett County, 1993 – 2003.

Lower Kenneth Creek at SR 1441, Harnett County.

Upper Kenneth Creek at SR 1441, Harnett County.

The benthic community was so sparse in 2003, that there was some question as to whether the stream may have stopped flowing during the 2002 drought. However, all other streams in this area showed no drought impacts and there was no reason geologically why this stream should have dried up. Even streams in the Carolina Slate Belt (sampled in another study) that were known to have gone completely dry in 2002 had started to recover by March 2003. Another possibility is that the benthic community may have been affected by some type of toxic input before the winter stoneflies emerged. The sudden decline in EPT S should be investigated further to clarify if the stream dried up in 2002 or if this stream suffered from an upstream toxic spill.

Kenneth Creek, SR 1441

Kenneth Creek is a tributary to Neil's Creek and drains the Town of Fuquay-Varina east and south of US 401. The monitoring site is approximately 4.5 miles below the town's 1.2 MGD Kenneth Creek WWTP.

In the reach that was sampled for benthic macroinvertebrates, the substrate was nearly all sand, with some gravel and a few rocks in one area where the stream narrowed to about four meters and the sand was scoured. Also, in this reach, riffles were absent and the pools were filled in. The banks were eroded and instream habitat was confined to sparse woody debris. The habitat score was 69. The average width was eight meters and the conductivity was 82 µmhos/cm.

An EPT sample produced only four EPT S and the community was rated Poor, the same rating it had received in 1993 and 1998. The impact from the Town of Fuquay-Varina's WWTP has been severe and long term, with little or no change in the benthic fauna. Only *Stenonema modestum* and *Cheumatopsyche* were abundant and no stoneflies have ever been collected at this site.

The primary impact to the benthic fauna seemed related to water quality and not habitat. Samples collected closer to the discharge at UT Kenneth Creek in 1990 and 1998 were not rated under current policy due to small stream size, but the same pattern of better water quality above the discharge and severe impacts below the discharge were found.

The fish community at this site has been monitored during every basinwide cycle and has gradually improved from Fair in 1994 to Good-Fair in 1998 to Good in 2003 (NCIBI = 34, 44, and 46, respectively). The change between 1998 and 2003 was slight and the dominant species during the past two cycles has been the white shiner.

Buies Creek, off SR 1519

The fish community of Buies Creek was sampled for the first time in 2003. The site is below the Town of Buies Creek but above the town's WWTP which discharges to the Cape Fear River.

Buies Creek off SR 1519, Harnett County.

The instream and riparian habitats were of high quality such as those found in the Sand Hills but because the stream is in the Rolling Coastal Plain, criteria and ratings have yet to be developed for this ecoregion. It is possible that this small stream (watershed area = 7.6 square miles) ceased flowing during the 2002 drought and the fish community has yet to recover. Only six species and 26 fish were collected; 15 of the 26 fish were redfin pickerel.

SPECIAL STUDIES

Impact of the 2002 Drought

The Cape Fear River at US 401 was sampled in October 2002 and January 2003 as part of a special study to determine the affects of the 2002 drought. Subsequent sampling to record recovery has been hindered by high flows. Large rivers such as the Cape Fear River are more likely to stratify during extended periods of drought, resulting in oxygen depletion on the bottom where the benthic macroinvertebrates colonize. The problem with the Cape Fear River during the drought was not one of too little water, but of high temperatures, low flows, and no mixing due to lack of rain and the resulting declines in the dissolved oxygen beyond what the benthic community could tolerate.

Wetlands Restoration Program Watershed Study

Little Branch, Buckhorn Creek, Avents Creek, Hector Creek, and Coopers Branch were sampled in 2003 as part of a special study for the Wetlands Restoration Program (Biological Assessment Unit Memorandum B-030523). This survey also included additional sites on Kenneth and Neills Creeks.

Lake Assessment

Harris Lake

This reservoir, an impoundment of Buckhorn Creek, provides cooling water for Progress Energy's Harris Nuclear Power Plant (Figures 43 and 44). Utley Creek which receives the Town of Holly Springs' WWTP discharge is a small tributary to the reservoir. The maximum depth of the reservoir is 20 feet. The immediate watershed is forested but the rapidly developing and expanding Towns of Holly Springs and Apex are to its north and east. The reservoir has been sampled 10 times by DWQ prior to 2003; it is frequently sampled by Progress Energy.

Figure 43. Harris Lake, Wake County.

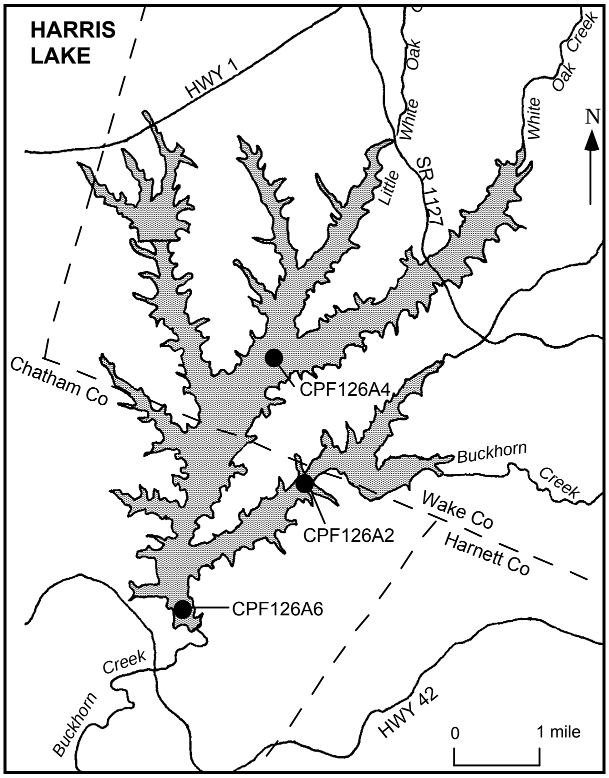


Figure 44. Sampling sites at Harris Lake, Wake and Chatham counties.

The reservoir was most recently sampled in 2003. Despite heavy rainfall within the watershed throughout the year, Secchi depths remained greater than one meter at each site. Fecal coliform bacteria concentrations were also low. Total phosphorus concentrations were similar to those previously measured. Ammonia concentrations were consistently below detection level at all sites and these concentrations were the lowest ever observed. Aquatic macrophytes, including *Hydrilla* sp., were observed throughout the reservoir. In 2003 the reservoir was classified as eutrophic based on the calculated NCTSI scores; a classification it had received in most years.

In 1998, chlorophyll *a* concentrations on two occasions were greater than the water quality standard of 40 µg/L. Nutrient concentrations were stable between 1997 and 2001 and concentrations of other chemical constituents did not exhibit significant temporal changes (CP&L 2002). *Hydrilla* was observed in the intake canal in 2001, but no fouling of the intake screens occurred. Grass carp have been stocked in the reservoir to manage the aquatic plant's growth.

CAPE FEAR RIVER SUBBASIN 08

Description

This subbasin includes the headwaters of the Deep River and its tributaries in Guilford and Randolph counties (Figure 45). The subbasin is primarily in the Southern Outer Piedmont, whereas the southeast portion to the Town of Randleman is in the Carolina Slate Belt (Griffith *et al*. 2002).

Many of the mainstem sites along the Deep River have a rocky substrate whereas tributary sites are very sandy and carry a heavy sediment load (Figure 46) and are of lower habitat quality (Appendix 2).

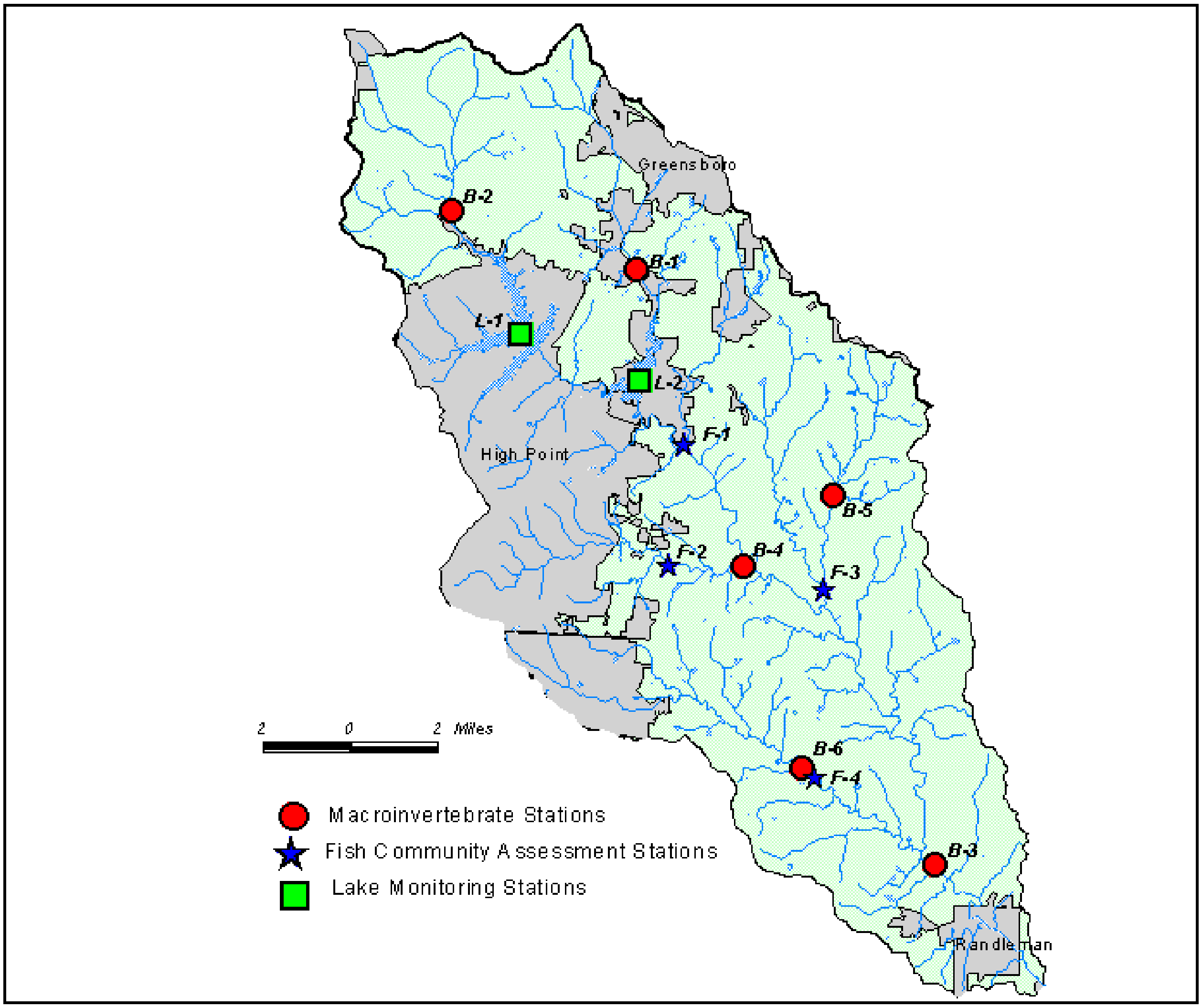


Figure 45. Sampling sites in Subbasin 08 in the Cape Fear River basin. Monitoring sites are listed in Table 26.

Figure 46. Richland Creek at SR 1154, Guilford County -- a typical, sand-bottomed tributary to the Deep River in Subbasin 08.

Urban areas in the subbasin include portions of the Triad Metropolitan area (the Cities of Greensboro and Highpoint) and the I-40 and I-85 corridors. More of this subbasin is urbanized than any other subbasin in the entire river basin (Table 25). The most recent landuse coverage showed more than 13 percent of the subbasin urbanized. Due to urban growth throughout the subbasin the amount of lands in pasture and forest have probably decreased as the percentage of urban landuse has further increased. The percentage of land in water is expected to increase in the near future as Randleman Dam is completed and the reservoir fills.

Table 25. Land use in Subbasin 08. Based upon CGIA coverage 1993 - 1995 (total area = 179 square miles (NCDENR 2000).

Land use	Percent
Water	2
Cultivated crop	2
Pasture	25
Urban	13
Forest	58

There are 24 NPDES permitted dischargers in the subbasin with three of these facilities having a permitted flow greater than 0.5 MGD:

- the Town of Randleman's WWTP discharging 1.7 MGD into the Deep River;
- the City of Highpoint's Frank L. Ward WTP discharging 10 MGD into an unnamed tributary to Richland Creek; and
- the City of Highpoint's Eastside WWTP discharging 16 MGD into Richland Creek.

Overview of Water Quality

In this subbasin, there were 6 sites monitored for benthic macroinvertebrates, 4 sites for fish community assessments, 2 reservoirs, 9 ambient and coalition monitoring sites, and 17 facilities that perform Whole Effluent Toxicity testing (Table 26, in part). Two or more of the monitoring programs are conducted at several of the sites. Prior to 2003, 101 of the 105 toxicity tests, passed (~ 96 percent passing rate). Since 2003, all 22 of the tests have passed. There are no facilities experiencing problems with their toxicity tests in this subbasin.

This subbasin drains the heavily urbanized areas of the City of High Point and the southwestern portion of the City of Greensboro. Urban streams in this subbasin and in Subbasin 02 carry a heavy load of discarded household debris such as tires, plastic bags, and plastic and aluminum beverage containers.

Three of the six benthic macroinvertebrate sites were rated Fair; the other three sites were rated Good-Fair. The sites rated Fair had either high concentrations of copper and other metals, fecal coliform bacteria, or nutrients. A strong odor of sewage was also detected at the Deep River at US 220 and at Richland Creek at SR 1145.

The fish community in Richland Creek, downstream of High Point, was also rated Fair. At an upstream site, high concentrations of fecal coliform bacteria have been documented. The fish community in Muddy Creek has fluctuated between Good and Fair. The benthic macroinvertebrate community rated this site Fair, but the quality of the sample was poor due to marginal sampling conditions. The fish community in Hickory Creek was rated Good, but upstream the benthic macroinvertebrates rated the stream Good-Fair and a chemical odor was detected at the time of sampling. The fish community in Bull Run was rated Good-Fair; there were no NPDES permitted dischargers in this watershed.

High Point and Oak Hollow Lakes have significant and chronic water quality problems. The reservoirs suffer from many problems related to cultural eutrophication – taste and odor problems related to planktonic algal blooms, problems related to bluegreen algal mats along the shoreline and in shallow water, and dissolved oxygen and aesthetic problems. The algal blooms result in exceedances of water quality standards for chlorophyll *a*, dissolved oxygen, and pH.

Except for the Deep River at Randleman, all of the ambient and coalition monitoring sites were supplementally classified as Water Supply IV CA. Statistically significant water quality standard exceedances of at least one water quality variable were documented at each of these nine sites:

- Richland Creek, below WWTP-- nitrite+nitrate, copper, zinc, and fecal coliform bacteria;
- Richland Creek, near High Point -- fecal coliform bacteria;
- West Fork Deep River -- turbidity, manganese; fecal coliform bacteria;
- East Fork Deep River – copper;
- Deep River, near Hayworth Spring -- dissolved oxygen;
- Deep River, near High Point – dissolved oxygen; fecal coliform bacteria;
- Deep River, near Randleman – copper;
- Deep River, at Randleman -- fecal coliform bacteria; and
- Muddy Creek -- fecal coliform bacteria.

Total phosphorus concentrations were greatest in the Deep River near High Point (median concentration ~ 1 mg/L) and decreased with distance downstream. Conductivity was also greatest in the Deep River near High Point (median measurement ~ 400 µmhos/cm) and decreased with distance downstream. These water quality patterns were indicative of urban nonpoint and point source contributions of pollutants.

Table 26. Waterbodies monitored in Subbasin 08 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	E Fk Deep R	Guilford	SR 1541	Fair	Fair
B-2	W Fk Deep R	Guilford	SR 1850	Good-Fair	Good-Fair
B-3	Deep R	Randolph	US 220 Bus	Good-Fair	Good-Fair
B-4	Richland Cr	Guilford	SR 1145	Poor	Fair
B-5	Hickory Cr	Guilford	SR 1131	Not Rated	Good-Fair
B-6	Muddy Cr	Randolph	SR 1929	Not Rated	Fair
F-1	Bull Run Cr	Guilford	SR 1144	---	Good-Fair
F-2	Richland Cr	Guilford	SR 1154	Poor	Fair
F-3	Hickory Cr	Guilford	SR 1140	---	Good
F-4	Muddy Cr	Randolph	SR 1929	Fair	Good
L-1	High Point Lake	Guilford			
L-2	Oak Hollow Lake	Guilford			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake monitoring sites.

River and Stream Assessment

Habitat characteristics and examples of high quality and low quality habitats at fish community sites in the basin are presented in Appendix 2.

East Fork Deep River, SR 1541

At this site on the East Fork Deep River, the habitat consisted of adequate instream cover and infrequent riffles. At the time of sampling flows were higher than normal and the stream was turbid. The substrate was mainly sand, but boulder/bedrock and rubble and gravel were present. A greenway trail follows the stream along its left bank. This site was eight meters wide with a drainage area of 14.3 square miles. The habitat score was 68.

East Fork Deep River at SR 1541, Guilford County.

The benthic community had an EPT S of eight, a BI of 7.1, and was rated Fair. The community was dominated by toxic tolerant taxa: *Conchapelopia* and *Polypedilum illinoense*. The site was unchanged from 1998.

West Fork Deep River, SR 1850

At this headwater site on the West Fork Deep River, the stream was about five meters wide with a mostly sand substrate. The banks were steep and eroded; the riparian zone was intact, providing good shading of the stream. Instream habitat was limited to leafpacks and woody debris. The habitat score was 51. The water was turbid due to heavy rain at the time of sampling.

West Fork Deep River at SR 1850, Guilford County.

This site was also sampled during basinwide surveys in 1993 and 1998. It has consistently rated Good-Fair. EPT S was similar for all three samples (12 - 15). Despite poor instream habitats, two stonefly species (*Perlesta* and *Pteronarcys*) remained abundant. *Neoperla* was also found, but was rare in 2003 compared to common in 1998. Other abundant EPT taxa included *Pseudocloeon propinquum*, *Stenonema modestum*, and *Cheumatopsyche.* The tolerant *Hydropsyche betteni* was also abundant in 2003, but was rare in all previous collections.

Deep River, US 220 Bus

The site on the Deep River near Randleman has a mean width of 25 meters. The substrate was mostly boulder and rubble with some sand behind the large rocks and along the margins. Habitat was good overall (score = 73), except for a lack of pools. Riffles were small, some areas of bank erosion were present, but the riparian zone was intact. At the time of sampling, the water was turbid from recent hard rains and there was the smell of sewage. Abundant growths of sponge and some bryozoans were present, which suggested low dissolved oxygen conditions.

Deep River at US 220 Bus, Randolph County.

This site has been sampled for benthic macroinvertebrates eight times since 1983. Early years were rated Poor or Fair. Since 1993, three samples, including 2003, have been rated Good-Fair. EPT S has changed little from 1998 to 2003, with 20 taxa found in 1993 and 1998 compared to 18 in 2003. *Centroptilum,* a margin and sand mayfly, was absent in 2003, possibly due to scour from high flows. Also absent was *Hydroptila* which was present (sometimes abundant) in all previous collections. *Hydropsyche betteni* was the dominant species in 2003; amphipods and water mites were also very abundant. No stoneflies have been collected at this site since 1987. Total S (87) had declined from the 131 found in 1993 and 1998; the BI has shown a steady improvement since 1985.

Bull Run Creek, SR 1144

The watershed of Bull Run Creek includes southwestern Guilford County south of I-40 and west of the US 29A/70A corridors. There are no NPDES facilities in the watershed and the monitoring site is approximately 0.2 miles above its confluence with the Deep River.

Bull Run Creek at SR 1144, Guilford County.

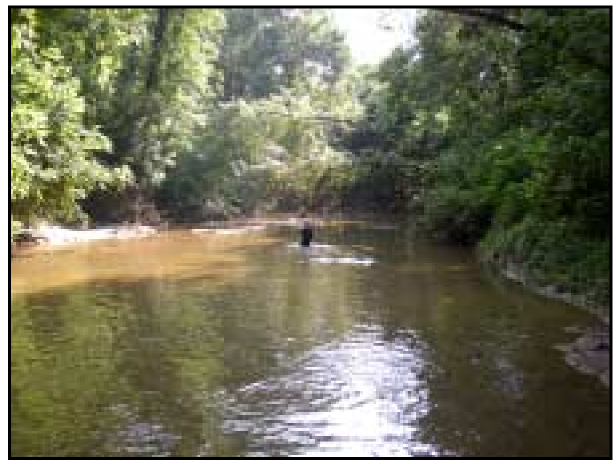
The fish community was sampled for the first time in 2003. The community was rated Good-Fair (NCIBI = 42) with the bluehead chub being the dominant species.

Richland Creek, SR 1154
Richland Creek drains the eastern part of the City of High Point, is bisected by I-85, and carries a heavy sediment (sand) and urban debris load. The monitoring site was approximately four miles below the city's 10 MGD WTP which discharges to an unnamed tributary to Richland Creek. [Note: although permitted to discharge 10 MGD, the actual discharge is ~ 1 MGD.]

Richland Creek at SR 1154, Guilford County.

The fish community was rated Poor in 1998 and Fair in 2003 (NCIBI = 26 and 36, respectively). Improvement between monitoring cycles was due to a more balanced trophic structure in 2003 than in 1998. The community was dominated by redbreast sunfish; there were no intolerant species or darters; and there was a high percentage of tolerant species (67 percent in both years).

Richland Creek, SR 1145
This site on Richland Creek, near its confluence with the Deep River, is located below the City of High Point's WWTP. The stream was about 10 meters wide with a soft sand substrate. Pools and riffles were absent. The banks were steep and eroded, however, the riparian was intact with large trees. Instream habitat was confined to the margins and woody debris. The habitat score was 51. The water was turbid with a strong sewage smell and conductivity was 255 µmhos/cm.



Richland Creek at SR 1145, Guilford County.

This site has been sampled eight times; all samples have been rated Poor or Fair. Four collections in the 1980's were rated Poor and since then the ratings have alternated between Fair and Poor. The 2003 results were similar to the 1993 collection, with the same BI (7.1). The benthic community was dominated by tolerant taxa including *Stenonema modestum, Hydropsyche betteni*, and numerous midges.

Hickory Creek, SR 1131
At this site Hickory Creek averages five meters wide with a soft sand substrate and highly eroded banks. There were no riffles or pools at this site, instream habitat was sparse and the total habitat score was 55. The water was turbid and a chemical odor was detected.

Hickory Creek at SR 1131, Guilford County.

An EPT sample in 1993 produced 18 taxa and a rating of Fair. The 1998 sample was Not Rated due to very low flows. In 2003, this site was rated Good-Fair with 17 EPT S collected. This Full Scale sample had fewer midges than other Hickory Creek sites (see Special Studies) and may have been due to recent high flows and channelization at the bridge that scoured away some taxa from the unstable substrate. The effect of the reduced chironomid taxa was a lowering of the BI (5.0).

Hickory Creek, SR 1140
The watershed of Hickory Creek includes south-central Guilford County, south of Greensboro, south of I-85, and east of US 220. The lower part of the watershed is rural and there are three small (total discharge = 0.05 MGD) NPDES dischargers in the watershed above the monitoring site. The site is 0.7 miles above its confluence with the Deep River.

Hickory Creek at SR 1140, Guilford County.

The fish community was sampled for the first time in 2003. The community was rated a low Good (NCIBI = 46) with the spottail shiner, a sand bottom stream indicator, being the dominant species. The site will not be sampled again as it will probably be inundated by the flood pool of Randleman Reservoir when it is filled.

Muddy Creek, SR 1929
The watershed of Muddy Creek includes northwest Randolph County, south and east of I-85 and US 301, and the Town of Archdale. The lower part of the watershed is rural and there are three small (total discharge = 0.08 MGD) NPDES discharges upstream of the monitoring site. The monitoring site is approximately five miles above its confluence with the Deep River.

In the reach sampled for benthic macroinvertebrates, the stream was about six meters wide and the substrate was soft sand. At the time of sampling, the water was very turbid and too deep for a good kick net collection. Riffles and pools were absent, the banks were eroded, and instream habitat was limited to sparse root mats and woody debris. The habitat score was 48.

Muddy Creek at SR 1929, Randolph County.

This site was sampled in the winter of 1993 and in the summer of 1998. The 1998 sample was Not Rated because of extremely low flows. In 2003, only seven EPT S were found compared to 13 during low flows in 1998. The site was rated Fair in 2003. EPT N was also very low in the 2003 sample (38) compared to 60 in 1998. Three EPT S were abundant: *Baetis flavistriga, Stenonema modestum,* and *Cheumatopsyche*. Three tolerant EPT S that were abundant in 1998 were absent in 2003. The BI was similar in both years (6.1 in

1998 and 6.3 in 2003). The benthic sample collected in 2003 was considered marginal and other locations on the stream should be considered for future sampling.

The fish community at this site has been monitored during every basinwide cycle and has fluctuated between Good in 1994 and 2003 (NIBI = 46 and 50, respectively) and Fair (NCIBI = 38) in 1998. Improvements documented in 2003 included an increase in the number of species, number of fish, diversity of sunfish, and in the trophic metrics; the percentage of tolerant fish declined slightly between 1998 and 2003. Five of the seven species collected in 2003 and not 1998 were represented by 1 or 2 fish per species. Like Hickory Creek, this site will not be sampled again as it will probably be inundated by the flood pool of Randleman Reservoir when it is filled.

SPECIAL STUDIES

Greensboro's Stormwater Services Division Fish Community Study

In 1999, the Staff of the City of Greensboro's Stormwater Services Division conducted an assessment of the fish communities of several streams in the Greensboro area in Guilford County (Anon. 2000). The assessment followed NC DWQ's Standard Operating Procedures for stream fish community assessment (NCDENR 1999, superceded by NCDENR 2001) and thus the data can be used for use support purposes. Bull Run, off SR 1549 (upstream from NC DWQ's site at SR 1144) was rated Good-Fair in September 1999.

Hickory Creek TMDL Stressor Study

A TMDL Stressor Study of the Hickory Creek watershed was conducted in April 2003. This survey included locations on Reddicks Creek, Jenny Branch, and Hickory Creek in addition to the basinwide site on Hickory Creek; the West Fork Deep River served as the reference site. Sedimentation, habitat degradation, and urban runoff were identified as the main impacts to this watershed. (Biological Assessment Unit Memorandum B-031027).

East Fork Deep River Stressor Study

A TMDL stressor study was done on the East Fork Deep River watershed in May 2003. This survey included a UT to East Fork Deep River, Long Branch, and East Fork Deep River sites, in addition to the basinwide site on the East Fork Deep River. Sedimentation, habitat degradation, and scour from stormflow were found to be the likely causes of stress to these streams (Biological Assessment Unit Memorandum B-030805).

UT East Fork Deep River

Two sites on an UT East Fork Deep River were sampled in 2000 to determine impacts from the construction of Millwood School Road. All streams were too small to be rated. Comparisons of sites upstream and downstream of the construction indicated a significant decline in water quality below the construction area (Biological Assessment Unit Memorandum B-001004).

Lake Assessment

High Point Lake

This reservoir, an impoundment of the East and the West Forks of the Deep River (Figures 47 and 48), is used as a water supply for the City of High Point and for recreation. Urban and residential areas as well as pasture and row crop farms dominate the watershed. The maximum depth is 33 feet. Prior to 2003, this lake had been sampled 26 times by DWQ.

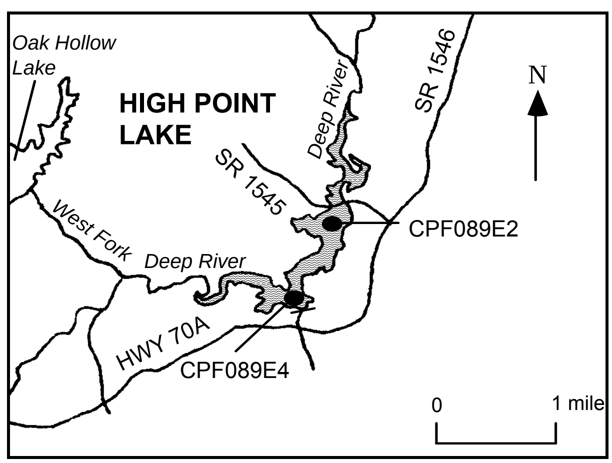


Figure 47. Sampling sites at High Point Lake, Guilford County.

Figure 48. High Point Lake, Guilford County.

There have been numerous complaints of taste and odor and aesthetic problems related to algal blooms and in the processed drinking water taken from this lake. The water treatment plant currently treats the raw water. Low dissolved oxygen concentrations have been measured at the intake and a forced air destratification system was installed in the mainstem of the reservoir to help increase the concentrations. Nutrient inputs and pesticides are also presenting management problems (Bill Frazier, Laboratory Supervisor, High Point Water Treatment Facility, pers. com., November 20, 2000).

The shoreline is heavily impacted by *Lyngbya wollei*. It is an invasive, filamentous algae known for forming thick mats, fouling boat motors, and clogging water intakes (Figure 49). The first large bloom was observed during the summer of 1999.

Figure 49. A floating mat of *Lyngbya wollei* at High Point Lake, Guilford County.

The reservoir was monitored from 2001 to 2003. In 2003, Secchi depths were less than one meter and total phosphorus and nitrogen concentrations were elevated (Appendix 22). Frequent rainfall in the watershed during the summer may have contributed to an increase in nonpoint source runoff to the reservoir. Turbidity (31 NTU) in August at Station CPF089E4 was greater than the water quality standard of 25 NTU. The water was frequently green.

Nutrient concentrations have ranged from moderate to elevated (Appendix 22). These concentrations were sufficient to support increased algal productivity and chlorophyll *a* concentrations greater than the water quality standard of 40 µg/L at Station CPF089E in 2003. Percent dissolved oxygen saturation values were consistently elevated at this site (range = 111 to 130 percent) and agreed with the chlorophyll *a* concentrations.

This productivity also influenced the surface pH values which were greater than the water quality standard of 9.0 s.u. at Station CPF089E2 in June and July and at Station CPF089E4 in July and August (Appendix 22). Algal blooms also occurred throughout 2003. These blooms ranged from mild to moderate and the majority of them were dominated by *Chrysochromulina* sp. This algae is a indicator of eutrophic conditions and can cause taste and odor problems in drinking water supplies (Wehr and Sheath 2003).

Chlorophyll *a* concentrations for 1998 - 2002 ranged from moderate to elevated, but were not greater than the water quality standard (Appendix 22). Concentrations of metals in the surface waters were within water quality standards. Based on the calculated NCTSI scores for 2001 to 2003, the reservoir was generally classified as eutrophic.

The City of High Point monitors High Point Lake and Oak Hollow Lake routinely for water chemistry, physical characteristics, algal concentrations, and algal composition. Their data corroborates DWQ findings.

Oak Hollow Lake

This reservoir, an impoundment of the West Fork Deep River (Figure 50), is commonly used for recreational activities. It has a maximum depth of 36 feet. The watershed is characterized by urban, residential, and some agricultural land uses; two 18-hole golf courses are along the shoreline (Figure 51). The reservoir has been sampled 22 times by DWQ prior to 2003.

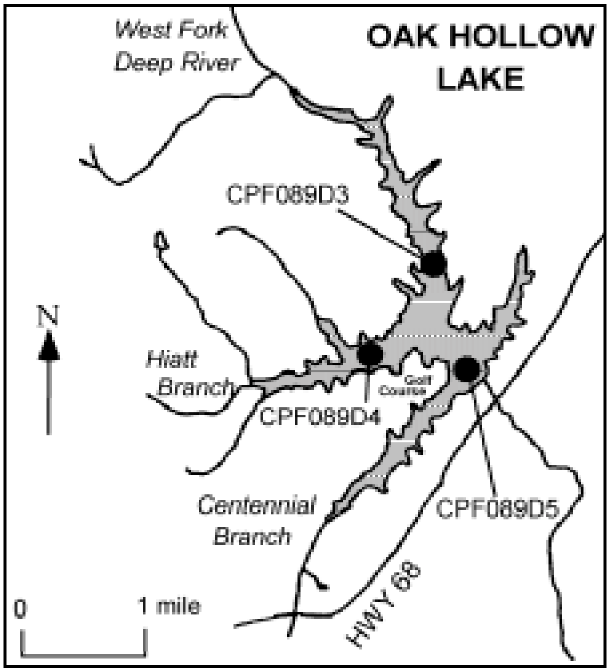


Figure 50. Sampling sites at Oak Hollow Lake, Guilford County.

Figure 51. Golf course on Oak Hollow Lake, Guilford County.

As with High Point Lake, nutrient runoff is a problem for Oak Hollow Lake and there have been frequent public complaints of taste and odor problems related to algal blooms. To reduce this problem, the water treatment plant currently treats the raw water. Low dissolved oxygen concentrations have been measured at the water intake and a destratification system (forced air) was installed in the mainstem of the reservoir to help increase the concentrations.

The reservoir was most recently monitored in 2003. Secchi depths were generally less than one meter and were lower than those previously observed. The water was consistently brown. This decrease in water clarity may have been influenced by the frequent rains within the watershed during the summer.

Nutrient concentrations were also greater than those previously measured (Appendix 22) and may have been due to increases in nonpoint source runoff. Chlorophyll *a* concentrations, however, were less than the water quality standard. By contrast, severe drought conditions during 2002 and subsequent reduction in nonpoint source runoff may have reduced nutrients and sediment inputs. Chlorophyll *a* concentrations were consistently low to moderate in 2002 (Appendix 22).

Based on the calculated NCTSI scores for 2003, the reservoir was classified as eutrophic. During a drought year, 2002, it was classified as oligotrophic in June and July and mesotrophic in August. In 2001, it was consistently classified as mesotrophic.

The City of High Point monitors High Point Lake and Oak Hollow Lake routinely for water chemistry, physical characteristics, algal concentrations, and algal composition. Dissolved oxygen stratification was documented in mid June 2002 and the water was brown-green. Surface dissolved oxygen (8.6 mg/L) and pH (8.1 s.u.) suggested the presence of an algal bloom. The water level was down almost three feet due to the drought. Two days later on June 20th, a fish kill of approximately 40 to 50 sunfish was reported. The cause of the kill was unknown (Bill Frazier, Laboratory Supervisor, High Point Water Treatment Facility, pers. com., June 2002). In August 2003 floating mats of water primrose created problems at the water intake.

CAPE FEAR RIVER SUBBASIN 09

Description

This subbasin, located primarily in south-central Randolph, includes one of the two middle sections of the Deep River and its tributaries from the Town of Randleman to the Randolph/Moore County line (Figure 52). The extreme northern part of the subbasin is in the Southern Outer Piedmont, whereas most of the subbasin is in the Carolina Slate Belt (Griffith *et al*. 2002).

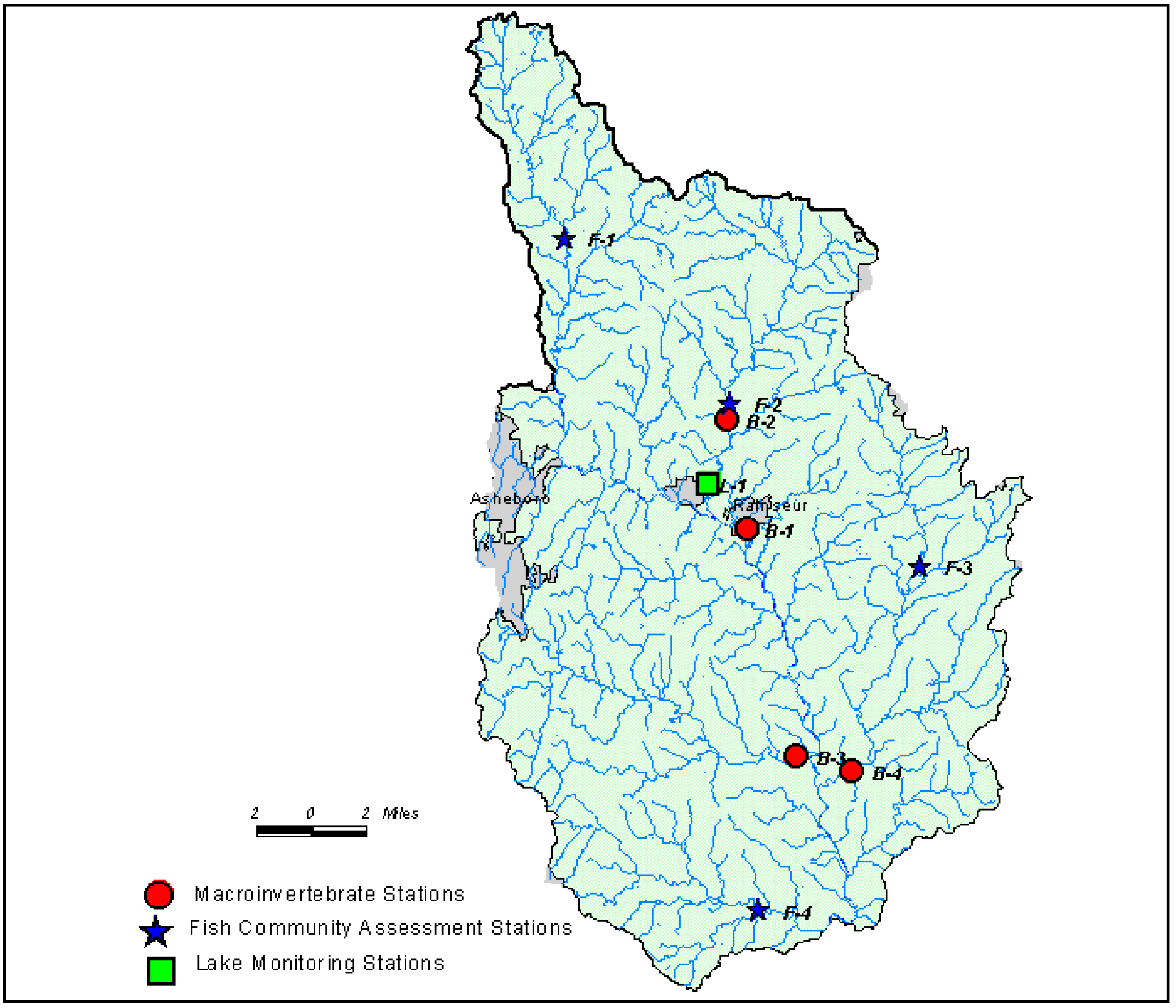


Figure 52. **Sampling sites in Subbasin 09 in the Cape Fear River basin. Monitoring sites are listed in Table 28.**

Typical streams in the Carolina Belt ecoregion have very rocky substrates (Figure 53). Many of the small tributary streams are prone to extremely low flow conditions during the summer due to low base flows and may often dry up completely during prolonged low flow periods.

Figure 53. Brush Creek at SR 1102, Randolph County -- a typical stream in the Carolina Slate Belt in Subbasin 09.

Approximately two-thirds of the landuse within this subbasin is forest with pasture constituting the other major use (Table 27). There are 15 NPDES permitted dischargers in the subbasin with only the City of Asheboro's WWTP (9 MGD into Hasketts Creek) having a permitted flow greater than 0.5 MGD.

Table 27. Land use in Subbasin 09. Based upon CGIA coverage 1993 - 1995 (total area = 446 square miles (NCDENR 2000).

Land use	Percent
Water	1
Cultivated crop	3
Pasture	27
Urban	1
Forest	69

Overview of Water Quality

In this subbasin, there were 4 sites that were monitored for benthic macroinvertebrates, 4 fish community sites, 1 reservoir, and 7 ambient and coalition monitoring sites (Table 28, in part). Five facilities in this subbasin were required to perform whole effluent toxicity testing. Prior to this sampling cycle, 53 of the 61 tests passed (~ 85 percent passing rate); during 2003, there was an 83 percent passing rate (12 passes out of 14 tests). No facility had major problems with meeting its permit limits.

Although the overall water quality and habitats in this subbasin were good, the benthic macroinvertebrate and fish communities at some sites such as Sandy Creek still seemed to be recovering from the 2002 drought and the abundance of precipitation in late 2002 and early 2003. Richland Creek at SR 2873 decreased one bioclassification for benthic macroinvertebrates from a borderline Excellent in 1998 to Good in 2003. The benthic community in the Deep River at SR 2615 improved steadily over the years from Fair to Good.

Brush Creek was sampled at two locations for benthic macroinvertebrates and fish. The upstream site at SR 1102 was rated Good based upon its fish community; a site further downstream decreased one bioclassification from Good in 1998 to Good-Fair in 2003 based on its benthic macroinvertebrates. Fork Creek at SR 1003 is a new fish community regional reference site. Although more fish species were collected at this site than any other in the entire Piedmont in 2003, the site was rated Good. Evidence of extreme high flows in the previous six months and the 2002 drought may have prevented an Excellent rating.

Sandy Creek Reservoir serves as the major water supply for the Town of Ramseur and was classified as eutrophic in 2003. Blooms of diatoms and bluegreen algae were prevalent during the summer and caused high chlorophyll *a* concentrations that exceeded the water quality standard. These blooms were also the source of drinking water taste and odor problems. Dissolved oxygen saturation levels were also elevated and exceeded the water quality standard.

There were no significant exceedances of standards for nitrite+nitrate-nitrogen, turbidity, dissolved oxygen, or chlorophyll *a* at any of the ambient or coalition sites. Dissolved oxygen concentrations were consistently good in the upper-mid section of the Deep River. Conductivities remained slightly elevated around Central Falls, but decreased in the river towards the lower end of the subbasin. Turbidity was well below the water quality standard at all sites.

Statistically significant exceedances were documented at:

- Deep River at Worthville – fecal coliform bacteria and copper; and
- Hasketts Creek -- fecal coliform bacteria, copper, and zinc.

Table 28. Waterbodies monitored in Subbasin 09 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Deep R	Randolph	SR 2615	Good-Fair	Good
B-2	Sandy Cr	Randolph	SR 2481	Excellent	Good
B-3	Richland Cr	Randolph	SR 2873	Excellent	Good
B-4	Brush Cr	Randolph	NC 22/42	Excellent	Good
F-1	Polecat Cr	Randolph	SR 2114	---	Good
F-2	Sandy Cr	Randolph	SR 2481	Excellent	Good
F-3	Brush Cr	Randolph	SR 1102	---	Good
F-4	Fork Cr	Randolph	SR 1003	---	Good
L-1	Sandy Creek Res	Randolph			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake assessment site.

River and Stream Assessment

Habitat characteristics and examples of high quality and low quality habitats at fish community sites in the basin are presented in Appendix 2.

Deep River, SR 2615

The Deep River at Ramseur is about 30 meters wide with a substrate composed of bedrock, boulder, and rubble; there were deposits of sand downstream of large boulders. Patches of *Podostemum* and *Justicia* were common and *periphyton* was abundant. The water was high and turbid at the time of sampling due to recent hard rains. The flow (~ 205 cfs) was nearly three times the normal level and was considered the maximum for safe sampling. Habitat was generally good except for a lack of pools and few riffles. Banks were generally intact, and the riparian zone was intact. The habitat score was 69.

Deep River at SR 2615, Randolph County.

This site has now been sampled eight times for benthic macroinvertebrates. This site has shown a gradual but steady improvement since first sampled in 1983. Samples from 1983 and 1985 were rated Fair; between 1986 and 1998, the site was rated Good-Fair. In 2003 it was rated Good based upon a BI of 5.72 and an EPT S of 19. The EPT S, however, was the lowest value ever documented at this site.

The macroinvertebrate community was dominated by hydropsychid caddisflies, including *Hydropsyche. betteni, H. demora, H. rossi,* and

Cheumatopsyche. Hydropsyche incommoda was also abundant in 2003, having not been collected since 1987. Baetid mayflies and *Isonychia* were also dominant organisms, as was the aquatic lepidopteran *Petrophila.*

Polecat Creek, SR 2114
The watershed of Polecat Creek includes southern Guilford and north-central Randolph counties. There are five NPDES dischargers in the headwaters of the stream with three of the dischargers on small unnamed tributaries near the Town of Pleasant Garden. Collectively, these five facilities discharge 0.15 MGD of treated effluent to upper Polecat Creek. The monitoring site was in the middle part of the watershed.

Polecat Creek at SR 2114, Randolph County.

The fish community was sampled for the first time in 2003. The community was rated a low Good (NCIBI = 46) with the tessellated darter being the dominant species. Only two species of sunfish, redbreast and bluegill, were collected despite good instream snags and undercut banks.

Sandy Creek, SR 2481
The watershed of Sandy Creek drains northeastern Randolph County. There is one small NPDES dischargers (0.009 MGD) on an unnamed tributary upstream of the monitoring site. During benthic macroinvertebrate sampling, the creek was about 15 meters wide with a mixed substrate of boulder, rubble and gravel; there were also some bedrock areas. The habitat was excellent with stable banks, frequent riffles, and a variety of instream structure; there were few pools and no macrophytes. The habitat score was 85.

Sandy Creek at SR 2481, Randolph County.

This site has been monitored during every basinwide cycle and has fluctuated between Good (NCIBI = 52) in 1994 and 2003 and Excellent (NCIBI = 60) in 1998. The fish community appeared to still be recovering from the 2002 drought and then from extremely high flows during late 2002 and the first half of 2003. Indicative of these extremes in flows, the total number of species and fish declined between 1998 and 2003 and 10 of the 12 largemouth bass collected were between 200 and 350 mm which also indicated that an upstream farm pond may have been breached due to high flows. The high flows may also have contributed nonpoint source nutrients which may have shifted the trophic structure to more omnivores+herbivores. The Bluehead chub was the dominant species during all three cycles but had increased from 28 to 37 percent of the fauna between 1998 and 2003.

The site has been sampled nine times for benthic macroinvertebrates. A summer sample in 1998 and a spring sample in 2001 were rated Excellent. Spring and summer collections in 2003 were rated Good. Heptageniid mayflies including *Stenonema modestum, Leucrocuta,* and *Stenacron* were the dominant organisms; *Isonychia* and *Acentrella* were also abundant. *Neoperla* and *Perlesta* have consistently been abundant at this site. An absence of margin caddisflies such as *Triaenodes* and *Nectopsyche,* suggested that the 2002 low flows may have impacted this part of the benthic community.

Richland Creek, SR 2873
Richland Creek has a rocky substrate including large areas of bedrock. There were large patches of *Justicia* along the margins and in shallow areas

midstream. Instream habitat was excellent, however, leafpacks were scarce. The habitat score was 87.

Richland Creek at SR 2873, Randolph County.

This site has been sampled four times for benthic macroinvertebrates. It was rated Good in 1993 and a borderline Excellent in 1998. In 2003 it was again rated Good. The EPT fauna was dominated by Heptageniid mayflies; four species of *Stenonema,* including *S. lenati,* two species of *Stenacron,* and *Leucrocuta.* Hydropsychid caddisflies, including *Hydropsyche betteni, H. venularis,* and *Cheumatopsyche* were abundant. Another caddisfly, *Macrostemum,* common in 1993 and 1998, was absent in 2003.

Brush Creek, SR 1102

The watershed of Brush Creek includes the extreme western part of Chatham and extreme eastern Randolph counties. Brush Creek is a large tributary (70 square miles) to the Deep River and could only be sampled in its upper end (watershed size = 19.1 square miles). There is one small (0.01 MGD) NPDES permitted discharger located approximately three miles upstream of the site. The fish community was sampled for the first time in 2003.

Brush Creek at SR 1102, Randolph County.

The monitoring site on Brush Creek like Collins Creek (Subbasin 04) is also located in the Carolina Slate Belt and both have almost identically sized watersheds. Whereas the fauna of Collins Creek had yet to recover from the 2002 drought, the fauna in Brush Creek had recovered. The fish community was rated Good and the dominant species was the white shiner.

Brush Creek, NC 22/42

Brush Creek is about 10 meters wide with a rocky bottom and frequent short riffles. There were large areas of bedrock and abundant *Justicia,* typical of streams in this area. There was some erosion along the banks and pools were infrequent, but the instream habitat was excellent. The habitat score was 85.

Brush Creek at NC 22/42, Randolph County.

This site has been sampled five times for benthic macroinvertebrates. A Full Scale sample taken in 1983 was rated Good. An EPT sample in 1990 was rated Excellent. The rating was again Good for EPT samples in 1993 and 1998. In 2003, EPT S and EPT N declined and resulted in a Good-Fair rating. Mayfly and stonefly diversities were similar to previous collections. Trichoptera taxa averaged 10 (7 - 12) in previous collections, however, only four taxa were found in 2003. Two species of *Hydropsyche* as well as *Polycentropus* and *Pycnopsyche* were absent in 2003 but were common in 1998.

Fork Creek, SR 1003

The watershed of Fork Creek includes southern Randolph and northern Moore counties. In its extreme headwaters, there is one small NPDES permitted facility (Randolph County Board of Education's Seagrove Elementary School, Q_w = 0.0088 MGD). At this crossing, the instream, riparian, and watershed characteristics are of exceptionally high quality (Appendix 2) and qualified the site as a new regional reference site.

Fork Creek at SR 1003, Randolph County.

Fork Creek was sampled for the first time for fish community assessment in 2003. More species (n = 23, including 3 species of darters, 10 species of minnows, and 4 species of catfish) were collected at this site than at any other site in the Piedmont in 2003. The community was rated Good and the Tessellated darter was the dominant species. Evidence of extremely high flows within the last six months and the 2002 drought may have prevented the community from being rated Excellent.

SPECIAL STUDIES

Fish Community Reference Sites

Sandy Creek at SR 2481, Randolph County, was sampled and evaluated as a possible fish community regional reference site in 1999. Although the community was rated Excellent, watershed characteristics precluded designating it as such (NC DWQ unpublished data).

Hasketts Creek TMDL Stressor Study

The Hasketts Creek watershed was the subject of a TMDL stressor study in 2003. This survey included five sites on Hasketts Creek and two locations on Penwood Branch. This catchment was severely degraded, likely due to urban runoff and the WWTP discharge, as well as lingering effects of drought (Biological Assessment Unit Memorandum B-031210).

Sandy Creek Reservoir

This reservoir, an impoundment of Big Sandy and Little Sandy Creeks, is a water supply reservoir for the Town of Ramseur. The maximum depth is 48 feet. The immediate watershed is moderately developed and land use is mostly characterized by forested and agricultural areas as well as urban development (Figures 54 and 55). The reservoir has been sampled five times by DWQ prior to 2003.

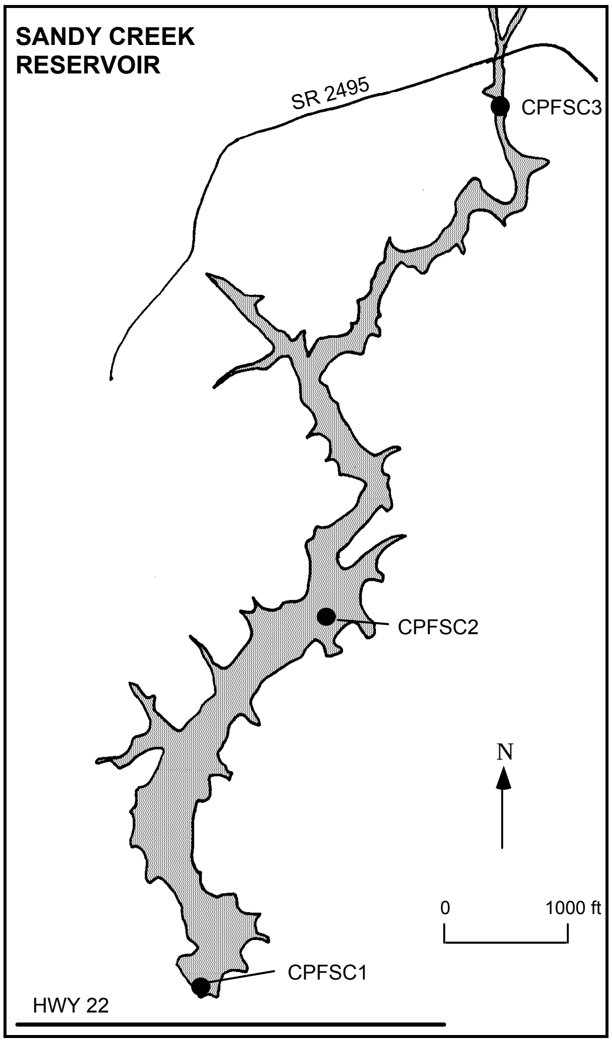


Figure 54. Sampling sites at Sandy Creek Reservoir, Randolph County.

Figure 55. Sandy Creek Reservoir, Randolph County.

The reservoir was most recently sampled in 2003. Nutrient concentrations were elevated and supported increased algal productivity as indicated by the elevated chlorophyll *a* concentrations. During the summer chlorophyll *a* concentrations were greater than the water quality standard of 40 µg/L (Appendix 22). Algal blooms, composed primarily of diatoms and bluegreens, also occurred throughout the summer. The blooms were most prevalent near the dam. The algal species found cause taste and odor problems in drinking water supplies.

Throughout the reservoir in 2003, surface percent dissolved oxygen (~ 130 – 165 percent) was routinely greater than the water quality standard. As in previous years, concentrations of metals in the surface waters were within water quality standards. Based on the calculated NCTSI scores, the reservoir was classified as eutrophic in 2003.

CAPE FEAR RIVER SUBBASIN 10

Description

This subbasin, located primarily in northern Moore and southern Chatham counties, includes one of the two middle sections of the Deep River and its tributaries (Figure 56). Cedar, Scotchman and Lick Creeks are classified as HQWs as is a portion of the Deep River from Grassy Creek to NC 42. Major tributaries to the Deep River include Bear and McLendons Creeks.

The subbasin is located primarily in the Carolina Slate Belt with the headwaters of McLendons and Wet Creeks in the Sand Hills and the lower portions of Richland and McLendons Creeks in the Triassic Basins. Streams in the Triassic Basins usually stop flowing during low flow periods. Many of the streams have instream and riparian habitats and watershed characteristics that are of exceptionally high quality (Appendix 2).

There are no large urban areas in this subbasin, less than one percent of the area is urbanized (Table 29). Most of the land is forested or in pasture. The small municipalities include the Towns of Star, Robbins, and Carthage. There are four NPDES permitted dischargers in the subbasin with two of these facilities having a permitted flow greater than 0.5 MGD:

- the Town of Star's WWTP discharging 0.6 MGD into Cotton Creek; and
- the Town of Robbins' WWTP discharging 1.3 MGD into the Deep River.

Table 29. Land use in Subbasin 10. Based upon CGIA coverage 1993 - 1995 (total area = 448 square miles (NCDENR 2000).

Land use	Percent
Water	1
Cultivated crop	1
Pasture	18
Urban	< 1
Forest	80

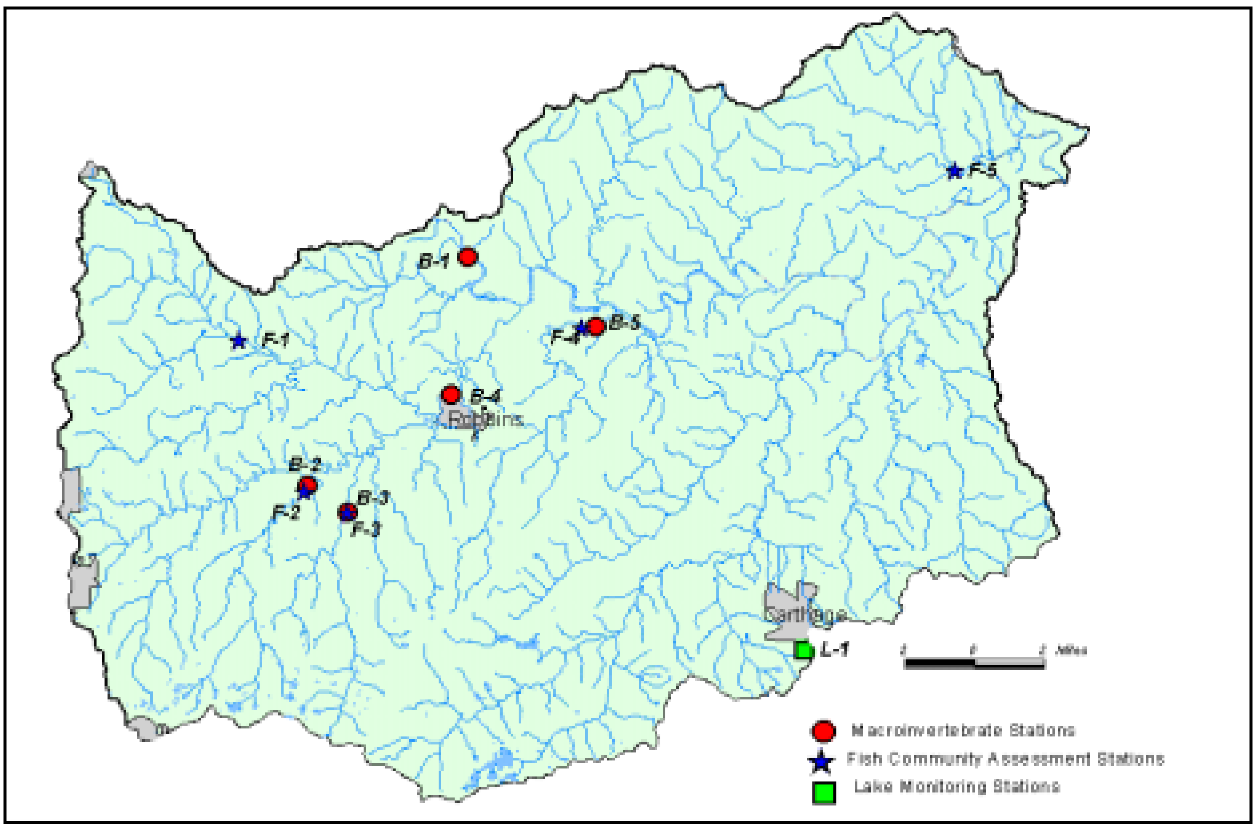


Figure 56. Sampling sites in Subbasin 10 in the Cape Fear River basin. Monitoring sites are listed in Table 30.

Overview of Water Quality

Three basinwide benthic macroinvertebrate sites sampled in 1998 (Cabin Creek at SR 1400, Falls Creek at SR 1606, and Big Governors Creek at SR 1625) were not sampled in 2003. Wet Creek, and Bear Creek retained the Good bioclassifications from 1998 in 2003 (Table 30). The rating at Mill Creek increased to Good-Fair to Good; Buffalo Creek was rated as Good Fair, possibly due to ephemeral qualities. The Deep River, classified as a HQW from Grassy Creek to NC 42, is the only basinwide site in this subbasin rated Excellent in 1998 and 2003. Many of the streams in this subbasin were affected by low flows in 1998 and 2002 but most recovered by the sampling season in 2003.

Only two fish community sites (Cabin Creek at SR 1275 and Indian Creek at SR 2306) were retained from the 1998 basinwide sampling. The NCIBI ratings at both of these sites declined from Excellent to Good and Fair respectively. Cabin Creek should recover from the effects of highly fluctuating flows soon. However, Indian Creek, a former reference site, suffered serious effects from extensive logging operations and subsequent scouring effects from high flows in 2003. Sites at Bear Creek, Wet Creek, and Buffalo Creek replaced those on Falls Creek, McClendon's Creek, and Richland Creek which had been sampled in 1998. Buffalo Creek at NC 22 and the Sand Hills stream, Wet Creek at NC 24/27, were sampled for the first time in 2003 resulting in Good and Not Rated (there are currently no Sand Hills criteria) bioclassifications respectively. The reference site at Bear Creek declined from Excellent to Good but should recover from drought effects. The fish communities in this subbasin have not recovered as quickly as the benthos communities. There are no NPDES permitted facilities in the watersheds of Bear, Buffalo, Wet, or Indian Creeks where fish community assessment were performed.

Carthage City Lake, the water source for the Town of Carthage, progressed from oligotrophy in June to eutrophy in August. Iron concentrations in August were 50 percent greater than the water quality standard limit.

Ambient water quality samples are currently collected from five sites in this subbasin. Three sites are located on the Deep River, one is on Bear Creek at NC 705, and one is on Cotton Creek at SR 1372 near Star. Dissolved oxygen and chlorophyll *a* concentrations were issues in the Deep River at NC 42, while copper concentrations were above the action limit at Cotton Creek and Deep River at NC 22. In addition, 17 percent of the nitrate+nitrite nitrogen concentrations and more than 80 percent of the fecal coliform concentrations in Cotton Creek were above the water quality standards.

Continuing effluent toxicity problems with the Town of Star's WWTP, mostly due to salts from textile wastes, have prompted town officials to explore sewer regionalization with the Towns of Bisco and Troy to resolve this issue. An engineering analysis was underway as of April 2004.

Table 30. Waterbodies monitored in Subbasin 10 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Deep River	Moore	SR 1456	Excellent	Excellent
B-2	Mill Cr	Moore	SR 1275	Good-Fair	Good
B-3	Wet Cr	Moore	NC 24/27	Good	Good
B-4	Bear Cr	Moore	NC 705	Good	Good
B-5	Buffalo Cr	Moore	NC 22	Not Rated	Good-Fair
F-1	Bear Cr	Moore	SR 1405	Excellent	Good
F-2	Cabin Cr	Moore	SR 1275	Excellent	Good-Fair
F-3	Wet Cr	Moore	NC 24/27	---	Not rated
F-4	Buffalo Cr	Moore	NC 22	---	Good
F-5	Indian Cr	Chatham	SR 2306	Excellent	Fair
L-1	Carthage City Lake	Moore			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake monitoring site.

Habitat characteristics and examples of high quality and low quality habitats at fish community sites in the basin are presented in Appendix 2.

Deep River, SR 1456
The Deep River at this location has a mean width of about 40 meters. The substrate is a mix of boulder and rubble with some sand behind large rocks. Habitat was good, except for a lack of pools, which are not expected in a big river. Riffles were infrequent and some areas of bank erosion were present. The riparian zone was intact, but very narrow on the right bank, with a large cow pasture behind. The habitat score was 64. At the time of benthic macroinvertebrate sampling, the water was high and turbid from recent rains. The flow was swift and was considered the deepest allowable for safe sampling.

Deep River at SR 1456, Moore County.

This site has been sampled nine times for benthic macroinvertebrates. The first sample collected in 1983 was rated Good. All other collections were rated Excellent, except an EPT sample from 2002 that was rated Good. That sample was part of a 2002 drought impact study. In 2003, the site was again rated Excellent which indicated that it had recovered from any effects of the drought.

The macroinvertebrate community was similar to Deep River site upstream at Ramseur. Hydropsychid caddisflies and baetid mayflies, as well as *Isonychia*, were dominant. The rare mayfly, *Stenonema lenati*, was also abundant. *Neoperla* and *Perlesta* were also found, but *Acroneuria* was absent in 2003. It had been common to abundant in all other previous collections.

Bear Creek, SR 1405
Draining primarily northwestern Moore County and to a lesser extent the extreme southern part of Randolph and eastern Montgomery County, Bear Creek is a fish community regional reference site.

Bear Creek at SR 1405, Moore County.

Like other sites in the Carolina Slate Belt, the fish community in Bear Creek seemed to be recovering from the 2002 drought. In 1998 the community was rated Excellent (NCIBI = 56) but only Good (NCIBI = 48) in 2003. As seen at other sites, the drought seemed to have decreased the abundance of bluehead chubs and increased the abundance of highfin shiners. This shifted the trophic metrics and along with the loss of the American eel and brassy jumprock contributed to the decline in the NCIB score and rating.

Cabin Creek, SR 1275
This stream is adjacent to and south of the Bear Creek watershed. This site is part of the NC Natural Heritage Program' s Cabin Creek Quartzite Slope Natural Area (Carter and LeGrand 1989). There is one NPDES permitted facility in the watershed above the monitoring site. It is the Town of Star's WWTP which discharges 0.6 MGD into Cotton Creek which is about 11 miles upstream, in the headwaters, from the fish monitoring site. This facility has had chronic problems with its effluent but the quantity and quality of its discharge has greatly decreased and improved since a textile mill ceased operations in 2002 (Cam McNutt, pers. com). Prior to that, high

conductivities were routinely measured in Cabin Creek during summer low flow periods, such as 652 µmhos/cm on June 14, 1999. Mill Creek, a tributary which joins Cabin Creek just above the site, had a conductivity of only 66 µmhos/cm on the same date.

Cabin Creek at SR 1275, Moore County.

Despite this upstream discharge, the fish community in Cabin Creek was Excellent in 1998 (NCIBI = 58). In 2003, due to the 2002 drought and flash floods in the watershed during June 2003 (with flows approaching 10,000 cfs, 40 times greater than the historical median flow), the community was rated only Good-Fair (NCIBI = 42). Similar to Bear Creek, there was a substantial increase in the dominance of the highfin shiner (from 12 to 68 percent), a significant decrease in the dominance of the bluehead chub (from 22 to 1 percent), a loss of two species of darters and one species of sucker, and a shift in the trophic metrics. This community should recover during normal flow periods and return to Excellent rating. More than 30 species have been collected at this site since 1998.

Mill Creek, off SR 1275

Mill Creek is a small seven meters wide stream with a drainage area of 16 square miles; it is a tributary to Cabin Creek. The water was tannin stained, the substrate consisted of equal parts boulder, rubble, gravel, and sand. The surrounding watershed is all forest. The habitat score was 71.

Mill Creek off SR 1275, Moore Co.

This site has been sampled five times for benthic macroinvertebrates and has been rated Good three times (including 2003). It was rated Excellent in winter 1993 and Good-Fair during the 1998 basinwide when summer flows were very low. In 2003, the increase in EPT S and EPT N, during a wet year, suggested that low flows likely influenced the 1998 rating and that this stream had recovered from any impacts from the 2002 drought.

The 2003 EPT sample collected 26 taxa, including several unusual and intolerant taxa such as *Mystacides sepulchralis* and *Acroneuria evoluta*. The very intolerant *Agapetus rossi* was collected from this site in April 2000.

Wet Creek, NC 24/27

The 15.9 square mile watershed of Wet Creek is adjacent to and south of that of Cabin and Mill Creeks. It is on the edge of the Sand Hills and Carolina Slate Belt ecoregions and shares water quality characteristics and faunal affinities of both ecoregions. The conductivity, 37 µmhos/cm, is low for a Piedmont stream but slightly elevated for a Sand Hills stream; whereas the pH, 6.6 s.u. is high for a Sand Hills stream. The water is clear but tannin stained. At this crossing, the instream, riparian, and watershed characteristics, regardless of which habitat (Piedmont or Sand Hills) criteria were used, are of exceptionally high quality (Appendix 2) and qualified the site as a new regional reference site.

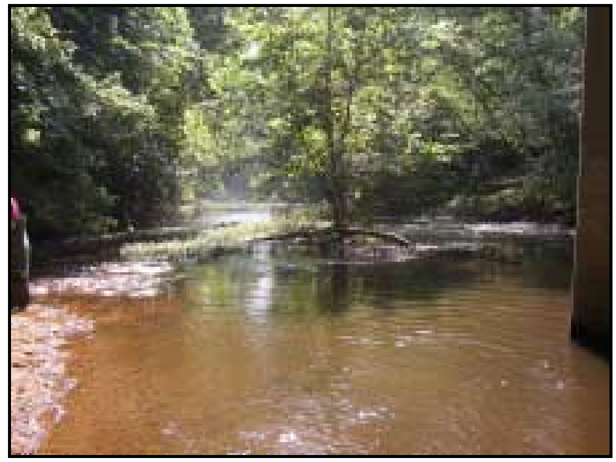
Wet Creek at NC 24/27, Moore County.

Wet Creek was sampled for the first time for fish community assessment in 2003. The same hydrological and meteorological events which impacted Cabin Creek also impacted Wet Creek. If classified as a Piedmont stream, the community would be rated Good-Fair, but should have been rated much better, Good or Excellent, if not for the impacts from the drought and flash floods. If classified as Sand Hills, the community would be "Not Rated" because criteria have yet to be developed for this ecoregion. Currently and pending resampling of this reference site, the community should remain "Not Rated".

The benthic macroinvertebrates at this site have been sampled three times and have always rated the site Good. Collections from 1993 and 1998 were conducted in early spring and included more stoneflies. Seasonal differences accounted for slight variations in the 2003 collection. Baetid mayflies and *Isonychia* were abundant, but blackflies were the dominant organism. EPT S in 2003 (24) was the same as 1998. The BI (4.7) was a little greater than the spring collections due to more tolerant taxa.

Bear Creek, NC 705

At this location Bear Creek is 15 meters wide with a drainage area of 139 square miles. It has a mixed substrate although there was more sand and the rocks were more embedded at this site compared to similar streams in this area. Periphyton was abundant, the instream habitat was good, and riparian zones were extensive. The habitat score was 85.



Bear Creek at NC 705, Moore County.

This site has been sampled three times for benthic macroinvertebrates. In 1993 the site was rated Good-Fair and in 1998, a low flow year, it was rated Good. In 2003, with normal flow, the site was again rated Good. All community metrics were nearly identical in 1998 and 2003. EPT N decreased slightly (EPT S increased), but the BI was the same (5.7) for both years, suggesting no change in water quality between years.

The benthic fauna was diverse with beetles and midges well-represented. Trichoptera were also numerous, including three species of *Triaenodes.* Amphipods were dominant in sweep net samples, and *Elliptio* was common.

Buffalo Creek, NC 22

The 21.4 square mile watershed of Buffalo Creek, a tributary to the Deep River, is on the eastern edge of the Carolina Slate Belt in northern Moore County and borders the Triassic Basins and Sand Hills ecoregions. At this crossing, the instream, riparian, and watershed characteristics are of exceptionally high quality (Appendix 2) and qualified the site as a new regional reference site. The stream was characterized by a mixed substrate with short riffles separated by long runs, and abundant Periphyton on the rocks. Near the bridge there were large patches of *Justicia* in the middle and along the margins of the stream. The riparian zone included a clear cut under a power line right-of-way but most of it was largely intact with mature trees.

Buffalo Creek at NC 22, Moore County.

Buffalo Creek was sampled for the first time for fish community assessment in 2003. It was rated Good (NCIBI = 52) and the dominant species were the highfin shiner and whitemouth shiner. As observed at other streams still recovering from the 2002 drought the abundance of bluehead chub was low. Four specimens of an unknown population of the Cape Fear shiner were also collected at this site. The confluence of Buffalo Creek and the Deep River is less than one-half mile below that of Falls Creek, another stream where an unknown population of Cape Fear shiner was collected by NC DWQ in 1998.

This site has been sampled three times for benthic macroinvertebrates. It was rated Good-Fair in 2003. The benthos are not as diverse here as in other nearby Carolina Slate Belt streams, and the benthic fauna has characteristics of a Triassic Basin stream. Some benthic taxa, such as S*tenonema femoratum*, are indicators of low flow, suggesting that this stream may dry up at times.

Indian Creek, SR 2306

The watershed of Indian Creek drains the extreme southern rural area of Chatham County. In 1998, habitat characteristics qualified the site as a regional reference site and the fish community was rated Excellent (NCIBI = 56). However, in 2003 the habitat was scored 56, a decrease of 18 points, and the community was rated Fair (NCIBI = 36). The decline in the ratings was due to a decrease in the number of species and fish, a loss of species of darters, suckers, and intolerant species, and a decrease in the number of species with multiple age classes. Extremes in flows (i.e., the 2002 drought and the high flows of 2003) and the extensive logging within the immediate watershed attributed to the fish community decline. Only a very narrow buffer of mature trees was left along both sides of the stream.

Indian Creek at SR 2306, Chatham County.

SPECIAL STUDIES

Fish Community Temporal Variability

The fish community in Cabin Creek at SR 1275, Moore County was sampled in April, June, and October 1999 to determine the temporal variability of the NCIBI during NC DWQ's traditional monitoring period. The community was rated Excellent in April and June, and Good in October (NCIBI = 54, 58, and 50, respectively). The decline in October followed a prolonged summer drought and then extremely high flows from Hurricane Floyd. Except for detectable impacts from droughts and hurricanes, it was determined that seasonality was not an important factor to consider when using the NCIBI to assess the fish community of a stream (Biological Assessment Unit Memorandum F-000922).

Impact of the Town of Star's WWTP

Cotton Creek was sampled at two locations above and below the Town of Star's WWTP in 2001. This study found the stream to be severely stressed from the toxicity of the discharge (Biological Assessment Unit Memorandum B-011116).

Impact of the 2002 Drought

Cabin Creek at SR 1400 was sampled once in 2002 and twice in 2003 as part of a study to determine effects from a drought in 2000 - 2002. The results will be included in a future memorandum.

Carthage City Lake
This lake is a small water supply reservoir for the Town of Carthage (Figures 57 and 58). The watershed is moderately developed. Maximum depth is eight to ten feet near the intake structure. During droughts, water is pumped from Nicks Creek (Subbasin 14) to maintain an adequate water level. The reservoir was sampled five times by DWQ prior to 2003.

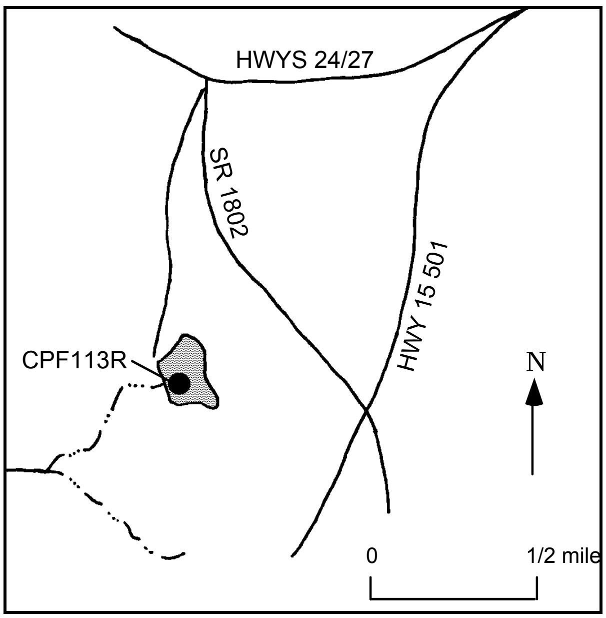


Figure 57. Sampling sites at Carthage City Lake, Moore County.

Figure 58. Water intake at Carthage City Lake, Moore County.

In 2003 the reservoir progressed from oligotrophy in June to eutrophy in August based on the calculated NCTSI scores. Data from previous years had classified the reservoir as oligotrophic. The increase in August was due to a significant decrease in Secchi depth and an increase in total organic nitrogen and total phosphorus as compared with values observed in June and July (Appendix 22). The heavy rainfall within the watershed over the summer may have contributed to an increase in nonpoint source nutrient loading and turbidity which resulted in the increase in the reservoir's trophic status. Concentrations of metals in the surface waters were within water quality standards with the exception for iron concentrations in August which was 50 percent greater than the action level of 1,000 µg/L.

CAPE FEAR RIVER SUBBASIN 11

Description

This subbasin is located in Lee and Chatham counties in the Triassic Basins (Griffith *et al*. 2002) (Figure 59). The watersheds contain the lowermost reaches of the Deep and Haw Rivers prior to their confluence to form the Cape Fear River. Tributary streams to the Deep River include the slow moving and turbid Little Pocket, Cedar, Georges and Big Buffalo Creeks. The geology and poor groundwater recharge capacity of these streams result in $7Q_{10}$ values of zero for all but the largest catchments.

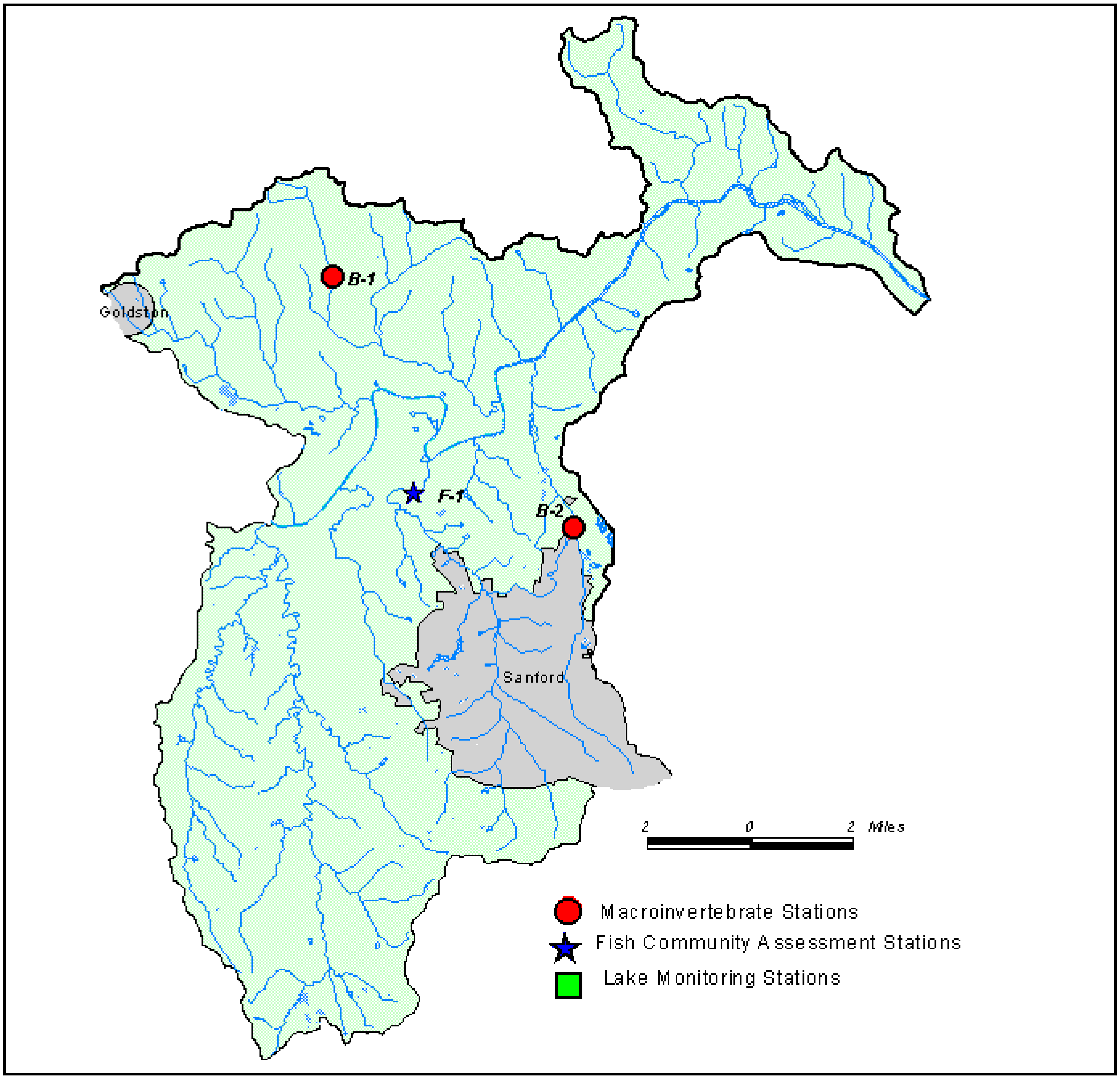


Figure 59. Sampling sites in Subbasin 11 in the Cape Fear River basin. Monitoring sites are listed in Table 32.

More than 80 percent of the land use within this subbasin is forest (Table 31). There are seven NPDES permitted dischargers in the subbasin with two of these facilities having a permitted flow greater than 0.5 MGD:

- Gold Kist, Inc.'s Cumnock facility's discharging 1 MGD into the Deep River; and
- the City of Sanford's WWTP discharging 6.8 MGD into the Deep River.

Table 31. Land use in Subbasin 11. Based upon CGIA coverage 1993 - 1995 (total area = 133 square miles (NCDENR 2000).

Land use	Percent
Water	1
Cultivated crop	1
Pasture	10
Urban	3
Forest	84

Overview of Water Quality

The benthic macroinvertebrate sites at Georges and Little Buffalo Creeks cannot currently be rated (Table 32) because criteria for evaluating Triassic Basin streams have not been developed. The fish community rating at Buffalo Creek slightly improved from Poor to Fair but the number of fish collected at this site has progressively declined since 1993.

Of the four ambient water chemistry locations on the Deep River in this subbasin, only the site at US 15/501 showed any statistically significant water chemistry measurements outside of acceptable limits. More than 22 percent of the dissolved oxygen readings at this site were less than 5 mg/L.

Table 32. Waterbodies monitored in Subbasin 11 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Georges Cr	Chatham	SR 2142	Not Rated	Not Rated
B-2	L Buffalo Cr	Lee	SR 1420	Not Rated	Not Rated
F-1	Big Buffalo Cr	Lee	SR 1403	Poor	Fair

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites.

River and Stream Assessment

The Deep River at SR 1007 and US 15/501 were not sampled for benthic macroinvertebrates in 2003 due to high flows during the sampling period. Habitat characteristics and examples of high quality and low quality habitats at fish community sites in the basin are presented in Appendix 2.

Big Buffalo Creek, SR 1403

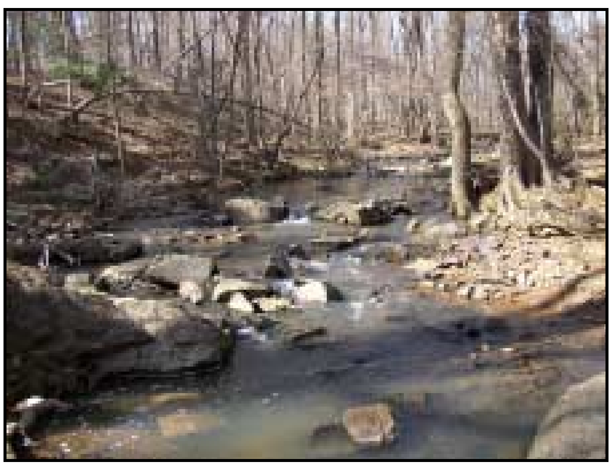
The watershed of Buffalo Creek includes the urban area of the City of Sanford and surrounding central Lee County. There is one small NPDES discharger (0.003 MGD) on Purgatory Branch upstream of the monitoring site.

Big Buffalo Creek at SR 1403, Lee County.

This site has been monitored during every basinwide cycle and has varied between Good-Fair in 1994, Poor in 1998, and Fair in 2003 (NCIBI = 42, 26, and 36, respectively). The community has a low diversity of species including darters and suckers, few fish, and a low percentage of species with multiple age groups. The number of fish collected at this site has progressively declined from 125 in 1993 to 110 in 1998 to 76 in 2003. The number of species collected has varied between 13 and 15. The dominant species have been the redbreast sunfish and bluegill.

Georges Creek, SR 2142
This stream is on the border of the Triassic Basin and the Carolina Slate Belt. Downstream of SR 2142, the stream is channelized, entrenched, and the substrate is sand and clay. During winter sampling there was little flow and the water was turbid. These are typical characteristics of a Triassic Basin stream.

However, above SR 2142, the mixed substrate of rocks and sand is typical for streams in this area. Instream habitat was good, with well-defined riffles. The banks were sloping and eroded, but the riparian zone was intact with numerous large trees. The habitat score was 87.



Georges Creek at SR 2142, Chatham County.

This site has been sampled for benthic macroinvertebrates three times. All collections were Not Rated. In 1998, a low flow year, only four EPT S were collected. In 2003, 17 EPT S were found. This suggested that the stream may stop flowing in the summer.

Little Buffalo Creek, SR 1420
This Triassic Basin stream is five meters wide with a soft sand and clay substrate. The banks were steep and undercut, with sand bars along the margins. Instream habitat was limited to woody debris and rootmats. The habitat score was 44.

Little Buffalo Creek at SR 1420, Lee County.

EPT samples have documented five taxa in 1993 and three taxa in 2003. Both collections were Not Rated because criteria for evaluating Triassic Basins streams have not been developed. It is suggested that Georges Creek and Little Buffalo should not be included in basinwide sampling until rating criteria have been developed.

SPECIAL STUDY
A UT Cape Fear River site was sampled below the City of Sanford's WWTP in 2003 to determine affects of alum sludge on the macroinvertebrate community (Biological Assessment Unit Memorandum B-030411). The stream was Not Rated because criteria for Triassic Basins streams have not been developed.

CAPE FEAR RIVER SUBBASIN 12

Description

This subbasin is almost entirely in Chatham County and is entirely within the Carolina Slate Belt (Griffith *et al*. 2002). It includes the entire Rocky River watershed from its source to its confluence with the Deep River. Major tributaries include Loves, Tick, and Bear Creeks (Figure 60).

The Rocky River is a large tributary of the Deep River and is approximately 35 river miles long. Typical streams in this ecoregion have very rocky substrates (Figure 61). Many of the small tributary streams are prone to extremely low flow conditions during the summer due to low base flows and may often dry up completely during prolonged low flow periods.

Figure 61. Tick Creek at US 421, Chatham County -- a typical stream in the Carolina Slate Belt in Subbasin 12.

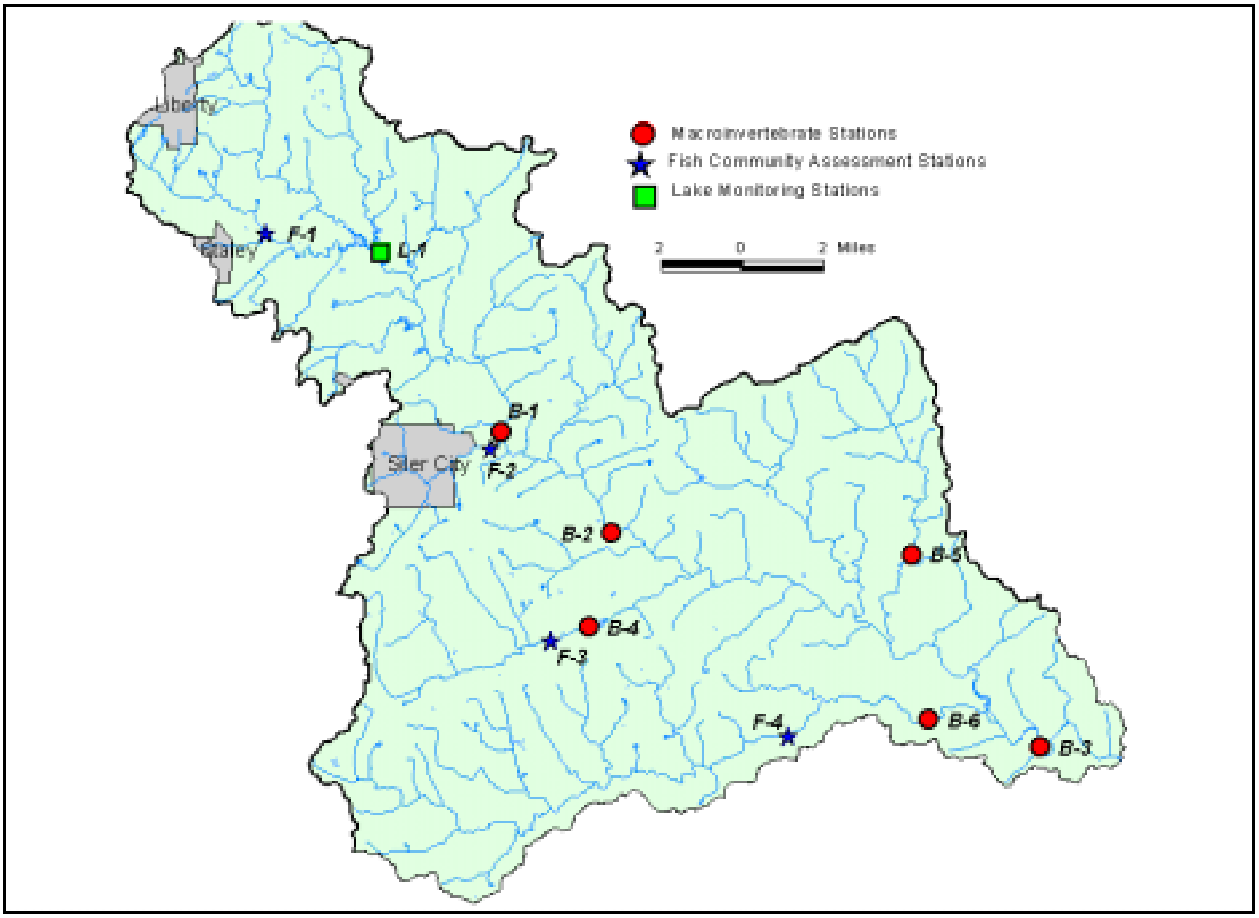


Figure 60. Sampling sites in Subbasin 12 in the Cape Fear River basin. Monitoring sites are listed in Table 34.

Land use within this subbasin is primarily forest with pasture making up the largest of the other landuse types (Table 33). There are four NPDES permitted dischargers in the subbasin with only the Town of Siler City's WWTP (4 MGD into Loves Creek) having a permitted flow greater than 0.5 MGD.

Table 33. Land use in Subbasin 12. Based upon CGIA coverage 1993 - 1995 (total area = 244 square miles (NCDENR 2000).

Land use	Percent
Water	1
Cultivated crop	3
Pasture	27
Urban	1
Forest	69

Overview of Water Quality

Six benthos and four fish samples were collected from this subbasin during 2003 basinwide surveys (Table 34). There are no NPDES permitted facilities in the watersheds of the Rocky River, Loves, or Tick Creeks where fish community assessment were performed. The Rocky River at SR 2170 retained its Good-Fair benthos rating from 1998, while a site at US 15/501 remained Good. The remaining fish and benthos sites either declined a classification or were not rated, both situations arising due to extremes in flows. Declines from Good to Good-Fair in Harlands Creek (benthos), Loves Creek (benthos and fish), and Bear Creek (fish) were likely due to delayed recovery from the 2002 drought, despite higher flows prior to sampling. The fish community in Tick Creek was sampled for the first time since 1994. The Fair rating also suggested impacts from the 2002 drought. Benthos data from Tick Creek resulted in a Good-Fair rating, as was found in 1998.

High flows prior to 2003 benthic sampling, on the other hand, resulted in marginal collections from the Rocky River at US 64 and Bear Creek, and accounted for their Not Rated status. Drought conditions followed by excessive flows (Hurricane Floyd) also occurred in 1999, confounding a fish community special study on Bear Creek. Despite extremes in flows, the study ultimately determined that seasonality was not an important factor in using NCIBI to assess the fish community in a stream.

There is one NPDES permitted facility in this subbasin. Siler City's WWTP discharges into Loves Creek 0.5 miles above its confluence with the Rocky River. Though a TMDL stressor study suggested that some impairment of Loves Creek could be attributed to the facility, the primary sources of impairment lay upstream of the WWTP. There were no instances where the facility's whole effluent toxicity tests failed to meet a permit limit or target value in 2003.

The Rocky River Reservoir, a water supply reservoir for Siler City, is an impoundment of the Rocky River high in its watershed. Monitoring results in 2003 characterized the reservoir as hypereutrophic, indicating significant nonpoint source runoff from agriculture. The further decline in water quality since its 1999 eutrophic classification likely resulted from the delivery of nutrients and sediment to the reservoir *via* heavy rainfall in 2003. Water clarity was consistently poor throughout 2003, and water quality standards were exceeded for concentrations of dissolved oxygen (routinely), chlorophyll *a* (in August), and iron (slightly above the action level). During a special study in 2002, nutrients and conductivity values were found to be elevated upstream of the reservoir in the Rocky River and the North Prong Rocky River as well.

There are three ambient monitoring sites in this subbasin, all of which are on the Rocky River. One is a DWQ monitoring site at NC 902 near Pittsboro; the other two are coalition monitoring sites at US 64 and SR 2170. Data for all sites were within prescribed water quality standards for nitrogen, turbidity, dissolved oxygen, pH, fecal coliform bacteria, and chlorophyll *a*.

Table 34. Waterbodies monitored in Subbasin 12 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Rocky R	Chatham	US 64	Good-Fair	Not Rated
B-2	Rocky R	Chatham	SR 2170	Good-Fair	Good-Fair
B-3	Rocky R	Chatham	US 15/501	Good	Good
B-4	Tick Cr	Chatham	SR 2120	Good-Fair	Good-Fair
B-5	Harlands Cr	Chatham	NC 902	Good	Good-Fair
B-6	Bear Cr	Chatham	SR 2155	Not Rated	Not Rated
F-1	Rocky R	Chatham	SR 1300	Good-Fair	Good-Fair
F-2	Loves Cr	Chatham	SR 2229	Good	Good-Fair
F-3	Tick Cr	Chatham	US 421	---	Fair
F-4	Bear Cr	Chatham	SR 2187	Good	Good-Fair
L-1	Rocky River Res	Chatham			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake monitoring site.

River and Stream Assessment

Habitat characteristics and examples of high quality and low quality habitats at fish community sites in the basin are presented in Appendix 2.

Rocky River, SR 1300

The headwaters of the Rocky River begin in the Town of Liberty and continue in a southeasterly fashion draining eastern Randolph and northwestern Chatham counties. Although situated in the Carolina Slate Belt where many streams have a typical cobble substrate (Figure 61), the stream bottom at this site also includes a lot of sand.

The Rocky River at SR 1300, Chatham County.

The fish community was rated Good-Fair in 1998 and 2003. The 2002 drought seemed to have had a certain degree of impact on this small stream (7.4 square mile watershed). As seen at other streams affected by the drought, the number of fish, the percentage of species with multiple ages, and the dominance of bluehead chub all decreased between 1998 and 2003.

Rocky River, US 64

The river at this benthic macroinvertebrate site was eight meters wide with a drainage area of 69.6 square miles. Though commercial sprawl from Siler City was apparent in the distance, land adjacent to the sampling reach was mainly forest, with road frontage and sparse areas of residential and active pasture also present. Banks were somewhat eroded, the canopy allowed for partial shading, and riparian areas were fragmented but extensive. Instream habitat was marginal, with only rocks in abundance. Riffles were relatively frequent, moderately embedded, and pools were infrequent. The water was turbid and heavy *Periphyton* was present on the rocks. The habitat received a score of 76.

Upstream view of Rocky River at US 64, Chatham County.

Prior to 1997, this site was rated only as Fair. An improvement to Good-Fair during 1997 and 1998 was attributed to water releases from the Rocky River Reservoir, just upstream of the US 64 bridge. Minimum flows allowed for more permanent below the dam.

However, results from a 2002 drought impact study indicated that Slate Belt streams were slowest to recover from the drought. This site was Not Rated in 2003, as low flows during the collection period resulted in a marginal sample. EPT S (15) continued to indicate drought impacts. Perhaps recovery (recolonization) at US 64 *via* downstream drift was prevented by the reservoir. The dominance of more tolerant filter feeders such as *Rheotanytarsus*, *Simulium*, *Corbicula fluminea* (not collected at this site before 2003), and *Sphaerium* (an organic indicator) likely accounted for the 2003 increase in BI (from 5.9 in 1998 to 6.5).

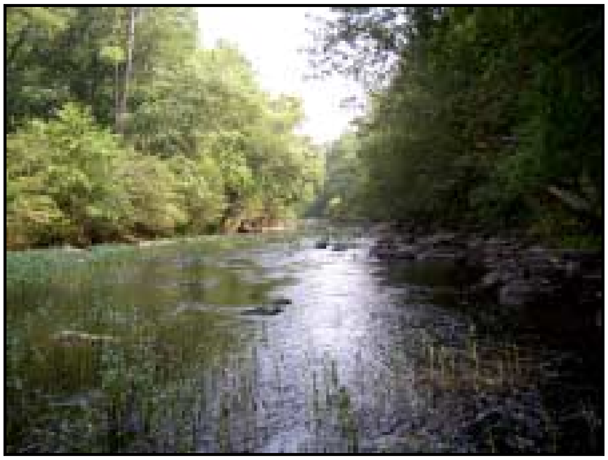
Rocky River, SR 2170
This site is located three miles below its confluence with Loves Creek. Data from this site and the US 64 site (upstream of Loves Creek) are used to assess impacts from Siler City's WWTP.

The stream width of the river at this site was 17 meters. The drainage area was 94.7 square miles and included mostly forested land, some residential, and some agricultural land. Cattle pens and outbuildings were adjacent to the site, but no cattle were observed in the stream or in adjacent pastures at the time of sampling. Banks were eroded but heavily vegetated, riparian areas were intact and broad, and the extensive canopy allowed for minimal sunlight beyond the open area at the bridge. Instream habitat was relatively abundant, with frequent and slightly embedded boulder, rubble, and gravel riffles. Pools were uncommon, but a variety of sizes. The stream appeared enriched at this site, as there was an abundance of periphyton, filamentous algae, and water willow in the open canopy areas near the bridge. The habitat score was 78.

Downstream view of the Rocky River at SR 2170, Chatham County.

This site was also sampled as a part the 2002 drought impact study. An EPT sample collected in September 2002 was rated Fair based upon an EPT BI of 4.87 and EPT S of 8. The fauna had clearly been impacted by the drought. In 2003, some recovery was noted as the site was once again rated Good-Fair; a rating it had received in 1993, 1999, and 1998. Consistent flow during the drought was likely provided by the discharge. No enrichment indicator species were collected in 2003 despite the enriched appearance.

Rocky River, US 15/501
The river at this site was approximately 25 meters wide with a drainage area of 237 square miles. It appeared as a rocky shallow run. Unembedded boulder and cobble riffles made up the majority of the reach. Pools were infrequent and found mostly at the downstream end of the reach. Adjacent land use was mostly forest. Riparian areas were extensive though fragmented and banks were stable and well vegetated. Instream habitat was dominated by rocks and macrophytes. In addition to water willow, periphyton and *Podostemum* also flourished in the open sunlight. The habitat score was 73.



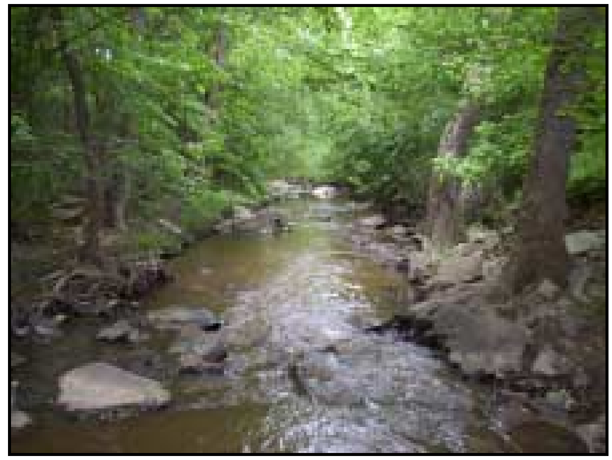
Downstream view of the Rocky River at US 15/501, Chatham County.

Upstream view of water willow coverage of the Rocky River at US 15/501, Chatham County.

The site was rated Good in 2003 based upon a 5.6 and EPT S of 28. It has been rated Good since 1990. Though the abundance of macrophytes and periphyton gave the appearance of enrichment, no organic indicator species were collected.

Loves Creek, SR 2229

The watershed of Loves Creek includes most of the urban area of Siler City in western Chatham County. The Siler City's WWTP discharges into Loves Creek just below the monitoring site.



Loves Creek at SR 2229, Chatham County.

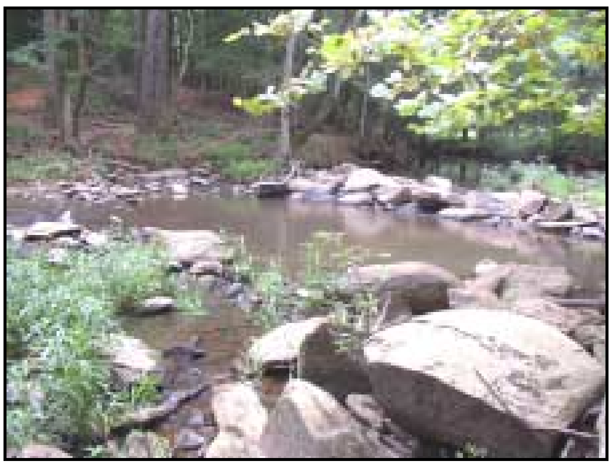
The fish community was rated Good in 1998 and Good-Fair in 2003. The redbreast sunfish continued to be the dominant species. Despite the loss of a species of sucker and darter, the community continued to be diverse and abundant.

Tick Creek, US 421

The watershed of Tick Creek drains a small portion of western Chatham County. Like other sites in the Carolina Slate Belt, the fish community in Tick Creek seemed to still be recovering from the 2002 drought. In 1994 the community was rated Excellent (NCIBI = 56) but only Fair (NCIBI = 38) in 2003; the stream was not sampled in 1998. As seen at other sites, the drought seemed to have decreased the abundance of bluehead chubs and increased the abundance of highfin shiners. This shifted the trophic metrics and along with the loss of several key species such as darters and suckers, a decrease in the total number of fish, and a loss of an intolerant species, contributed to the decline in the NCIB score and rating.

Tick Creek at US 421, Chatham County.

Tick Creek, SR 2120
The creek at this site had a variable width of eight meters and a drainage area of 17 square miles. Adjacent land use was mainly forest, with roughly equally parts pasture, fallow fields, and (slightly less) rural residences. Riparian zones were heavily fragmented and cattle had unrestricted access to the stream for the majority of the sampling reach. The hardwood canopy provided ample shading, but the forest understory was decimated by grazing and hoof traffic, leaving bare dirt and severely eroded banks. The stream was a series of boulder riffles and deep rocky pools, with moderate embeddedness in frequent (though short) riffles. Instream habitat included macrophytes, woody debris, undercut banks, root mats, and leaves. The overall habitat was scored a 69.



Downstream view of Tick Creek at SR 2120, Chatham County.

Close-up view of dirt cattle trails on the left bank of Tick Creek at SR 2120, Chatham County.

The benthic fauna was rated Good-Fair in 2003, as it was in 1998, and suggested no overall change in water quality. The Full Scale sampling method was used in 2003 while in 1998 the EPT method was used. Despite the more rigorous sampling, the two collections had identical EPT BI (5.93) and EPT N (75). However, EPT S was greater in 2003 than in 1998 (20 and 15, respectively). The collection of *Eccoptura xanthenes* and *Perlesta* (both Rare) in 2003 but absent in 1998 was the only noticeable difference in the community.

Harlands Creek, NC 902
This small five meter wide stream was mostly forested for the majority of its 16 square mile drainage. Riparian areas were intact and extensive along the sampling reach, and banks were moderately eroded. The majority of the sampling reach was slightly embedded cobble and boulder riffles. A wider, sandy run was upstream and the water pooled into more of a slow moving run below the reach. Rocks were abundant, though some root mats and woody debris also contributed areas for benthos colonization. The habitat was scored an 82.

Harlands Creek at NC 902, Chatham County.

This site was rated Good-Fair in 1990, February 1998, and 2003. Only a July 1998 sample was rated Good. The BI ranged from 3.85 to 4.97 (1990 and 2003, respectively). EPT S has ranged from 15 in 1990 to 23 in 1998. The loss of *Acroneuria* and leptocerid caddisflies in 2003 may be due to the slow recovery and recolonization of this small stream from the 2002 drought.

Bear Creek, SR 2187
The watershed of Bear Creek is south and east of the Tick Creek watershed. There are three small, domestic NPDES permitted dischargers in the watershed upstream of the monitoring sites with a combined flow of 0.02 MGD. The closest one is approximately 3.6 miles above the site. This site is part of the NC Natural Heritage Program's Bear Creek Natural Area (Hall and Boyer 1992).

Bear Creek at SR 2187, Chatham County.

Like other sites in the Carolina Slate Belt, the fish community in Bear Creek was impacted by the 2002 drought and then by extremely high flows. In 1998 the community was rated Good (NCIBI = 50) but only Good-Fair (NCIBI = 44) in 2003. The extremes in flows decreased the diversity of fish, the total abundance of fish, and the percentage of species with multiple age groups. The percentage of tolerant fish also increased between 1998 and 2003. These declines were based upon a very small sample size -- only 61 fish were collected in 2003, the second fewest fish of any site in the Piedmont portion of the basin (Appendix 9). In 1998 the ratings were based upon a sample size of almost 400 fish.

Bear Creek, SR 2155
This stream was sampled in March 2003 due to the documented lack of flow during the summer. Land use in this 50.3 square mile watershed was mostly forest with some rural residences. The stream was 10 meters wide at this site; flow was high and slightly turbid. Cobble riffles were frequent and extensive with moderately high embeddedness; pools were infrequent. Erosion areas were present, but the banks were well vegetated, riparian areas were intact and extensive, and the canopy provided good shading. The habitat was scored an 85.

Bear Creek at SR 2155, Chatham County.

The creek was considered Not Rated in 1990 and 1999 due to low flows. The site was again considered Not Rated in 2003, although it would have been assigned an "unimpaired" status if high flows had not resulted in a marginal sample. EPT S and EPT BI were similar between 1990 and 2003 and suggested little change in water quality over time.

Because low flows have consistently impeded collection of a proper sample and therefore made the site difficult to rate, Bear Creek at SR 2155 should be declined as a long-term basinwide site.

SPECIAL STUDIES
Fish Community Temporal Variability
The fish community in Bear Creek at SR 2187, Chatham County was sampled in April, June, and October 1999 to determine the temporal variability of the NCIBI during NC DWQ's traditional monitoring period. The community which was rated Good in April 1998 was Good-Fair in April and Fair in October. The decline in October followed another prolonged summer drought and then extremely high flows from Hurricane Floyd. It was determined that seasonality at sites not impacted by prolonged extremes in flows was not an important factor to consider when using the NCIBI to assess the fish community of a stream (Biological Assessment Unit Memorandum F-000922).

Loves Creek TMDL Stressor Study
Loves Creek was surveyed in 2003 to update its status on the 303(d) list. A 2.8 mile segment of

the stream above Siler City's WWTP was rated Partially Supporting and the 0.5-mile segment below the WWTP was Not Supporting based on the 1997 Poor benthic rating.

In 2003 with all sites resulting in Not Rated or Fair bioclassifications, the stream was not removed from the 303(d) list. Conditions above the WWTP suggested that the facility was not the primary cause of impairment. The discharge and sedimentation added to the stress the stream already experienced, but impacted water quality already existed upstream of the discharge.

Loves Creek suffers from the effects of urban runoff, hydromodification from impervious surfaces associated with development, and agricultural inputs. The combined effects are chemical and/or physical pollutants in the stream, habitat degradation, sedimentation, loss of bank root mass, channel erosion, and enrichment. Until actions are taken to reduce urban stormwater runoff, it is reasonable to assume that the water quality of Loves Creek will remain Fair or will decline further (Biological Assessment Unit Memorandum B-031118).

Lake Assessment

Rocky River Reservoir

This reservoir, an impoundment of the Rocky River, serves as a water supply for Siler City (Figure 62). The impoundment was expanded in 1988 to raise the existing storage capacity from 60 million gallons to 424 million gallons. The expansion raised the water level by approximately 10 feet. The watershed is primarily agricultural with some pasture immediately adjacent to the lake. This reservoir has been sampled five times prior to 2003 by DWQ.

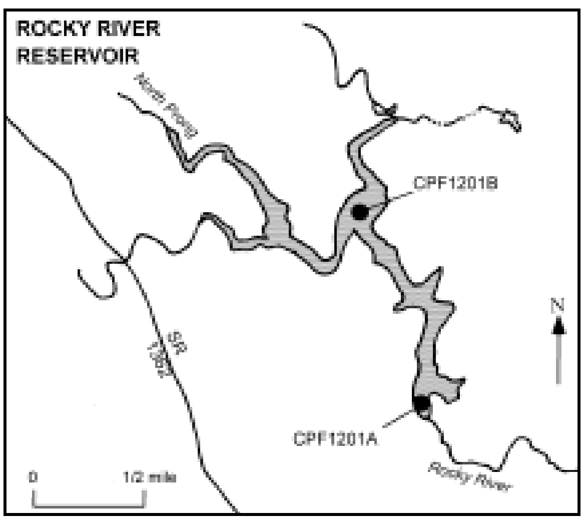


Figure 62. Sampling sites at Rocky River Reservoir, Chatham County.

The reservoir was most recently sampled in 2003. This reservoir demonstrated excessive nutrient enrichment and very high levels of biological productivity. Frequent rainfall events during the summer may have increased the amount of nonpoint source runoff from the rural watershed to the reservoir and increased the nutrient loading. Cattle and horses have direct access to the upper end of this reservoir. Pastureland for these animals slopes downhill to the water's edge (Figure 63). This provides one source of nonpoint nutrient contributions to the reservoir.

Figure 63. Rocky River Reservoir, Chatham County.

Secchi depths were consistently less than one meter, indicating poor water clarity (Appendix 22). Poor water clarity was also documented in 1998. In August, a chlorophyll *a* concentration of 54 µg/L was observed at Station CPF1201B, which was greater than the water quality standard of 40 µg/L. Other chlorophyll *a* concentrations, while not greater than the water quality standard, were elevated. Algal blooms of diatoms or green algae were found in June and July. Algal densities lower than those found in early summer were found in August and consisted of cryptomonads.

Total phosphorus concentrations ranged from 0.15 to 0.20 mg/L. Throughout the lake in 2003, surface percent dissolved oxygen (~ 115 – 150 percent) was routinely greater than the water quality standard. Concentrations of metals in the surface waters were within water quality standards with the exception for iron concentrations which were slightly greater than the action level of 1,000 µg/L. Recent rainfall within the watershed may have contributed to an increase of iron-rich sediment entering the reservoir and becoming suspended within the water column.

Based on the calculated NCTSI scores for 2003, the reservoir was classified as hypereutrophic; a classification it had received in earlier years.

In 2002 a Special Study was conducted to determine the sources of the largest nutrient. Elevated nutrients and conductivity values were observed at the Rocky River at SR 1300 and at the North Prong Rocky River at SR 1358 above Rocky River Reservoir.

CAPE FEAR RIVER SUBBASIN 13

Description

This subbasin includes the entire Upper Little River watershed from its source to the confluence with the Cape Fear River; major tributaries include Juniper and Barbeque Creeks (Figure 64). The headwaters of the Upper Little River lie in the Triassic Basins ecoregion (Griffith *et al*. 2002) in Lee County southwest of the City of Sanford. The river flows east into the Northern Outer Piedmont ecoregion where it is joined by Juniper Creek. The river turns southeast near the Harnett County border, and is eventually joined by Barbeque Creek, where it enters the Rolling Coastal Plain ecoregion. Just before entering the Cape Fear River, the Upper Little River enters the Southeastern Floodplains and Low Terraces ecoregion.

The City of Sanford is the only urban area in the subbasin. The towns of Lillington and Erwin lie just outside the subbasin. Almost two-thirds of the subbasin is forested (Table 35). There is one NPDES permitted discharger in this subbasin. Carolina Trace Utilities discharges 0.3 MGD into the Upper Little River.

Table 35. Land use in Subbasin 13. Based upon CGIA coverage 1993 - 1995, total area = 221 square miles (NCDENR 1999).

Land use	Percent
Water	2
Cultivated crop	23
Pasture	8
Urban	1
Forest	65

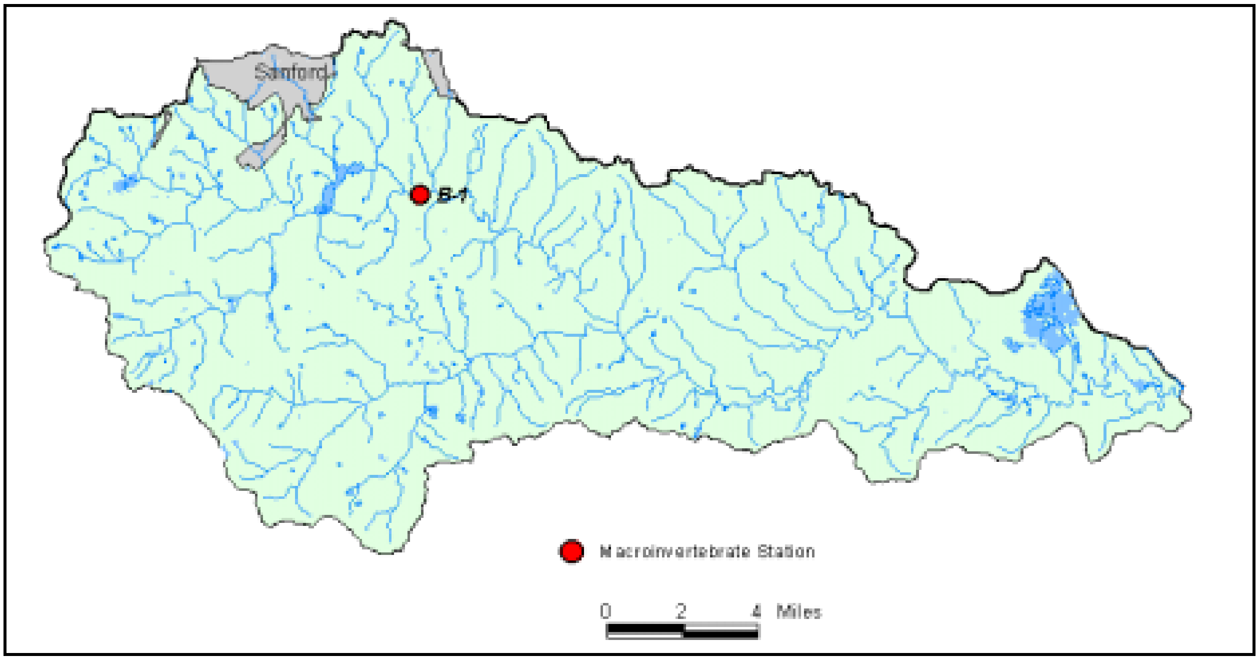


Figure 64. Sampling sites in Subbasin 13 in the Cape Fear River basin. Monitoring sites are listed in Table 36.

Overview of Water Quality

No fish community or lake assessments were performed in this subbasin in 2003. High flows allowed only one benthos site to be sampled in 2003 (Table 36). The Upper Little River retained the Good-Fair rating it received in 1998. Though the rating did not change, impacts to the community were suggested by an increase in the EPT BI.

Ambient water quality data were collected from the Upper Little River near Lillington. Data were within water quality standards for nitrate+nitrite nitrogen, dissolved oxygen, most metals, fecal coliform bacteria, and chlorophyll *a*. However, violations of water quality standards were recorded for turbidity, pH, and manganese.

Table 36. Waterbodies monitored in Subbasin 13 in the Cape Fear River basin for basinwide assessment, 1998 - 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Upper Little R	Harnett	SR 1222	Good-Fair	Good-Fair

[1]B = benthic macroinvertebrate monitoring site.

River and Stream Assessment

Due to high summer flows (Appendix 1), the Upper Little River at NC 27 and Barbecue Swamp were not sampled. These two sites should be sampled during basinwide monitoring in 2008.

Upper Little River, SR 1222

This site was located downstream of Lake Trace. The river's 54 square mile watershed encompasses forest and agricultural land uses with primarily forest and small fallow fields immediately adjacent to the site. The river was 12 meters wide and the water was clear but tannin stained. The riparian zone was intact and extensive on the left bank, while the right bank was fairly wide but fragmented. The canopy provided adequate shading, but banks were sparsely vegetated, allowing moderate erosion. Substrate was mostly sand, but some rubble and gravel were also present. Instream habitats were woody debris, leaves, undercut banks, and root mats. Pools, though infrequent, were a variety of sizes. The habitat score was 70.

Upper Little River at SR 1222, Harnett County.

The site was rated Good-Fair; a rating it has held since 1988. However, the EPT BI was at an all time high in 2003 (Figure 65). 2003 EPT S declined to mid-range when compared to the other years (17 *vs*. 21 in 1998, 13 in 1993, and 19 in 1988). Though no real changes in water quality were indicated, if the EPT BI trend continues, the site will likely decline in rating.

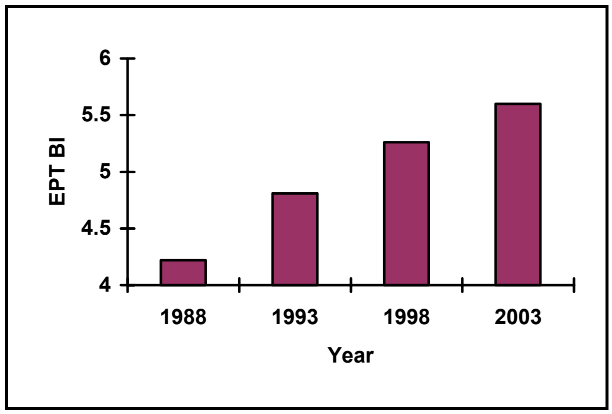


Figure 65. EPT Biotic Index (EPT BI) at the Upper Little River at SR 1222, Harnett County, 1988 – 2003.

CAPE FEAR RIVER SUBBASIN 14

Description

This subbasin encompasses the entire Lower Little River watershed (Figure 66). Major tributaries include Nicks, Crane, Buffalo, and Anderson Creeks and Jumping Run. This subbasin is almost entirely within the Sand Hills ecoregion (Griffith *et al.* 2002) (Figure 1). The lowermost reaches of the Little River are within the Southeastern Floodplains and Low Terraces. The (Lower) Little River is classified as High Quality Waters from its source to Crane Creek.

Almost 80 percent of the subbasin is forested and less than three percent of the area is urban (Table 37). The urban areas include the Towns of Southern Pines, Pinehurst, and Spring Lake. There are 10 NPDES permitted dischargers in the subbasin with three of these facilities having a permitted flow greater than 0.5 MGD:

- Heater Utilities Inc.'s Woodlake Country Club WWTP discharging 1 MGD into Crane Creek;
- the Town of Spring Lake's WWTP discharging 1.5 MGD into the Lower Little River; and
- the US Army's Fort Bragg WWTP and WTP discharging 8 MGD into the Lower Little River.

Table 37. Land use in Subbasin 14. Based upon CGIA coverage 1993 - 1995 (total area = 484 square miles (NCDENR 2000).

Land use	Percent
Water	2
Cultivated crop	8
Pasture	8
Urban	2
Forest	79

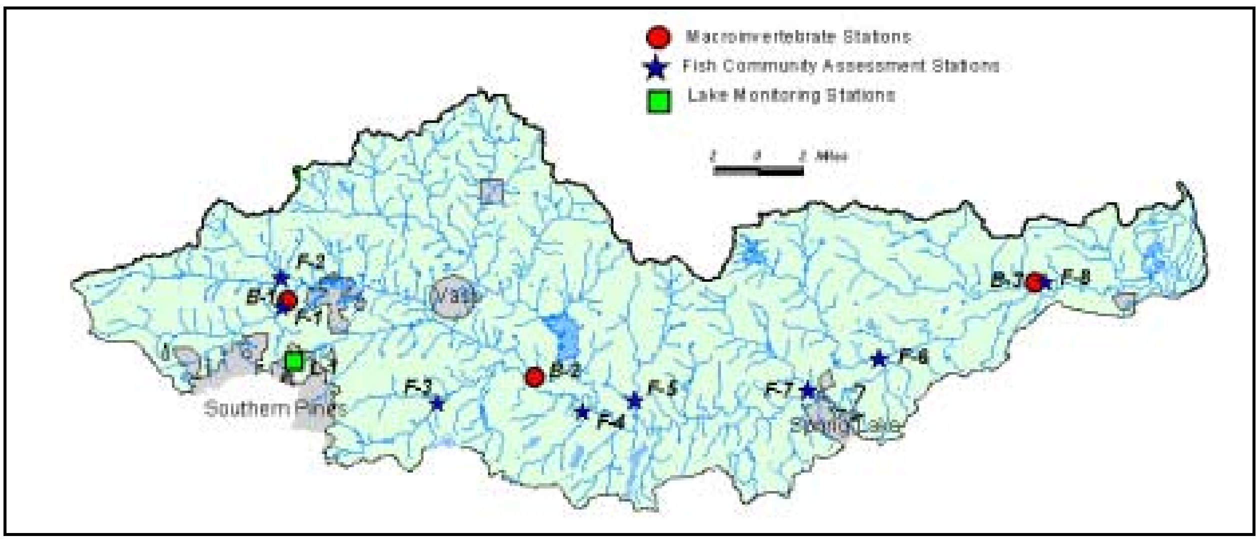


Figure 66. Sampling sites in Subbasin 14 in the Cape Fear River basin. Monitoring sites are listed in Table 38.

Overview of Water Quality

Three benthos and eight fish community assessment sites were surveyed in this subbasin in 2003 (Table 38). High summer flows prevented collection from the three remaining established benthos sites. One benthos site showed improvement over the 1998 survey -- Anderson Creek was rated Good, an improvement from Good-Fair. The remaining two benthos collections declined from the 1998 survey. Nicks Creek declined from Good to Good-Fair and the Lower Little River was rated Good-Fair, compared to its previous Excellent rating. Both declines may be attributed to the 2002 drought conditions.

A special study on Little Crane Creek concluded that the stream was not impaired. Mill Creek was also sampled for benthos during a special study, resulting in an Excellent rating and a candidate for potential reclassification to ORW.

There are no NPDES permitted facilities in the watersheds of the Little River, Nicks, James, Flat, Buffalo, and Anderson Creeks or Muddy Run where fish community assessment were performed. Six of the eight streams sampled for fish community assessments were sampled for the first time in 2003. However, criteria have not been developed for rating these Sand Hill streams, so all of them are classified as Not Rated.

Fort Brag's WTP and WWTP discharges 8.0 MGD into the Little River and the Town of Spring Lake's WWTP discharges 1.5 MGD into the Lower Little River. Both facilities remained within compliance for whole effluent toxicity testing requirements for 2003.

Only one lake was monitored in this subbasin in 2003. Old Town Reservoir is an impoundment of Mill Creek and is mainly used for recreation. Water clarity was considered good and concentrations of chlorophyll *a*, metals, and nutrients were within water quality standards throughout 2003. The reservoir was considered mesotrophic in June and July and eutrophic in August.

Three ambient monitoring sites are located on the Lower Little River in this subbasin: at Lobelia, at Manchester, and at Spring Lake. Water quality standards were met at all three stations for nitrate+nitrite nitrogen, turbidity, dissolved oxygen, metals, fecal coliform bacteria and chlorophyll *a*. However, all three sites reported pH values that statistically exceeded water quality standards.

Table 38. Waterbodies monitored in Subbasin 14 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Nicks Cr	Moore	NC 22	Good	Good-Fair
B-2	Lower Little R	Moore	SR 2023	Excellent	Good-Fair[2]
B-3	Anderson Cr	Harnett	SR 2031	Good-Fair	Good
F-1	Nicks Cr	Moore	NC 22	Not Rated[3]	Not Rated
F-2	Little R	Moore	NC 22	---	Not Rated
F-3	James Cr	Moore	off SR 2026	---	Not Rated
F-4	Flat Cr	Hoke	Manchester Road	---	Not Rated
F-5	Buffalo Cr	Moore	SR 1001	Not Rated	Not Rated
F-6	Jumping Run	Cumberland	NC 210	---	Not Rated
F-7	Muddy Cr	Cumberland	SR 1001	---	Not Rated
F-8	Anderson Cr	Harnett	SR 2031	Not Rated	Not Rated
L-1	Old Town Reservoir	Moore			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake monitoring sites.
[2] sampled in January 2003 as part of a drought-recovery study.
[3]sampled in 1996.

River and Stream Assessment

Due to high summer flows (Appendix 1), only three of the six proposed benthic macroinvertebrate sites could be sampled. The Lower Little River at NC 87/24 and at US 401 and Jumping Run at SR 2031 were not sampled in 2003, but should be sampled during the next round of basinwide monitoring in 2008.

Eight streams were sampled in this subbasin for fish community assessments. Six of these, the Little River, Jumping Run, and James, Flat, and Muddy Creeks, were sampled for the first time for fish community assessments in 2003. However, criteria have not been developed to assign ratings to these communities and all of them are classified as "Not Rated". Many of the streams had high quality instream and riparian habitats (Appendix 2). Based upon the instream, riparian, and watershed characteristics, sites on James, Flat, and Muddy Creeks were qualified as new regional reference sites. General characteristics of Sand Hills streams and their fish fauna are discussed in Appendix 8.

Little River, NC 22
The watershed of the Little River drains central Moore County. The river bordered a golf course

which had narrowed the riparian zone along side the right bank.

Little River, NC 22, Moore County.

The Little River was sampled for the first time for fish community assessment in 2003. Thirteen species were present and the dominant species were the bluegill and coastal shiner.

Nicks Creek, NC 22

The watershed of Nicks Creek is adjacent to and south of the Little River watershed; the creek is a tributary to the headwater area of the Little River. The 26.8 square mile watershed is primarily forested. The benthic macroinvertebrate site is above the culverts whereas the fish community site is below the culverts.

Nicks Creek at NC 22, Moore County.

During fish community sampling, woody debris lines, far back in the riparian zone and resulting from the extremely high flows of early June 2003 (refer to Cabin Creek, Subbasin 10), were evident. In 2003, only 36 fish were collected of which 11 were bluegill. Fifteen species were present in 2003. In all; 20 species have been documented from this site based upon 1996 and 2003 data.

At the upper portion of the benthic site was a broad open area that appeared to be a constructed lake or wetland area (Figure 67). A rip-rap and earthen dam retained an impoundment and wetland areas surrounded the vicinity. A rip-rapped still water channel ran from the dam outfall to Nicks Creek, suggesting that the stream likely received waters and sediment from the impoundment at some point. In the uppermost portion of the sampling reach, the stream took a 90 degree turn above the confluence with the constructed channel. Nicks Creek appeared channelized above that confluence, suggesting that it had been diverted around the impoundment area.

Figure 67. View from top of the dam of the "impoundment" near Nicks Creek at NC 22, Moore County.

Overall, the riparian zones were fragmented, but relatively broad. Banks were well-vegetated and somewhat eroded. Along the stream banks were berms and large quantities of overbank deposits (perhaps from dredging associated with or as a result of upstream impoundment activities) reached well into the floodplain (Figure 68).

Figure 68. Overbank deposits, Nicks Creek at NC 22, Moore County.

At the benthic site the stream was five meters wide and flow was high, giving the appearance of a large swift-moving run. Sand was the dominant substrate, although gravel and cobble were also present. Instream habitats were relatively plentiful. Pools were infrequent and the same size. Overall habitat was scored a 76.

The benthic community was rated Good each time it was sampled until 2003, when it declined to Good-Fair. The EPT BI has gradually increased and the EPT S has gradually declined since 1988 (Figure 69).

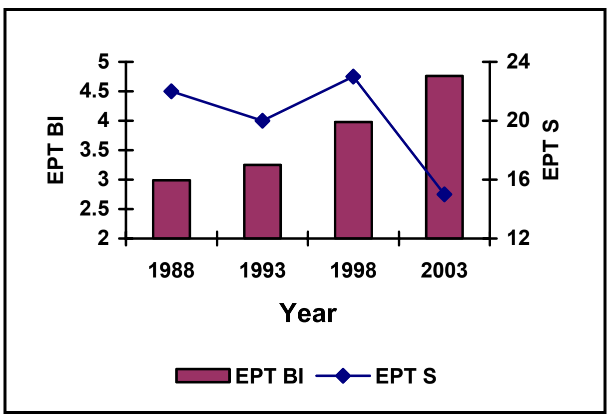


Figure 69. EPTBiotic Index (EPT BI) and EPT taxa richness (EPT S) at Nicks Creek at NC 22, Moore County, 1988 – 2003.

The loss of *Macrostemum* and *Acroneuria*, abundant in previous samplings, was noteworthy. Flooding in the area and resulting scour may partially explain deterioration of the benthic community in 2003. It was uncertain the degree to which the impoundment and its construction or maintenance activities affected the stream.

Lower Little River, SR 2023
The water level at this site was too high to permit sampling during the regular basinwide monitoring period. Results of a sample collected in January 2003 as part of a study on the impact of the 2002 drought was substituted for the basinwide sample.

The Lower Little River originates in Moore County northwest of Pinehurst in the Sand Hills ecoregion (Griffith *et al*. 2002) and flows east along the Hoke County line into Cumberland County. At SR 2023, the river's drainage area is 154 square mile, with mostly forest and some pasture land adjacent to the sampling reach. Riparian areas were intact and extensive, banks were stable, and instream habitat was abundant as woody debris, undercut banks, root mats, leaves, and macrophytes provided area for colonization for greater than 50 percent of the reach. Gravel was the dominant substrate. The river at the time of sampling was at high flow and appeared primarily as a run with few pools. The habitat score was 94.

Downstream view of the Lower Little River at SR 2023, Moore County, January 2003.

The benthic community still showed drought impacts in January 2003 (Figure 70). In October 2002, the community was rated Good-Fair; it was still Good-Fair in January 2003. Between 1988 and 1998, the stream had been rated Excellent. Other drought impacted streams took until summer 2003 or later to recover (DWQ unpublished data).

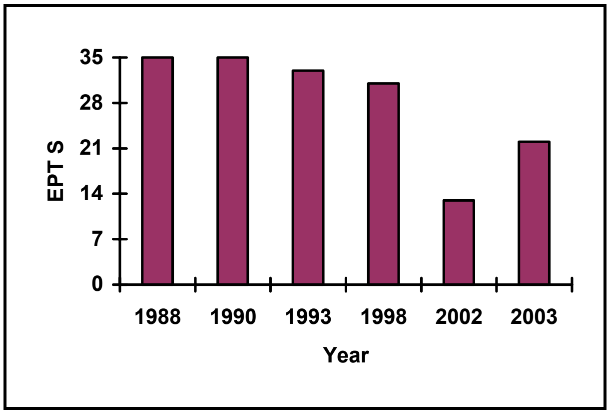


Figure 70. EPT taxa richness (EPT S) at the Lower Little River at SR 2023, Moore County, 1988 – 2003. Note: 1990, 2002, and 2003 data were based upon EPT samples.

James Creek, off SR 2026
The watershed of James Creek begins near the Weymouth Woods Sand Hills Nature Preserve and includes southeastern Moore and northwestern Hoke counties and Fort Bragg.

James Creek off SR 2026, Moore County.

In 2003, only 20 fish representing seven species were collected at this site; the dominant species was the dusky shiner.

Flat Creek, Manchester Road
The watershed of Flat Creek includes the property of Fort Bragg in northern Hoke County. The monitoring site was approximately 0.5 mile above the creek's confluence with the Little River. Above the concrete culverts which run under Manchester Road, the stream is a typical Sand Hills stream (Appendix 2). However below the culverts the stream has unique clay-sandstone type riffles and fast flowing chutes. This substrate and channel type were also found in sections of Jumping Run and Anderson Creek.

Flat Creek at Manchester Road, Hoke County.

Seventy-three fish representing 12 species were collected at this site; the dominant species was the margined madtom.

Buffalo Creek, SR 1001
Buffalo Creek is in the south-central corner of Moore County and also drains southwestern Harnett County. This site is part of the NC Natural Heritage Program' s Buffalo Creek Pipewort Natural Area (Carter and LeGrand 1989).

Buffalo Creek at SR 1001, Moore County.

The fish community was sampled in 1998 and 2003. Only eight species are known from this site; six were collected in 1998 and seven in 2003. In 1998 28 fish were collected; in 2003 only 14. This stream had the lowest diversity and abundance of any Sand Hills site in 2003.

Jumping Run, NC 210

The watershed of Jumping Run drains southern Harnett County and a small portion of northern Cumberland County. There is one NPDES permitted discharger (0.4 MGD) in the middle of the watershed. The monitoring site was approximately 0.4 mile above the stream's confluence with the Little River. This site had very fast flows and deep chutes.

Jumping Run at NC 210, Cumberland County.

Its fauna may have been influenced by the site's proximity to the Little River. Large specimens of spotted sucker, spotted bass, and flathead catfish were collected. The latter two species are exotic species that were introduced in the 1960s into the Little River and the upper reaches of the mainstem Cape Fear River. In 2003 spotted bass were found at Hector and Kenneth Creeks (Subbasin 07), Jumping Run, Muddy and Anderson Creeks, and Gum Log Canal (Subbasin 15).

Muddy Creek, SR 1001

The watershed of Muddy Creek drains southern Harnett County west of NC 24/87 and a small portion of northern Cumberland County. The monitoring site was approximately 0.7 mile above its confluence with the Little River. This site is part of the NC Natural Heritage Program' s Overhills Sand Hills Significant Natural Heritage Area (LeBlond and Sorrie 2002).

Muddy Creek at SR 1001, Cumberland County.

The pH (4.4 s.u.) was the lowest of any site in the Sand Hills in 2003 (Appendix 14). The dominant species was the redbreast sunfish and sawcheek darter.

Anderson Creek, SR 2031

The watershed of Anderson Creek, in southern Harnett County, is on the eastern edge of the Sand Hills and borders the Southeastern Floodplains and Low Terraces and the Rolling Coastal Plain ecoregions. The monitoring site was approximately 1.3 miles above its confluence with the Little River. The stream at this location has a drainage of area of 34.7 square miles.

Land use adjacent to the sampling reach was mostly forest with some residences. Riparian areas were intact, but the left bank was narrowed by residences. Erosion areas were present, but vegetation was diverse and held banks well even at high flows. The dominant bottom substrate was sand though a fair amount of gravel was also present. At high flow the stream is a swift run. Instream habitat was relatively abundant and included woody debris, leaf packs, root mats, undercut banks, and some macrophytes.

Downstream view of Anderson Creek at SR 2031, Harnett County.

The fish community was sampled in 1998 and 2003. Seventeen species are known from this site and in both years the bluegill and dusky shiner were the dominant species.

The benthic community improved from Good-Fair in 1993 and 1998 to Good in 2000 during a special study. The site remained Good in 2003. A number of intolerant taxa were collected in 2003, two of which, *Acroneuria lycorias* (Abundant) and *Oecetis georgia* (Rare), were not previously collected from the site.

SPECIAL STUDIES

Crane Creek Watershed

Seven sites within the Crane Creek watershed (Moore and Harnett counties) were assessed in April 2002 at the request of the Watershed Assessment and Restoration Project Unit's local Watershed Planning Initiative. More than 75 percent of the watershed is forested with only one percent developed and the remainder used for agriculture. During a prolonged statewide drought, the forested sub–watersheds had lower conductivity and pH than did the sub-watersheds with slightly greater percentage of agricultural landuse. Aquatic and riparian habitats were of high quality throughout the watershed. Fish community characteristics were similar to those from regional reference sites in the Sand Hills, although conductivity was greater in the Crane Creek watershed than at the reference sites. The benthic macroinvertebrates rated most of the sub-watersheds Good but with some indications that stream flow in the smaller watersheds may become intermittent during low flow periods each year. Two smaller sub-watersheds, although not rated, did not have any evidence of being impaired. Thus, based on these evaluations, no impaired drainages were identified in this watershed (Biological Assessment Unit Memorandum F-020815).

SPECIAL STUDIES

Little Crane Creek

Flow was not adequate during the 2002 to include sampling of Little Crane Creek as part of the Crane Creek Watershed Assessment and Restoration Project. In April 2003 Little Crane Creek was sampled at NC 24/27 and off US 1. An additional sample from Crane Creek at SR 1810 was included to aid in data interpretation. The sites did not appear to have fully recovered from the 2002 drought, however, the Little Crane Creek watershed was not impaired (Biological Assessment Unit Memorandum B-030815). This confirms the 2002 report conclusion that no impaired drainages could be identified in the Crane Creek watershed.

Stoney Creek Watershed Assessment and Restoration Project

Anderson Creek at SR 2031 was sampled in September 2000 as a part of the Stoney Creek (Neuse River Basin, Wayne County) Watershed Assessment and Restoration Project. It was intended to serve as a reference stream for the study. The location and the results proved too dissimilar to Stoney Creek to be included in the study (Biological Assessment Unit Memorandum B-021023).

Mill Creek HQW Request

Mill Creek at SR 1853 (Moore County) was sampled in July 2000 to verify its potential for reclassification as Outstanding Resource Waters. The EPT sample was rated Excellent with an EPT BI of 3.78 and EPT S of 26 (Biological Assessment Unit Memorandum B-000712).

Old Town Reservoir
This reservoir, located near Southern Pines, is an impoundment of Mill Creek (Figures 71 and 72). The lake's watershed is relatively undeveloped with the exception of a golf course. Formerly a water supply source, the reservoir is now used for public recreation. The maximum lake depth is 23 feet. Prior to 2003, this reservoir has been sampled 13 times by DWQ.

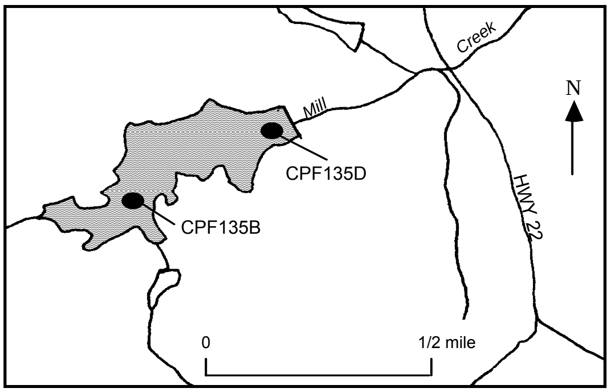


Figure 71. Sampling sites at Old Town Reservoir, Moore County.

Figure 72. Old Town Reservoir, near the dam, Moore County.

The reservoir was most recently sampled in 2003. Secchi depths, which were two meters or more in June, gradually decreased over the summer, but remained over one meter at both sampling sites. In 1998, Secchi depths ranged from 1.5 to 3.8 meters, indicating good water clarity (Appendix 22). Nutrient concentrations in 2003 remained fairly consistent over the summer and chlorophyll *a* concentrations ranged from low to moderate. These concentrations were similar to those measured since 1988. Metal concentrations in surface waters were within water quality standards in 1998 and 2003. Based on the calculated NCTSI scores, the reservoir was mesotrophic in June and July and eutrophic in August.

CAPE FEAR RIVER SUBBASIN 15

Description

This subbasin is located in three ecoregions -- the Sand Hills, the Atlantic Southern Loam Plains, and the Southeastern Floodplains and Low Terraces (Griffith *et al*. 2002). The City of Fayetteville is the largest urban area and borders Fort Bragg (Figure 73). Much of the Fort Bragg area has been established as a "Significant Natural Heritage Area" (LeBlond and Sorrie 2002) with many rare plant and animal species. The Cape Fear River flows through the eastern part of the subbasin whereas the western and central regions are made up of the Rockfish and Little Rockfish Creeks watersheds.

The most recent landuse coverage (1993 - 1995) showed more than two-thirds of the subbasin forested and almost 10 percent urban (Table 39). However, due to recent growth in the Fayetteville metropolitan area, the percentage of lands remaining forested or in pasture is expected to decline.

Table 39. Land use in Subbasin 15. Based upon CGIA coverage 1993 - 1995 (total area = 600 square miles (NCDENR 2000).

Land use	Percent
Water	2
Cultivated crop	14
Pasture	10
Urban	10
Forest	64

There are six NPDES permitted dischargers in the subbasin with four of these facilities having a permitted flow greater than 0.5 MGD:

- Monsanto Company discharging 0.9 MGD into the Cape Fear River;
- the Town of Raeford's WWTP discharging 3 MGD into Rockfish Creek; and
- PWC/Fayetteville's Rockfish Creek and Cross Creek WWTPs discharging 14 and 22 MGD, respectively into the Cape Fear River.

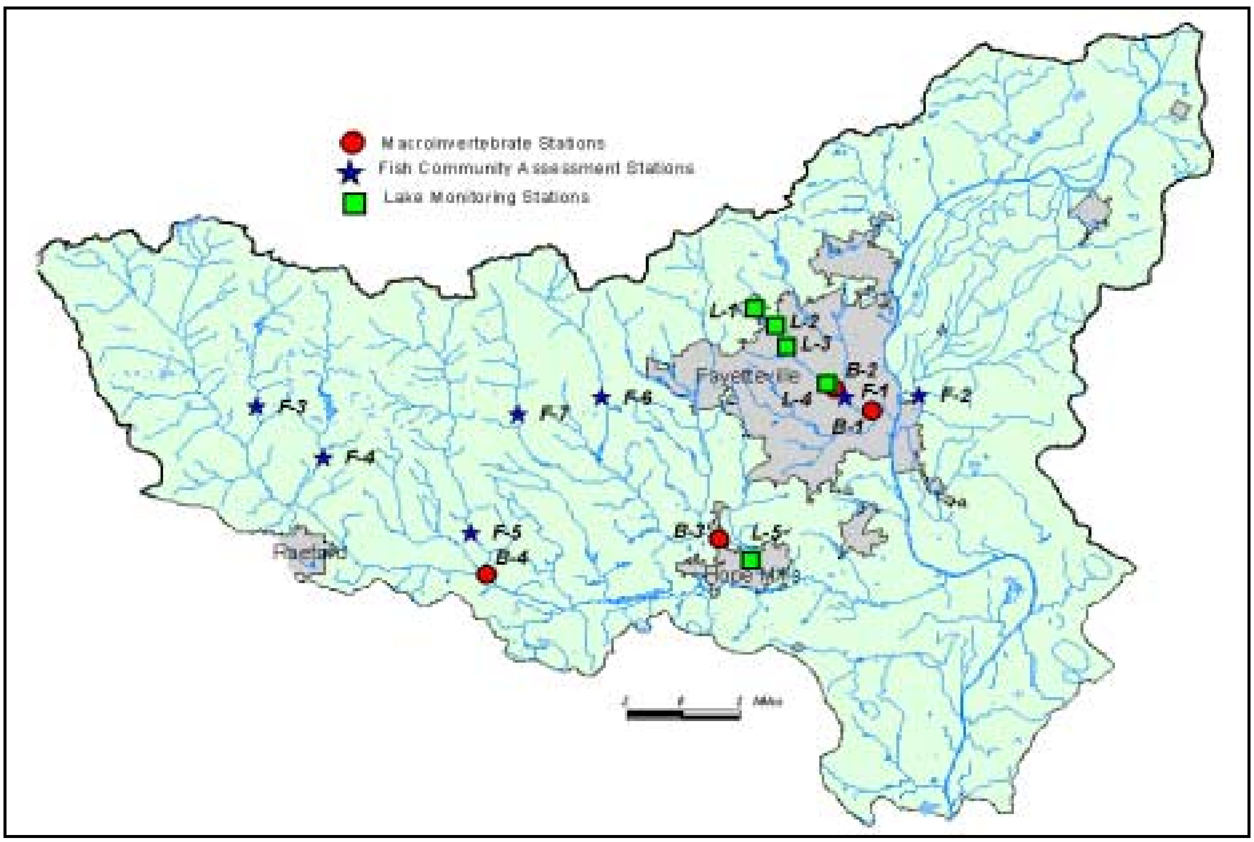


Figure 73. Sampling sites in Subbasin 15 in the Cape Fear River basin. Monitoring sites are listed in Table 40.

Overview of Water Quality

An upper benthic monitoring site on Rockfish Creek is below the Town of Raeford's WWTP. Since 1993, the site has been rated as Good (Table 40). Facility upgrades were believed responsible for this improved water quality from Good-Fair in 1990 to Good since then. The downstream site on Rockfish Creek site has been Excellent since 1983, except for a slight decrease to Good in 1993. This site could not be sampled in 2003 due to high flows. Little Rockfish Creek was sampled above the confluence with Rockfish Creek. Even though its watershed is urban and agricultural, benthos ratings since 1993 have been Good.

The Good or Excellent ratings in Rockfish Creek contrasted sharply with the Poor or Fair ratings in the Cross Creek catchment. This urbanized watershed was sampled at six sites in August 2003 as part of a TMDL stressor study. No benthos sample from the Cape Fear River was collected in 2003 due to high flows.

Fish community samples from seven Sand Hills streams were not rated, but there are no NPDES permitted facilities in the watersheds of Juniper, Nicholson, Puppy, Little Rockfish, or Bones Creeks where fish community assessments were performed.

Four impoundments on Little Cross Creek -- Bonnie Doone, Kornbow, Mintz Pond, and Glenville Lake, serve as primary or backup water supplies for the City of Fayetteville. All were eutrophic or mesotrophic in 2003, which suggested increased enrichment since sampled in 1998. Hope Mills Lake on Little Rockfish Creek suffered a catastrophic dam failure in May 2003 which drained the lake.

There are 15 ambient water quality monitoring sites in this subbasin sampled by either DWQ or a coalition member. No particular trends or problems were apparent from these data, although Rockfish Creek sites were distinguished by low conductivity values (median near 40 µmhos/cm) and pH values sometimes less than 5.5 s.u. Four facilities monitor whole effluent toxicity with no major problems noted.

Table 40. Waterbodies monitored in Subbasin 15 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Cross Cr	Cumberland	Green Street	---	Good-Fair
B-2	L Cross Cr	Cumberland	Washington Drive	Fair	Fair
B-3	L Rockfish Cr	Cumberland	NC 59	Good	Good
B-4	Rockfish Cr	Hoke	SR 1432	Good	Good
F-1	Cross Cr	Cumberland	NC 87/210/24	Not Rated	Not Rated
F-2	Gum Log Canal	Cumberland	SR 1728	---	Not Rated
F-3	Juniper Cr	Hoke	Plank Road	---	Not Rated
F-4	Nicholson Cr	Hoke	SR 1301	---	Not Rated
F-5	Puppy Cr	Hoke	SR 1406	Not Rated	Not Rated
F-6	Bones Cr	Cumberland	SR 1400	---	Not Rated
F-7	L Rockfish Cr	Hoke	Plank Road	---	Not Rated
L-1	Bonnie Dune Lake	Cumberland			
L-2	Kornbow Lake	Cumberland			
L-3	Mintz Pond	Cumberland			
L-4	Glenville Lake	Cumberland			
L-5	Hope Mills Lake	Hoke			

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites; L = lake assessment sites.

River and Stream Assessment

Benthic macroinvertebrate samples were not collected from the Cape Fear River and lower Rockfish Creek due to continuous high flows during the sampling season (Appendix 1). These sites will be monitored in the 2008 basinwide cycle.

Seven streams were sampled in this subbasin for fish community assessments. Five of these, Gum Log Canal, Juniper, Nicholson, Little Rockfish, and Bones Creeks, were sampled for the first time for fish community assessments in 2003. However, criteria have not been developed to assign ratings to these communities and all of them are classified as “Not Rated”. Many of the streams had high quality instream and riparian habitats (Appendix 2). Based upon the instream, riparian, and watershed characteristics, sites on Juniper, Nicholson, and Little Rockfish Creeks qualified as new regional reference sites. General characteristics of Sand Hills streams and their fish fauna are discussed in Appendix 8.

Cross Creek, NC 87/210/24
The watershed of Cross Creek is very urbanized and drains the northern portion of the City of Fayetteville. The altered stream has lost much of its natural Sand Hills characteristics (Appendices 2 and 13).

Cross Creek at NC 87/210/24, Cumberland County.

In 1998, 134 fish representing six species were collected; in 2003, 118 fish representing 10 species were collected. The dominant species both years was the redbreast sunfish.

Cross Creek, Green Street
This site is not far from the stream’s confluence with the Cape Fear River. The surrounding land use was entirely urban, with only a grass buffer adjacent to the stream and many breaks in the riparian zone. Mean stream width was nine meters and parts of the stream had been channelized. There was some rubble under the bridge, but other parts of the stream were sand or bedrock. Good roots mats were present along the banks. Periphyton growths were abundant on the rubble, suggesting some enrichment. The overall habitat was poor (habitat score = 52). High rainfall the week prior to sampling caused severe flooding in some parts of the City of Fayetteville.

Cross Creek at Greet Street, Cumberland County.

The benthic community was rated Fair in 1993 based on an EPT sample, but Good-Fair in 2003 based on a Full Scale sample. This change in rating, however, did not reflect a real improvement in water quality. EPT S was similar for both samples (9 and 10), and the extreme high flows prior to the 2003 collection might have scoured out many of the pollution-indicator taxa. This possibility was supported by the low numbers of Chironomidae in the 2003 sample, as well as very low Total S (38).

Little Cross Creek, Washington Drive
This segment of Little Cross Creek is downstream of Glenville Lake. The stream was channelized, had an average width of five meters, and a hardpan clay bottom. The stream was mostly a uniform run habitat, but pieces of urban debris formed occasional riffles. The surrounding area was residential with little riparian buffer zone. The habitat score was 34.

Little Cross Creek at Washington Drive, Cumberland County.

This site was rated Fair in 1998 and 2003 with identical EPT S (7). The fauna in 2003 was dominated by tolerant taxa, especially *Polypedilum convictum* and hydropyschid caddisflies.

Gum Log Canal, SR 1728

The watershed of Gum Log Canal includes eastern Cumberland County, east of the Cape Fear River, but west of I-95. It is a tributary to Locks Creek which is a tributary to the Cape Fear River. There is one small (0.025 MGD) NPDES permitted discharger in the stream's headwaters. According to Fels (1997) the watershed of Gum Log Canal is in the Inner Coastal Plain. However, Griffiths *et al*. 2002) showed the watershed straddling the Sand Hills, Southeastern Floodplains and Low Terraces, and the Atlantic Southern Loam Plains. The stream has unusual habitat and water quality characteristics for a Sand Hills or Coastal Plain stream (Appendices 2 and 13).

Gum Log Canal at SR 1728, Cumberland County.

The fish community is as uncharacteristic of a Sand Hills or Coastal Plain stream as is its habitats. If the stream is placed in one of these two ecoregions, then the fish community is "Not Rated". The habitats, conductivity, and pH are clearly modified by riparian alteration and nutrient enrichment from cattle.

However, if this reach of stream is considered as an isolated remnant of the Northern Outer Piedmont, the fish community is rated Excellent (NCIBI = 60)! Characteristics of the community were:

- the community was diverse (n = 22 species, including 2 species of darters, 6 species of sunfish, and 2 species of suckers);
- the community was abundant (n = 304 fish);
- the redfin pickerel, spotted sucker, notchlip redhorse, brown bullhead, redbreast sunfish, bluegill, largemouth bass, and spotted bass were all represented by large-bodied specimens;
- the fauna included four species whose southeastern distributions in the Cape Fear River extend no further than Gum Log Canal – bluehead chub, white shiner, notchlip redhorse sucker, and green sunfish;
- the green sunfish and the spotted bass are also introduced species in the basin; and
- the white shiner population is also disjunct from its the closest populations in Subbasin 07.

Gum Log Canal at SR 1730 (upstream from the fish community site) was found to support rare mussel species (Fullerton *et al*. 2001). Until further information can be obtained about this stream, the stream can be considered as an unusual Sand Hills stream or an Excellent Piedmont stream isolated from similar streams such as Hector and Avents Creeks (Subbasin 07).

Juniper Creek, Plank Road

The watershed of Juniper Creek in central Hoke County drains the property of Fort Bragg. In 2003, 10 species were collected and the dominant species was the dusky shiner.

Juniper Creek at Plank Road, Hoke County.

Nicholson Creek, SR 1301

The watershed of Nicholson Creek is adjacent and east of the Juniper Creek River watershed. The site about two miles downstream of Mott Lake. In 2003, like Juniper Creek, 10 species were collected and the dominant species was the dusky shiner.

Nicholson Creek at SR 1301, Hoke County.

Puppy Creek, SR1406
The watershed of Puppy Creek transitions an area between the Sand Hills and the Atlantic Southern Loam Plains. The stream originates in Fort Bragg and then is dissected by US 401. The conductivity and pH were low in 1998 and 2003 (Appendix 14).

Puppy Creek at SR 1406, Hoke County.

Few fish and species are known from this site. Only 24 fish and 11 species were collected in 2003 and 35 fish and 8 species in 1998. Fourteen species are known from this site but no species was dominant in 2003, all were represented by 1 - 4 fish per species.

Bones Creek, SR 1400
This site on Bones Creek is on the periphery of Fort Bragg; the watershed above the site is on Fort Bragg property. In 2003, 13 species were collected and the dominant species was bluegill.

Bones Creek at SR 1400, Cumberland County.

Little Rockfish Creek, Plank Road
The watershed of Little Rockfish Creek is adjacent to and east of the Puppy Creek River watershed. And like other streams in this subbasin, the monitoring site and watershed are on Fort Bragg property. This site is just downstream of the NC Natural Heritage Program' s Fort Bragg Little Rockfish Creek Significant Natural Heritage Area (LeBlond and Sorrie 2002). The conductivity (11 µmhos/cm) was the lowest of any site in the Sand Hills in 2003 (Appendix 14).

Little Rockfish Creek at Plank Road, Hoke County.

In 2003, few fish and species (n = 29 and 9, respectively) were collected at this site. The dominant species was the dusky shiner.

Little Rockfish Creek, NC 59
This reach of Little Rockfish Creek has an average width of eight meters and fairly good habitat (score = 67). Although it flows through the City of Fayetteville, there were fairly wide riparian zones. However, there were breaks in the riparian zone, some bank erosion, and few pools.

Little Rockfish Creek, downstream of NC 59, Cumberland County

This site has been rated Good since 1993 with EPT S of 22 and 23. Intolerant species have been collected in all years, but some of the more intolerant taxa (*Acroneuria*, *Pteronarcys*, and *Nyctiophylax*) were present only in 1993.

Rockfish Creek, SR 1432
At this site the creek is about 15 meters wide with good habitat (score = 91). This site is downstream of Fort Bragg, the Town of Raeford, and the town's WWTP.

Rockfish Creek, SR 1432, Hoke County.

A Good-Fair rating in 1990 was attributed to the discharge. The site has been rated Good since 1993. EPT S has been very consistent over this time period: 23 for EPT samples and 25 for Full Scale samples. Intolerant taxa were abundant in all samples since 1993, especially *Brachycentrus numerosus*.

SPECIAL STUDIES
Cross Creek/Little Cross Creek TMDL Stressor Study
A TMDL stressor study of the Cross Creek and Little Cross Creek watersheds was conducted in August 2003. This survey included 2 sites on Little Cross Creek, 3 sites on Cross Creek, 1 site on UT Cross Creek. The results indicate that altered hydrology and sedimentation were the likely causes of stress to these streams (Biological Assessment Unit Memorandum B-040226)

Streams on Fort Bragg
Three streams within Fort Bragg (Juniper, Puppy, and Little Rockfish Creeks) were sampled for benthic macroinvertebrates to supplement fish community samples that could not be rated. The benthic samples indicated possible water quality problems in Puppy Creek (Biological Assessment Unit Memorandum B-031027).

OTHER INVESTIGATIONS
A survey of nongame species in streams of Cumberland and Hoke counties was conducted by Fullerton *et al*. (2001). Comparisons of their data with earlier collections suggested a significant loss of species diversity over time within the area.

Lake Assessment

A series of four reservoirs (Bonnie Doone, Kornbow, Mintz Pond, and Glenville) on Little Cross Creek were sampled in 2003 (Figure 74). The reservoirs serve as primary water supplies or backup water supplies for the City of Fayetteville. Each reservoir is sampled at a single location near the dam.

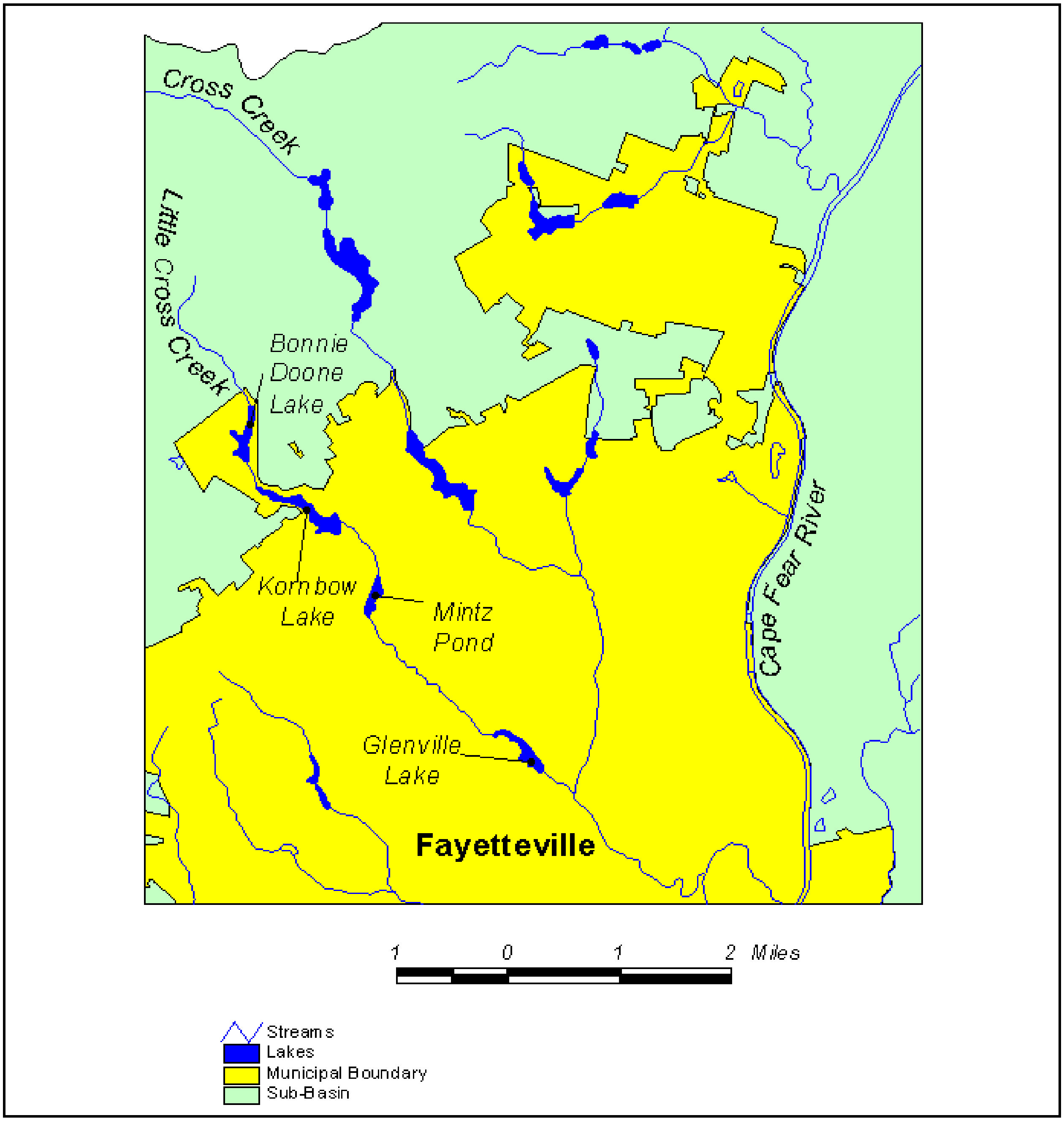


Figure 74. **Reservoirs on Little Cross Creek sampled as part of the Cape Fear River basin monitoring program.**

Bonnie Doone Lake
Fort Bragg Military Base is located in close proximity to Bonnie Doone Lake. Firebreaks located on the base and the sandy soil contribute large amounts of sediments into the lakes through stormwater runoff. The surrounding shoreline of Bonnie Doone is forested (Figure 75). The western side of the lake beyond the forested buffer is urbanized. This lake has been monitored four times by DWQ prior to 2003.

Figure 75. Bonnie Doone Lake, Cumberland County.

In 2003 Secchi depths ranged from 1.3 meters in June to 0.8 meter in August. The decrease in water clarity may have been due to recent rainfall within the watershed which suspended sediments into the water column. Increased turbidity and total suspended solids in August coincided with the decreased Secchi depth (Appendix 22).

Total phosphorus and total Kjeldahl nitrogen concentrations were greater than those observed in 1998, but still remained within low to moderate ranges. Chlorophyll *a* concentrations were also low to moderate. Concentrations of metals in the surface waters were within water quality standards with the exception for iron concentrations which were two to three times the action level of 1,000 µg/L. This was attributed to the high iron content of the soil and also the frequent rainfall during the summer, which transported these soil particles into the water column. Iron concentrations were also elevated in 1998. The lake was classified as mesotrophic in 2003 based on the calculated NCTSI scores.

Kornbow Lake
The immediate shoreline of the lake is forested and beyond that are residential developments (Figure 76). This lake has been sampled four times by DWQ prior to 2003.

Figure 76. Kornbow Lake, Cumberland County.

In 2003 Secchi depths were greater than one meter (Appendix 22) but were less than those previously measured. Frequent rainfall during the summer may have contributed to the decrease in water clarity. Increased turbidity and total suspended solids in coincided with the decreased Secchi depth (Appendix 22).

Nutrient and chlorophyll *a* concentrations were low to moderate, as they were in 1998. Concentrations of metals in the surface waters were within water quality standards with the exception for iron concentrations which were almost twice the action level of 1,000 µg/L. This was attributed to the high iron content of the soil and also the frequent rainfall during the summer, which transported these soil particles into the water column. Elevated iron concentrations have posed no problems with the processed drinking water (Sidney Post, Watershed Resource Specialist, City of Fayetteville. pers. com.). Based on the calculated NCTSI scores for 2003, the lake was classified as mesotrophic in June and July and eutrophic in August.

Staff from the City of Fayetteville monitors the water quality of this lake as well as other waterbodies in the city. Water clarity has decreased in recent years in the headwaters of Kornbow Lake due to sedimentation, but no change in water clarity has been observed near the dam. The lake is 90 percent infested with variable-leaf water milfoil (*Myriophyllum heterophyllum*). However, because this lake and its watershed are monitored by the North Carolina Natural Heritage Program, the city is discouraged from removing this plant. To protect the lake, 150 acres in the headwaters have been purchased by the City with money received from the Clean Water Management Trust Fund.

Mintz Pond

The immediate shoreline of Mintz Pond is forested (Figure 77) but the lake is surrounded by urban development. The impoundment is shallow with a maximum depth of only five feet at the dam. This small lake has been sampled four times by DWQ prior to 2003.

Figure 77. Mintz Pond, Cumberland County.

In 2003 Secchi depths were similar to those observed since 1992, indicating that the water clarity has not decreased. Surface dissolved oxygen was low in June and July (Appendix 22), but was not less than the water quality standard of 4.0 mg/L for an instantaneous reading. Low dissolved oxygen concentrations (range = 2.5 - 6.4 mg/L) have been measured in previous years and this may be related to the presence of large areas of water lilies (*Nymphaea odorata*) observed along the shoreline and upper end of the lake. The low concentrations may be the result of the decomposition of organic material and respiration by plants.

Except for total phosphorus, nutrient concentrations were greater in 2003 than in 1998. Concentrations of metals in the surface waters were within water quality standards with the exception for iron concentrations which were almost twice the action level of 1,000 µg/L. This was attributed to the high iron content of the soil and also the frequent rainfall during the summer, which transported these soil particles into the water column. Elevated iron concentrations have posed no problems with the processed drinking water (Sidney Post, Watershed Resource Specialist, City of Fayetteville. pers. com.). Based on the calculated NCTSI scores, the lake was classified as eutrophic in June and August and mesotrophic in July.

Water lilies have been observed along the lake shoreline since 1998 but are not at nuisance levels. Along with the water lilies are smaller beds of watershield *Brasenia schreberi*. Variable-leaf watermilfoil is found throughout the lake. The macroscopic algae, *Nitella sp*. is also found growing on the lake's bottom; it is an indicator of clear water.

Glenville Lake

The immediate shoreline of Glenville Lake is forested with residential development located along the western side of the lake just beyond the 50 foot forested buffer (Figure 78). The maximum depth is approximately 12 feet. The lake has been sampled five times prior to 2003 by DWQ.

Figure 78. Glenville Lake at dam, Cumberland County.

In 2003 the water level was lowered in June to allow for work on the dam, so the lake was not sampled in that month. Secchi depths (which were less than one meter) and nutrient concentrations were similar to those observed in other years (Appendix 22). Chlorophyll *a* concentrations were moderate. Surface dissolved oxygen concentrations and pH values were not elevated which suggested that algal productivity was not excessive. Concentrations of metals in the surface waters were within water quality standards with the exception for iron concentrations which were almost twice the action level of 1,000 µg/L. Based on the calculated NCTSI scores, the lake was eutrophic in 2003.

Sedimentation has been a problem in this lake and the lake is gradually filling in (Sidney Post, Watershed Resource Specialist, City of Fayetteville. pers. com.). There has also been a problem with the removal of riparian buffers in the upstream region of the lake. Aquatic macrophytes are not a problem although the algal population has increased slightly in recent years. The water treatment plant has not had any problems processing raw water drawn from the lake.

Hope Mills Lake

This small, shallow reservoir is located on Little Rockfish Creek in the Town of Hope Mills (Figure 79). Once used for hydroelectric power and for a textile mill, the reservoir is now used for recreation. It has been sampled eight times by DWQ prior to 2003.

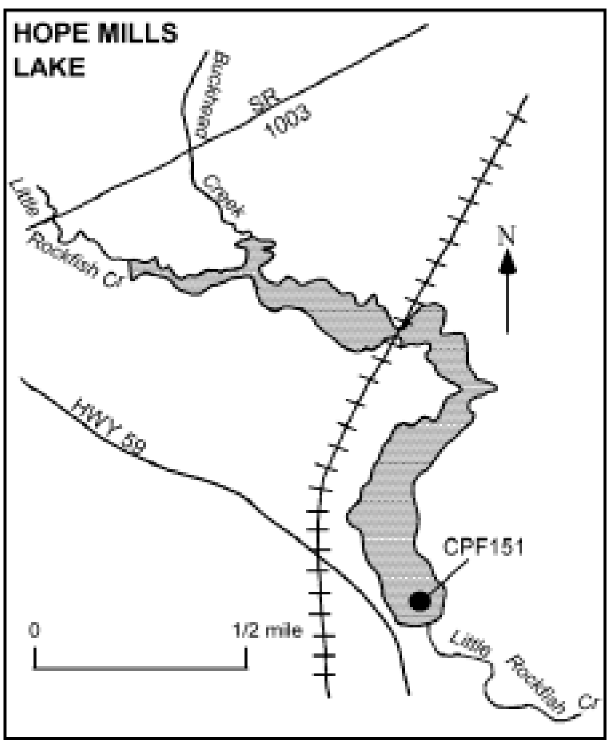


Figure 79. Sampling site at Hope Mills Lake, Cumberland County.

Six to eight inches of rain fell in the Rockfish Creek on May 25, 2003 resulting in the catastrophic failure of the earthen dam on May 26, 2003 (Figures 80 and 81). Subsequently, the lake could not be sampled in 2003.

Figure 80. Hope Mills Lake swimming area, 1998, Cumberland County.

Figure 81. Hope Mills Lake swimming area, 2003, Cumberland County.

CAPE FEAR RIVER SUBBASIN 16

Description

This subbasin is located primarily in the Carolina Flatwoods ecoregion, although areas along the Cape Fear River are included in Southeastern Floodplains and Low Terraces ecoregion (Figure 82). The Cape Fear River in this subbasin is deep and slow moving, with two locks to aid in navigation. Major tributaries include Harrison, Turnbull, and Ellis Creeks. These are black-water streams, highly colored by humic acids, and tend to have little flow during the summer. Low pH values (near 4.0 s.u.) in these streams occur after periods of high flow which flush organic matter from surrounding areas into the streams. Both flow extremes produce a high degree of stress for the aquatic fauna, imposing a natural limit on their diversity.

The Bladen Lakes State Park is located in this subbasin and includes several natural bay lakes. Like the streams, the lakes are naturally darkly colored. The pH in these bay lakes is extremely low, usually ranging from 3.7 - 4.0 s.u. (Mottessi and Savacool 1997). The entire Bladen Lakes area has been established as a “Significant Natural Heritage Area”, with a large number of rare plant and animal species (LeBlond and Sorrie, 2002).

This is a very rural area with less than one percent of the subbasin urbanized (Table 41). Small towns include Elizabethtown and White Lake. Almost eighty percent of the land is forested. Confined animal operations are spread through most of the subbasin.

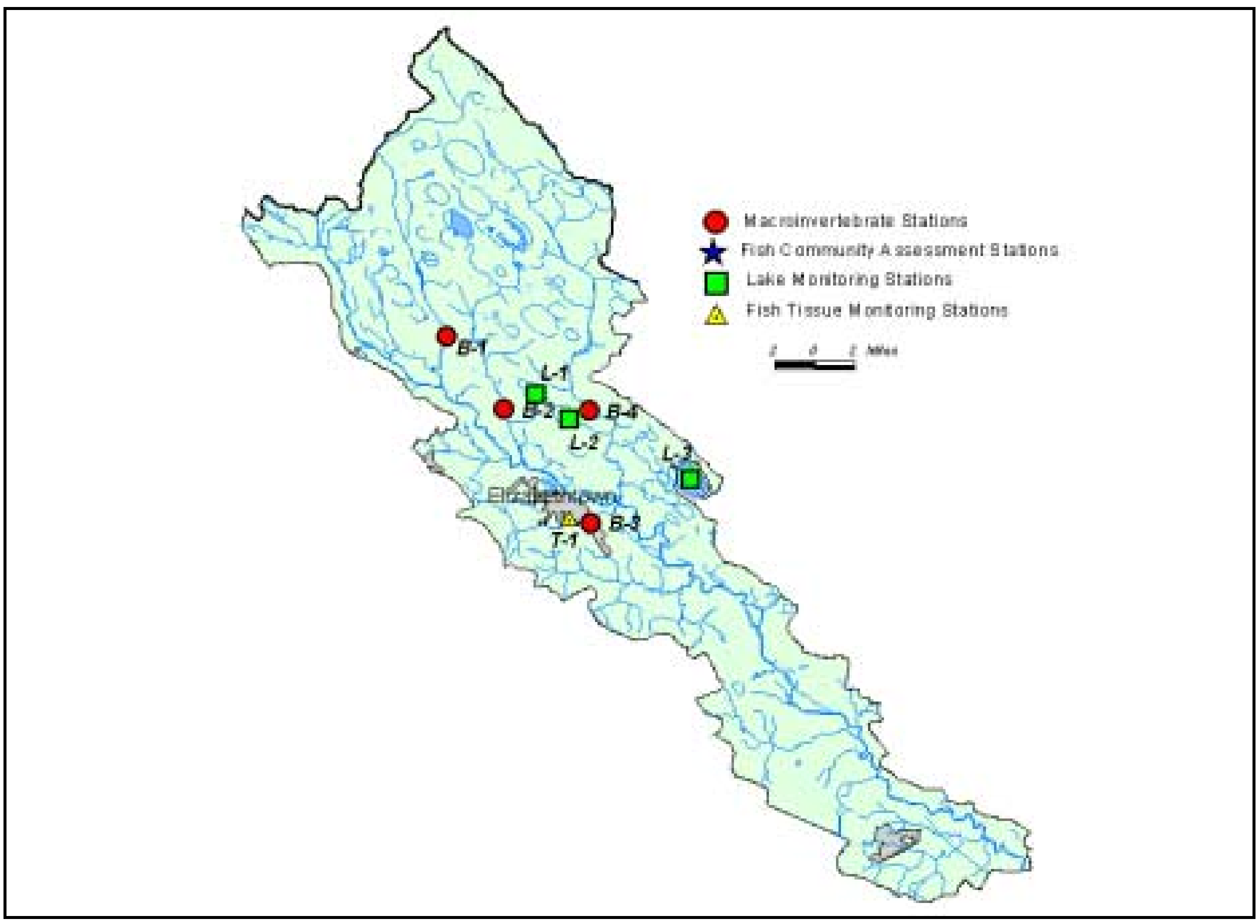


Figure 82. Sampling sites in Subbasin 16 in the Cape Fear River basin. Monitoring sites are listed in Table 42.

Table 41. Land use in Subbasin 16. Based upon CGIA coverage 1993 - 1995 (total area = --- square miles (NCDENR 2000).

Land use	Percent
Water	3
Cultivated crop	13
Pasture	6
Urban	1
Forest	79

The four largest dischargers in the subbasin are:

- Veeder-Root (5.0 MGD),
- Smithfield Packing (3.0 MGD),
- Alamac Knit Fabrics (2.5 MGD); and
- Dupont of Fayetteville (2.0 MGD).

All of these facilities discharge into the Cape Fear River.

Overview of Water Quality

Benthic macroinvertebrate collections were used to evaluate four major tributary streams in this subbasin (Table 42). These streams were rated as Good-Fair using Coastal A criteria, but the macroinvertebrate fauna was characterized by very intolerant species. The very low pH of these streams (4.0 - 4.3 s.u.) limited the diversity of these streams.

Salters and Jones Lakes are Carolina Bay Lakes receiving almost no overland inputs of water, relying on precipitation and groundwater for recharge. Both lakes are located in state forests and are therefore protected and undeveloped. They are classified as dystrophic. White Lake, also a bay lake has been classified as oligotrophic. But nuisance growths of filamentous algae in 2001 caused aesthetic concerns to users of the lake.

The frequency and magnitude of algal blooms in the mainstem of the Cape Fear River were studied during the 2002 drought. The most severe blooms occurred upstream in Chatham County with the magnitude declining downstream towards Bladen County.

There were 22 ambient water quality monitoring sites in this subbasin sampled by either DWQ or coalition members. There was relatively uniform water quality along this portion of the Cape Fear River, although low dissolved oxygen concentrations did occur during the summer. Dissolved oxygen concentrations less than 4.0 mg/L were observed for Cape Fear River near Tarheel in 2001 and 2002. Long-term data indicated a gradual increase in conductivity at all sites, reflecting more development, more dischargers in upstream subbasins, or both. Six facilities monitor their effluent for toxicity. No facility experienced test failures in 2003.

Table 42. Waterbodies monitored in Subbasin 16 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Harrison Cr	Bladen	SR 1318	Good-Fair	Good-Fair
B-2	Ellis Cr	Bladen	NC 53	Good-Fair	Good-Fair
B-3	Browns Cr	Bladen	NC 87	---	Not Rated
B-4	Turnbull Cr	Bladen	SR 1511	Good	Good-Fair
T-1	Cape Fear R	Bladen	at Elizabethtown		
L-1	Salters Lake	Bladen			
L-2	Jones Lake				
L-3	White Lake	Bladen			

[1]B = benthic macroinvertebrate monitoring sites; T = fish tissue monitoring sites; and L = lake assessment sites.

River and Stream Assessment

No macroinvertebrate sampling was conducted at mainstem Cape Fear River or lower Rockfish Creek sites in 2003 due to persistent high flow conditions during the summer (Appendix 1). These sites will be monitored in the 2008 basinwide cycle.

The substrate for Ellis, Turnbull and Harrison Creeks was mostly sand, with some silt deposited along the banks. Snag habitat and leaf pack habitats were abundant in all streams and habitat scores were high at all sites (75 - 80). The pH of tributary sites ranged from 5.0 to 5.2 s.u. in 1993, but pH values declined to 4.0 - 4.4 s.u. in 2003 after prolonged summer high flows. A similar drop in pH (to 4.0 s.u.) was observed during a macroinvertebrate collection from Turnbull Creek in November 1999, following Hurricane Floyd (Biological Assessment Unit Memorandum B-991203). These decreases in pH probably reflected flushing of water from the highly acidic Bay Lakes area. Dissolved oxygen concentrations also declined in these streams between the two summer samples, from a mean of 6.6 mg/L in 1998 to a mean of 4.7 mg/L in 2003.

Benthos samples were rated with Coastal A criteria, but this rating system does not make any allowance for naturally low pH values. Low pH is known to limit the benthic diversity, especially mayflies (Rosemond *et al*. 1992). This may explain the extremely low diversity of mayflies in summer samples, with *Stenonema modestum* the only mayfly collected in the major tributaries since 1993. Future improvements to the rating system for Coastal A streams may result in Good or Excellent ratings for these streams because the fauna includes many highly intolerant species. These streams are most similar to low pH swamp streams in Subbasin 23.

Harrison Creek, SR 1318
Harrison Creek was sampled adjacent to a small city park in the White Oak community. The stream was about eight meters wide with large amounts of wood in the stream.

Harrison Creek at SR 1318, Bladen County.

The stream was rated Good-Fair in 1998 and 2003. The presence of very intolerant taxa, including *Acroneuria arenosa* (Common) and *Chimarra* sp. (abundant) suggested good water quality.

Ellis Creek, NC 53
Ellis Creek was the smallest of the major streams in the subbasin with a mean width of five meters. It also had more silt (30 percent) than the other streams, presumably due to lower flow rates.

Ellis Creek, NC 53, Bladen County.

The stream has consistently been rated Good-Fair since 1993. EPT S was also very stable at 15 and 16 taxa. Long-lived perlid stoneflies were not collected at this site in 2003, but several very intolerant taxa such as *Chimarra* (abundant), *Acroneuria arenosa* (Rare), and *Molanna tryphena* (Common) were collected.

Browns Creek, NC 87
Browns Creek is a small stream (five meters wide) located near the Town of Elizabethtown. The stream was sampled downstream of the town where landuse was a combination of forest and agriculture. Unlike the other streams in this subbasin, Brown Creek does not drain any pocosins, so the pH was close to neutral (6.4 s.u.). The benthic community was sampled in February because it was uncertain whether there would be adequate summer flow. Unusually high summer flows in 2003 left this issue unresolved.

Browns Creek, NC 87, Bladen County.

Turnbull Creek at SR 1511, Bladen County.

Using Swamp Region A criteria, Browns Creek was rated Moderate and intolerant taxa were absent.

Turnbull Creek, SR 1511
Turnbull Creek had a width of about seven meters. The substrate was mostly sand, although the fauna was largely associated with snag habitat.

In 2003, this stream had the lowest pH (4.0 s.u.) of any of the streams in this subbasin. It still was rated Good-Fair, a slight decline from the Good rating in 1998. This was the only stream in the subbasin where *Chimarra* was not abundant. Intolerant taxa at this site included *Acroneuria* (two species Common) and *Oecetis morsei* (Common).

OTHER DATA
The Lower Cape Fear Coalition monitoring program run by UNC-Wilmington (Mallin *et al*. 2002) includes three sites in this subbasin: Turnbull and Harrison Creeks and the Cape Fear River at NC 11. Few water quality problems were found at these sites. Recent data can be found at http://www.uncwil.edu/cmsr/aquaticecology/lcfrp/WQ%20Reports/01-02/Sec3Subbasins/03-06-16.htm.

Fish Tissue Contaminants

Cape Fear River at Elizabethtown
Eleven fish tissue samples were collected from the Cape Fear River at Elizabethtown during 2000. Total mercury concentrations exceeded the US EPA and North Carolina criteria of 0.4 ppm in one sample each of largemouth bass and bowfin. All other metals were at concentrations were less than those of concern (Appendix 16).

Lake Assessment

Three natural Carolina Bay lakes were sampled in this subbasin (Figure 83). Each shallow lake was sampled at two or three locations. Bay lakes receive almost no overland inputs of water, relying instead on precipitation and groundwater for recharge. Jones and Salters Lakes are dystrophic and the NCTSI scores could not be accurately calculated due to the naturally dark, tannin-stained waters.

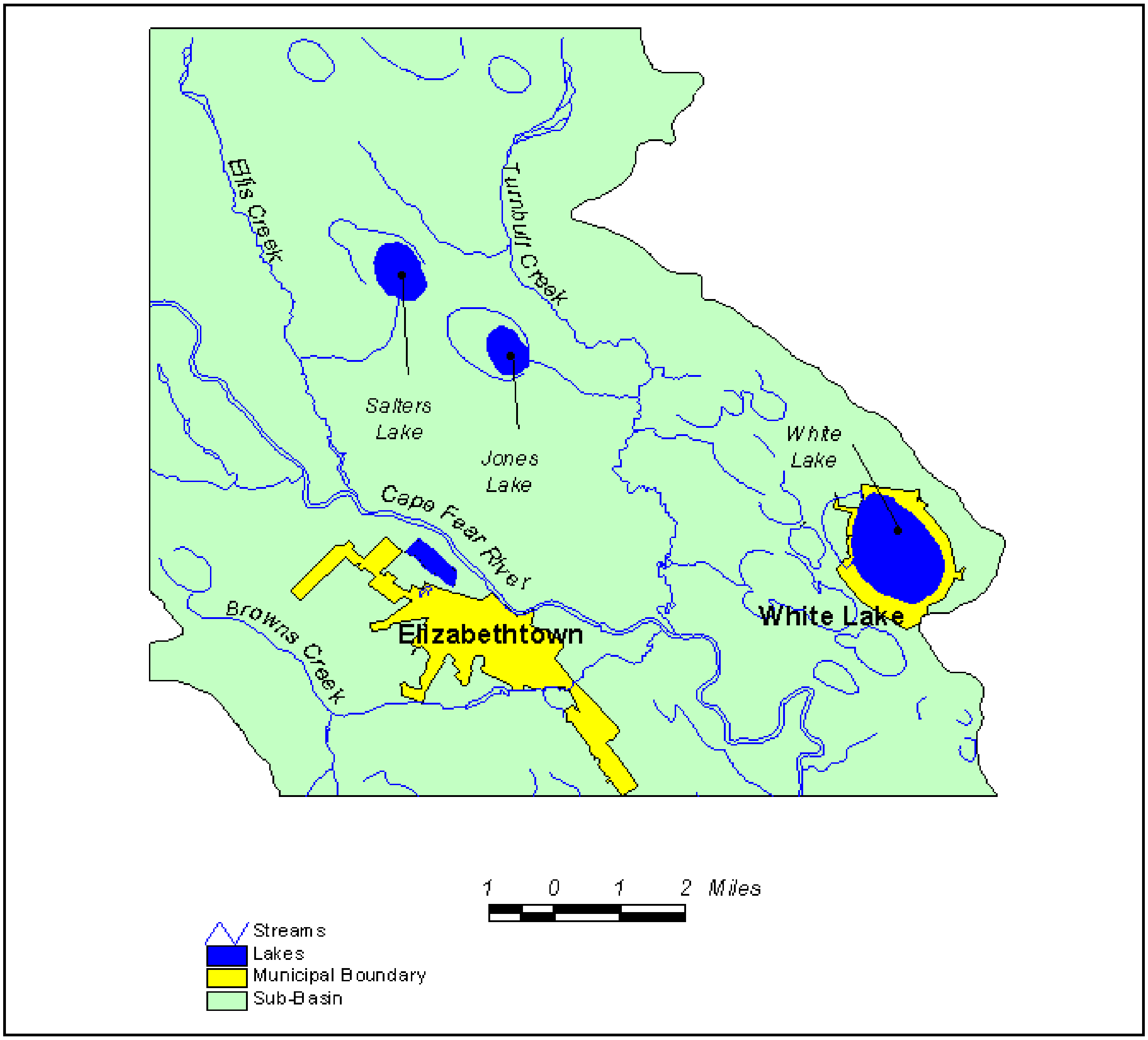


Figure 83. **Bay lakes sampled as part of the Cape Fear River basin monitoring program.**

Salters Lake

Salters Lake is part of the Jones Lake State Park and Bladen Lake State Forest. The drainage area consists of wetlands and forest (Figure 84). Public access to this lake is limited by park policy. The lake has been sampled six times by DWQ prior to 2003.

Figure 84. **Salters Lake, Bladen County.**

The lake was most recently sampled in 2003. Secchi depths were less than one meter, but were not significantly less than those observed in previous years despite the frequent rainfall within the watershed during the summer. The greatest total Kjeldahl nitrogen concentration was observed in July at Station CPF153C (0.57 mg/L). The greatest total phosphorus concentrations were observed in August (Appendix 22). Rainfall within 48 hours of sampling on August 7 may have contributed to the increase in nutrients from nonpoint source runoff and sediment suspension in this shallow lake. The greatest chlorophyll a concentrations were also observed in August. These values, however, were not greater than the water quality standard of 40 µg/L.

Jones Lake

Jones Lake is situated in the flat swampy terrain of Jones Lake State Park. A public park with a swimming area is located on the southeastern shoreline of this lake (Figure 85). The lake has been sampled 14 times by DWQ prior to 2003.

Figure 85. Jones Lake, Bladen County.

The lake was most recently sampled in 2003. Despite rainfall within the lake's watershed prior to sampling, Secchi depths and conductivities were similar to those observed in previous years. Total Kjeldahl nitrogen and ammonia, however, were greater in 2003 than in previous years and may have been due to swamp runoff into the lake, suspension of peat particles into the water column from the lake bottom, or both. Chlorophyll *a* concentrations were low, which is common in dystrophic lakes.

White Lake

White Lake is located east of the Town of Elizabethtown. Although the State owns the property around the lake to the mean high water mark, the land above this demarcation is privately owned. The shoreline is extensively developed for the tourism industry and the lake is used extensively for water-based recreation (Figure 86). While it is a Bay Lake, the water is unusually and exceptionally clear instead of tannin-stained. The lake has been sampled 18 times by DWQ prior to 2003.

Figure 86. White Lake, Bladen County.

The lake was most recently sampled in 2003. Despite the frequent rain in the summer, Secchi depths were often to the lake bottom (2.9 meters), indicating good water clarity. Nutrient concentrations remained low and did not vary from those observed since 1981. Chlorophyll *a* concentrations, however, were slightly greater than those previously measured with a notable concentration of 32 µg/L at Station CPF155B in June. Small clumps of floating algae were observed near the marina and rainfall had occurred within the watershed prior to sampling. An algal bloom consisted of the chrysophyte, *Dinobryon* sp. and small green algae, *Cosmarium* sp. These algae are commonly found in acidic and oligotrophic waters. In previous years, mats of the submerged alga *Ulothrix* sp. were observed on the bottom. Calculated NCTSI scores for 2003 determined that White Lake was oligotrophic and continued to exhibit good water quality.

On June 12, 2001, an algae and aquatic weed survey of the lake was conducted in response to ongoing public concerns regarding the aesthetic impacts these plants present, particularly when benthic mats float to the shore and decay. The filamentous algae, *Zygnema* sp., was observed in shallow areas, approximately five feet deep. This was also the dominant taxon at the time of the survey.

Phytoplankton Monitoring

DWQ investigated the frequency and magnitude of algal blooms in the mainstem of the Cape Fear River during the 2002 summer drought. Collections were made above Buckhorn Dam (in Subbasin 07) and at Tarheel, Elizabethtown, and Kelly (DWQ's Ecosystem Unit's Cape Fear Algal Report 020903). The most severe blooms occurred at the Buckhorn site, with the magnitude of blooms declining further downstream. This was the first record of blooms in this portion of the river which was in agreement with the high pH data at nearby ambient water chemistry sites during the summer of 2002.

CAPE FEAR RIVER SUBBASIN 17

Description

This subbasin is located primarily in the Carolina Flatwoods ecoregion, although some areas along the coast are in the Carolina Barrier Islands and Coastal Marshes ecoregion. This subbasin constitutes the lower reaches of the Cape Fear River including the Brunswick River and Town, Smith, and Livingston Creeks (Figure 87). Small tributaries in this subbasin stop flowing during the summer, while others are tidally influenced. Streams that drain forested areas in this subbasin are usually colored by tannic acids.

This subbasin contains the City of Wilmington and the Town of Southport. Both areas are undergoing rapid development. Ten years ago, almost three-fourths of the subbasin was forested (Table 43). However, rapid development throughout New Hanover and Brunswick counties undoubtedly increased the percentage of urbanized land since then. These developed areas provide sources of nonpoint source pollution.

Table 43. Land use in Subbasin 17. Based upon CGIA coverage 1993 - 1995 (total area = 547 square miles (NCDENR 2000).

Land use	Percent
Water	9
Cultivated crop	8
Pasture	4
Urban	4
Forest	75

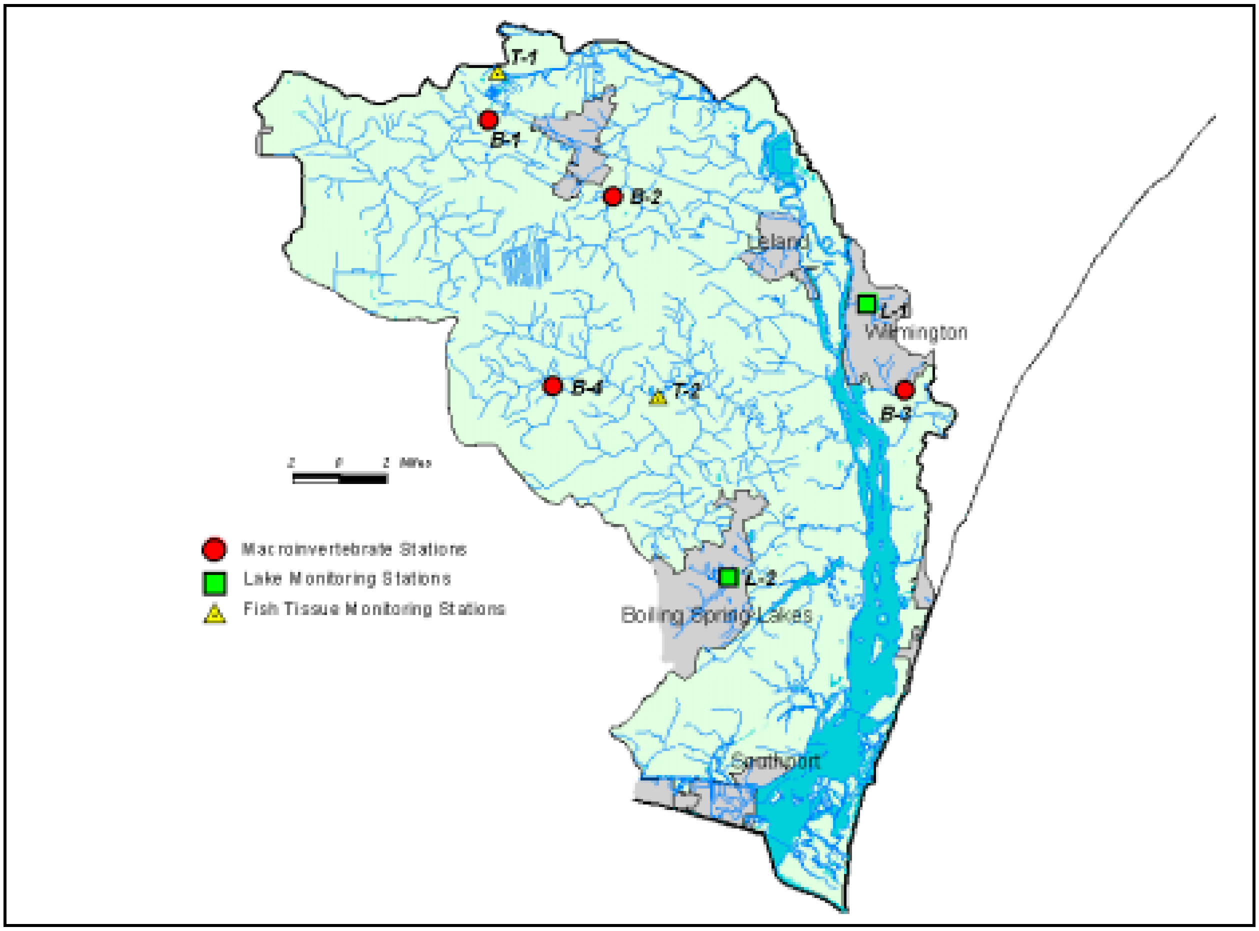


Figure 87. Sampling sites in Subbasin 17 in the Cape Fear River basin. Monitoring sites are listed in Table 44.

The areas to the west of the Cape Fear River contain many “Significant Natural Areas” (Nifong 1981), all of which are water-dependent. These include several savannahs, the Smithville Carolina Bay Lake Complex, Orton Pond, and an area of limestone sinkholes/ponds around Boiling Springs and the Sunny Point Military Ocean Terminal.

There are more than 40 NPDES permitted dischargers in the subbasin, of which half discharge directly into the Cape Fear River. Ten of these are major dischargers (≥ 1 MGD), with the largest dischargers being:

- Federal Paper (50 MGD to the Cape Fear River);
- the City of Wilmington’s North Side WWTP (8 MGD into Smith Creek); and
- the City of Wilmington’s South Side WWTP (12 MGD into the Cape Fear River).

Overview of Water Quality

DWQ benthic sampling indicated a Good-Fair bioclassification for Livingston Creek in 1998 and 2003 (Table 44). Hood and Barnards Creeks, two swamp streams, were given Moderate stress ratings. High flows in 2003 may have contributed to their decline compared to 1998. Lewis Swamp has a primarily forested watershed and was rated Natural in 1998 and 2003. Fish tissue sampling found high mercury levels in largemouth bass and bowfin at a site on the Cape Fear River.

Greenfield Lake is very eutrophic with extensive growths of aquatic plants. Boiling Springs Lake is a dystrophic lake that has recently experience problems with sinkholes formed by acidic waters dissolving the underlying limestone.

DWQ and coalition monitoring was conducted at 22 ambient water chemistry sites. Low summer dissolved oxygen concentrations occurred in the estuarine portion of the Cape Fear River, with concentrations less than 4.0 mg/L regularly occurring from Indian Creek to Channel Marker 35. The lower mainstem of the river can be very turbid after rainfall and had high concentrations of inorganic nutrients and fecal coliforms. Low dissolved oxygen and algal blooms occurred during low rainfall periods when the river water was less turbid, although hurricanes were also associated with low dissolved oxygen concentrations.

Coalition monitoring found the benthic macroinvertebrate community in the estuarine portion of the river composed of tolerant taxa. These taxa were very resilient to repeated pollution events, especially low dissolved oxygen concentrations that followed hurricanes or phytoplankton blooms.

Twenty-two faculties in the subbasin conducted whole effluent toxicity monitoring, but only the Leland Industrial Park’s WWTP had toxicity problems. This facility now sends its wastewater to the Northeast Brunswick County WWTP.

Table 44. Waterbodies monitored in Subbasin 17 in the Cape Fear River basin for basinwide assessment, 1998 and 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Livingston Cr	Columbus	US 74	Good-Fair	Good-Fair
B-2	Hood Cr	Brunswick	US 74/76	Natural	Moderate
B-3	Barnards Cr	New Hanover	US 421	Moderate	Moderate
B-4	Lewis Swp	Brunswick	SR 1410	Natural	Natural
T-1	Cape Fear R	Columbus	Near Riegelwood		
T-2	Town Creek	Columbus	Near NC 17		
L-1	Greenfield Lake				
L-2	Boiling Springs Lake				

[1]B = benthic macroinvertebrate monitoring sites; T = fish tissue monitoring sites; and L = lake assessment sites.

River and Stream Assessment

No macroinvertebrate sampling was conducted at mainstem river sites in 2003 due to persistent high flow conditions during the summer (Appendix 1). During February and March 2003, flows were too high and a benthic sample could not be collected from Town Creek. Multiple samples in 1998 and

1999, however, had demonstrated Natural conditions at this regional reference stream.

Livingston Creek, US 74
Livingston Creek was evaluated for benthos as a Coastal A stream. This stream, however, is very near Hood Creek and probably experienced very low flows in August 2003. When sampled in September, significant flow was found only in a shallow area about 200 - 300 meters upstream of US 74. In comparing the 1998 and 2003 collections, the stream width had decreased from 9 to 5 meters and dissolved oxygen had decreased from 5.4 to 3.9 mg/L. Overall habitat, however, was good (score = 77).

Low flow conditions at Livingston Creek, US 74, Columbus County.

In spite of the low flow, this site was rated Good-Fair in 1998 and 2003. Highly intolerant species were not found in either collection; philopotamid caddisflies and stoneflies were also absent.

Hood Creek, US 74/76
This stream is classified as occurring in the Swamp P region. Hood Creek can have very low summer flows, so this stream was sampled for benthic macroinvertebrates in March 1998 and February 2003. Summer flows in 2003 were actually well below normal (sometimes less than 1.0 cfs).

Hood Creek at US 74/76, Brunswick County.

The stream was rated Natural in 1998, but declined to Moderate in 2003. There was no change in the dominant species between years; most of the change was due to the loss of rare taxa. Some of this decline may have been related to the high flows recorded throughout most of late 2002 and early 2003.

Barnards Creek, US 421
Barnards Creek originates in a residential section of the City of Wilmington. It has a distinct channel, with a sand-silt substrate and a mean width of three meters. Macrophytes were abundant in some parts of the stream. This stream normally has no flow during the summer, so the benthic macroinvertebrates were sampled in February 2003 and classified with Region B swamp stream criteria.

In 1998 and 2003 the stream was slightly acidic (pH = 6.6 and 6.8 s.u.), but conductivity was elevated at 178 and 224 µmhos/cm. Although the macroinvertebrate fauna was dominated by an *Gammarus fasciatus*, 4 or 5 EPT taxa were present, and *Cheumatopsyche* and *Caenis* were abundant in both years. Total S was low (only 30 taxa in 2003), but the overall rating was Moderate in both years.

Lewis Swamp, SR 1410
Lewis swamp drains a largely forested area, although some residential land use also occurs in this area. The stream had a distinct channel downstream of the bridge, but in 2003 there was a beaver pond in the upstream area. Below the beaver dam the swamp had a more braided channel. There was an area of relatively swift flow immediately upstream of the bridge.

Lewis Swamp, SR 1410, Brunswick County.

The benthic fauna was sampled in the winter and classified with Region P swamp stream criteria. Although there were many between-year changes in the composition of the community, summary parameters were fairly stable between 1998 and 2003: Total S (55 and 63), EPT S (12 and 14), and BI (6.3 and 6.6). This site was rated Natural in both years.

SPECIAL STUDIES

Survey of Streams within the St. James Plantation Development

Five sites were sampled for benthic macroinvertebrates on Jump and Run, Beaverdam, and UT Beaverdam Creeks in March 1999. The purpose of these samples was to evaluate the effects of ditching during the development of the St. James Plantation community. Large amounts of sediment were introduced into Beaverdam Creek, promoting a shift towards silt-tolerant species. However, the analysis was complicated by a discharge into Beaverdam Creek from the Brunswick County Water Treatment Plant. The discharge increased the pH and provided permanent flow. A surprisingly intolerant macroinvertebrate community was found in some portions of Beaverdam and UT Beaverdam Creek (Biological Assessment Unit Memorandum B-990401).

Survey of Unnamed Tributary Draining the Flemington Landfill

The Flemington Landfill is now closed, but a small (about one meter wide) unnamed tributary to the Cape Fear River) still drains this area. The benthic community was not rated due to the size of the stream, but the community indicated poor water quality and some instream toxicity (Biological Assessment Unit Memorandum B-010516).

Post Hurricane Floyd Study

Hood Creek and several other streams were sampled for benthic macroinvertebrates to determine any affects from Hurricane Floyd (1999). Minimal impact was found in the these streams (Biological Assessment Unit Memorandum B-991203).

OTHER DATA

The Lower Cape Fear Coalition monitoring program run by UNC-Wilmington (Mallin *et al*. 2002) includes 14 sites in this subbasin, mostly on the Cape Fear River and near the mouth of major tributaries (Mallin *et al*. 2002). Areas of concern involve nutrient inputs, low dissolved oxygen levels (especially after hurricanes), areas of high turbidity (Brunswick and the Cape Fear Rivers), and fecal contamination. Recent data can be found on-line at http://www.uncwil.edu/cmsr/aquaticecology/lcfrp/WQ%20Reports/01-02/Sec3Subbasins/03-06-17.htm

Fish Tissue Contaminants

Cape Fear River at Riegelwood and Town Creek at NC 17

Sixty-five fish tissue samples were collected at these two sites from 2000 to 2002. Total mercury concentrations exceeded the US EPA and North Carolina criteria of 0.4 ppm in 34 (52 percent) of the samples. Total mercury concentrations also exceeded the current US Food and Drug Administration action level of 1.0 ppm in 8 (12 percent) of the samples. Most samples with mercury concentrations exceeding state and federal limits were composed of largemouth bass, bowfin, and chain pickerel. All other metals were at concentrations were less than those of concern (Appendix 16).

The NPDES permit for International Paper Company's Riegelwood mill (No. NCO003298) requires the annual collection and analysis of fish tissue for the presence of dioxins and furans. According to monitoring protocols gamefish and bottom feeder species are collected at three stations along the Cape Fear River from 11 miles upstream of Lock and Dam No. 1 to 13 miles below the mill discharge. The current NC Department of Health and Human Services' action level of dioxin in edible fish fillets is 3.0 ppt (parts per trillion). Average dioxin concentrations (2,3,7,8, TCDD) from fish in the vicinity of the mill have remained less than this level over the last 11 years.

Lake Assessment

Greenfield Lake

Greenfield Lake was created prior to 1750 to provide water for milling and irrigation for the Greenfields Plantation. The City of Wilmington encompasses the lake (Figure 88). This swampy and cypress-filled lake (Figure 89) has a maximum depth of 12 feet. It was sampled six times prior to 2003 by DWQ.

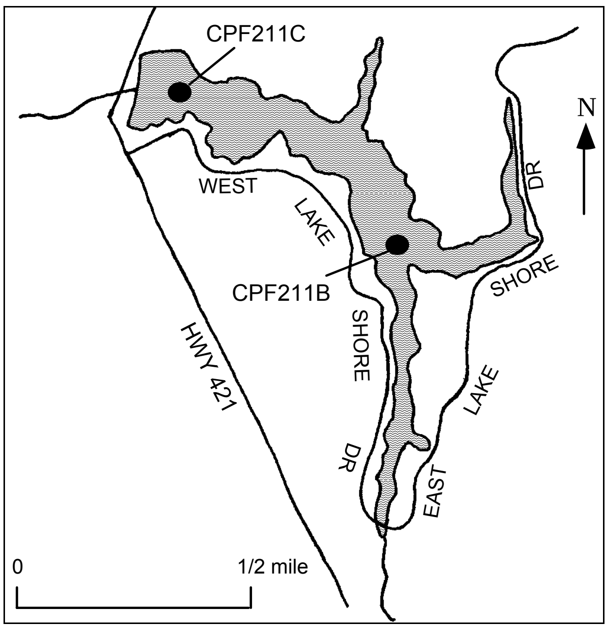


Figure 88. Sampling sites at Greenfield Lake, New Hanover County.

Figure 89. Greenfield Lake, New Hanover County.

The lake was most recently sampled in 2003. As in previous years, approximately 75 percent of the lake surface was covered with duckweed watermeal, and filamentous algae. *Chara* and *Egeria densa* are also found throughout the lake at nuisance levels.

In 2003 Secchi depths were greater than one meter (range = 1.2 -1.6 meters). Nutrient concentrations ranged from low to elevated. In August, surface dissolved oxygen concentrations at both monitoring sites were less than the water quality standard of 4.0 mg/L for an instantaneous reading (Appendix 22). The depressed oxygen concentrations may have resulted from the decomposition of benthic organic matter as well as oxygen uptake by algae. Based on the calculated NCTSI scores, Greenfield Lake was classified as mesotrophic in June and eutrophic in July and August, 2003.

The lake is on the 303(d) list due to impairment from aquatic macrophytes (primarily watermeal, duckweed, and Brazilian elodea) (NCDENR 2003a). Large areas of the lake were infested with alligator weed in 2003, which suggested that coverage may be increasing. This plant had formed dense mats which were blocking drainage structures leading to the lake

Water chemistry data and lake morphometry data were also collected in 2003 to aid in the development of a nutrient management plan to control the aquatic macrophytes. The TMDL study is scheduled for completion in late 2004.

Boiling Springs Lake

Boiling Springs Lake is a blackwater lake located in eastern Brunswick County (Figures 90 and 91). Land use upstream of the lake is mostly forested and residential. The lake is used for fishing and boating and is fed by several springs. The maximum depth is approximately 26 feet. The lake has been monitored five times prior to 2003 by DWQ.

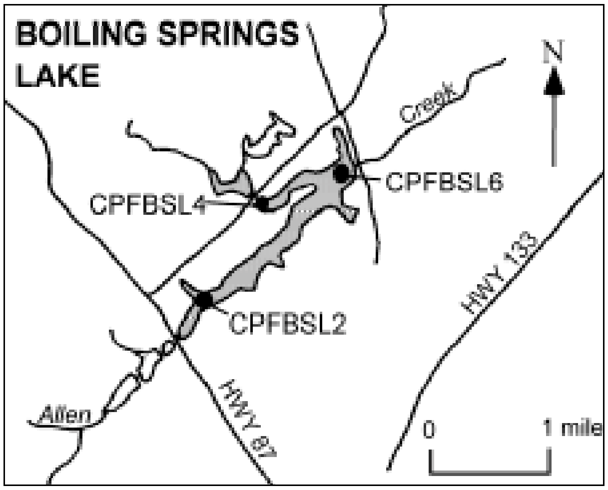


Figure 90. Sampling sites at Boiling Springs Lake, Brunswick County.

Figure 91. Boiling Springs Lake, Brunswick County.

The lake was drained in February 2002 after it was suspected that water was draining from sinkholes at a rate of an inch a day. Fifty-five sinkholes were discovered in the lake and several others outside the town limits *via* satellite photos. The sinkholes formed in the underlying limestone due to exposure to the acidic water of the lake. Tannic acid from pine trees dissolves limestone and it is believed that many of the small ponds in and around the Town of Boiling Springs may be the result of sinkholes (N & O 2002). The sinkholes were repaired and the lake was refilled in late 2002.

The lake was most recently sampled in 2003. Secchi depths were less than one meter and were similar to previously collected data. Chlorophyll *a* concentrations were greater than those previously observed but remained low (< 10 µg/L). Total phosphorus ranged from low to moderate and nitrogen concentrations were generally elevated. Frequent rainfall and storms in the summer may have increased nonpoint source runoff as well as suspended particulate organic matter normally at the bottom of the lake into the water column. This may have caused the increase in the observed nitrogen concentrations. Due to the dystrophic nature of this lake, the NCTSI scores cannot be accurately determined.

CAPE FEAR RIVER SUBBASIN 18

Description

Headwater areas and tributary streams in this subbasin are located within the Rolling Coastal Plain (Griffith *et al*. 2002). These streams flow into the South and Black Rivers which are located in the Southeastern Floodplains and Low Terraces ecoregion (Figure 92). Streams are slow moving, swampy, and darkly stained. The South River below Big Swamp is supplementally classified as Outstanding Resource Waters.

A majority of the land remains forested (Table 45) although there are many confined animal operations, primarily swine. Small municipalities include the towns of Dunn and Roseboro. There are two permitted dischargers in the subbasin, discharging a total of 0.03 MGD.

Table 45. Land use in Subbasin 18. Based upon CGIA coverage 1993 - 1995, total area = 495 square miles (NCDENR 1999).

Land use	Percent
Water	1
Cultivated crop	34
Pasture	7
Urban	2
Forest	56

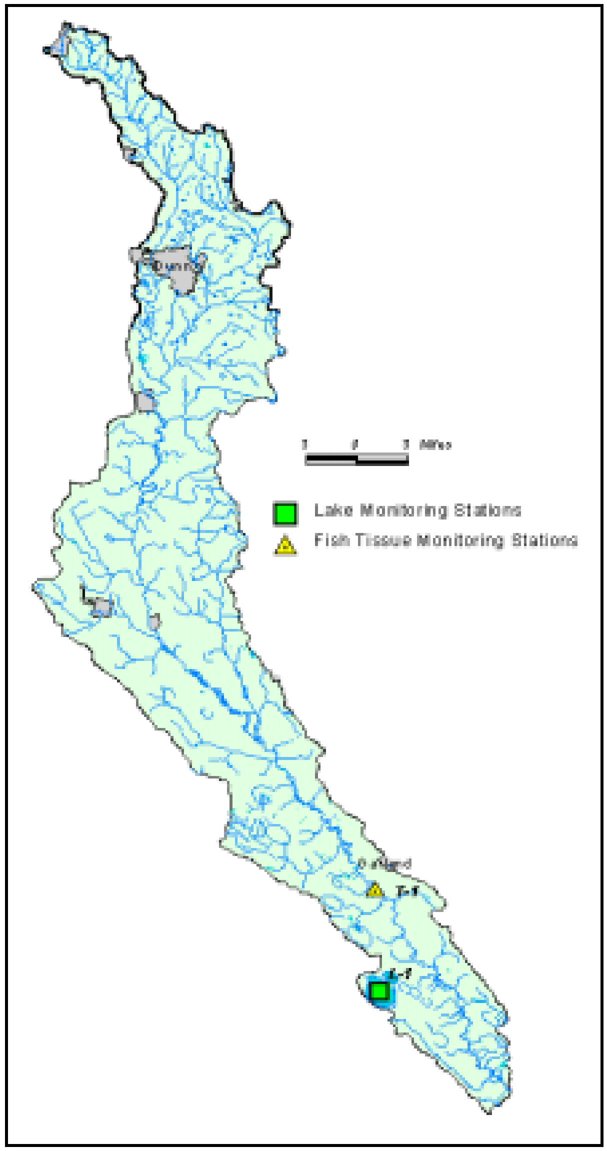


Figure 92. Sampling sites in Subbasin 18 in the Cape Fear River basin. Monitoring sites are listed in Table 46.

Overview of Water Quality

The benthic macroinvertebrate site on the South River has received a Good or Excellent rating since 1983. The 2002 drought affected the river but to what extent could not be determined due to higher than normal flows in 2003. Total mercury concentration in fish tissue (Table 46), though, continued to be a problem. Species affected include those currently under advisory and fishes typically associated with low mercury concentrations.

Bay Tree Lake, a dystrophic bay lake, had greater clarity in 2003 as measured by a Secchi disc and lower conductivity than in previous year. This resulted from increased precipitation in 2003. The lake continues to support low concentration of chlorophyll *a* and nutrients.

The two ambient monitoring sites on the South River, also coalition sites, showed no elevated water quality parameters (e.g. metals, fecal coliform, or chlorophyll *a*). There are no facilities in this subbasin that are required to perform Whole Effluent Toxicity testing.

Table 46. Waterbodies monitored in Subbasin 18 in the Cape Fear River basin for basinwide assessment, 1998 - 2003.

Map #[1]	Waterbody	County	Location	1998	2003
T-1	South R	NC 701	Sampson		
L-1	Bay Tree Lake	Bladen			

[1]T = fish tissue monitoring site and L = lake assessment site.

River and Stream Assessment

No streams in this subbasin were sampled in 2003 due to persistent high flow conditions during the summer (Appendix 1).

SPECIAL STUDIES
Impact of the 2002 Drought
An ongoing investigation on the effects of the 2002 drought included sampling of the South River in October 2002. The site was severely affected by the drought, after being Good or Excellent for five previous samplings since 1983.

Fish Tissue Contaminants

South River at NC 701
Forty fish tissue samples were collected from this site during 1999 and 2003. Total mercury concentrations exceeded the US EPA and North Carolina criteria of 0.4 ppm in 34 (85 percent) of the samples. Total mercury concentrations also exceeded the current US Food and Drug Administration action level of 1.0 ppm in 12 (32 percent) of the samples. Samples with mercury concentrations exceeding state and federal limits were composed of species currently under advisory (largemouth bass, bowfin, and chain pickerel) but also included species commonly associated with low mercury concentrations (spotted suckers, flathead catfish, redbreast sunfish, bluegill, warmouth, and yellow perch). All other metals were at concentrations were less than those of concern (Appendix 16).

Lake Assessment

Bay Tree Lake
Bay Tree Lake is a shallow (maximum depth is six feet), natural, Carolina Bay lake located near the Town of Elizabethtown (Figures 93 and 94). The lake is part of Bay Tree State Park. Typical of bay lakes, it receives no significant overland inflows. There is a network of drainage canals built along its northern and eastern shores. The surrounding land is flat, composed of wetlands and upland forests. Prior to 2003, the lake had been sampled seven times by DWQ.

Figure 93. Bay Tree Lake, Bladen County.

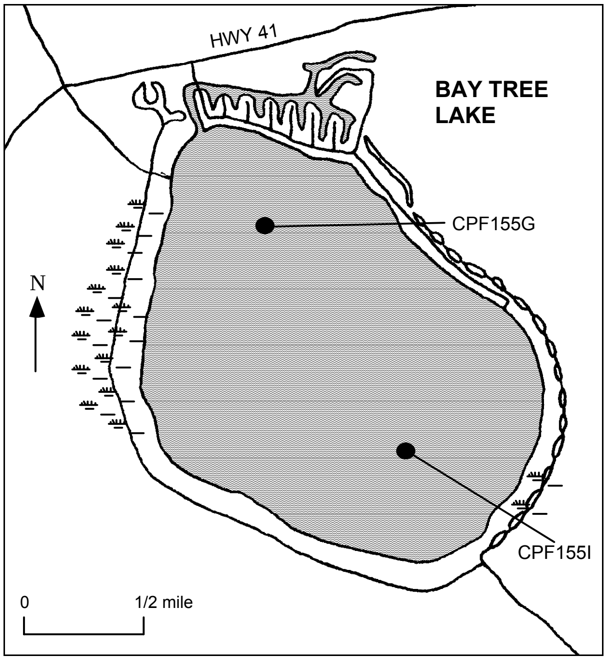


Figure 94. Sampling sites at Bay Tree Lake, Bladen County.

The lake was most recently monitored in 2003. Secchi depths were greater than those observed on previous sampling trips, but may have been more the result of an increase in the volume of water in the lake than an improvement in water clarity. As with measurements taken in earlier years, readings in 2003 were often to the bottom of the lake. Conductivities were slightly lower than in previous years and may have been due to increased dilution from frequent rainfall. The pH values were also slightly lower in 2003 than in previous years, suggesting an increase in suspended tannic materials. Nutrient concentrations and Chlorophyll a concentrations remained low. This lake is dystrophic and the NCTSI scores could not be accurately calculated due to the naturally dark, tannic waters.

CAPE FEAR RIVER SUBBASIN 19

Description

This subbasin is located primarily in the Rolling Coastal Plain ecoregion (Griffith *et al*. 2002). It contains a section of the Black River (upstream of the confluence with the South River) and its major tributaries, Six Runs, Great Coharie, and Little Coharie Creeks (Figure 95). The lower reaches of these watersheds are contained within the Southeastern Floodplain and Low Terraces. The Black River and Six Runs Creek are designated as Outstanding Resource Waters.

Land adjacent to the Black River is primarily undisturbed forest and approximately 50 percent of the subbasin is still forested (Table 47). The subbasin also contains very high concentrations of confined animal operations, especially swine. The Town of Clinton is the largest developed area within this subbasin. There are eight permitted dischargers in this subbasin, the largest being the Town of Clinton's WWTP (5.0 MGD to Williams Old Mill Branch). The remaining seven all discharge < 0.8 MGD.

Table 47. Land use in Subbasin 19. Based upon CGIA coverage 1993 - 1995, total area = 739 square miles (NCDENR 1999).

Land use	Percent
Water	< 1
Cultivated crop	34
Pasture	11
Urban	1
Forest	54

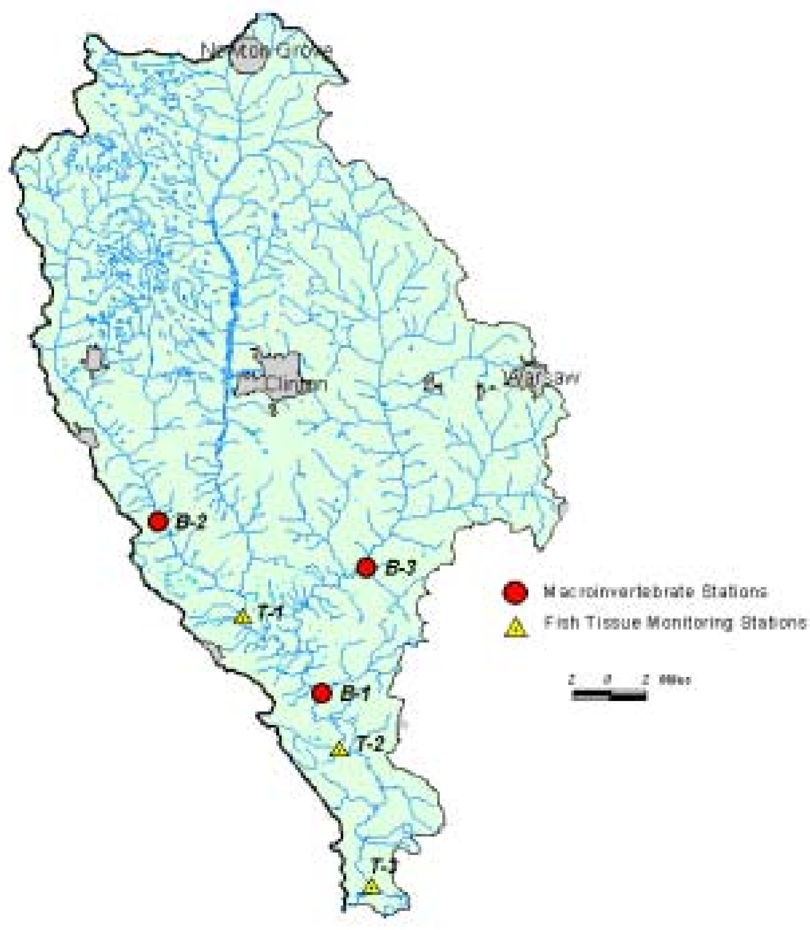


Figure 95. Sampling sites in Subbasin 19 in the Cape Fear River basin. Monitoring sites are listed in Table 48.

Overview of Water Quality

The effects of past desnagging operations are still apparent in this subbasin. After Hurricane Fran in 1996 the Natural Resource Conservation Service provided assistance for landowners to remove blow-down from waterways. The result was total removal of all snag habitat and subsequent reductions in macroinvertebrate diversity in the 1998 samplings. Interpreting current water quality relative to previous conditions, including the effects of the many hog operations in this subbasin, is made more difficult because of this habitat alteration. The Black River, for example, returned to Excellent based on benthos data after the hurricane desnagging and the 2002 drought. Little Coharie Creek showed improvement from Good-Fair in 1993 and 1998 to Good in 2003 (Table 48). But Six Runs Creek has not returned to Excellent since the desnagging efforts began.

Total mercury concentrations of fish tissue samples exceeded the US EPA and North Carolina criteria in 75 percent of the samples from Great Coharie Creek and two sites on the Black River. In 13 percent of these samples, mercury concentrations also exceeded the current US Food and Drug Administration action level. Fishes that exceeded state and federal limits for mercury included both species currently under advisory and species with historically low levels of mercury.

Ambient water chemistry data were collected from six DWQ and three coalition sites in this subbasin. No elevated water quality parameters (e.g. metals, fecal coliform, or chlorophyll *a*) were detected. There are two facilities that are required to perform Whole Effluent Toxicity testing -- Clinton-Larkins WPCF and the Town of Rosboro's WWTP. Neither facility failed testing during 2003.

Table 48. Waterbodies monitored in Subbasin 19 in the Cape Fear River basin for basinwide assessment, 1998 - 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Black R	Sampson	NC 411	Good	Excellent[2]
B-2	Little Coharie Cr	Sampson	SR 1214	Good-Fair	Good
B-3	Six Runs Cr	Sampson	SR 1960	Good	Good
T-1	Great Coharie Cr	Sampson	NC 701		
T-2	Black R	Sampson	NC 41		
T-3	Black R	Sampson	Near Ivanhoe		

[1]B = benthic macroinvertebrate monitoring sites and T = fish tissue monitoring sites.
[2]sampled in 2002.

River and Stream Assessment

Great Coharie Creek and the Black River were not sampled in 2003 due to high flow conditions that persisted at the sites during the summer sampling period (Appendix 1).

Black River, NC 411

Due to high water levels, the Black River was not sampled in 2003, but was sampled in 2002 for an investigation of the prolonged 2002 drought. Generally, this site has been rated Excellent since 1985. A rating of Good in October 1998 was the result of flooding due to Hurricane Bonnie the previous month.

There is an unusually diverse aquatic community found in this large (17 meters wide) black-water river (Figure 96).

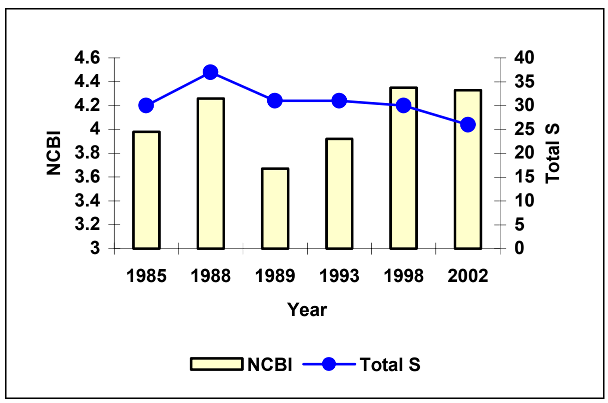


Figure 96. Taxonomic richness (Total S) and Biotic Index (NCBI) at the Black River at NC 411, Sampson County, 1985 to 2002.

However, it was noted that in 1998 and 2002 most of the snag habitat had been removed from the river. Also, some intolerant taxa were not collected in those years, but were present in previous years. These taxa include *Baetisca gibbera, Paraleptophlebia, Pteronarcys dorsata*, and *Lepidostoma* sp. Other taxa changes indicated an increase in enrichment (e.g. *Dicrotendipes*, *Rheotanytarsus*, and *Dugesia tigrina*). This large watershed (676 square miles) includes many confined animal operations.

Little Coharie Creek, SR 1214
Little Coharie Creek has a drainage area of 139 square miles, a width of 10 meters, and a sandy substrate. Good flow occurred only in limited areas. Instream habitat was improved over 1998 sampling and the overall habitat scored high (77).

Little Coharie Creek at SR 1214, Sampson County.

This stream was rated Good in 1989 and Good-Fair in 1993 and 1998. The site currently rates Good with little change in EPT S over the last 10 years.

Six Runs Creek, SR 1960
After receiving an Excellent rating in 1993, this site has remained Good for the past two sampling events. The absence of snag habitats in this 15-meter wide stream was cited as a concern during 1998. Snag habitat was more common in 2003, but still remains scarce. This was reflected in the continued absence of snag-associated taxa like *Brachycentrus numerosus* and *Lepidostoma* sp. Overall, the habitat scored 72. Drainage area for this site is 226 square miles.

Six Runs Creek at SR 1960, Sampson County.

SPECIAL STUDIES
Impact of the Town of Magnolia's WWTP
Benthic macroinvertebrate samples were collected below the Town of Magnolia's WWTP to determine any impacts of chronic bypassing of sludge during precipitation events. Sampling was conducted in April 2000 on UT Millers Creek, the receiving stream, and UT Stewarts Creek at SR 1107, a reference site. The data strongly suggested that chronic bypassing and sludge from the WWTP resulted in toxic conditions downstream (Biological Assessment Unit Memorandum B-000426).

Impacts from Hurricane Fran
The sampling of Stewarts Creek at SR 1943 in October 1996 after Hurricane Fran (September 1996) resulted in a Fair rating and placement of the stream on 303 (d) list (Biological Assessment Unit Memorandum B-970117). Only eight EPT taxa were collected and the BI was 5.2. This differed from the Good-Fair rating in December 1989 with 17 EPT S and a BI of 4.7.

Two samples were collected in 2003, one in March and one in September. Both samples indicated that this site has recovered from the effects of the hurricane (EPT S = 20). Based on the September 2003 data, the site currently is rated Good. (Biological Assessment Unit Memorandum B-030910).

Fish Tissue Contaminants

Great Coharie Creek at NC 701, Black River at NC 41, and Black River at Ivanhoe

Seventy-four fish tissue samples were collected from these sites during 2000 and 2003. Total mercury concentrations exceeded the US EPA and North Carolina criteria of 0.4 ppm in 56 (75 percent) of the samples. Total mercury concentrations also exceeded the current US Food and Drug Administration action level of 1.0 ppm in 10 (13 percent) of the samples. Samples with mercury concentrations exceeding state and federal limits were composed of species currently under advisory (largemouth bass, bowfin, and chain pickerel) but also included species commonly associated with low mercury concentrations (spotted suckers, bluegill, and yellow perch). All other metals were at concentrations were less than those of concern (Appendix 16).

CAPE FEAR RIVER SUBBASIN 20
Description

This subbasin is located primarily in the Carolina Flatwoods ecoregion with areas along the Black River in the Mid-Atlantic Floodplains and Low Terraces ecoregion. Waterbodies include the lower Black River and its tributaries Colly Creek, Lyons Swamp Canal and Moores Creek (Figure 97).

Except for the Black River, all streams in this subbasin may stop flowing during years with normal summer rainfall. Tributary streams (Colly Creek and Lyon Swamp Canal) in the western part of the subbasin drain out of an area of Carolina Bays and are highly acidic (Mallin 2002). Moores Creek, in the eastern part of the subbasin, however, has a greater pH and a more diverse aquatic fauna. Lyons Swamp Canal has been extensively channelized and has very poor riparian habitats (Figure 98).

Figure 98. Lyon Swamp Canal, NC 11, Bladen County.

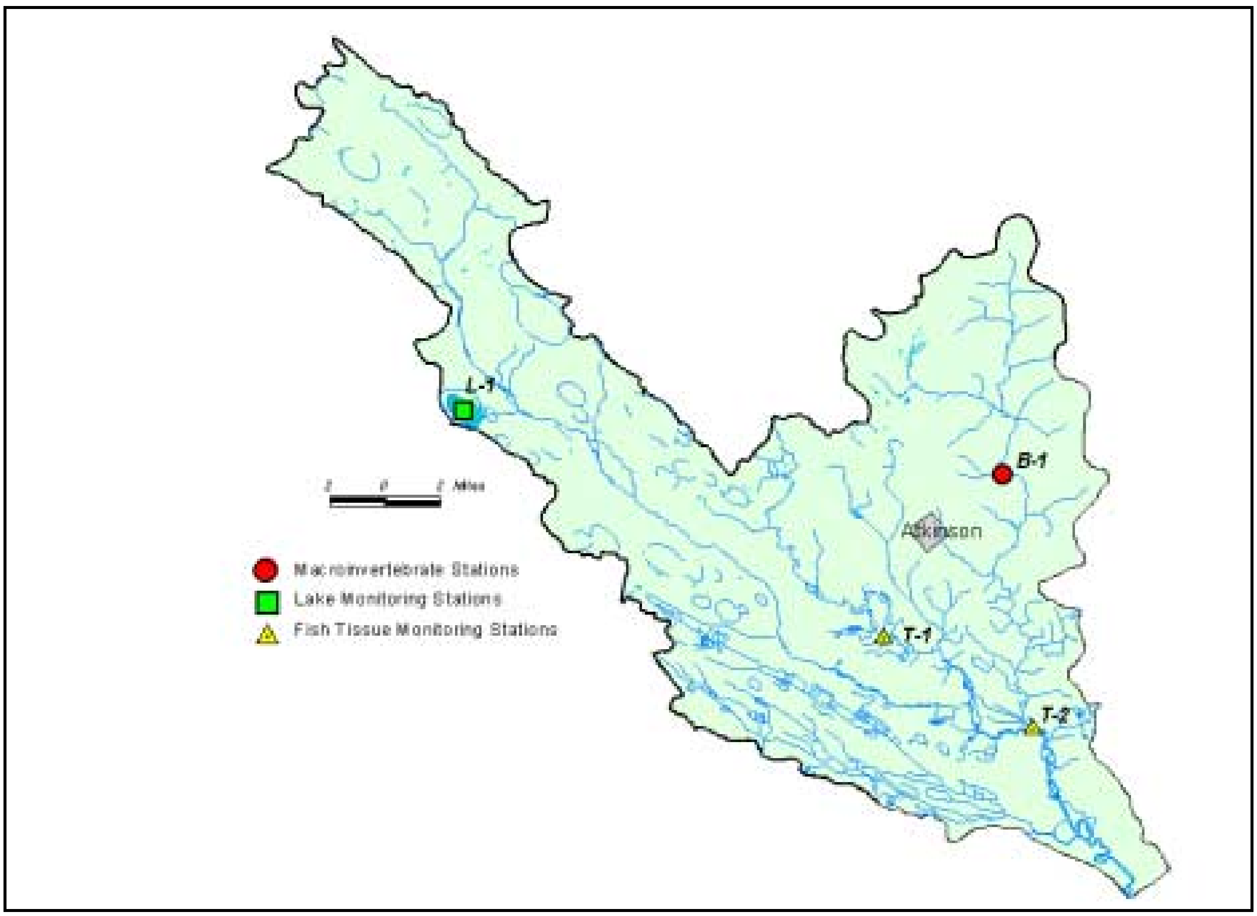


Figure 97. Sampling sites in Subbasin 20 in the Cape Fear River basin. Monitoring sites are listed in Table 50.

The Black River has been classified as Outstanding Resource Waters (ORW). It supports a cypress-gum swamp that is one of the best examples of old-growth swamp forest in the eastern United States (LeBlond, 2000). The subbasin also contains Singletary Lake State Park. The aquatic fauna is limited by extremely low pH values. The pH in Singletary Lake is usually around 4.0 s.u., while the pH of streams in this area varies from 3.4 to 5.6 s.u.

This subbasin contains no major urban areas, but includes the Towns of White Lake, Currie, and Atkinson. Almost 80 percent of the subbasin is forested (Table 49). The Town of White Lakes WWTP (0.6 MGD to UT Colly Creek) is the only NPDES permitted discharger in the subbasin.

Table 49. Land use in Subbasin 20. Based upon CGIA coverage 1993 - 1995, total area = 343 square miles (NCDENR 1999).

Land use	Percent
Water	< 1
Cultivated crop	18
Pasture	3
Urban	< 1
Forest	78

Overview of Water Quality

Benthic macroinvertebrate data indicated Excellent water quality in the Black River for nearly a decade, although high flows prevented any sample collection in 2003. The diversity of the aquatic fauna in tributary streams is limited by intermittent flow (usually with no summer flow) and extremely low pH values.

Moores Creek was the only site sampled for benthic macroinvertebrates in 2003 (Table 50). This stream was rated as moderately stressed in 1998 and 2003.

Fifty fish tissue samples were collected from Moores Creek and the Black River in this subbasin sites from 1999 to 2001. Total mercury concentrations exceeded the US EPA and North Carolina criteria in 64 percent of the samples. Total mercury concentrations also exceeded the current US Food and Drug Administration action level 20 percent of the samples. Samples with mercury concentrations exceeding state and federal limits were composed of species currently under advisory but also included species commonly associated with low mercury concentrations.

Singletary Lake is a dystrophic lake surrounded by wetlands. Water quality was similar to previous years although rainfall appeared to have stirred up benthic and epiphytic algae resulting in elevated chlorophyll *a* concentrations.

Ambient water chemistry data were collected from three sites in this subbasin. No elevated water quality parameters (e.g. metals, fecal coliform, or chlorophyll *a*) were detected at any of the sites.

Table 50. Waterbodies monitored in Subbasin 20 in the Cape Fear River basin for basinwide assessment, 1998 - 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Moores Cr	Bladen	NC 53 or SR 1128	Moderate	Moderate
T-1	Moores Cr	Bladen	At mouth		
T-2	Black R	Bladen	At Longview		
L-1	Singletary Lake	Bladen			

[1]B = benthic macroinvertebrate monitoring sites.; T = fish tissue monitoring sites; and L = lake assessment sites.

River and Stream Assessment

Due to high summer flows, the Black River was not sampled in 2003 (Appendix 1). Lyon Swamp Canal was not sampled in 2003 due to high winter flows. At Lyon Swamp Canal benthic macroinvertebrate data are not good indicators of water quality and the monitoring site at NC 11 should be declined from basinwide assessment.

Moores Creek, SR 1128

Moores Creek was evaluated as a Region A swamp stream and sampled during the winter of

2003. The site at NC 53 was too deep to sample, so the location was moved one bridge upstream to SR 1128. Both sites had similar pH values (5.6 and 5.7 s.u.) and conductivity (70 and 71 μmhos/cm). The stream had a mean width of 10 meters with a firm sand-silt bottom. There was good habitat diversity including snags, macrophytes, patches of filamentous algae, and roots (habitat score = 85).

Moores Creek, SR 1128, Pender County.

The fauna was dominated by typical swamp-stream fauna, including isopods, orthoclad midges and *Leptophlebia intermedia*. The stream was rated Moderate in 1998 and 2003.

ADDITIONAL DATA

The Center for Marine Science at the University of North Carolina-Wilmington has been sampling the lower Cape Fear River for water chemistry, macroinvertebrates, and fish since June 1995. There are three sites in this subbasin, two on the Black River and one on Colly Creek (Mallin *et al*. 2002). Few significant problems were noted. Recent reports by this group can be found at http://www.uncwil.edu/cmsr/aquaticecology/lcfrp.

Fish Tissue Contaminants

Moores Creek at mouth and Black River at Longview

Fifty fish tissue samples were collected from these sites from 1999 to 2001. Total mercury concentrations exceeded the US EPA and North Carolina criteria of 0.4 ppm in 32 (64 percent) of the samples. Total mercury concentrations also exceeded the current US Food and Drug Administration action level of 1.0 ppm in 10 (20 percent) of the samples. Samples with mercury concentrations exceeding state and federal limits were composed of species currently under advisory (largemouth bass, bowfin, and chain pickerel) but also included species commonly associated with low mercury concentrations (spotted suckers, redear sunfish, spotted sunfish, warmouth, and black crappie). All other metals were at concentrations were less than those of concern (Appendix 16).

Lake Assessment

Singletary Lake

Singletary Lake, located near Bay Tree and White Lakes, is a natural Carolina Bay Lake (Figures 99 and 100). The surrounding terrain is flat and swampy with almost no overland water inputs. The lake is owned by the State of North Carolina and used for swimming, boating, and fishing. The lake has been sampled six times prior to 2003.

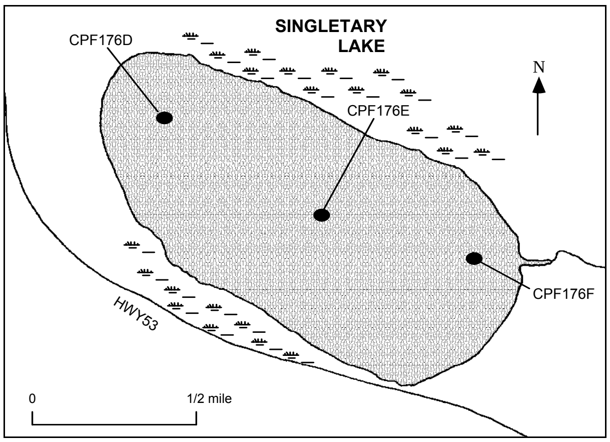


Figure 99. Sampling sites at Singletary Lake, Bladen County.

Figure 100. Singletary Lake, Bladen County.

The lake was most recently sampled in 2003. Despite the frequent rainfall, Secchi depths and nutrient concentrations were not different from those observed in previous years. Chlorophyll *a* concentrations were generally slightly higher in 2003 than in previous years with the most notable increase (25 µg/L) observed at Station CPF176E in June. As with White Lake, the source of this chlorophyll *a* may have been suspended benthic and epiphytic algae released into the water column by rain events over the lake. Algal densities were within normal ranges for an oligotrophic lake (2,000 units/ml). However, biovolume was 4,000 mm^3/m^3, which was close to the level considered to be a bloom (5,000 mm^3/m^3). The dominant alga was *Gonyostomum* sp. This lake is dystrophic and the NCTSI scores could not be accurately calculated due to the naturally dark, tannic waters.

CAPE FEAR RIVER SUBBASIN 21

Description

This subbasin, located in the Rolling Coastal Plain ecoregion (Griffith *et al*. 2002), contains the headwaters of the Northeast Cape Fear River and its tributaries (Figure 101). Most of this subbasin is in northern Duplin County, with approximately one-third of the subbasin in southern Wayne County. Cultivated crops constitute almost 50 percent of the landuse (Table 51). The only town in this area is Mt. Olive. There are two significant dischargers in this subbasin:

- the Mt. Olive Pickle Company, (0.4 MGD, to Barlow Branch; and
- the Town of Mt. Olive (1 MGD, to the Northeast Cape Fear River.

Table 51. Land use in Subbasin 21. Based upon CGIA coverage 1993 - 1995, total area = 119 square miles (NCDENR 1999).

Land use	Percent
Water	< 1
Cultivated crop	45
Pasture	7
Urban	1
Forest	47

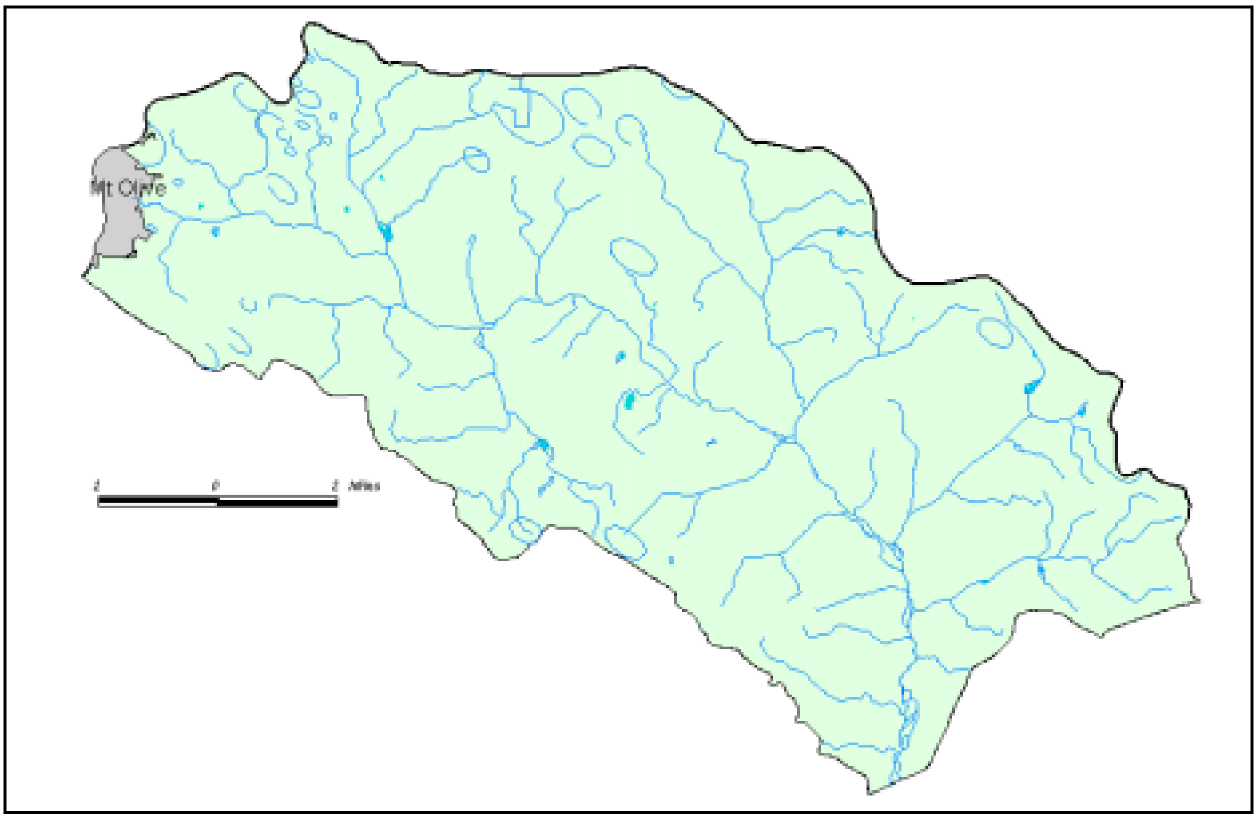


Figure 101. Subbasin 21 in the Cape Fear River basin. No basinwide monitoring was conducted in this subbasin during the assessment period.

Overview of Water Quality

Two ambient water chemistry monitoring sites exist on the Northeast Cape Fear River, near Mt. Olive and near the Town of Williams. These stations revealed no elevated water quality parameters except for one chlorophyll *a* measurement.

Two facilities are required to perform Whole Effluent Toxicity testing – the Mt. Olive Pickle Company and the Town of Mt. Olive's WWTP. Compliance records indicated that both facilities were tested 20 times (including four times each in 2003). The WWTP has passed every test whereas Mt. Olive Pickle has always failed its tests. In 1996, the Environmental Management Commission granted the facility a variance from the chloride action level and for its whole effluent toxicity limit.

River and Stream Assessment

Due to high flows, the Northeast Cape Fear River at SR 1948 was not sampled in 2003 (Appendix 1). Buck Marsh Branch at NC 111 will no longer be used as a summer basin site because it is more appropriately sampled in the winter. No benthic macroinvertebrate sites were sampled in this subbasin in 1998 due to low flow conditions. Except for one special study, this subbasin has not been assessed in the past 10 years

SPECIAL STUDIES
Kenansville WWTP
As part of an investigation of an alleged sludge spill from the Town of Kenansville's WWTP, the Wilmington Regional Office requested the assistance of the Biological Assessment Unit. Two sites on Grove Creek were sampled in March 2001; one at SR 1301 (upstream of spill) and another at NC 11 (downstream of spill). No discernible impacts on the benthic macroinvertebrate community were documented at either site (Biological Assessment Unit Memorandum B-010419).

CAPE FEAR RIVER SUBBASIN 22

Description

This subbasin, containing the Northeast Cape Fear River and its tributaries in Duplin County (Figure 102), is located in the Middle Atlantic Coastal Plain ecoregion with a portion of the headwaters area in the Southeastern Plains ecoregion (Griffith *et al*. 2002). More than one-half of the subbasin is forested (Table 52), but there are also large concentrations of confined animal operations (primarily swine). Only one percent of the subbasin is urbanized near the towns of Beulaville, Kenansville, Rose Hill, and Wallace.

There are 13 permitted dischargers in this subbasin. The largest of these are:

- the Town of Wallace's WWTP No. 2 (5.4 MGD to Rockfish Creek);
- Circle S Foods (1.5 MGD to Rockfish Creek);
- Guilford Mills, Inc (1.5 MGD to Northeast Cape Fear River), and
- the Town of Wallace's WWTP No. 1 (1.0 MGD to Rockfish Creek).

The remaining nine dischargers have a combined outflow of less than 1.0 MGD.

Table 52. Land use in Subbasin 22. Based upon CGIA coverage 1993 - 1995, total area = 829 square miles (NCDENR 1999).

Land use	Percent
Water	1
Cultivated crop	30
Pasture	10
Urban	1
Forest	58

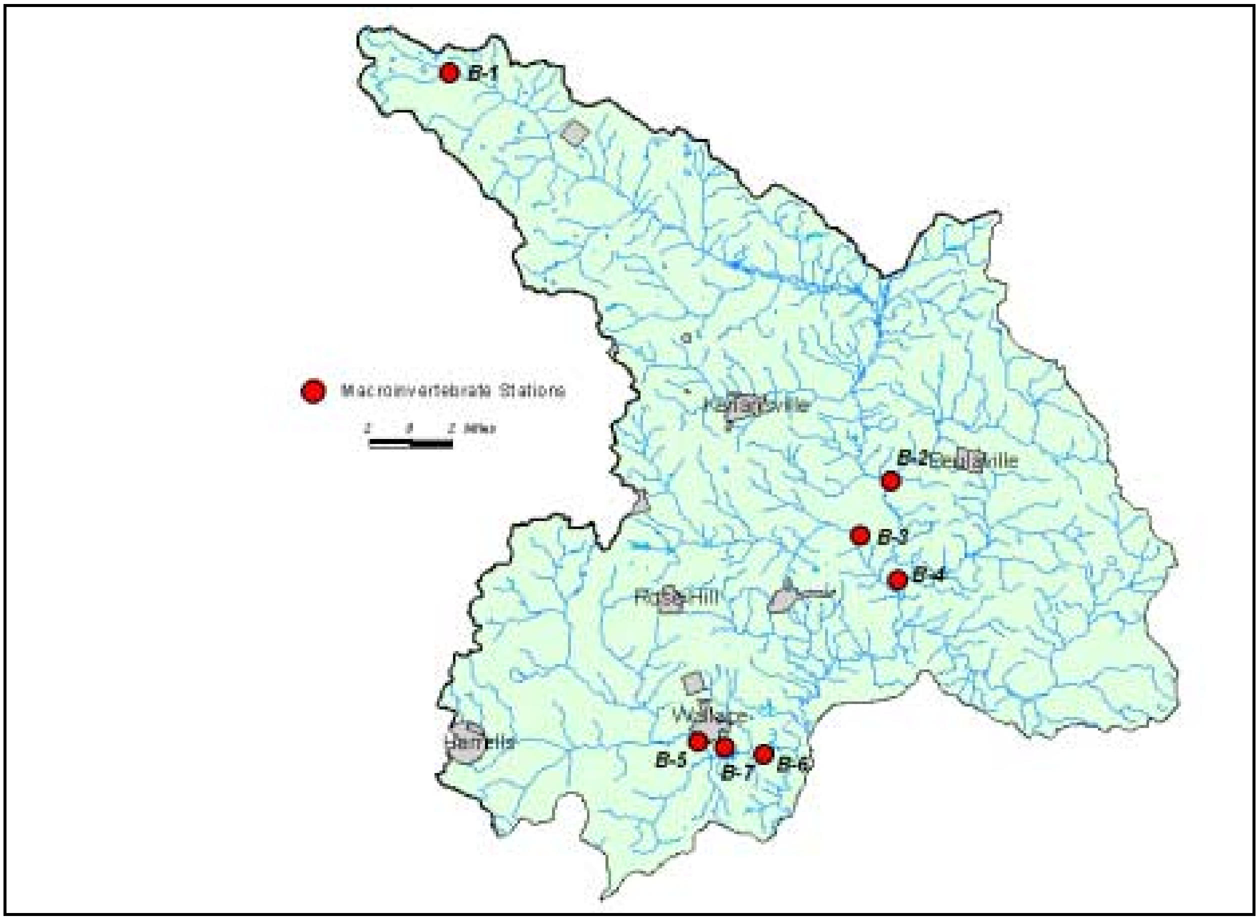


Figure 102. Sampling sites in Subbasin 22 in the Cape Fear River basin. Monitoring sites are listed in Table 53.

Overview of Water Quality

Water quality monitoring in 2003 showed that nonpoint source pollution including organic loadings from animal operations was affecting water quality in this subbasin. The only swamp site monitored, Goshen Swamp, had low dissolved oxygen indicators and rated Severe. Both Rockfish Creek sites showed an abundance of organic enrichment indicators. Most streams in this subbasin received high habitat scores but rated Fair and Good-Fair with respect to their benthic communities (Table 53).

Cabin Lake is a man-made lake that is dystrophic with naturally low pH and tannic-colored waters. Monitoring revealed extremely elevated nutrient concentrations. The source was thought to be the animal operations in the immediate area near the lake (exacerbated by the abundant precipitation in 2003 through runoff). Increased algal productivity resulted in two blooms during the summer.

Three DWQ and five coalition monitoring sites are located in this subbasin. Little Rockfish Creek had fecal coliform concentrations that significantly exceeded water quality standards.

Seven facilities in this subbasin are required to perform Whole Effluent Toxicity testing. Charles F. Cates & Sons has failed all of its 16 tests. The Environmental Management Commission granted the facility a variance from the chloride action level and its whole effluent toxicity limits. Four other facilities had failure rates between 5 and 46 percent during the assessment period.

Table 53. Waterbodies monitored in Subbasin 22 in the Cape Fear River basin for basinwide assessment, 1998 - 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Goshen Swp	Duplin	SR 1725	---	Severe
B-2	Limestone Cr	Duplin	SR 1702	Good-Fair	Good-Fair
B-3	Stockinghead Cr	Duplin	SR 1953	Good-Fair	Good-Fair
B-4	Muddy Cr	Duplin	NC 41	Fair	Fair
B-5	Rockfish Cr	Duplin	SR 1165	Fair	Good-Fair
B-6	Rockfish Cr	Duplin	I-40	Good-Fair	Good-Fair
B-7	Little Rockfish Cr	Duplin	NC 11	---	Not Rated
L-1	Cabin Lake	Duplin			

[1]B = benthic macroinvertebrate monitoring sites; L = lake assessment site.

River and Stream Assessment

Goshen Swamp, SR 1725

Goshen Swamp at SR 1725 was considered severely stressed in 2003. In May 1993, before the current techniques to rate swamp streams were developed, three locations were sampled (SR 1302, Wayne County and US 117 and NC 403 Duplin County) to measure the effects of effluent from the Cates Pickle Company in Panther Branch. At that time, water quality reportedly recovered in Goshen Swamp within two miles of Panther Branch (receiving stream). The three 1993 sampling locations averaged 10 EPT with a BI of 6.7.

Goshen Swamp at SR 1725 is located upstream of the 1993 samplings and the input from the Cates Pickle Company. However, there are a large number of agricultural areas in these headwaters including hog farms that may be impacting water quality. Low dissolved oxygen conditions are evident by an abundance of *Kiefferulus* sp. and *Bittacomporpha clavipes*. The habitat scored 80, suggested that the water quality itself is degraded. The drainage area is 13 square miles.

Goshen Swamp, SR 1725, Duplin County.

Limestone Creek, SR 1702

Limestone Creek at SR 1702 has a drainage area of 60 square miles and a width of four meters, with a uniform substrate of unstable fine sand. This stream was recently de-snagged. Recent sand deposits were evident on the banks, which were continuously eroding back to the stream. Instream habitat was scarce because of this blanket of sand and to recent de-snagging efforts. Riparian areas had little vegetation to hold the banks in place. Pools were essentially absent. The overall habitat score was 40.

Limestone Creek at SR 1702, Duplin County.

In 1993 Limestone Creek rated Excellent, but this rating declined to Poor after a spill of chicken waste in June 1995. This rating improved to Good-Fair in 1998. It was rated Good-Fair in 2003. The community has recovered from the spill, but continued to suffer the effects of habitat removal and nonpoint source inputs.

Stockinghead Creek, SR 1953

Stockinghead Creek has a drainage area of 66 square miles with an average depth of 0.5 meters and a width of eight meters. In 2003 the site was rated Good-Fair with 16 EPT S and a BI of 5.14. This was similar to ratings of Good-Fair in 1998 (12 EPT) and 1993 (13 EPT). The site continued to be dominated by *Acerpenna pygmaea*, *Stenonema modestum* and *Stenacron interpunctum*. Overall habitat is relatively good, scoring 76, yet the instream habitat consists of mostly sand (80 percent) and silt (20 percent).

Stockinghead Creek, SR 1953, Duplin County,

Muddy Creek, NC 41

Muddy Creek has a drainage area of 47 square miles and is three meters wide with a substrate composed of mostly sand and some silt. Despite the Fair rating, the habitat, bank condition and riparian zone continue to be good. The overall habitat score was 78. This watershed also contains many hog farms.

Muddy Creek was not rated in 1993 because of its small size (one meter wide). The change in width was probably due to Hurricane Fran (1996). An increase in water quality occurred from 1993 to 1998, as evident by the increase of intolerant EPT taxa. However, Muddy Creek remained Fair with respect to water quality in 2003, in spite of a high habitat score.

Rockfish Creek, SR 1165

This site, located above the Town of Wallace, drains an area of 132 square miles and was 12 meters wide with sand substrate and good instream habitat. De-snagging efforts had reduced the riparian habitat during 1998. The overall habitat score was 69 in 2003. The rating declined from Good-Fair in 1993 to Fair in 1998. The 2003 rating, Good-Fair, showed that the stream had recovered. EPT S decreased from 14 in 1993 to 8 in 1998. This trend was reversed in 2003 when 17 EPT S were collected. Organic enrichment indicator taxa found in 1998 (*Cricotopus bicinctus, Dicrotendipes* sp*., Chironomus,* and *Phaenopsectra*) were absent in 2003.

Rockfish Creek at SR 1165, Duplin County.

Rockfish Creek, I-40
This site has a 175 square mile drainage area and is 11 meters wide with a predominately sand substrate. Instream habitat was moderate, with recent de-snagging efforts evident. Flow was reduced in much of the reach. The habitat scored slightly lower (56) than the upstream site (69). This site is directly downstream of three major NPDES dischargers, the two Town of Wallace's municipal WWTPs (55.4 MGD) and Circle S Food's WWTP (15 MGD).

Rockfish Creek at I 40, Duplin County.

Water quality improved from Fair to Good-Fair between 1993 and 1998. The Fair rating in October 1998 was the result of sampling after Hurricane Bonnie. It appeared that the catchment has recovered from the effects of Hurricane Bonnie as the site currently rates Good-Fair. However, organic enrichment indicator taxa such as *Cricotopus bicinctus*, *Phaenopsectra*, and *Tribelos* were abundant in 2003. These taxa were less common in 1993 and 1998.

Little Rockfish Creek, NC 11
Little Rockfish Creek was sampled for the first time in February 2003 as a swamp stream. No rating was assigned because this site would be more appropriately sampled as a Coastal A stream because it had good flow. This site was inadvertently not resampled in summer. The habitat at this site scored 53 and the drainage area is nine square miles.

Little Rockfish Creek, NC 11, Duplin County.

Only four EPT S were found in February, and the BI measured 7.3, an obvious sign of degradation.

Lake Assessment

Cabin Lake
Cabin Lake is a part of the Duplin County Cabin Lake Recreational Park (Figures 103 and 104). Located between the towns of Kenansville and Beulaville, the lake was formed from the damming of Cabin Creek in 1993. Land use within the immediate watershed consists of farmlands, forests, and animal operations.

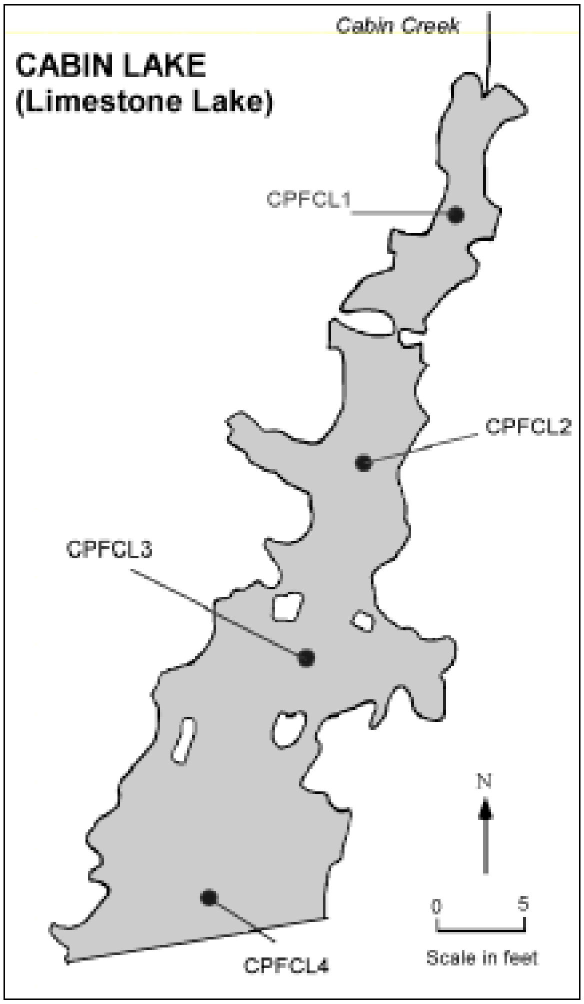


Figure 103. Sampling sites at Cabin Lake, Duplin County.

Figure 104. Swimming area at Cabin Lake, Duplin County.

Cabin Lake was sampled most recently in 2003. The pH is naturally low and the water is tannin stained, typical of dystrophic lakes. Secchi depths were consistently low (Appendix 22). Surface dissolved oxygen concentrations were also low, but were not less than the water quality standard of 4.0 mg/L for an instantaneous reading. Nutrient concentrations were extremely elevated.

Chlorophyll *a* concentrations increased from a lake-wide mean of 7µg/L in June to 91 µg/L in August. The greatest concentration (240 µg/L) was observed at Station CPFCL2 in August. This increase in algal productivity was likely a response to the elevated nutrient concentrations. Water samples were also collected from Cabin Creek in August. Nutrient concentrations were similar to those observed in the lake and the chlorophyll a concentration was 150 µg/L.

Small diatoms (primarily *Synedra* sp.) dominated the phytoplankton in June and July with a mild algal bloom present in July. In August a bloom comprised of the flagellate *Gonyostomum* sp. was found. This algae, common in low pH waters, can form nuisance blooms in summer but there are no known human or environmental health risks (Wehr and Sheath 2003). Due to the dystrophic nature of this lake, the NCTSI score could not be determined.

Fecal coliform bacteria concentrations were greatest at Station CPFCL1 in June and July (140 and 88 colonies/100 ml, respectively). The highest concentrations in August were observed in the creek immediately upstream of the lake (130 colonies/100 ml). Concentrations near the lower end of the lake (Station CPFCL4) in 2003 ranged from 5 to 65 colonies/100 ml.

These concentrations did not represent the results of a geometric mean of five consecutive samples taken within a 30 day period; however they were less than the geometric mean (200 colonies/100 ml) and instantaneous standards (400 colonies/100 ml). These concentrations may have been influenced by an increase in nonpoint source runoff from the frequent rainfall events which occurred within the watershed during the summer. There have been no reported complaints of illness or skin problems related to swimming. Bacteria sampling is also conducted by the county health department. Bacterial concentrations in the lake have not been found to present a potential health risk to swimmers.

CAPE FEAR RIVER SUBBASIN 23

Description

This subbasin includes the lower half of the Northeast Cape Fear River catchment (Figure 105). All streams in this subbasin may stop flowing during a summer with normal rainfall and much of the Northeast Cape Fear River has no visible flow during the summer. This subbasin is located primarily in the Carolina Flatwoods Ecoregion. But two other ecoregions also are present -- the Mid-Atlantic Floodplains and Low Terraces which borders the Northeast Cape Fear River and Nonriverine Swamps and Peatlands located in the eastern portion of the subbasin. Streams that flow out of these two swamps, Angola and Holly Shelter Swamps, are strongly colored by humic acids and may have pH values less than 4.0 s.u.

This patchwork of different ecoregions creates three very different stream types:

- The Northeast Cape Fear River -- portions of the river with higher current speed have the potential for high species diversity, although the river is potentially impacted by many point and nonpoint source problems.
- Highly acidic swamp streams -- the diversity of aquatic species may be limited by low pH values, especially if the pH is less than 4.0 s.u. Lowest pH values occur during periods of high flow. These streams are placed in Swamp Region P (Pocosin).
- Slightly acidic swamp streams -- these streams occur in the western or southern portion of the subbasin near Wilmington. These streams are placed in Swamp Regions A or B.

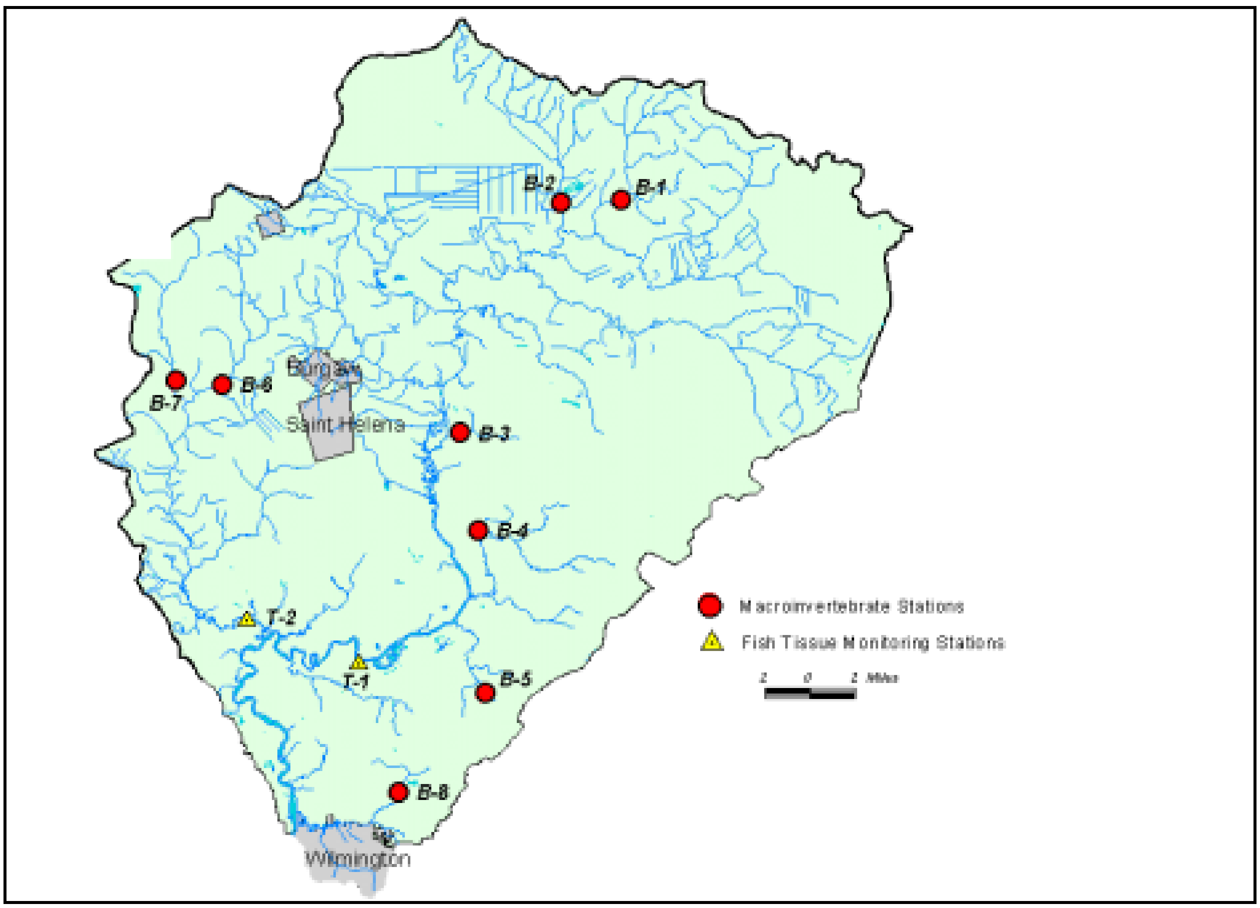


Figure 105. Sampling sites in Subbasin 23 in the Cape Fear River basin. Monitoring sites are listed in Table 55.

More than eighty percent of the subbasin was forested in 1993 (Table 54). However, in the southern part of the subbasin, the northern metropolitan area of the City of Wilmington is expanding and the percentage of urban land use will undoubtedly increase as the percentage of forested land declines. There is little development in the wet Pocosin areas, but agricultural land use (row crops and confined animal operations) is found along the edges of the pocosins and throughout the rest of the subbasin.

Table 54. Land use in Subbasin 23. Based upon CGIA coverage 1993 - 1995, total area = 795 square miles (NCDENR 1999).

Land use	Percent
Water	1
Cultivated crop	11
Pasture	3
Urban	2
Forest	83

There are only seven permitted dischargers; the largest is Occidental Chemical (1.7 MGD to the Northeast Cape Fear River) and the Town of Burgaw's WWTP (0.8 MGD to Burgaw Creek).

Overview of Water Quality

Though it could not be sampled in 2003 due to high water levels, the middle portion of the Northeast Cape Fear River has the greatest potential for a diverse aquatic fauna, as this area combines good habitat, high pH values, and high current speed. Tributary streams are often limited by low pH, especially those draining Holly Shelter Creek. Two of these were rated as Natural in 2003 (Merricks and Lillington Creeks) and Angola Creek was rated as Good (Table 55). Some streams have shown a temporary impact after hurricanes. A Moderate stress rating was given to benthic samples from Holly Shelter and Cypress Creeks. Severe stress was noted at Long and Smith Creeks which are channelized streams with tolerant benthic fauna.

Ambient water chemistry data were collected from 10 DWQ and coalition monitoring sites. Low dissolved oxygen concentrations were frequently documented from all sites, especially during the summer or following hurricanes. A comparison of the Northeast Cape Fear River with the Black River, a similar river but having less development that the Northeast Cape Fear River, suggested wastewater treatment plants and hog farms magnified the negative impacts of recent hurricanes. Problems related to low dissolved oxygen and high nutrient and fecal coliform bacteria concentrations have been documented in Burgaw Creek. Whole effluent toxicity monitoring at three facilities in the subbasin indicated no toxicity problems.

Table 55. Waterbodies monitored in Subbasin 23 in the Cape Fear River basin for basinwide assessment, 1998 - 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Holly Shelter Cr	Pender	NC 50	---	Moderate
B-2	Angola Cr	Pender	NC 53	Not Rated	Good
B-3	Lillington Cr	Pender	SR 1520	Moderate (1997)	Natural
B-4	Merricks Cr	Pender	NC 210	Natural	Natural
B-5	Island Cr	New Hanover	SR 1336	---	Not Rated
B-6	Long Cr	Pender	NC 53	Not Rated	Severe
B-7	Cypress Cr	Pender	NC 53	Moderate	Moderate
B-8	Smith Cr	New Hanover	I-40	---	Severe
T-1	Northeast Cape Fear R	New Hanover	Near Castle Hayne		
T-2	Long Cr	Pender	Near Clark's Landing		

[1]B = benthic macroinvertebrate monitoring sites, and T = fish tissue monitoring sites.

River and Stream Assessment

Flow conditions during February 2003 were slightly above normal, but this did not preclude being able to sample most of the prior basinwide benthic macroinvertebrate swamp streams. These elevated flows tended to produce low pH values in swamp streams that drained pocosins, especially those streams that flowed out of Holly Shelter Swamp. No samples were collected in 2003 at either Shelter Swamp or Juniper Creek because these streams have a pH less than 4.0 s.u. Criteria have not been developed for these naturally depauperate streams.

High flows were observed during the summer, especially in the Northeast Cape Fear River (Appendix 1). Because of these flows, no macroinvertebrate samples were collected from the Northeast Cape Fear River. Hurricane Isabel in September 2003 may have affected the river, as previous sampling showed severe affects to the macroinvertebrate fauna following Hurricane Bonnie in 1998. Burgaw Creek was not sampled due to extremely low flows in August 2003.

Holly Shelter Creek, NC 50

This benthic macroinvertebrate site in the headwaters of Holly Shelter Creek is located above the confluence with Moores Creek. Although the site is between two large pocosins, it does not receive much swamp drainage. Based on this characteristic, plus the absence of the mayfly *Stenonema*, this site was assigned to benthic Swamp Region B. The surrounding land use was forest, but the catchment contained a significant amount of agricultural land use. The creek had a distinct channel six meters wide; the bottom substrate was mostly sand; and there were large amounts of woody debris.

Total S and EPT S were in the Natural range, but the Biotic Index was slightly elevated. The dominant taxon was *Orthocladius oliveri*. The overall rating was Moderate, but problems appeared to be minimal. *Leptophlebia*, *Caenis* and *Ptilostomis* were abundant and one rare caddisfly (*Oecetis* sp. E Floyd) was collected. There was high diversity for Crustacea (6 taxa) and Mollusca (8 taxa).

Angola Creek, NC 53

Angola Creek had a wide and braided channel, although most of the flow went through an area only five meters wide. The habitat score was 86. Angola Creek drains Angola Swamp, but land use in this area also includes many hog farms.

During periods of low summer rainfall (e.g. July 1998), there is very little flow in the creek. So this site had been evaluated as a Region P swamp stream. However, the creek was too deep to sample during the winter of 2003 and this site could not be sampled until September 2003. Since there was good flow in September, Coastal A criteria were used to assign a rating. The creek has never supported high numbers of typical swamp species (amphipods and isopods), lending support to a Coastal A classification.

The water was a very dark in September and the dissolved oxygen was only 1.9 mg/L. A similar low dissolved oxygen concentration was measured in 1998. Mallin *et al*. (2002) found that dissolved oxygen was less than 3.0 mg/l in Angola Creek for 7 out of 12 monthly samples.

Angola Creek, NC 53, Pender County.

Angola Creek was first sampled in February, May, August, and November 1993. These data showed high diversity during winter and spring, with 17 and 18 EPT S. Much lower EPT S was found in summer and fall (9 and 11 EPT S), and this pattern was seen again in July 1998. In September 2003, however, 20 EPT S were collected and the stream was rated Good. This result was unexpected at a site with a dissolved oxygen concentration of only 1.9 mg/L. There were five species collected in the genus *Oecetis*, including *Oecetis* sp. F Floyd. The community was dominated by large numbers of filter-feeding caddisflies (*Cheumatopsyche*, *Hydropsyche venularis*, and *Hydropsyche decalda*), suggesting inputs of particulate organic matter.

Lillington Creek, SR 1520

Lillington Creek is confined to a single channel during normal flow conditions, although it spreads out into the floodplain during higher flows. The stream became more braided 50 - 100 meters downstream of the bridge, but this area was not included in the macroinvertebrate assessment. *Vallisneria* and periphyton growths were abundant in areas of more open canopy. High quality habitat was reflected in a habitat score of 89.

Land use is mostly forest, with a few hog farms in the catchment.

Lillington Creek, SR 1520, Pender County. Downstream of bridge, channel is constrained at this point.

Lillington Creek, SR 1520, Pender County. Upstream of bridge, the channel is less distinct.

The creek was initially sampled in February 1997 with some damage still evident from Hurricane Fran in September 1996. It was rated Moderate, but improved to Natural in 2003. The pH decreased from 5.2 s.u. in 1997 to 4.5 s.u. in 2003, so lower taxa richness values in 2003 were expected. EPT S, however, actually increased from 7 species in 1997 to 12 species in 2003. *Eurylophella prudentalis*, *Leptophlebia bradleyi*, and *Polycentropus* which were absent in 1997 were abundant in 2003. These changes probably reflected recovery from damage caused by Hurricane Fran.

Merricks Creek, NC 210

Land use in this catchment is mostly forest, although there are two hog farms upstream of NC 210. The stream is largely confined to a channel at low flows, but becomes braided at normal to high flows. Although this site has a high quality habitat (score = 83), it has been repeatedly affected by hurricanes. Much of the woody substrate was covered with a layer of filamentous algae. This brown filamentous growth was found to be a mixture of diatoms and green algae embedded in a gelatinous matrix of chrysophytes. The diatoms (*Eunotia* and *Frustulia*) and the green algae (*Meogeotiopsis*) are indicative of acidic environments. The chrysophyte (*Tetrasporopsis perforata*) is found in “slowly moving waters of brown-water creeks in late winter when the temperature is below 10^{o}C. It is most abundant in the lower coastal plain in February. At times it virtually covers the bottom of swampy brown-water creeks (Whitford 1984). This suggested that the very abundant filamentous algae growths did not indicate an enrichment problem. Similar periphyton growths had been noted for prior winter collections at this site.

Merricks Creek, NC 210, Pender County, 1999. Upstream of bridge with the bridge pool in the foreground.

The macroinvertebrate fauna has been sampled five times during winter months. The BI was consistently low, 5.7 - 6.3, indicating good water quality. Stream pH varied from 4.4 to 5.5 s.u., and this appeared to have some effect on EPT taxa S, although other factors (especially hurricanes) also may have been important.

This stream was selected as a reference site for benthic Swamp Region P streams. It was rated

Moderate in 1997 following some hurricane damage, but was rated Natural for all other collections. Midges are usually dominant and typical swamp taxa (amphipods and isopods) were also abundant in all samples.

Island Creek, SR 1336
Island Creek was selected to serve as a reference site for streams in the City of Wilmington area, but it was found to be very different from other nearby streams. Island Creek drains the southern part of Holly Shelter Swamp and had a pH of only 4.1 s.u. A distinct channel was observed near the bridge, and the stream was very braided further downstream. The wet width of the stream was over 20 meters.

As might be expected for a highly acidic swamp, isopods were dominant (three species of *Asellus*). The habitat score (93), total taxa richness (24), and EPT S (4) were similar to natural swamp streams with pH values near 4.0 s.u. The BI was slightly elevated (7.0), but this was not unusual considering the extremely low pH. For these reasons, this stream was classified as Not Rated.

Long Creek, NC 53
Much of Long Creek has been channelized, but the stream has become braided in sections that are affected by beaver dams. In these areas, the stream flows into the floodplain, creating a more natural swamp stream morphology. Conductivity was elevated at this site (140 µmhos/cm) and the habitat score was low (56). The habitat was fairly uniform with a very silty substrate and duckweed was very abundant.

Long Creek, NC 53, Pender County. Channelized segment to the left, area of swifter current to the right. Two beaver dams occur in this stream reach.

Long Creek, NC 53, Pender County. Area of swifter current with a more braided area above the beaver dam.

Unlike streams that drain pocosins, Long Creek has a pH close to neutral (6.2 s.u.) which potentially could allow a more diverse community. Total S, however, was very low (31), and the community was dominated by very tolerant species such as Lumbriculidae and *Orthocladius oliveri*. The abundance of *Sphaerium*, *Musculium,* and *Physella* suggested that low dissolved oxygen may sometimes be a problem in Long Creek. The overall rating for Long Creek was Severe.

Cypress Creek, NC 53
Cypress Creek was about eight meters wide, usually confined to a distinct channel. The pH was fairly high (6.2 s.u.) because this stream does not drain any pocosins. The habitat appeared adequate to support a diverse aquatic fauna with a habitat score of 86. There were patches of *Vallisneria* as well as abundant periphyton. Local residents reported beaver and Nutria in this area. Land use was a mixture of forest and agriculture, including some hog farms.

Upstream view of Cypress Creek, NC 53, Pender County.

Cypress Creek, NC 53, Pender County, showing beaver dam.

Chironomidae were dominant (especially *Hydrobaenus*), but there were also 4 EPT S. *Caenis* and *Callibaetis* were abundant. The overall rating, based on Swamp Region B criteria, was Moderate in 1998 and 2003. However, from 1998 to 2003 the BI increased from 7.3 to 7.9 and EPT S decreased from 9 to 4.

Smith Creek, I-40

The lower section of Smith Creek was deep and slow moving, with some estuarine influences. A wadeable freshwater segment could not be located downstream of I-40. Above I-40, the stream may have been channelized at some time. The stream is entrenched, with eroding banks and a uniform sand substrate. Land use includes forest and residential areas. Although this stream is close to Island Creek, it is much different in character. Island Creek is a braided and highly acidic swamp stream placed in Swamp Region P, while Smith Creek is a channelized, nearly neutral (pH = 6.3 s.u.) stream placed in Swamp region B.

Smith Creek, above I-40, New Hanover County.

In spite of good flow and adequate habitat (score = 54), this stream was rated Severe. Total S (30) and EPT S (1) were well below expected levels and the community was dominated by facultative and tolerant species. Typical swamp stream species (e.g., orthoclad midges, isopods, and amphipods) were absent from this portion of Smith Creek.

SPECIAL STUDIES

Burnt Mill Creek

Burnt Mill Creek was sampled at two locations in the City of Wilmington during 2001 as part of a Collaborative Assessment of Watersheds and Streams projects. The stream is channelized with very poor habitat and water quality. This stream was consistently rated Poor using benthic macroinvertebrate data (Biological Assessment Unit Memorandum B-010522).

OTHER DATA

Mallin *et al*. (2002) studied the Lower Cape Fear River system, including a number of sites in the Northeast Cape Fear catchment. Sites in this subbasin included Angola and Burgaw Creeks and two sites on the Northeast Cape Fear River. Annual reports are produced for this project, and are available at http://www.uncwil.edu/cmsr/aquaticecology/lcfrp.

Of particular interest was the reaction of this system to hurricanes over the last decade. Hurricane Floyd (1999) had few significant impacts, but Hurricane Fran (1996) and Hurricane

Bonnie (1998) caused extended periods of low dissolved oxygen (sometimes-anoxic conditions) which triggered fish kills. Problems in the Northeast Cape Fear were more acute than those seen in the Black River, possibly due to more problems with confined animal operations.

Fish Tissue Contaminants

Northeast Cape Fear River near Castle Hayne and Long Creek near Clark's Landing

Sixty-eight fish tissue samples were collected from these sites from 2000 to 2002. Total mercury concentrations exceeded the US EPA and North Carolina criteria of 0.4 ppm in 30 (44 percent) of the samples. Total mercury concentrations also exceeded the current US Food and Drug Administration action level of 1.0 ppm in 5 (7 percent) of the samples. Samples with mercury concentrations exceeding state and federal limits were composed of species currently under advisory (largemouth bass, bowfin, and chain pickerel). All other metals were at concentrations were less than those of concern (Appendix 16).

CAPE FEAR RIVER SUBBASIN 24

Description

This subbasin is located primarily in the Carolina Flatwoods ecoregion, although the coastal fringe is located in the Carolina Barrier Islands and Coastal Marshes ecoregions (Figure 106). Aquatic resources include a series of small tidal creeks that flow into Masonboro Sound, Topsail Sound, and the Intracoastal Waterway. The sounds are connected to the Atlantic Ocean by a series of inlets.

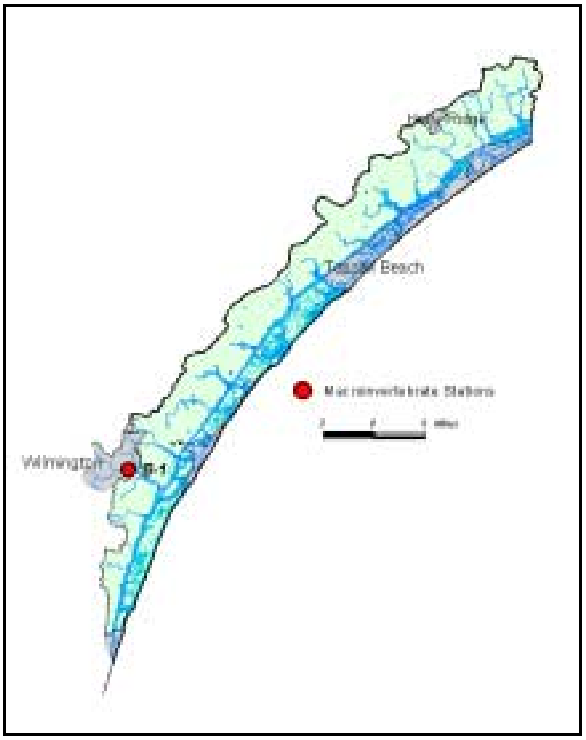


Figure 106. Sampling sites in Subbasin 24 in the Cape Fear River basin. Monitoring sites are listed in Table 57.

This subbasin contains portions of the City of Wilmington metropolitan area plus the Towns of Wrightsville Beach and Carolina Beach. Almost two-thirds of the basin is forested (Table 56) although changing landuse practice have probably increased the percentage of urban lands during the past 10 years. There are 4 permitted dischargers in this subbasin, but none larger than 0.5 MGD.

Table 56. Land use in Subbasin 24. Based upon CGIA coverage 1993 - 1995, total area = 162 square miles (NCDENR 1999).

Land use	Percent
Water	18
Cultivated crop	7
Pasture	5
Urban	8
Forest	63

Overview of Water Quality

Water quality appeared to be high in most of the sounds and small tidal creeks in this subbasin. Masonboro, Middle, Topsail, and Stump Sounds are all classified as ORW, as are their tributaries. The most significant water quality threat in this subbasin seemed to be the rapid urbanization of the subbasin and the increasing runoff that accompanies such development. Problems in Bradley Creek, which drains the City of Wilmington, have been documented.

Only Hewletts Creek was sampled for benthos (Table 57) and it was given a Moderate stress rating.

There are six coalition and DWQ ambient chemistry monitoring locations in the subbasin. No substantial water problems were noted in these data. The Holly Ridge WWTP has had ongoing effluent toxicity problems since 1991 and has submitted plans for a plant upgrade.

Table 57. Waterbodies monitored in Subbasin 24 in the Cape Fear River basin for basinwide assessment, 1998 - 2003.

Map #[1]	Waterbody	County	Location	1998	2003
B-1	Hewletts Cr	New Hanover	SR 1492	Moderate	Moderate

[1]B = benthic macroinvertebrate monitoring site.

River and Stream Assessment

Hewletts Creek, SR 1492
Hewletts Creek drains a residential area of the City of Wilmington. It is placed in Swamp Region B, although it was found to still have some flow during the summer. The stream was six meters wide with a uniform sand substrate; the riparian zone was wide along both shorelines; pools were infrequent due to the filled-in nature of the stream channel, and there were good snags and root mat habitats. The habitat was score 75.

Hewletts Creek, SR 1492, New Hanover County.

Conductivity was elevated (203 µmhos/cm), but not high enough to suggest any estuarine influence, at the time of sampling. While a few estuarine species have been collected at this site (*Cassidinidea*, *Cyathura*, and mud crabs), these may have migrated upstream from the nearby oligohaline part of the creek. Many of the dominant macroinvertebrates at this site would not tolerate even low levels of salinity.

Six EPT taxa were found at this site in 1998 and 2003 with *Stenonema modestum* and *Cheumatopsyche* being abundant. Some fairly intolerant caddisflies have been found here, including *Heteroplectron americanum*, *Triaenodes*, and *Pycnopsyche*. The overall rating of this swamp stream was Moderate.

AMBIENT MONITORING SYSTEM

A general understanding of human activities and natural forces that affect pollution loads and their potential impacts on water quality can be obtained through routine sampling from fixed water quality monitoring stations. During this assessment period (September 1, 1998 through August 31, 2003) four programs were actively involved with monitoring water quality in the Cape Fear basin (Table 58).

Table 58. Programs and monitoring organizations that contributed data to this document.

Program	No. of Monitoring Stations
DWQ Ambient Monitoring System	85
Upper Cape Fear River Basin Association (UCFBRA)	46
Middle Cape Fear River Basin Association MCFBRA)	38
Lower Cape Fear River Program (LCFRP)	34

The DWQ manages and regulates water quality statewide. Each of the participating monitoring organizations (UCFRBA, MCFRBA, and LCFRP) represent groups of NPDES dischargers that conduct instream monitoring and are referred to as coalitions in this document. Details on the discharge monitoring coalition program are available at: http://www.esb.enr.state.nc.us/EU.html. This website, maintained by the DWQ Environmental Sciences Branch, contains links to web sites maintained by each individual coalition.

The DWQ's Ambient Monitoring System program and coalition monitoring programs are based on a network of fixed stations located at convenient access points (e.g. bridge crossings) that are sampled on a monthly basis. These locations were chosen to characterize the effects of point source dischargers and nonpoint sources such as agriculture, animal operations, and urbanization within watersheds. Currently, neither the DWQ, nor the Coalitions conduct probabilistic (random) monitoring.

The establishment of coalitions has resulted in more intense monitoring in areas of concern. During this assessment period about twice as many sites in the basin were monitored than in any previous assessment period. Data from 173 monitoring stations are used in this document; 30 of these stations were monitored independently by DWQ and one of the coalitions (Figures 107 – 109; Table 59).

All monitoring entities essentially measure similar parameters. However there are differences in the frequency of sampling and the detection level for many parameters (primarily metals and nutrients) can vary between analytical laboratories. These factors may affect summaries of the data. For example, the coalitions measure dissolved oxygen twice per month in the summer, whereas the DWQ measures it only once per month.

Data are used to identify long term trends within watersheds, to develop Total Maximum Daily Loads (TMDLs) and to compare measured values with water quality standards to identify possible areas of impairment. An overview of water quality constituents and how results can be interpreted is found at: http://h2osparc.wq.ncsu.edu/info/. Within this document, an analysis of how monitoring results compare with water quality standards and action levels is presented. A conceptual overview of water quality standards is provided at: http://www.epa.gov/waterscience/standards. Specific information on North Carolina water quality standards is provided at: http://h2o.enr.state.nc.us/admin/rules.

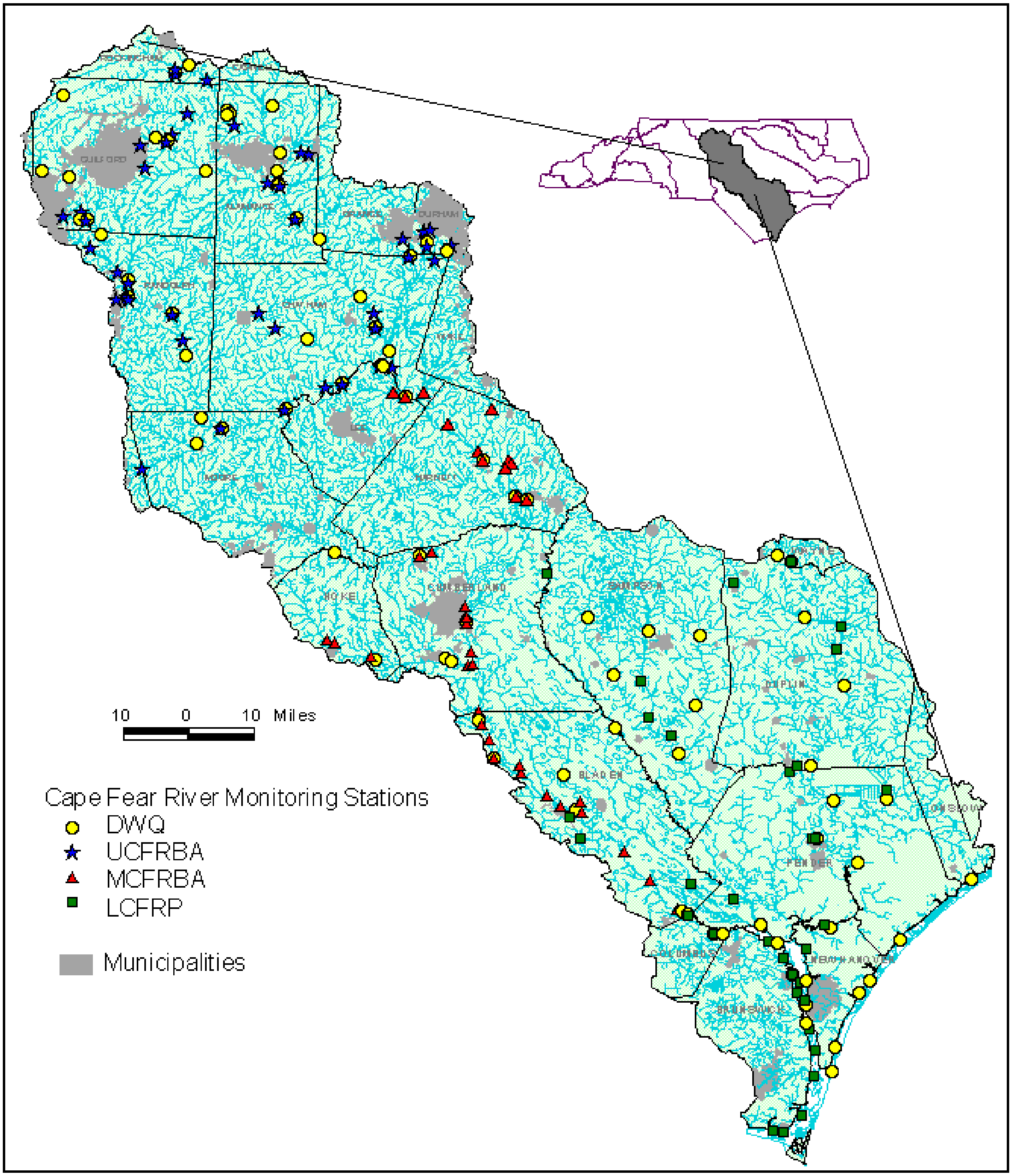


Figure 107. DWQ's ambient monitoring system and coalition monitoring sites within the Cape Fear River basin.

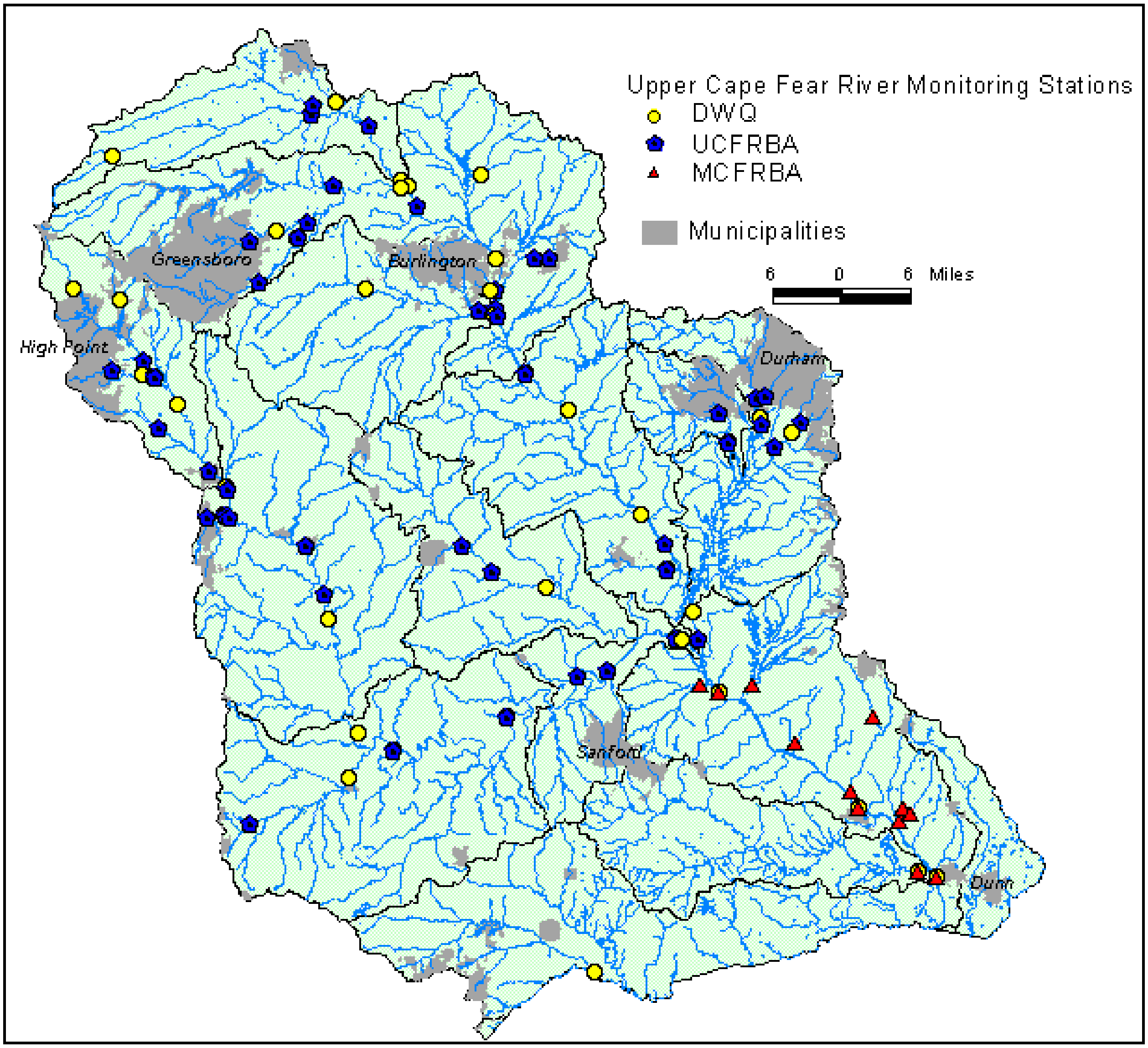


Figure 108. **DWQ's ambient monitoring system and coalition monitoring sites by subbasin within the upper and middle Cape Fear River basin.**

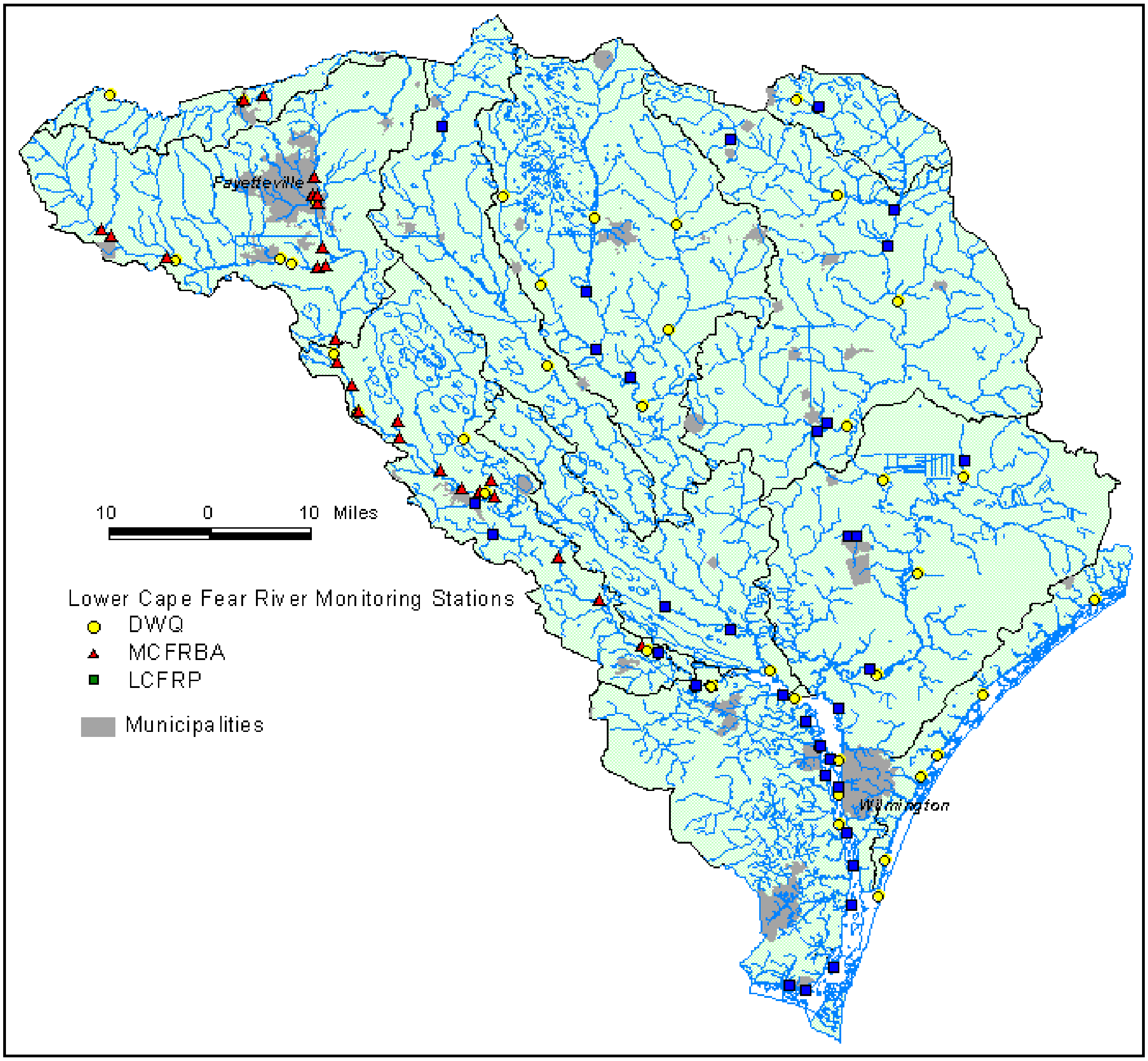


Figure 109. **DWQ's ambient monitoring system and coalition monitoring sites by subbasin within the lower Cape Fear River basin.**

Table 59. Monitoring stations in the Cape Fear River basin, 1998 - 2003. Stations with a program code prefix of "A" denote a DWQ monitoring site; those with a program code prefix of "C" denote a coalition monitoring site.

Subbasin/ Code[1]	Station	Location	Class	County
030601				
A1	B0040000	Haw R at SR 2109 near Oak Ridge	C NSW	Guilford
A2 C1	B0050000	Haw R at US 29A near Benaja	C NSW	Rockingham
C2	B0070010	Troublesome Cr at US 29 Bus. near Reidsville	C NSW	Rockingham
A3	B0160000	Little Troublesome Cr at SR 2600 near Reidsville	C NSW	Rockingham
C3	B0170000	Haw R at SR 2614 near Williamsburg	C NSW	Rockingham
A4	B0190000	Haw R at NC 87 near Altamahaw	C NSW	Alamance
A5	B0210000	Haw R at SR 1561 near Altamahaw	C NSW	Alamance
030602				
C4	B0400000	Reedy Fork at SR 2719 near Monticello	C NSW	Guilford
C5	B0480050	N Buffalo Cr at N Buffalo Cr WWTP	C NSW	Guilford
A6	B0540000	N Buffalo Cr at SR 2832 near Greensboro	C NSW	Guilford
C6	B0540050	N Buffalo Cr at SR 2770 near McLeansville	C NSW	Guilford
C7	B0670000	S Buffalo Cr at SR 3000 near Greensboro	C NSW	Guilford
A7 C8	B0750000	S Buffalo Cr at SR 2821 at McLeansville	C NSW	Guilford
A8 C9	B0840000	Reedy Fork at NC 87 at Ossipee	C NSW	Alamance
C10	B0850000	Haw R at SR 1530 near Ossipee	C NSW	Alamance
A9	B1095000	Jordan Cr at SR 1754 near Union Ridge	WS-II HQW NSW	Alamance
A10	B1140000	Haw R at NC 49 at Haw River	C NSW	Alamance
C11	B1200000	Haw R at NC 54 near Graham	C NSW	Alamance
A11	B1260000	Town Branch at SR 2109 near Graham	C NSW	Alamance
C12	B1350000	Moadams Cr near Mebane	C NSW	Alamance
C13	B1380000	Moadams Cr at SR 1940 near Florence Town	C NSW	Alamance
C14	B1440000	Haw R at SR 2158 near Swepsonville	C NSW	Alamance
030603				
A12 C16	B1960000	Alamance Cr at SR 2116 at Swepsonville	C NSW	Alamance
A13	B1670000	Lake MacIntosh at NC 61 near Whitsett	WS-IV NSW CA	Guilford
C15	B1940000	Big Alamance Cr at NC 87 near Swepsonville	C NSW	Alamance
030604				
A14 C17	B1980000	Haw R at SR 2171 at Saxapahaw	C NSW	Alamance
A15	B2000000	Haw R at SR 1005 near Saxapahaw	C NSW	Alamance
A16	B2100000	Haw R at SR 1713 near Bynum	WS-IV NSW	Chatham
C18	B2210000	Haw R at US 64 near Pittsboro	WS-IV NSW	Chatham
A17 C19	B2450000	Robeson Cr at SR 1943 near Hanks Chapel	WS-IV NSW	Chatham
030605				
C21	B3020000	New Hope Cr at NC 54 near Durham	WS-IV NSW	Durham
C22	B3025000	Third Fork Cr at NC 54 near Durham	WS-IV NSW	Durham
A19 C23	B3040000	New Hope Cr at SR 1107 near Blands	WS-IV NSW	Durham
C24	B3300000	Northeast Cr at SR 1102 near RTP	WS-IV NSW	Durham
A20	B3660000	Northeast Cr at SR 1100 near Nelson	WS-IV NSW	Durham
C25	B3670000	Northeast Cr at SR 1731 near Durham	WS-IV NSW	Chatham
030606				
C26	B3899180	Morgan Cr at WWTP entrance at Chapel Hill	WS-IV NSW	Orange
A21 C27	B3900000	Morgan Cr at SR 1726 near Farrington	WS-IV NSW	Chatham
030607				
A18	B4050000	Haw R below Jordan Dam near Moncure	WS-IV	Chatham
C20	B4080000	Haw R at SR 1011 near Haywood	WS-IV	Chatham
C28	B6130500	Lick Cr at SR 1500 near Corinth	WS-IV	Lee
A22 C29	B6160000	Cape Fear R at NC 42 near Corinth	WS-IV CA	Chatham
C30	B6200000	Buckhorn Cr at NC 42 near Fuquay-Varina	C	Chatham
C31	B6230000	Avents Cr at SR 1418 near Cokesbury	WS-IV HQW	Harnett
C32	B6252000	Neills Cr at US 401 near Lillington	WS-IV	Harnett
C33	B6320000	Kenneth Cr at SR 1441 near Angier	WS-IV	Harnett
A23 C34	B6370000	Cape Fear R at US 401 at Lillington	WS-IV	Harnett
C35	B6480000	Buies Cr at US 421 at Buies Creek	WS-IV	Harnett
C36	B6483000	E Buies Cr at SR 2054 at Buies Creek	WS-IV	Harnett
C37	B6485000	Buies Cr at Keith Hills Golf Course	WS-IV	Harnett
A42 C58	B6840000	Cape Fear R at NC 217 at Erwin	WS-V	Harnett

Table 59 (continued).

Subbasin/ Code[1]	Station	Location	Class	County
030608				
A24	B4210000	W Fork Deep R at SR 1818 near High Point	WS-IV CA*	Guilford
A25	B4240000	E Fork Deep R at SR 1541 near High Point	WS-IV*	Guilford
C38	B4350000	Deep R at SR 1113 near Hayworth Spring	WS-IV CA*	Guilford
C39	B4378000	Richland Cr at SR 1193 near High Point	WS-IV*	Guilford
A26	B4410000	Richland Cr at SR 1145 near High Point	WS-IV CA*	Guilford
A27 C40	B4440000	Deep R at SR 1129 near High Point	WS-IV CA*	Guilford
A28	B4615000	Deep R at SR 1921 near Randleman	WS-IV CA*	Randolph
C41	B4626000	Muddy Cr at SR 1929 near Glenola	WS-IV CA*	Randolph
C42	B4770500	Deep R US 220 Bus. Main St at Randleman	C	Randolph
030609				
A29 C43	B4800000	Deep R at SR 2122 at Worthville	C	Randolph
C44	B4850000	Hasketts Cr at US 220 Bus. near North Asheboro	C	Randolph
A30 C45	B4890000	Hasketts Cr at SR 2128 near Central Falls	C	Randolph
C46	B4920000	Deep R at SR 2261 near Central Falls	C	Randolph
A31 C47	B5070000	Deep R at SR 2615 at Ramseur	C	Randolph
C48	B5100000	Deep R at SR 2628 near Parks Crossroads	C	Randolph
A32	B5131000	Deep R at NC 42 near Coleridge	C	Randolph
030610				
A33	B5190000	Deep R at SR 1456 near High Falls	C	Moore
C49	B5390800	Cotton Cr at SR 1372 near Star	WS-III	Montgomery
A34	B5480000	Bear Cr at NC 705 at Robbins	C	Moore
A35 C50	B5520000	Deep R at NC 22 at High Falls	C HQW	Moore
A36 C51	B5575000	Deep R at NC 42 at Carbonton	WS-IV	Chatham
030611				
C52	B5685000	Deep R at Deep River Park bridge near Cumnock	C	Chatham
A37 C53	B5820000	Deep R at US 15 and 501 near Sanford	C	Lee
A38 C56	B6040300	Deep R at SR 1011 old US 1 near Moncure	WS-IV	Chatham
A39	B6050000	Deep R at CSX RR Bridge near Moncure	WS-IV	Chatham
030612				
A40	B6000000	Rocky R at NC 902 near Pittsboro	C	Chatham
C54	B5950000	Rocky R at US 64 near Siler City	C	Chatham
C55	B5980000	Rocky R at SR 2170 near Siler City	C	Chatham
030613				
A41 C57	B6830000	Upper Little R at SR 2021 near Lillington	WS-IV	Harnett
030614				
A43	B7245000	Lower Little R at SR 2023 near Lobelia	WS-III HQW	Moore
A44 C59	B7280000	Lower Little R at SR 1451 at Manchester	C	Cumberland
C60	B7300000	Lower Little R at NC 210 near Spring Lake	C	Cumberland
030615				
C61	B7480000	Cape Fear R at Hoffer WTP Intake at Fayetteville	WS-IV CA	Cumberland
C62	B7500000	Cape Fear R at I-95 below Fayetteville	C	Cumberland
A45	B7600000	Cape Fear R at NC 24 at Fayetteville	C	Cumberland
C63	B7610000	Cape Fear R at Riverside Landing	C	Cumberland
C75	B8290000	Cape Fear R at Dupont Water Intake	C	Cumberland
C73	B7589000	Cross Cr at WWTP	C	Cumberland
C74	B7590000	Cross Cr at US 301 Bus. & I-95 Bus. - Fayetteville	C	Cumberland
C64	B7679000	Rockfish Cr at SR 1300 Vass Road	B	Hoke
C65	B7679300	Rockfish Cr at US 401 bypass near Raeford	B	Hoke
A46 C66	B7700000	Rockfish Cr at SR 1432 near Raeford	B	Hoke
A47	B8220000	Rockfish Cr near US 301 Hope Mills	C	Cumberland
A48	B8224000	Rockfish Cr at SR 2350 near Cedar Creek	C	Cumberland
C67	B8229000	Rockfish Cr at Special Forces Club	C	Cumberland
C68	B8230000	Rockfish Cr at NC 87 near Fayetteville	C	Cumberland
030616				
A49	B8300000	Cape Fear R at W. O. Huske Lock near Tar Heel	C	Bladen
C76	B8301000	Cape Fear R below Lock and Dam 3 boat ramp	C	Bladen
C77	B8302000	Cape Fear R at power lines near Tolarsville	C	Bladen
A50 C78	B8305000	Cape Fear R at SR 1316 at Tarheel	C	Bladen

Table 59 (continued).

Subbasin/ Code[1]	Station	Location	Class	County
C79	B8306000	Cape Fear R below Harrison Cr near Ruskin	C	Bladen
C80	B8315000	Harrison Cr at SR 1320 at Burney	C	Bladen
C81	B8320000	Cape Fear R at US 701 at Elizabethtown	C	Bladen
A51	B8321000	Turnbull Cr at SR 1509 near Johnsontown	C	Bladen
C82	B8330000	Cape Fear R DNS mouth of Ellis Cr	C	Bladen
C83	B8339000	Cape Fear R above Lock and Dam 2	C	Bladen
A52	B8340000	Cape Fear R at Lock 2 near Elizabethtown	C	Bladen
C69	B8340050	Browns Cr at NC 87 mouth	C	Bladen
C84	B8340100	Turnbull Cr - NC 53 & NC 41 near Elizabethtown	C	Bladen
C85	B8340130	Cape Fear R at RM 70	C	Bladen
C70	B8340200	Hammond Cr at SR 1704	C	Bladen
C86	B8340650	Cape Fear R at RM 55	WS-V	Bladen
C87	B8348000	Cape Fear R at SR 1730 near Carvers	WS-IV	Bladen
C88	B8349000	Cape Fear R above Lock and Dam 1 - East Arcadia	WS-IV CA	Bladen
A53	B8350000	Cape Fear R at Lock 1 near Kelly	WS-IV Sw	Bladen
A54 C71	B8360000	Cape Fear R at NC 11 near Kings Bluff	WS-IV Sw	Bladen
030617				
A55 C89	B8445000	Livingston Cr at mouth near Riegelwood	C Sw	Columbus
C90	B8449000	Cape Fear R near Neils Eddy Landing near Acme	C Sw	Columbus
A56	B8450000	Cape Fear R at Neils Eddy Landing near Acme	C Sw	Columbus
C91	B8465000	Cape Fear R at Dupont Intake	C Sw	Brunswick
A57	B9020000	Cape Fear R DNS Hale Pt Landing near Phoenix	C Sw	Brunswick
C92	B9030000	Cape Fear R at Indian Creek	C SW	Brunswick
A58 C93	B9050000	Cape Fear R at Navassa	SC	Brunswick
C94	B9050100	Cape Fear R at Horseshoe Bend	SC	Brunswick
A59	B9740000	Northeast Cape Fear R at US 421 at Wilmington	SC Sw	New Hanover
C95	B9790000	Brunswick R at boat ramp In Belville	SC	Brunswick
C96	B9795000	Cape Fear Rat Channel Marker 54	SC	New Hanover
A60 C97	B9800000	Cape Fear R at Channel Marker 61 at Wilmington	SC	New Hanover
A61	B9820000	Cape Fear R at Channel Marker 56 near Wilmington	SC	New Hanover
C98	B9845100	Cape Fear R at Channel Marker 42	SC	Brunswick
C99	B9850100	Cape Fear R at Channel Marker 35	SC	Brunswick
C100	B9910000	Cape Fear R at Channel Marker 23	SA HQW	Brunswick
C101	B9921000	Cape Fear R at Channel Marker 18	SC	Brunswick
C102	B9980000	ICW 1000 ft. west of Southport discharge	SA HQW	Brunswick
030618				
C103	B8470000	South R at US 13 near Cooper	C Sw	Sampson
A62	B8919000	South R at SR 1503 near Parkersburg	C Sw ORW+	Bladen
030619				
A63	B8490000	Little Coharie Cr at SR 1414 near Salemburg	C Sw	Sampson
A64	B8545000	Little Coharie Cr at SR 1240 near Roseboro	C Sw	Sampson
A65	B8580000	Great Coharie Cr at SR 1311 near Clinton	C Sw	Sampson
C104	B8604000	Great Coharie Cr at SR 1214	C Sw	Sampson
C105	B8610001	Little Coharie Cr at SR 1207 near Ingold	C Sw	Sampson
A66	B8679500	Six Runs Cr at SR 1919 near Moltonville	C Sw	Sampson
A67	B8725000	Six Runs Cr at SR 1960 near Taylors Bridge	C Sw ORW+	Sampson
C106	B8740000	Six Runs Cr at SR 1003	C Sw ORW+	Sampson
A68	B8750000	Black R at NC 411 near Tomahawk	C Sw ORW+	Sampson
030620				
C107	B8981000	Colly Cr at NC 53	C Sw	Bladen
C108	B9000000	Black R at NC 210 above Thorofare	C Sw ORW+	Pender
A69	B9013000	Black R at Raccoon Island near Huggins	C Sw ORW+	Pender
030621				
A70	B9080000	Northeast Cape Fear R at SR 1937 near Mt Olive	C Sw	Wayne
A71 C109	B9090000	Northeast Cape Fear R at NC 403 near Williams	C Sw	Duplin
030622				
A72	B9190500	Goshen Swamp at SR 1004 - Westbrook Crossroad	C Sw	Duplin
C110	B9191000	Goshen Swamp at NC 11 and NC 903	C Sw	Duplin
C111	B9191500	Northeast Cape Fear R near Sarecta	C Sw	Duplin

Table 59 (continued).

Subbasin/ Code[1]	Station	Location	Class	County
C72	B9130000	Panther Branch below UT near Faison	C Sw	Duplin
A73	B9196000	Northeast Cape Fear R at SR 1961 at Hallsville	C Sw	Duplin
C112	B9430000	Rockfish Cr at US 117	C Sw	Duplin
C113	B9460000	Little Rockfish Cr at NC 11	C Sw	Duplin
A74	B9470000	Rockfish Cr at I-40 at Wallace	C Sw	Duplin
030623				
A75	B9480000	Northeast Cape Fear R at SR 1318 near Watha	C Sw	Pender
A76 C114	B9490000	Angola Cr at NC 53	C Sw	Pender
C115	B9500000	Burgaw Canal at SR 1345 Wright St at Burgaw	C Sw	Pender
A77 C116	B9520000	Burgaw Canal at US 117	C Sw	Pender
A78	B9550000	Lillington Cr at SR 1520 near Stag Park	C Sw	Pender
A79 C117	B9580000	Northeast Cape Fear R at US 117 at Castle Hayne	B Sw	New Hanover
C118	B9670000	Northeast Cape Fear R below GE	C Sw	New Hanover
030624				
A80	B9865000	ICW at Morris Landing	SA ORW	Onslow
A81	B9872000	ICW at Channel Marker 102 near Long Point	SA ORW	Pender
A82	B9872500	ICW at Channel Marker 123 near Howe Point	SA ORW	New Hanover
A83	B9874000	ICW at US 74 and 76 at Wrightsville Beach	SB #	New Hanover
A84	B9876000	ICW at Channel Marker 151 near Everett N	SA ORW	New Hanover
A85	B9879000	Carolina Beach Harbor at Channel Marker 7	SB	New Hanover

[1]program codes: DWQ Ambient Monitoring System sites A1 through A85; UCFRBA sites: C1 through C27 and C38 through C56; MCFRBA sites C28 through C37, C57 through C68, and C73 through C88; and LCFRP sites: C69 through C72 and C89 through C118.

Data Assessment and Interpretation

Monitoring and sampling results considered in this report represent samples collected or measurements taken at less than one-meter depth. During 2003 data handling improvements were implemented for the results submitted by the coalitions. These included the use of the standard data qualifiers and method codes that are used for the DWQ results and the use of consistent data structures that aid in database management.

Median and percentile statistics were calculated for most of the data using JMP statistical software (version 5.01; SAS Institute, Cary, NC). Values less than the minimum reporting level were evaluated as equal to the reporting level. Box and whisker plots are (constructed using SigmaPlot version 8.02) presented for some water quality parameters (e.g. dissolved oxygen and nutrients) collected at monitoring stations along mainstem portions of rivers.

Analytical Considerations

Three issues were noted by the DWQ Laboratory Section as part of the analytical processes during this assessment period:

1) laboratory or sampling related contamination may have produced higher than expected values of zinc between April 1995 and March 1999; results within this period were not summarized in this report; and
2) improved analytical techniques and protocols for nutrient samples were implemented. No nutrient samples were processed during the period when the techniques and protocols were being implemented.
3) In early 2001 the Laboratory Section reviewed their internal QA/QC programs and some of the analytical methods. This effort resulted in a marked increase in reporting levels for certain parameters. New analytical equipment and methods were subsequently acquired to establish new lower reporting levels and more scientifically supportable quality assurance. Because of the improvements the reporting levels quickly declined back down to or near the previous reporting levels. Nutrients were especially affected by these changes (Table 60).

Table 60. Changes in the Laboratory Section's reporting levels for nutrients. All concentrations are in mg/L

		Reporting level by date			
Parameter	Method Code	Pre-2001	3/13/2001 to 3/29/2001	3/30/2001 to 7/24/2001	7/25/2001 to present
NH_3	610	0.01	0.5	0.2	0.01
TKN	625	0.1	1.0	0.6	0.20
No_2+NO_3	630	0.01	0.5	0.15	0.01
TP	665	0.01	0.5	0.1	0.02

Providing Confidence in the Exceedances of Water Quality Standards

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

This document uses a nonparametric procedure (Lin *et al.* 2000) to identify when a sufficient number of exceedances have occurred that indicate a true exceedance probability of 10 percent. Calculating the minimum number of exceedances needed for a particular sample size was done using the CRITBIMON function in Microsoft Excel®. This statistical function suggests that at least three exceedances need to be observed in a sample of 10 in order to be [about] 95 percent confident that 10 percent of the results exceed the water quality standard. For example, there is less statistical confidence associated with a 1 exceedance out of 10 (35 percent) than when there are 3 exceedances out of 10 (93 percent confidence (Figure 110).

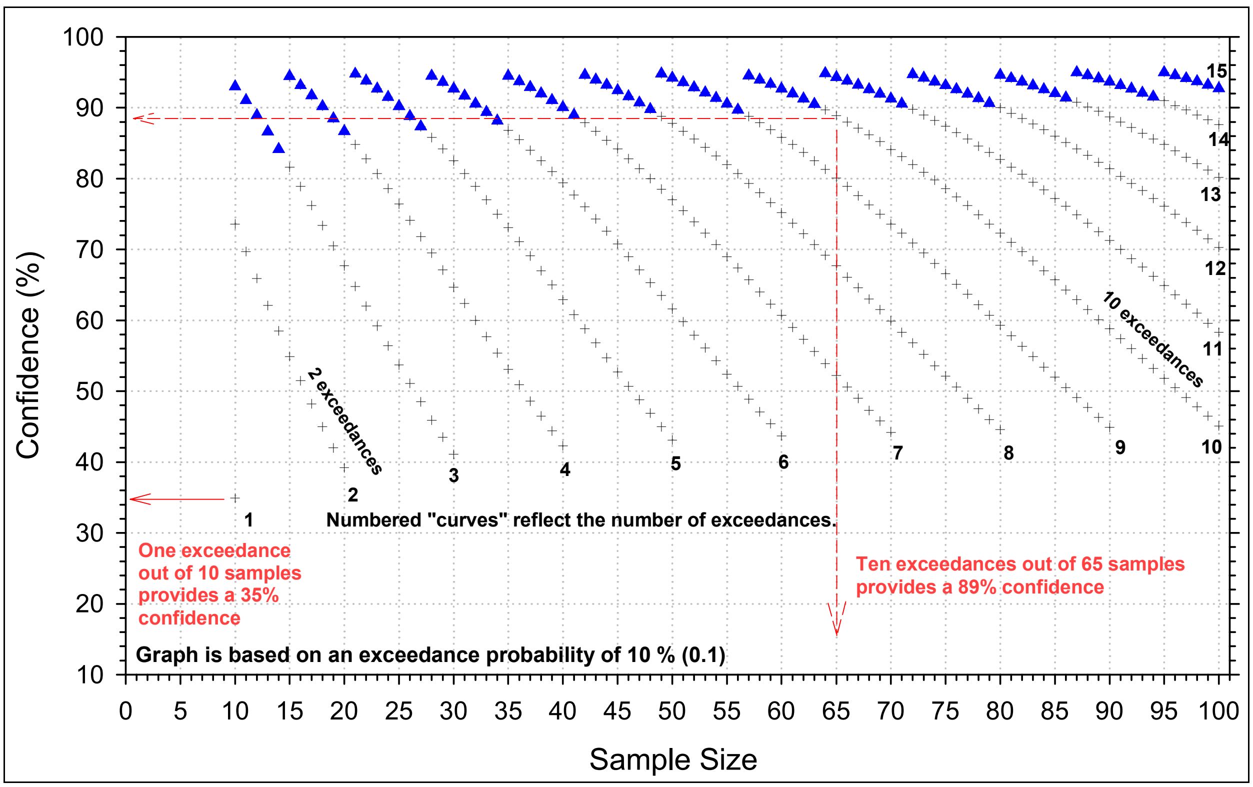


Figure 110. The amount of statistical confidence associated with a particular number of exceedances and sample sizes when evaluating a 10 percent exceedance threshold. Triangles denote where the number of exceedance correspond with a sample size that provides about a 95 percent confidence that the population has 10 percent or more results violating a water quality standard or action level.

Methods Used to Summarize Results
Methods used to summarize the results in this report encompass both tabular and graphical formats. Individual summary sheets for each station provide details on station location, stream classification, along with specifics on what parameters were measured, the number of samples taken (i.e. sample size), the number of results below reporting levels, the number of result exceeding a water quality standard or action level, and a general overview of the distribution of the results using percentiles. These station summary sheets provide the most details on a station-by-station basis and should represent the final authority regarding interpretation. Since there are 203 summary sheets, these are not included in this report, but are available at: http://www.esb.enr.state.nc.us/Basinwide/CPFSummaries_20040406/StationsBySubbasin_edit.htm.

Summaries of where exceedances of water quality standards or actions levels occurred is provided (Tables 61 - 64.) These tables provide the proportion (%) of results that exceed the water quality standard or action level assigned to that monitoring station by stream classification. Only exceedances greater than 10 percent (20 percent for fecal coliform results > 400 colonies/100mL) and based on a sample size of at least 10 are included. Red bold text denotes exceedances that provide about a 95 percent confidence level that 10% of results exceed a water quality standard or action level, except for fecal coliform bacteria. Here, red bold text for fecal coliform bacteria denotes exceedances that provide about a 95 percent confidence level that 20 percent of the results exceed 400 colonies/100mL.

Exceedances for iron are not included because Piedmont soils are rich in iron and may confound the interpretation of aqueous iron concentrations. In addition, stations with a supplemental classification of "Swamp Water" and with proportions (%) of results, greater than 10 percent for dissolved oxygen (DO) less than 4.0 or 5.0 mg/L are not included. This is because the low concentrations may be the result of natural (i.e. swampy) conditions. Individual station summary sheets do provide information on iron and include proportions of dissolved oxygen less than 4 and 5 mg/L at stations with a supplemental classification of "Swamp Water".

Use Support Assessment Considerations
1) The dissolved freshwater oxygen concentrations of 5.0 and 4.0 mg/L are presented as evaluation levels. Instantaneous concentrations of 4.0 mg/L or less can occur and may be acceptable if caused by natural (e.g. swampy) conditions.
2) Action levels (copper, iron, and zinc) are used primarily as evaluation guidelines because results include fractions that may have little effect on aquatic life. Where appropriate, follow-up toxicological work will need to be conducted before use support determination can be made for these parameters.
3) The geometric mean and median statistics were calculated for fecal coliform results for each station.

Specific information on water quality standards and action levels is found in the NCAC (2002).

Dissolved Oxygen
Dissolved oxygen is one of the most important of all the chemical measurements. Dissolved oxygen provides valuable information about the biological biochemical conditions of water and is one of the most important environmental factors affecting aquatic life and the capacity of water to assimilate point and nonpoint discharges. Water quality standards for dissolved oxygen vary depending on the classification of the body of water [see, for example: 15A NCAC 02B.0211(1)(b) and 15A NCAC 02B.0220 (1)(b)] but generally results less that 5.0 or 4.0 mg/L can be problematic. Consistent patterns of low concentrations of dissolved oxygen can be subject to intense management review and corrective actions, although patterns of low dissolved oxygen can occur naturally in and near wetlands.

pH
The pH of natural waters can vary throughout the state. Low values (<< 7.0 s.u.) can be found in waters rich in dissolved organic matter, such as wetlands, whereas high values (>> 7.0 s.u.) are found during algal blooms. Point source dischargers can also influence the pH of a stream. The measurement of pH is relatively easy, however extremely accurate measurements are difficult to make under field conditions. This is due, in part, because the scale for measuring pH is logarithmic (i.e. a pH of 8 is ten times less concentrated in hydrogen ions than a pH of 7).

The water quality standards for pH in freshwaters consider values less than 6.0 s.u. or greater than 9.0 s.u. to warrant attention; whereas in salt waters pH values less than 6.8 or greater than 8.5 warrant attention.

Conductivity
Conductivity is a measure of the ability of water to conduct an electric current. The presence of ions and temperature are major factors in the ability of water to conduct a current. Clean, freshwater has a low conductivity, whereas high conductivities may indicate polluted water. Measurements reported are corrected for temperature, thus the range of values reported over a period of time indicate the relative presence of ions in water. Conductivities in US waters commonly vary between 50 to 1,500 µmhos/cm (APHA 1998).

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

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

Metals
A number of metals are essential micronutrients for the support of aquatic life, however there are threshold concentrations over which metals can be toxic. Currently the DWQ and coalitions monitor total (not dissolved) concentrations for aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, manganese, nickel, and zinc. Aluminum and iron are commonly found in soils. A good review of metals in aquatic environments may be found in Kadlec and Knight (1996).

Most of the concentrations rarely exceeded the analytical reporting level. Concentrations greater than the reporting level were generally too few to interpret statistically.

Nutrients
Compounds of nitrogen and phosphorus are major components of living organisms and thus are essential to maintain life. These compounds are grouped together and given the term “nutrients.” When nutrients are introduced to an aquatic ecosystem from municipal and industrial treatment processes, or runoff from urban or agricultural land, then the potential to accelerate the growth of plants can increase. Generally, the introduction of nutrients from anthropogenic sources to aquatic environments increases the potential to stimulate growth.

Nitrogen compounds include ammonia-nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN) and nitrite+nitrate nitrogen (NO^2+NO_3-N). Ammonia-nitrogen is a metabolic by-product of the decomposition of organic material and combines with water to form the ammonium ion (NH_4^+). It is frequently present in higher concentrations near wastewater treatment plants. Ammonium-nitrogen is more prevalent than NH_3 in water, and depending on pH may be present as NH_4OH, a form toxic to aquatic organisms and fish.

Fecal Coliform Bacteria
Concentrations of fecal coliform bacteria can vary greatly. The descriptive statistics used to evaluate fecal coliform bacteria data include the geometric mean and the median depending on the classification of the waterbody. For all freshwater sites and saltwater sites where the waterbody is classified as SB or SC the standard specified in Administrative Code 15A NCAC 02B.0211 (3)(e) (effective April 1, 2003) is applicable:

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

For saltwater sites classified as “SA” the standard specified in Administrative Code 15A NCAC 02B.0221(3)(d) is applicable:

“Organisms of coliform group: fecal coliform group not to exceed a median MF of 14/100 ml and not more than 10 percent of the samples shall exceed an MF count of 43/100 ml in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions”.

The strict application of the standard is often hindered because the monthly (*circa* 30 day) sampling frequency employed for water quality monitoring usually does not provide more than one sample per 30-day period. However, water quality problems can be discerned using monthly sampling.

Freshwater sites where the geometric mean was greater that 200 colonies/100ml, or where the proportion of results was greater than 20 percent are listed in Table 63. There were no exceedances of the standards for saltwater stations, so no saltwater stations are listed in the table. Thirty-two of the 65 sites had concentrations that statistically exceeded the criteria.

Water Quality Patterns along Major Rivers in the Cape Fear Basin

Box and whisker plots were used to depict spatial differences (upstream to downstream) in a variety of water quality parameters along major rivers (Figures 111 - 126). These rivers include the Haw, Deep, Northeast Cape Fear, and Cape Fear and Rockfish Creek. These rivers have a considerable number of sample sites located along them whereas other rivers in the basin may have three or fewer sample sites.

These graphs provide a visual comparison of results for those stations monitored by DWQ and a coalition partner and were used in elucidating upstream to downstream water quality patterns. In many cases DWQ and a coalition collected data from a common sample site, thus allowing visual comparisons of results between data sources. While graphs portray information visually; specific and accurate details can only be conveyed in tables. Individual station summary sheets should be consulted when exact information is needed.

Haw River

Dissolved oxygen appeared depressed in the upstream portions of the Haw River (Figure 111). However, most of the concentrations less than 5.0 mg/L occurred during the severe drought summers of 2001 and 2002.

All other parameters showed a marked increase between Altamahaw (Station B0210000) and Ossipee (Station B0850000; Figures 112 - 114). These increases reflected point and nonpoint discharges from the Greensboro metropolitan area that eventually flow to Reedy Fork, which is a major tributary to the Haw River between Altamahaw and Ossipee.

Deep River

The City of High Point dominates the upstream portions of the Deep River watershed and water chemistry results reflected the impacts of point and nonpoint sources. Results for dissolved oxygen were lower in the upstream reaches of this river, and results for specific conductance and nutrients were much greater in the upstream portions than the downstream portions (Figures 115 - 118).

Rockfish Creek

Much of the Rockfish Creek watershed lies within the Fort Bragg military reservation, west of the City of Fayetteville. Overall, the upstream to downstream patterns in water quality for all parameters showed no spatial differences with the exception of the most downstream site at NC 87 in Fayetteville (Station B8230000). Here water quality is influenced by urban point and nonpoint discharges (Figures 119 and 120).

Northeast Cape Fear River

All the monitoring stations along the Northeast Cape Fear River are located in stream segments with a supplemental water quality classification of “Swamp Water.” Dissolved oxygen concentrations for all stations depicted at least 10 percent of the results were less than 5.0 mg/L (Figure 121).

Specific conductance was greatly elevated in the headwaters of this freshwater, rural watershed (Figure 121). These elevated measurement were the result of discharges from Mount Olive pickle processing facility near the Town of Mount Olive.

Overall median concentrations for nutrients were similar among the stations, however total phosphorus appeared elevated at the station near Williams (Station B9090000). DWQ and the Lower Cape Fear River Program (LCFRP) collected data from this station, and water quality patterns were similar. DWQ and LCFRP showed similar median concentrations and depict similar interquartile ranges. Why the variability in phosphorus is greater at the monitoring site near Williams than at any other monitoring site was unknown.

Cape Fear River

Water quality data along the Cape Fear River was collected from 37 monitoring stations operated by DWQ and the three coalitions. Data from seven stations were collected by DWQ and one of the coalitions. Characteristics between the upstream and downstream portions of the river change from freshwater to saltwater with estuarine conditions beginning at about Neils Eddy Landing near Acme (see specific conductance, Figure 123).

Generally dissolved oxygen concentrations were good throughout the river with one exception a sag occurring in the lower reaches of the river beginning at about Neils Eddy Landing (Figure 123). Reasons for this sag are under investigation and may include natural (wetland) and anthropogenic (point and nonpoint discharges) influences.

Nitrite+nitrate nitrogen (NO_x) increased slightly in the mid portions of the river between Tar Heel and Neils Eddy Landing (Figure 124). Median concentrations and interquartile ranges of NO_x increased slightly between these sites. Nearly concomitant patterns can be observed for total phosphorus. However total phosphorus concentrations seemed to increase slightly just downstream of Fayetteville (Figure 125). The reasons for these increases was unknown.

Comparisons Between DWQ and NPDES Coalition Data.

The box and whisker plots depicted similar patterns and distributions of results where samples were taken from the same stations. Minor differences were attributed to the coalitions being required to make more frequent measurements (twice monthly) for dissolved oxygen, temperature, specific conductance ,and pH during the summer. Other differences were attributed to differences in reporting levels for metals and nutrients between the DWQ Laboratory Section and the contract laboratories for the coalitions. Additionally, the Upper and the Middle Cape Fear River Basin Associations were established within the past five years. Thus the period of record for these two coalitions was only a subset of the period the DWQ uses in their five year basin planning cycles.

Table 61. **Summary of elevated water quality parameters in the Cape Fear River basin, 1998 - 2003.[1] Only proportions greater than 10 percent that represent results violating a water quality standard or action level and based on a sample size of at least 10 are presented. Red bold text denotes data that statistically exceeded the standards or action levels.**

Subbasin/Station	Program	Nitrite + Nitrate-Nitrogen (% > 10 mg/L)	Turbidity (% > 50 FW % > 25 SW)	Dissolved oxygen (% < 4.0 mg/L)	Dissolved oxygen (% < 5.0 mg/L)	pH (%)[2]
030601						
B0040000	DWQ				**17.4**	.
B0050000	UCFRBA				**16.1**	.
B0070010	UCFRBA			12.8	**34.0**	.
030602						
B0750000	DWQ		13.0			.
B1095000	DWQ				13.0	.
030605						
B3020000	UCFRBA		12.2	12.9	**35.5**	.
B3025000	UCFRBA		12.2		**25.0**	.
B3300000	UCFRBA		14.6	11.3	**25.8**	.
B3660000	DWQ	**46.3**	10.3			.
B3670000	UCFRBA	**29.3**	14.6			.
030306						
B3900000	UCFRBA	12.2				.
030607						
B6130500	MCFRBA			15.6	**28.1**	.
B6160000	DWQ					12.3
B6370000	MCFRBA		10.9			.
B6483000	MCFRBA			**21.7**	**32.6**	.
030608						
B4210000	DWQ		**22.9**			.
B4240000	DWQ		10.9			.
B4350000	UCFRBA				**24.2**	.
B4410000	DWQ	**23.5**				.
B4440000	DWQ	14.3		17.1	**22.9**	.
B4440000	UCFRBA				**35.9**	.
030609						
B5070000	DWQ					.
B5190000	DWQ		10.9			.
030610						
B5390800	UCFRBA	**17.1**		.		.
B5480000	DWQ				14.3	.
B5520000	DWQ		13.6			.
B5575000	DWQ				12.1	.
B5575000	UCFRBA			11.1	**26.7**	.
030611						
B5685000	UCFRBA				14.5	.
B5820000	UCFRBA				**22.6**	.
030613						
B6830000	MCFRBA					14.1
030614						
B7245000	DWQ					**67.9**
B7280000	DWQ					**29.1**
B7300000	MCFRBA					**26.6**
030615						
B7679000	MCFRBA					**88.5**
B7700000	DWQ					**41.1**
B7700000	MCFRBA					**61.9**
B8220000	DWQ					**40.0**
B8224000	DWQ					**69.8**
B8229000	MCFRBA					**21.6**
B8230000	MCFRBA					**50.0**

Table 61 (continued).

Subbasin/Station	Program	Nitrite + Nitrate-Nitrogen (% > 10 mg/L)	Turbidity (% > 50 FW % > 25 SW)	Dissolved oxygen (% < 4.0 mg/L)	Dissolved oxygen (% < 5.0 mg/L)	pH (%)[2]
030616						
B8305000	DWQ				10.9	
B8315000	MCFRBA					**89.8**
B8321000	DWQ			13.8	**20.7**	**100.0**
B8340050	LCFRP					12.5
B8340100	MCFRBA					**100.0**
B8340200	LCFRP				**16.1**	14.3
B8349000	MCFRBA				10.5	10.6
030617						
B9050000	DWQ			13.8	**36.2**	**31.0**
B9050000	LCFRP			10.1	**47.2**	**43.3**
B9050100	LCFRP				**37.1**	**37.1**
B9790000	LCFRP				14.3	**19.6**
B9795000	LCFRP				**16.4**	10.4
B9800000	DWQ			14.5	**34.5**	**23.6**
B9800000	LCFRP				**25.4**	**17.9**
B9820000	DWQ				**23.2**	**21.4**
B9845100	LCFRP				10.4	
B9980000	LCFRP				11.1	
030620						
B8981000	LCFRP					**87.5**
030623						
B9550000	DWQ					**61.5**
030624						
B9872500	DWQ				11.4	
No. of stations that statistically exceeded the standards or action levels.		**4**	**1**	**1**	**19**	**20**

[1]For Station B9080000 (Northeast Cape Fear River at SR 1937 near Mt Olive) 51.4 percent of the samples (n = 37) exceeded the chloride standard (230 mg/L).

[2]For freshwater the water quality standards are pH < 6.0 and/or pH > 9.0; for swamp water the water quality standards are pH < 4.3 and/or pH > 9.0; for tidal saltwater the water quality standards are pH < 6.8 and/or pH > 8.5 or if swamp water then pH < 4.3 and/or pH > 8.5.

Table 62. **Summary of elevated metals concentrations in the Cape Fear River basin, 1998 - 2003. Only proportions greater than 10 percent that represent results violating a water quality standard or action level and based on a sample size of at least 10 are presented. Red bold text denotes data that statistically exceeded the standards or action levels. FW = freshwater and SW = saltwater.**

Subbasin/ Station	Program	Arsenic (% > 50 µg/L)	Copper (% > 7 µg/L FW % > 3 µg/L SW)	Manganese (% > 200 µg/L)	Lead (% > 25 µg/L)	Zinc (% > 50 µg/L FW % > 86 µg/L SW))
030601						
B0050000	DWQ		**63.3**			
B0170000	UCFRBA		13.6			
B0210000	DWQ		11.1			
030602						
B0540000	DWQ		**20.0**			**83.3**
B0540050	UCFRBA		**22.7**			**27.3**
B0670000	UCFRBA		18.2			
B0750000	DWQ		**26.7**			**75.0**
B0750000	UCFRBA		13.6			**36.4**
B0840000	DWQ		13.3			**45.8**
B1095000	DWQ			**51.9**		
B1140000	DWQ		**21.4**			**26.1**
B1260000	DWQ		14.8			
B1380000	UCFRBA		**22.7**			
030603						
B1670000	DWQ		12.5	18.8		
B1960000	DWQ		**25.0**			17.4
B1960000	UCFRBA		18.2			
030604						
B2000000	DWQ		19.0	.	.	**43.8**
B4050000	DWQ			**25.0**		
B4080000	UCFRBA			13.6		
030605						
B3020000	UCFRBA			**47.6**		
B3025000	UCFRBA		18.2			
B3040000	DWQ			18.2		
B3040000	UCFRBA			**35.3**		
B3300000	UCFRBA		**31.8**	**52.4**		
B3660000	DWQ		**66.7**	**27.3**		**69.2**
B3670000	UCFRBA		**40.9**	**40.9**		**27.3**
030606						
B3899180	UCFRBA			18.2		
B3900000	DWQ			**81.8**		
B3900000	UCFRBA			**59.1**		
030607						
B6370000	DWQ		14.7			
B6840000	MCFRBA		15.3			
030608						
B4210000	DWQ			**30.0**		
B4240000	DWQ		**23.3**			12.5
B4350000	UCFRBA			19.0		
B4378000	UCFRBA					
B4410000	DWQ	17.6	**70.6**			**81.8**
B4440000	DWQ		18.2		18.2	
B4440000	UCFRBA		13.6			
B4615000	DWQ		**30.0**			12.5
030609						
B4800000	DWQ		**30.0**			
B4800000	UCFRBA		**22.7**			
B4850000	UCFRBA		14.3			
B4890000	DWQ		**100.0**			**65.2**
B4920000	UCFRBA		**22.7**			
B5070000	DWQ		14.3			
B5100000	UCFRBA		13.6			

Table 62 (continued).

Subbasin/ Station	Program	Arsenic (% > 50 µg/L)	Copper (% > 7 µg/L FW % > 3 µg/L SW)	Manganese (% > 200 µg/L)	Lead (% > 25 µg/L)	Zinc (% > 50 µg/L FW % > 86 µg/L SW))
030610						
B5190000	DWQ		**20.6**			
B5390800	UCFRBA		**27.3**			
B5520000	DWQ		**27.3**			
030611						
B5820000	DWQ		14.7			
B6040300	UCFRBA			11.8		
030612						
B6000000	DWQ		11.8			11.1
B5980000	UCFRBA		**31.8**			
030613						
B6830000	DWQ			**23.1**		
030615						
B7500000	MCFRBA					**18.6**
B7600000	DWQ		15.2			
B8220000	DWQ		14.3			
030616						
B8301000	MCFRBA					11.5
B8305000	DWQ		14.7			
B8349000	MCFRBA					10.5
030617						
B9050000	DWQ		**40.5**			
B9050000	LCFRP		**25.5**			
B9050100	LCFRP		16.7			
B9800000	DWQ		**27.0**			
B9800000	LCFRP		**23.3**			
B9820000	DWQ		**32.4**			
B9845100	LCFRP		**30.0**			
B9850100	LCFRP		**29.3**			
B9910000	LCFRP		**31.9**			
B9921000	LCFRP		**25.6**			
030623						
B9520000	LCFRP		**31.9**			
030624						
B9740000	DWQ		**27.0**			
B9795000	LCFRP		**20.9**			
B9876000	DWQ		10.3			
B9879000	DWQ		**20.7**			
No. of stations that statistically exceeded the standards or action levels.		**0**	**31**	**10**	**0**	**11**

Table 63. Summary of fecal coliform bacteria concentrations at 65 sites in the Cape Fear River basin, 1998 - 2003. Results only include stations with geometric means (GeoMean) > 200 colonies/100 ml or where more than 20 percent of the results were greater than 400 colonies/100 ml. N = number of samples. Proportions greater than 20 percent that are based on a sample size of at least 10 and which are denoted by red bold text represent statistically significant water quality standard violations.

Subbasin/ Station	Program	Location	Class	N	GeoMean	% > 400
030601						
B0040000	DWQ	Haw R at SR 2109 near Oak Ridge	C NSW	47	175.5	21.3
030602						
B0400000	UCFRBA	Reedy Fork at SR 2719 near Monticello	C NSW	19	185.0	31.6
B0480050	UCFRBA	N Buffalo Cr at N Buffalo Cr WWTP	C NSW	41	626.6	**61.0**
B0540000	DWQ	N Buffalo Cr at SR 2832 near Greensboro	C NSW	53	294.3	**41.5**
B0540050	UCFRBA	N Buffalo Cr at SR 2770 near McLeansville	C NSW	41	439.4	**43.9**
B0670000	UCFRBA	S Buffalo Cr at SR 3000 near Greensboro	C NSW	41	458.3	**51.2**
B0750000	DWQ	S Buffalo Cr at SR 2821 at McLeansville	C NSW	53	237.3	**30.2**
B0750000	UCFRBA	S Buffalo Cr at SR 2821 at McLeansville	C NSW	41	573.4	**58.5**
B0840000	DWQ	Reedy Fork at NC 87 at Ossipee	C NSW	52	342.3	**40.4**
B0840000	UCFRBA	Reedy Fork at NC 87 at Ossipee	C NSW	27	321.4	**40.7**
B0850000	UCFRBA	Haw R at SR 1530 near Ossipee	C NSW	41	315.4	**39.0**
B1140000	DWQ	Haw R at NC 49N at Haw River	C NSW	49	164.1	28.6
B1200000	UCFRBA	Haw R at NC 54 near Graham	C NSW	41	215.8	26.8
B1260000	DWQ	Town Branch at SR 2109 near Graham	C NSW	48	217.1	**39.6**
B1350000	UCFRBA	Moadams Cr at Corrigidor Rd near Mebane	C NSW	41	249.0	**34.1**
B1380000	UCFRBA	Moadams Cr at SR 1940 near Florence Town	C NSW	41	323.4	**36.6**
B1440000	UCFRBA	Haw R at SR 2158 near Swepsonville	C NSW	41	161.7	24.4
B1940000	UCFRBA	Big Alamance Cr at NC 87 near Swepsonville	C NSW	41	169.9	26.8
B1960000	UCFRBA	Alamance Cr at SR 2116 at Swepsonville	C NSW	41	164.6	22.0
030604						
B1980000	UCFRBA	Haw R at SR 2171 at Saxapahaw	C NSW	41	131.0	22.0
B2000000	DWQ	Haw R at SR 1005 near Saxapahaw	C NSW	29	84.4	20.7
030605						
B3020000	UCFRBA	New Hope Cr at NC 54 near Durham	WS-IV NSW	41	139.5	29.3
B3025000	UCFRBA	Third Fork Cr at NC 54 near Durham	WS-IV NSW	41	219.4	**39.0**
B3040000	UCFRBA	New Hope Cr at SR 1107 near Blands	WS-IV NSW	41	169.2	29.3
B3300000	UCFRBA	Northeast Cr at SR 1102 near RTP	WS-IV NSW	41	154.5	24.4
B3660000	DWQ	Northeast Cr at SR 1100 near Nelson	WS-IV NSW	63	314.0	**36.5**
B3670000	UCFRBA	Northeast Cr at SR 1731 near Durham	WS-IV NSW	41	141.4	22.0
030606						
B3899180	UCFRBA	Morgan Cr at Mason Farm WWTP - Chapel Hill	WS-IV NSW	41	144.3	29.3
B3900000	UCFRBA	Morgan Cr at SR 1726 near Farrington	WS-IV NSW	41	144.3	24.4
030607						
B6130500	MCFRBA	Lick Cr at SR 1500 near Corinth	WS-IV	63	121.8	20.6
B6230000	MCFRBA	Avents Cr at SR 1418 near Cokesbury	WS-IV HQW	63	155.1	20.6
B6370000	MCFRBA	Cape Fear R at US 401 at Lillington	WS-IV	63	104.9	25.4
B6483000	MCFRBA	E Buies Cr at SR 2054 at Buies Creek	WS-IV	45	156.4	26.7
B6485000	MCFRBA	Buies Cr at Keith Hills Golf Course	WS-IV	2	247.4	50.0
B6840000	MCFRBA	Cape Fear R at NC 217 at Erwin	WS-V	63	83.6	20.6
030608						
B4210000	DWQ	W Fork Deep R at SR 1818 near High Point	WS-IV CA	34	334.6	**32.4**
B4350000	UCFRBA	Deep R at SR 1113 near Hayworth Spring	WS-IV CA	41	170.3	29.3
B4378000	UCFRBA	Richland Cr at SR 1193 near High Point	WS-IV	41	730.3	**63.4**
B4410000	DWQ	Richland Cr at SR 1145 near High Point	WS-IV CA	16	338.5	**37.5**
B4440000	DWQ	Deep R at SR 1129 near High Point	WS-IV CA	33	281.0	**33.3**
B4440000	UCFRBA	Deep R at SR 1129 near High Point	WS-IV CA	42	648.8	**57.1**
B4615000	DWQ	Deep R at SR 1921 near Randleman	WS-IV CA	49	161.1	28.6
B4626000	UCFRBA	Muddy Cr at SR 1929 near Glenola	WS-IV CA	41	348.7	**56.1**
B4770500	UCFRBA	Deep R US 220 Bus. Main St at Randleman	C	41	252.0	**31.7**

Table63 (continued).

Subbasin/ Station	Program	Location	Class	N	GeoMean	% > 400
030609						
B4800000	DWQ	Deep R at SR 2122 at Worthville	C	54	233.5	**38.9**
B4800000	UCFRBA	Deep R at SR 2122 at Worthville	C	29	207.8	**34.5**
B4850000	UCFRBA	Hasketts Cr at US 220 Bus. near North Asheboro	C	40	419.8	**45.0**
B4890000	DWQ	Hasketts Cr at SR 2128 near Central Falls	C	53	155.3	20.8
B4890000	UCFRBA	Hasketts Cr at SR 2128 near Central Falls	C	12	244.2	33.3
B4920000	UCFRBA	Deep R at SR 2261 C53 near Central Falls	C	41	180.0	29.3
B5070000	UCFRBA	Deep R at SR 2615 at Ramseur	C	41	136.2	26.8
B5100000	UCFRBA	Deep R at SR 2628 near Parks Crossroads	C	41	185.4	22.0
030610						
B5390800	UCFRBA	Cotton Cr at SR 1372 near Star	WS-III	41	1289.1	**80.5**
030611						
B5820000	DWQ	Deep R at US 15 and 501 near Sanford	C	54	63.2	20.4
030615						
B7500000	MCFRBA	Cape Fear R at I-95 below Fayetteville	C	62	140.4	25.8
B7589000	MCFRBA	Cross Cr at walkway at WWTP	C	50	359.2	**50.0**
B7590000	MCFRBA	Cross Cr at US 301 Bus & I-95 Bus - Fayetteville	C	12	558.1	**75.0**
B7679300	MCFRBA	Rockfish Cr at US 401 bypass near Raeford	B	2	291.5	50.0
B7700000	MCFRBA	Rockfish Cr at SR 1432 near Raeford	B	62	239.5	**37.1**
B8230000	MCFRBA	Rockfish Cr at NC 87 near Fayetteville	C	14	124.5	**42.9**
030616						
B8315000	MCFRBA	Harrison Cr at SR 1320 at Burney	C	59	137.3	20.3
030622						
B9460000	LCFRP	Little Rockfish Cr at NC 11	C Sw	60	181.4	**33.3**
030623						
B9500000	LCFRP	Burgaw Canal at SR 1345 Wright St at Burgaw	C Sw	60	140.3	**28.3**
B9520000	DWQ	Burgaw Canal at US 117	C Sw	10	246.9	30.0
B9520000	LCFRP	Burgaw Canal at US 117	C Sw	60	193.5	**33.3**
No. of stations that statistically exceeded the standard						**29**

Table 64. Summary of chlorophyll *a* concentrations at 33 sites in the Cape Fear River basin, 1998 - 2003. N = Number of samples. Red bold text denotes data that statistically exceeded the standard.

Subbasin/ Station	Program	Location	N	No > 40 µg/l	Proportion (%) > 40 µg/l
030602					
B1260000	DWQ	Town Branch at SR 2109 near Graham	9		
B2100000	DWQ	Haw R at SR 1713 near Bynum	2		
030604					
B2450000	DWQ	Robeson Cr at SR 1943 near Hanks Chapel	25	6	**24.0**
030607					
B6160000	DWQ	Cape Fear R at NC 42 near Corinth	4	3	75.0
B6160000	MCFRBA	Cape Fear R at NC 42 near Corinth	30	5	16.7
B6370000	DWQ	Cape Fear R at US 401 at Lillington	1		
030608					
B4210000	DWQ	W Fork Deep R at SR 1818 near High Point	28	1	3.6
030609					
B4800000	UCFRBA	Deep R at SR 2122 at Worthville	25	1	4.0
B4890000	UCFRBA	Hasketts Cr at SR 2128 near Central Falls	2		
B4920000	UCFRBA	Deep R at SR 2261 near Central Falls	27	2	7.4
B5131000	DWQ	Deep R at NC 42 near Coleridge	24		
030610					
B5575000	DWQ	Deep R at NC 42 at Carbonton	27		
B5575000	UCFRBA	Deep R at NC 42 at Carbonton	26	7	**26.9**
030612					
B6000000	DWQ	Rocky R at NC 902 near Pittsboro	3		
030616					
B8290000	MCFRBA	Cape Fear R at Dupont Water Intake	30	8	**26.7**
B8300000	DWQ	Cape Fear R at W. O. Huske Lock near Tar Heel	7	4	57.1
B8305000	MCFRBA	Cape Fear R at SR 1316 at Tarheel	2		
B8339000	MCFRBA	Cape Fear R above Lock and Dam 2	30	3	10.0
B8340000	DWQ	Cape Fear R at Lock 2 near Elizabethtown	7	3	42.9
B8349000	MCFRBA	Cape Fear R above Lock and Dam 1 - East Arcadia	30		
B8360000	LCFRP	Cape Fear R at NC 11 near Kings Bluff	34		
030617					
B8450000	DWQ	Cape Fear R at Neils Eddy Landing near Acme	3	1	33.3
B9020000	DWQ	Cape Fear R DNS Hale Pt Landing near Phoenix	3		
B9050000	LCFRP	Cape Fear R at Navassa	34		
B9800000	LCFRP	Cape Fear R at Channel Marker 61 at Wilmington	42		
B9921000	LCFRP	Cape Fear R at Channel Marker 18	46		
030621					
B9080000	DWQ	Northeast Cape Fear R at SR 1937 near Mt Olive	4	1	25.0
030622					
B9460000	LCFRP	Little Rockfish Cr at NC 11	34	1	2.9
030623					
B9480000	DWQ	Northeast Cape Fear R at SR 1318 near Watha	1		
B9500000	LCFRP	Burgaw Canal at SR 1345 Wright St at Burgaw	46	7	15.2
B9520000	LCFRP	Burgaw Canal at US 117	46	1	2.2
030624					
B9876000	DWQ	ICW at Channel Marker 151 near Everett N	1		
B9879000	DWQ	Carolina Beach Harbor at Channel Marker 7	1		
No. of stations that statistically exceeded the standard					**3**

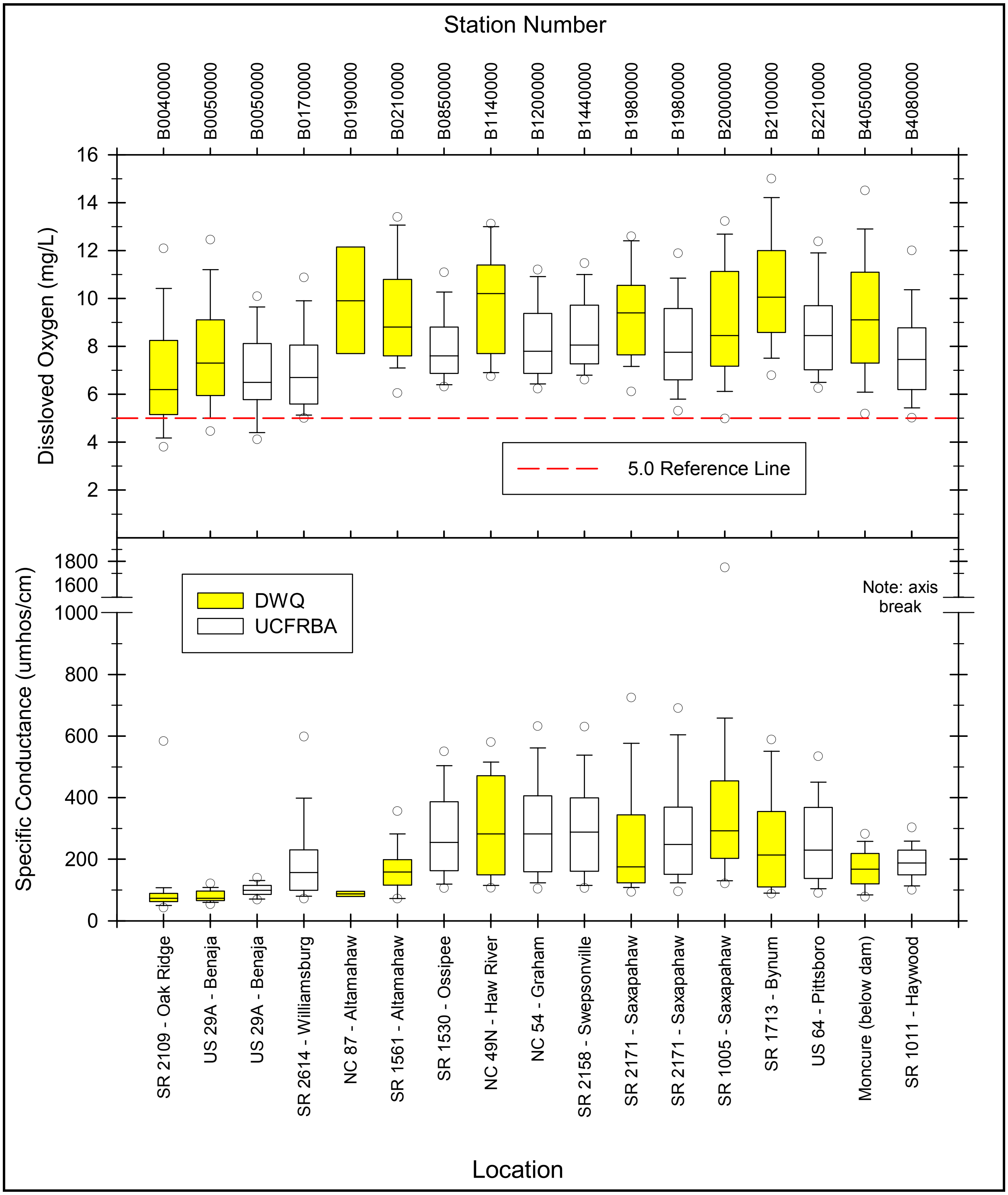


Figure 111. **Upstream (left) to downstream (right) dissolved oxygen and conductivity patterns along the Haw River, September 01, 1998 – August 31, 2003.**

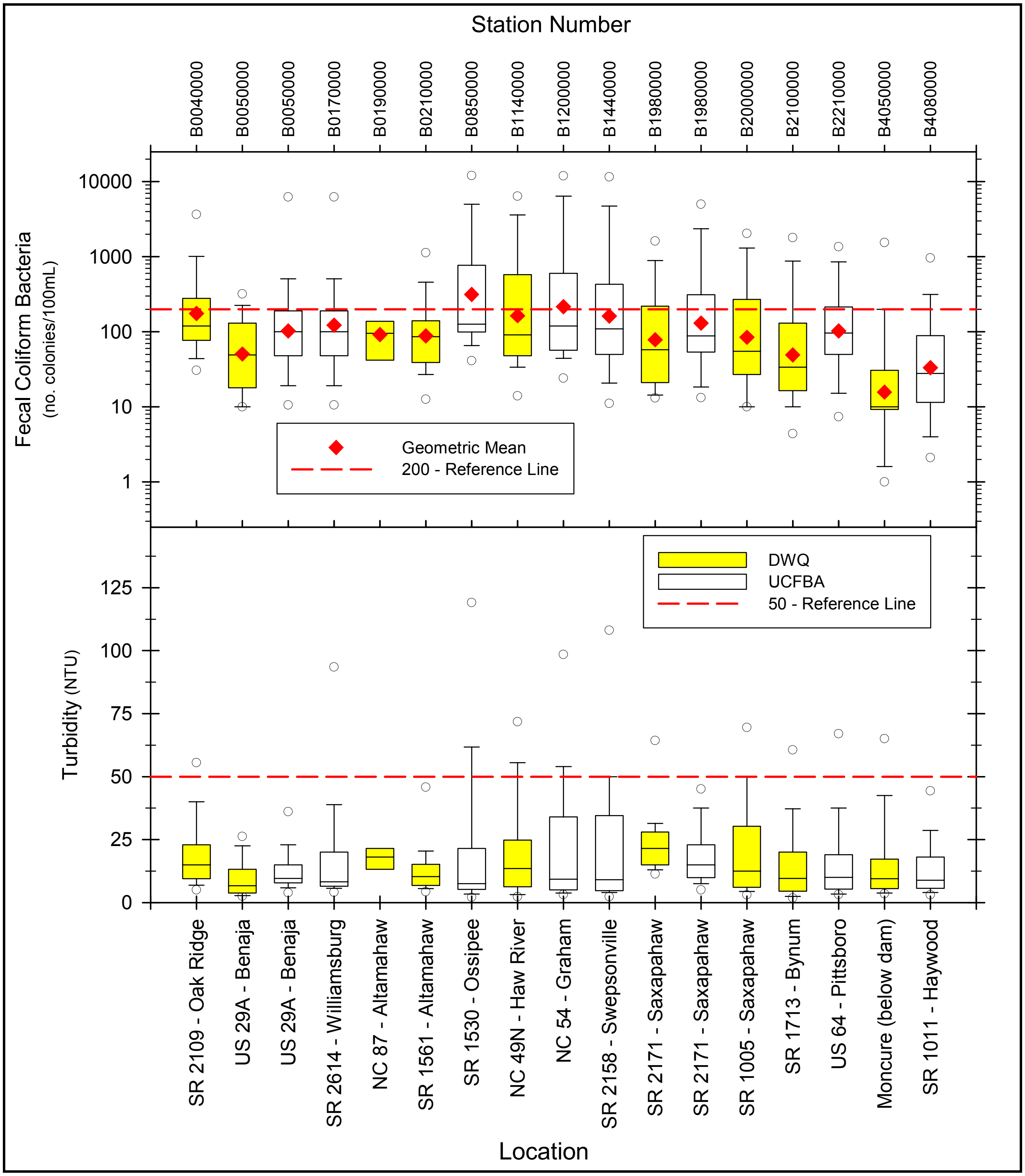


Figure 112. **Upstream (left) to downstream (right) fecal coliform bacteria and turbidity patterns along the Haw River, September 01, 1998 – August 31, 2003.**

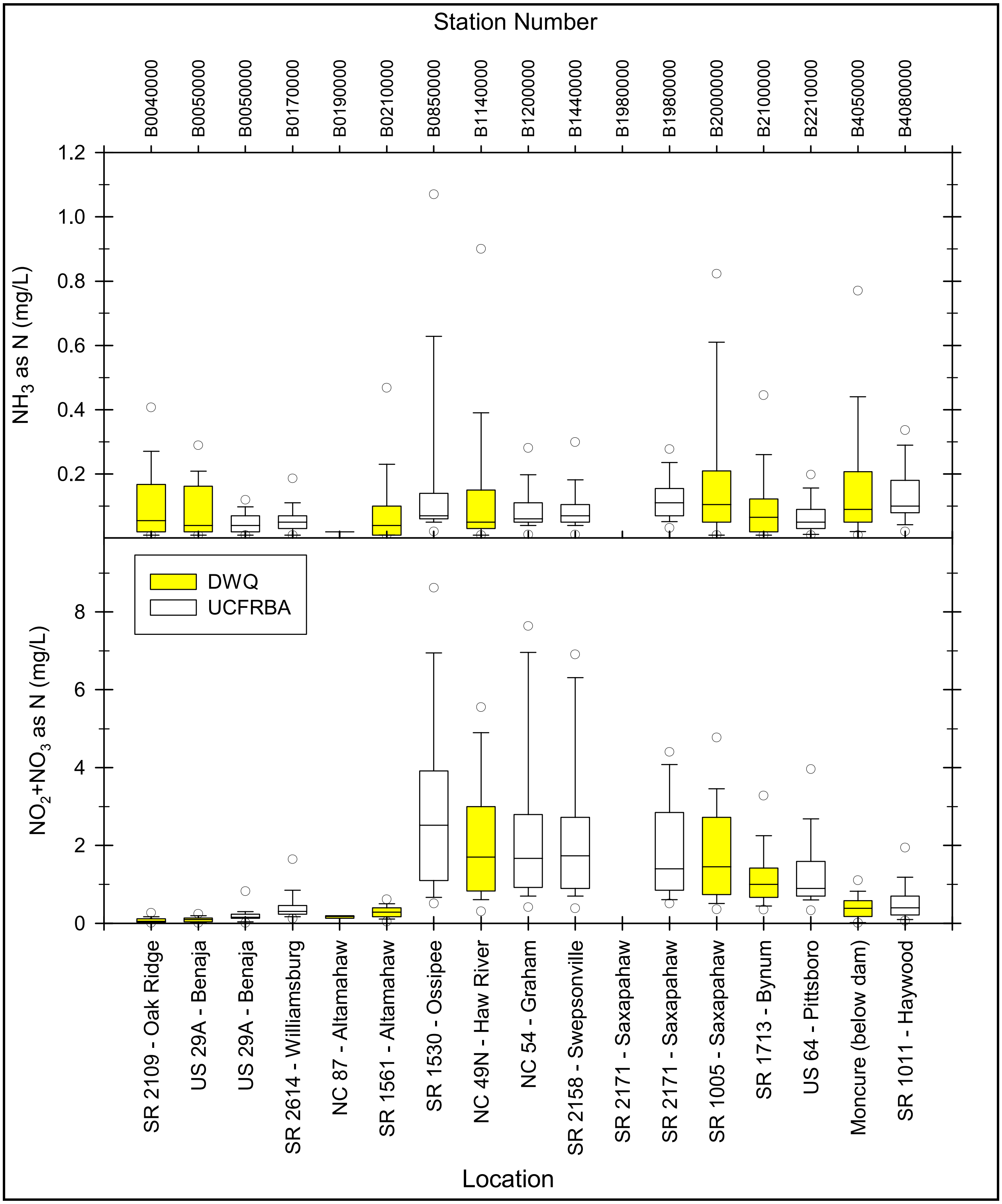


Figure 113. **Upstream (left) to downstream (right) ammonia nitrogen (NH_3 as N) and nitrite+nitrate nitrogen (NO_2+NO_3 as N) patterns along the Haw River, September 01, 1998 – August 31, 2003.**

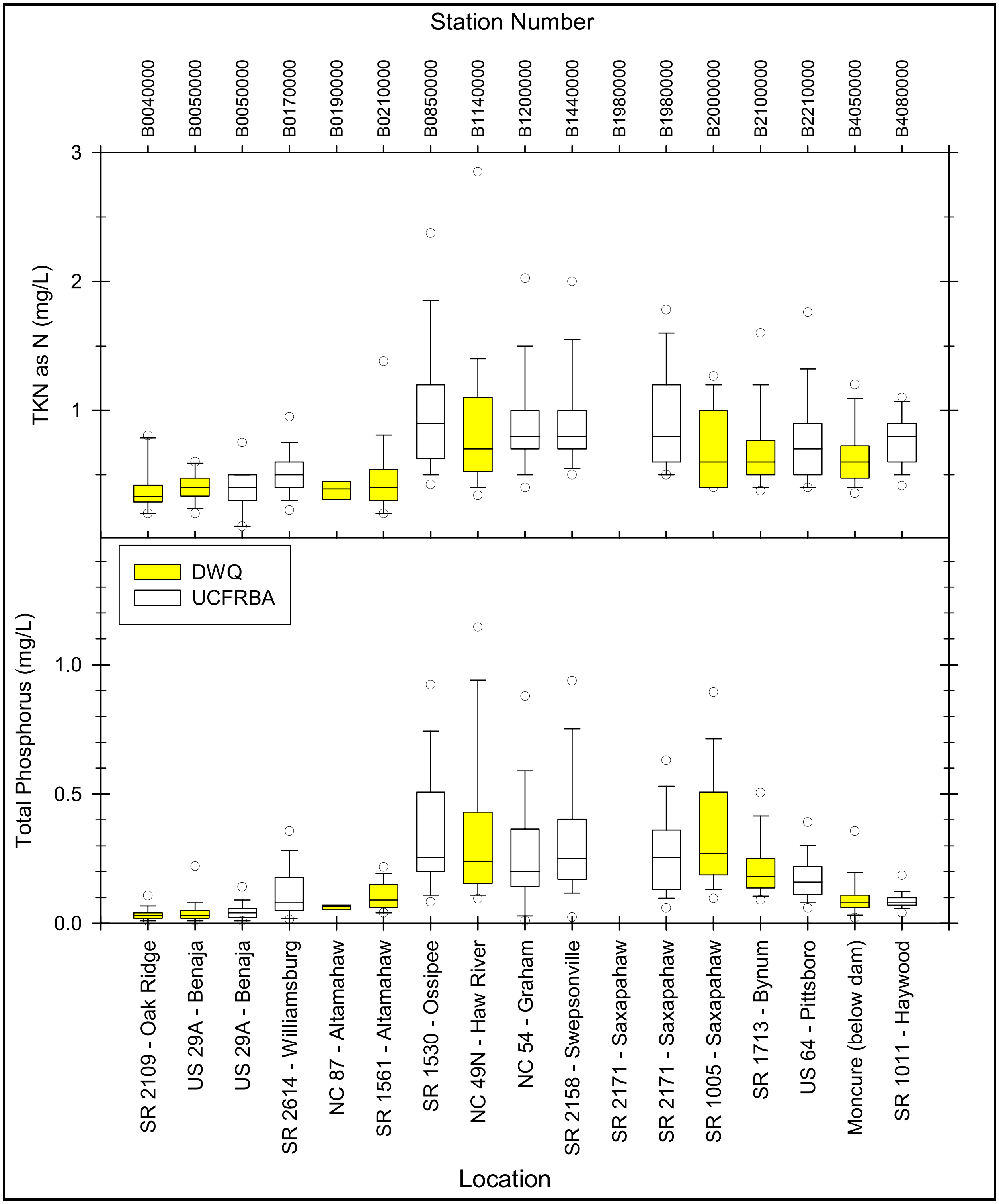


Figure 114. **Upstream (left) to downstream (right) total Kjeldahl nitrogen (TKN as N) and total phosphorus patterns along the Haw River, September 01, 1998 – August 31, 2003.**

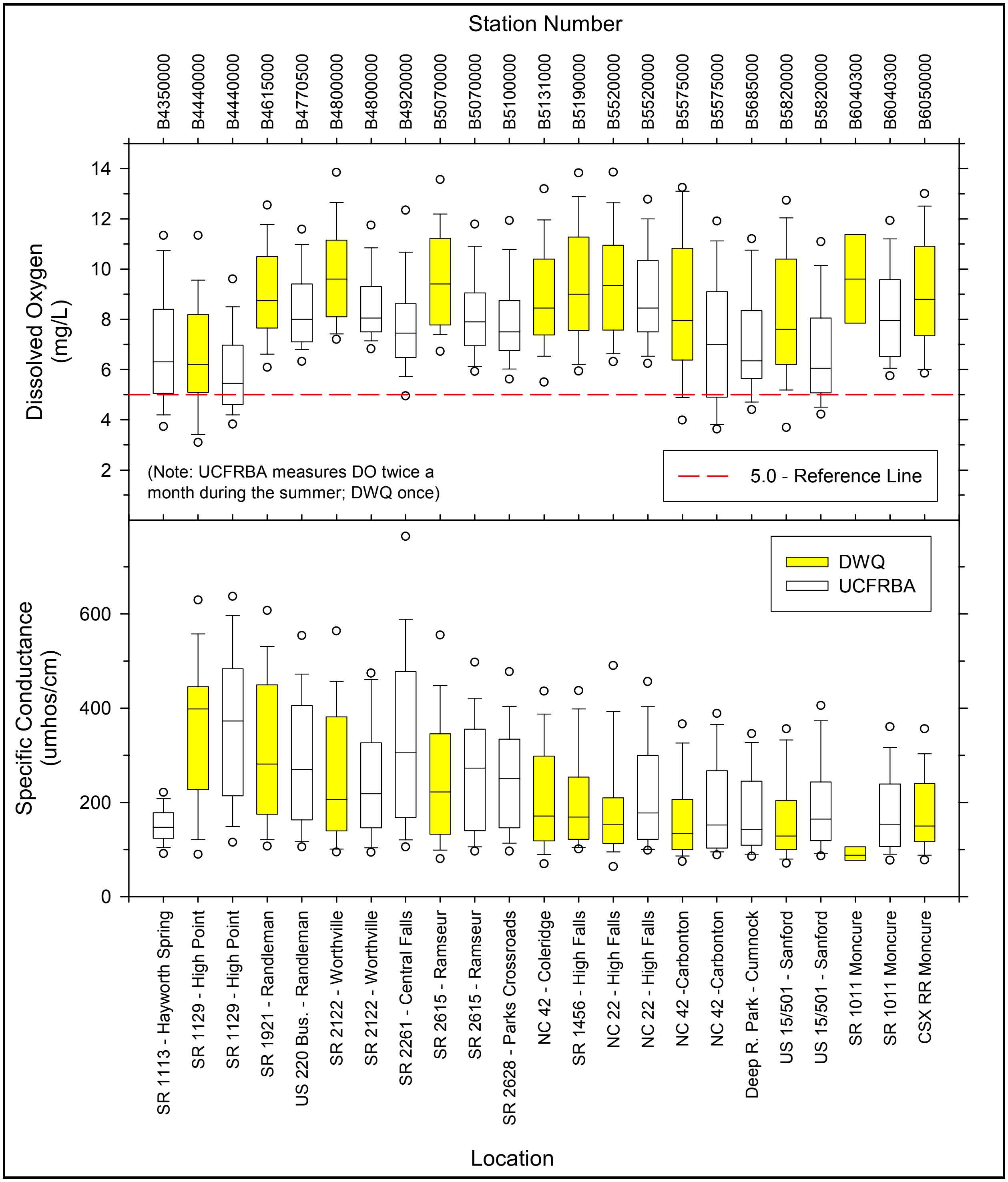


Figure 115. **Upstream (left) to downstream (right) dissolved oxygen and conductivity patterns along the Deep River, September 01, 1998 – August 31, 2003.**

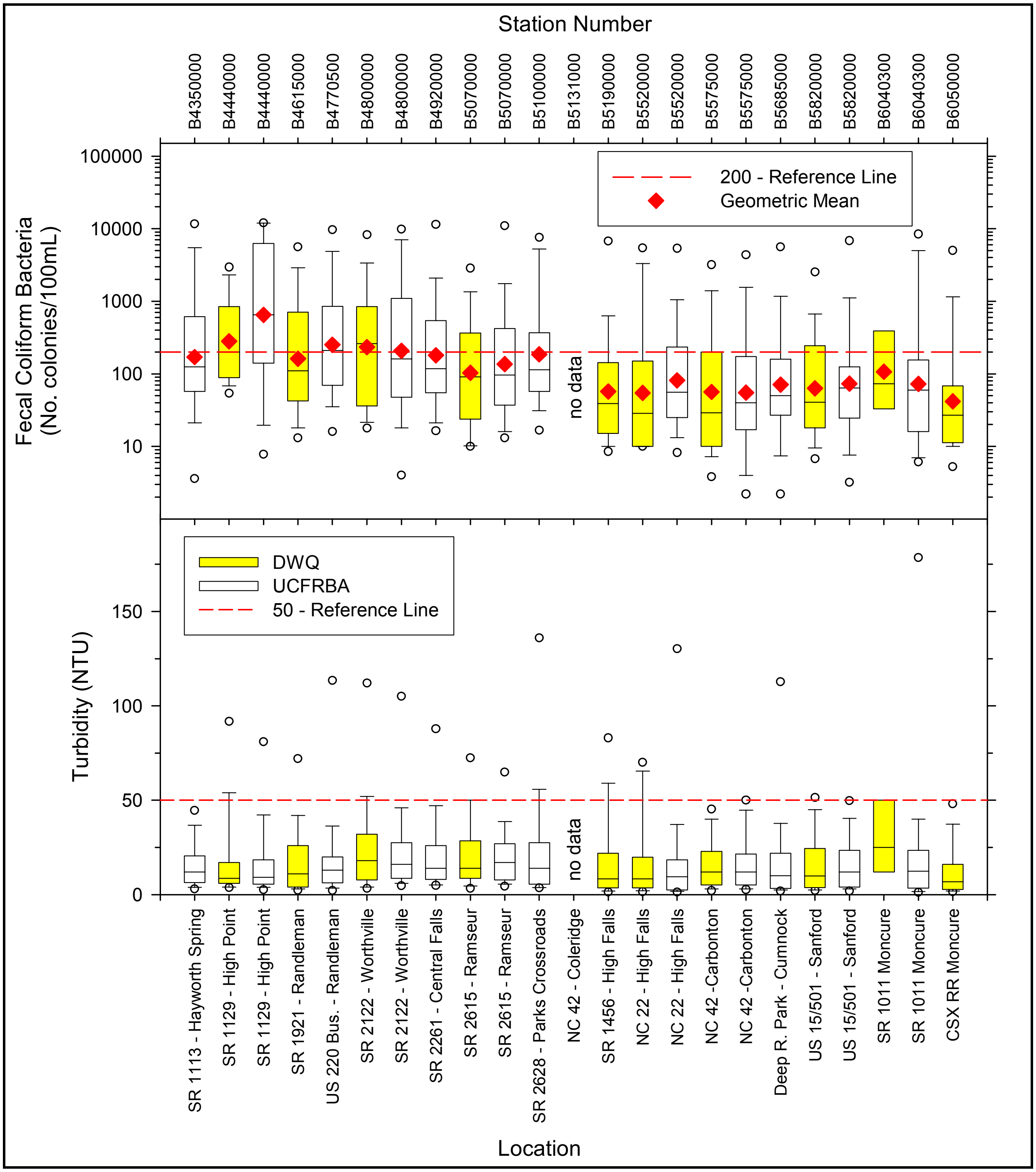


Figure 116. **Upstream (left) to downstream (right) fecal coliform bacteria and turbidity patterns along the Deep River, September 01, 1998 – August 31, 2003.**

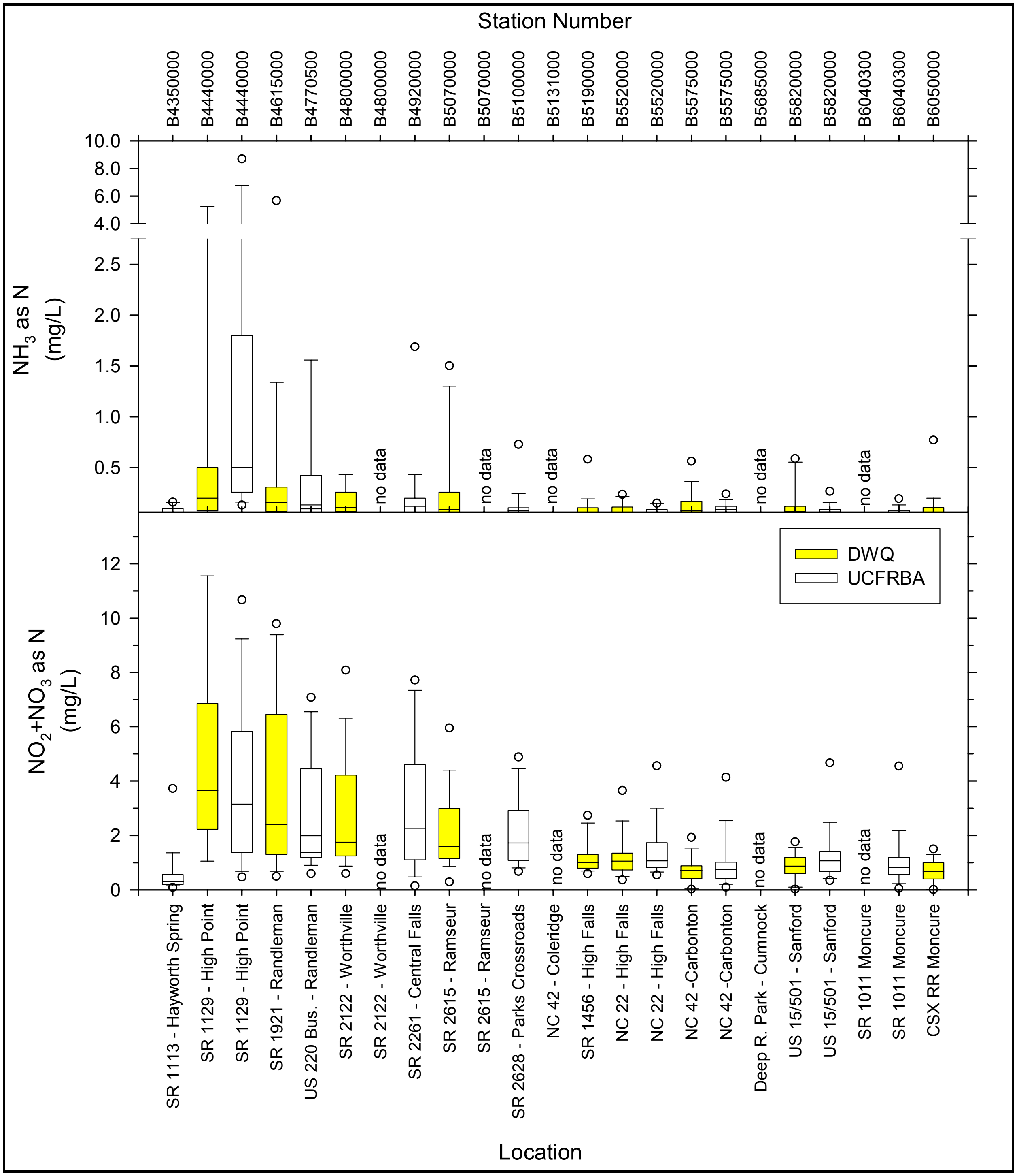


Figure 117. **Upstream (left) to downstream (right) ammonia nitrogen (NH_3 as N) and nitrite+nitrate nitrogen (NO_2+NO_3 as N) patterns along the Deep River, September 01, 1998 – August 31, 2003.**

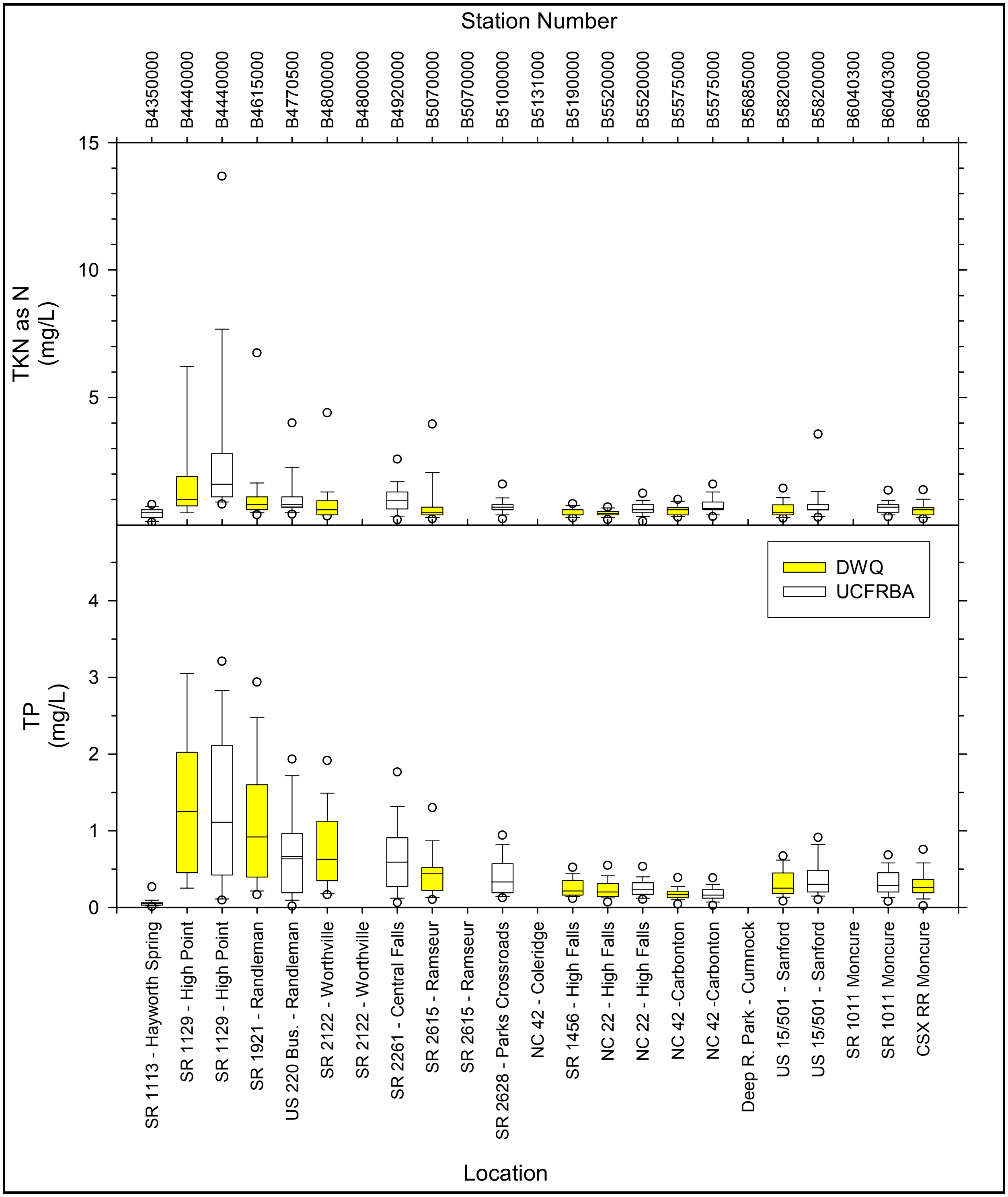


Figure 118. **Upstream (left) to downstream (right) total Kjeldahl nitrogen (TKN as N) and total phosphorus patterns along the Deep River, September 01, 1998 – August 31, 2003. Five sites had no data.**

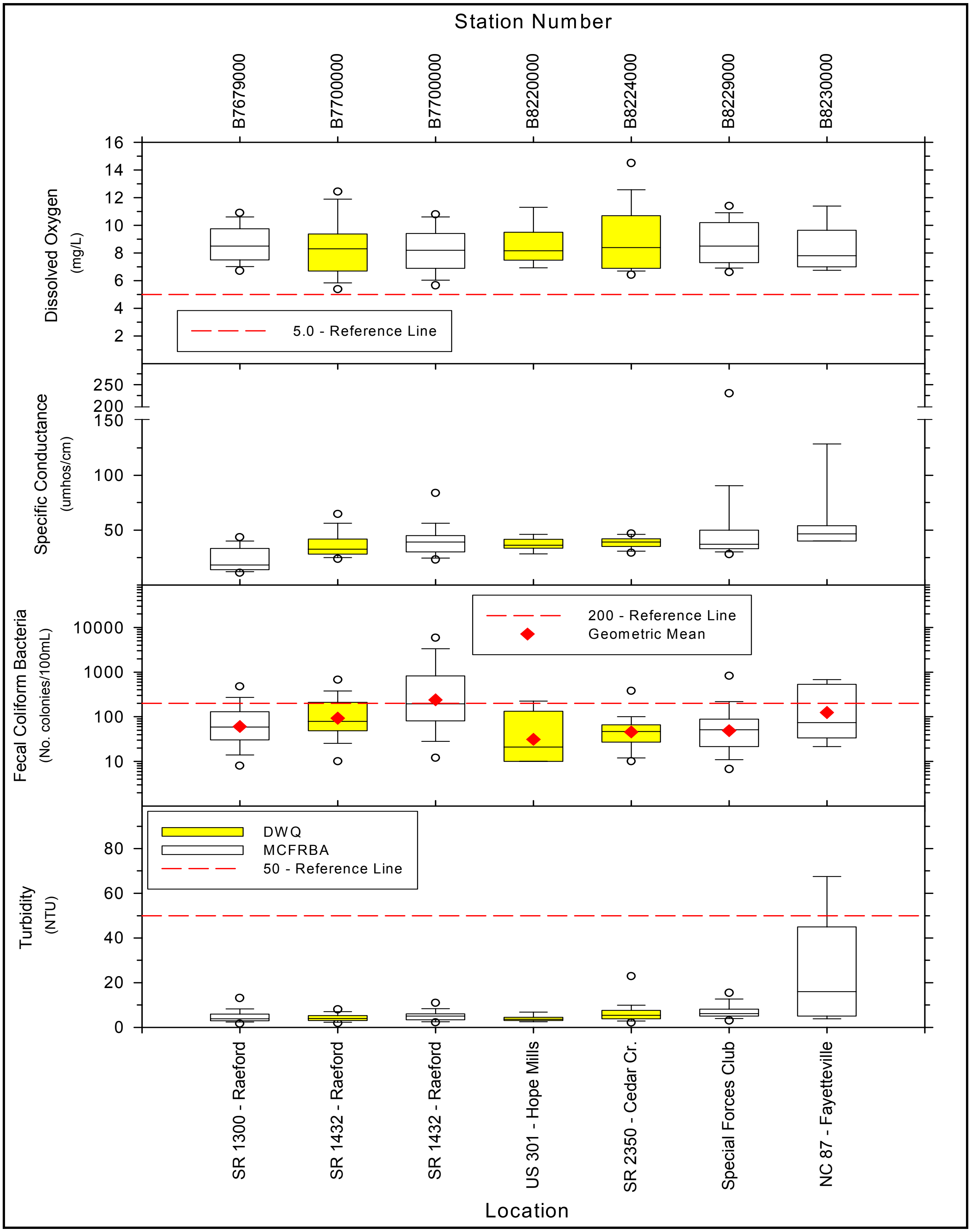


Figure 119. **Upstream (left) to downstream (right) dissolved oxygen, conductivity, fecal coliform bacteria, and turbidity patterns along Rockfish Creek, September 01, 1998 – August 31, 2003.**

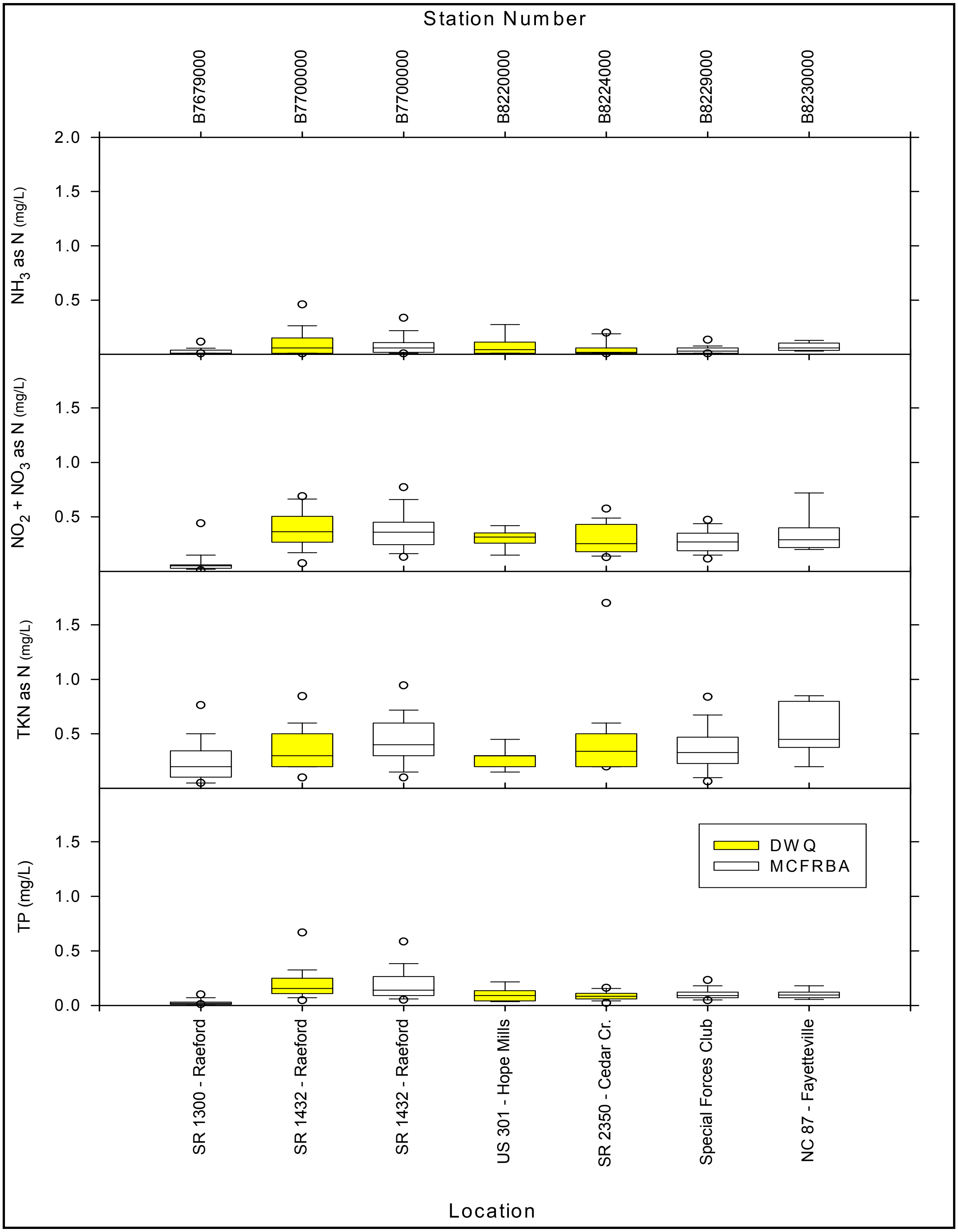


Figure 120. **Upstream (left) to downstream (right) nutrient patterns along Rockfish Creek, September 01, 1998 – August 31, 2003.**

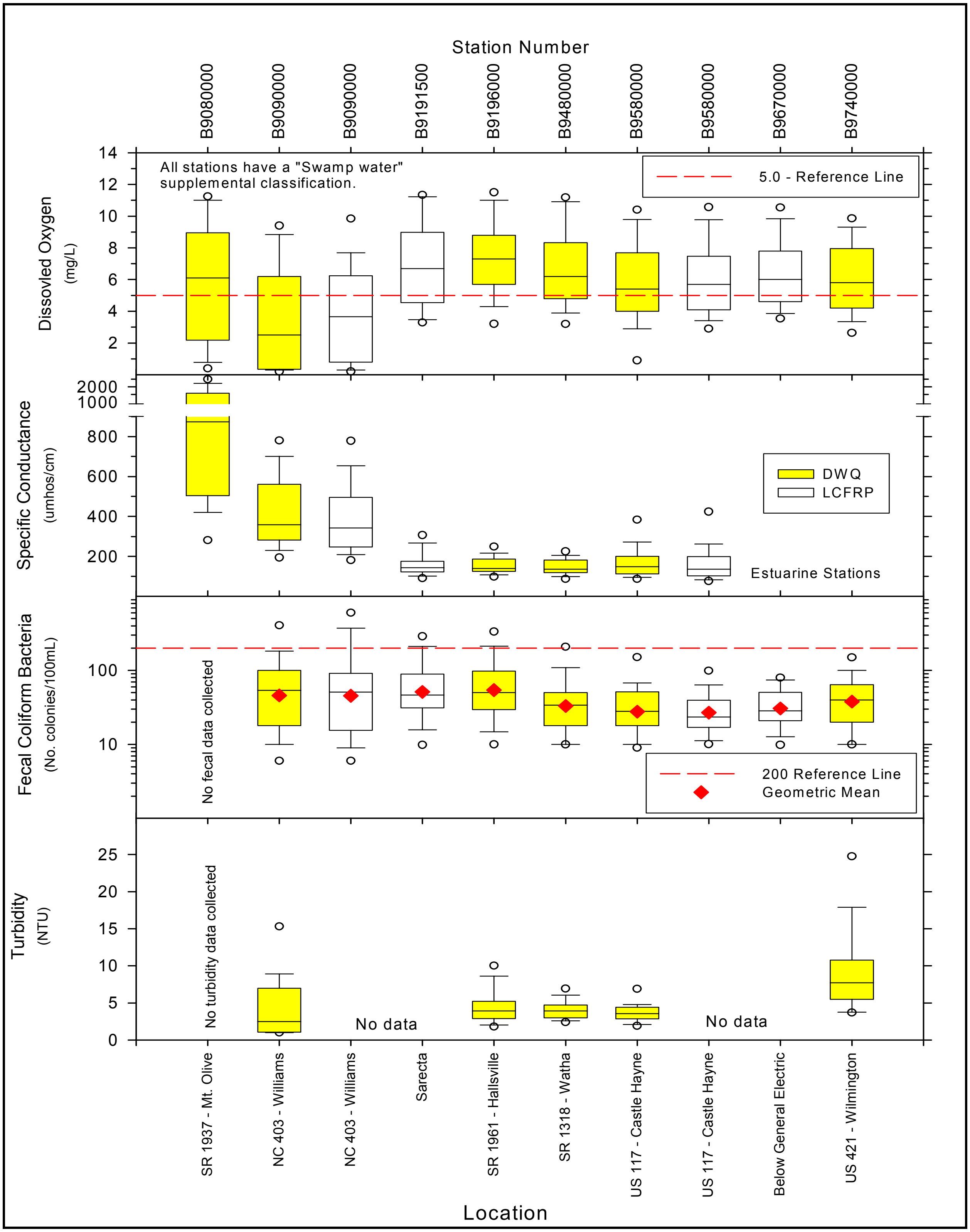


Figure 121. **Upstream (left) to downstream (right) dissolved oxygen, conductivity, fecal coliform bacteria, and turbidity patterns along the Northeast Cape Fear River, September 01, 1998 – August 31, 2003.**

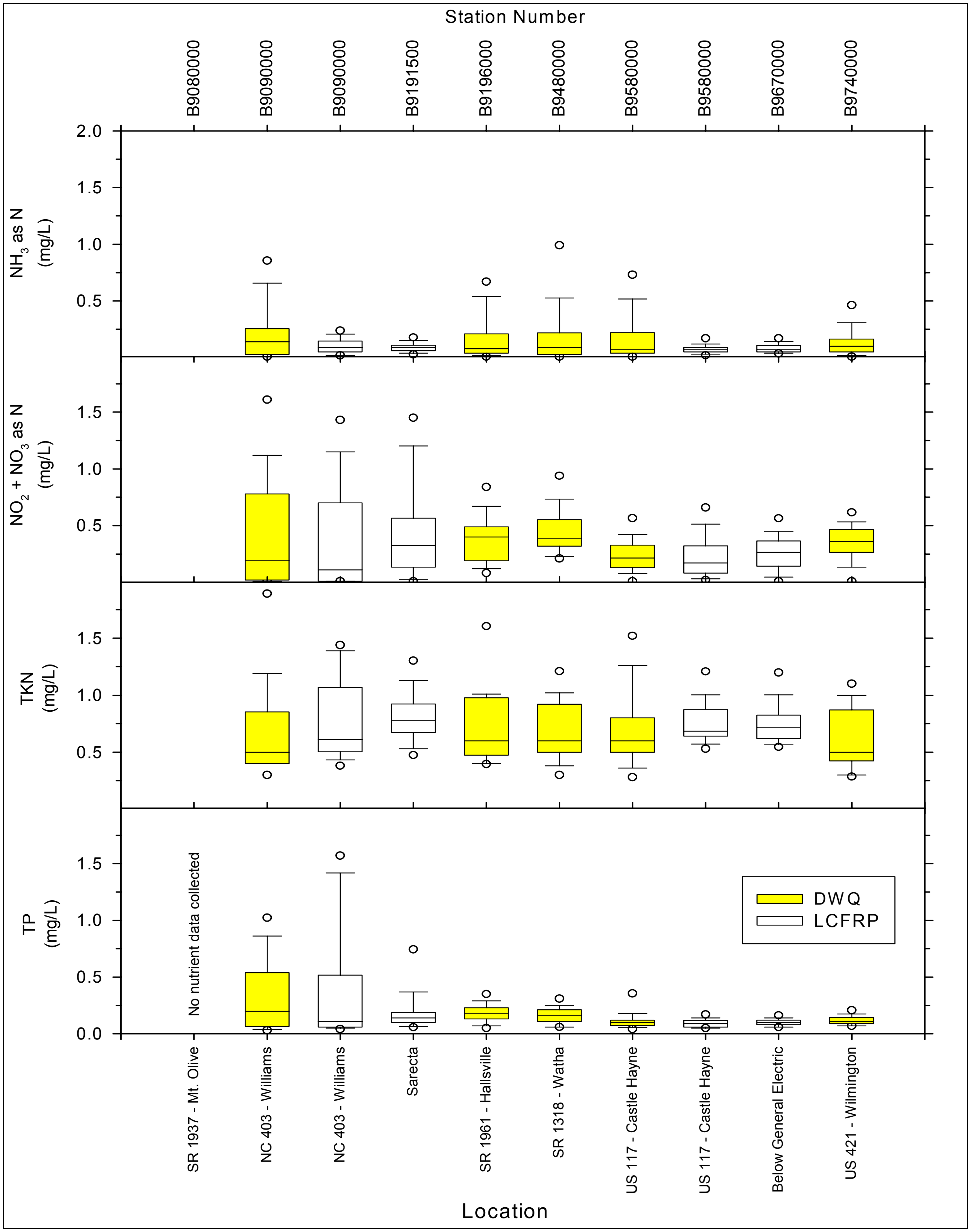


Figure 122. **Upstream (left) to downstream (right) nutrient patterns along the Northeast Cape Fear River, September 01, 1998 – August 31, 2003.**

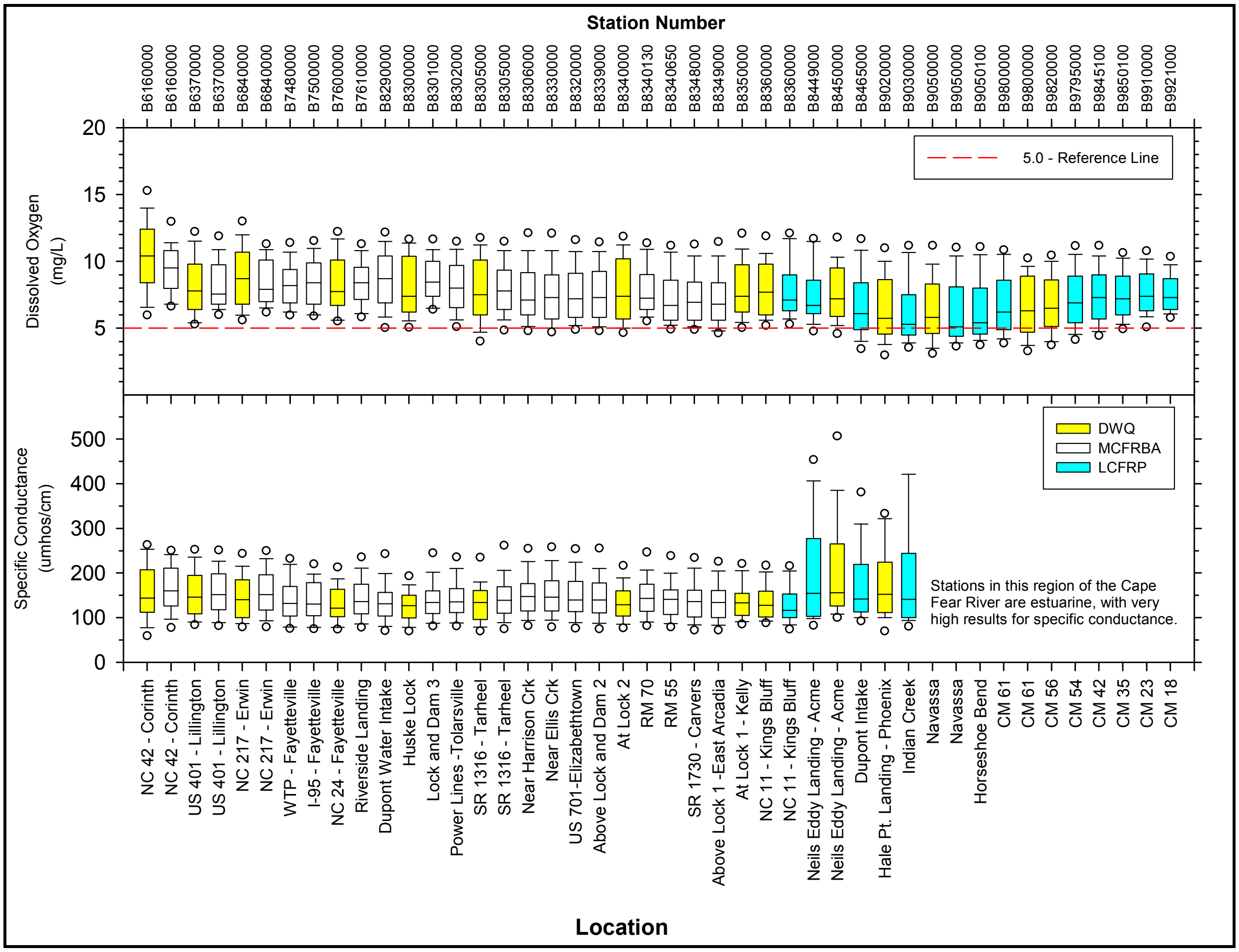


Figure 123. Upstream (left) to downstream (right) dissolved oxygen and conductivity patterns along the Cape Fear River, September 01, 1998 – August 31, 2003.

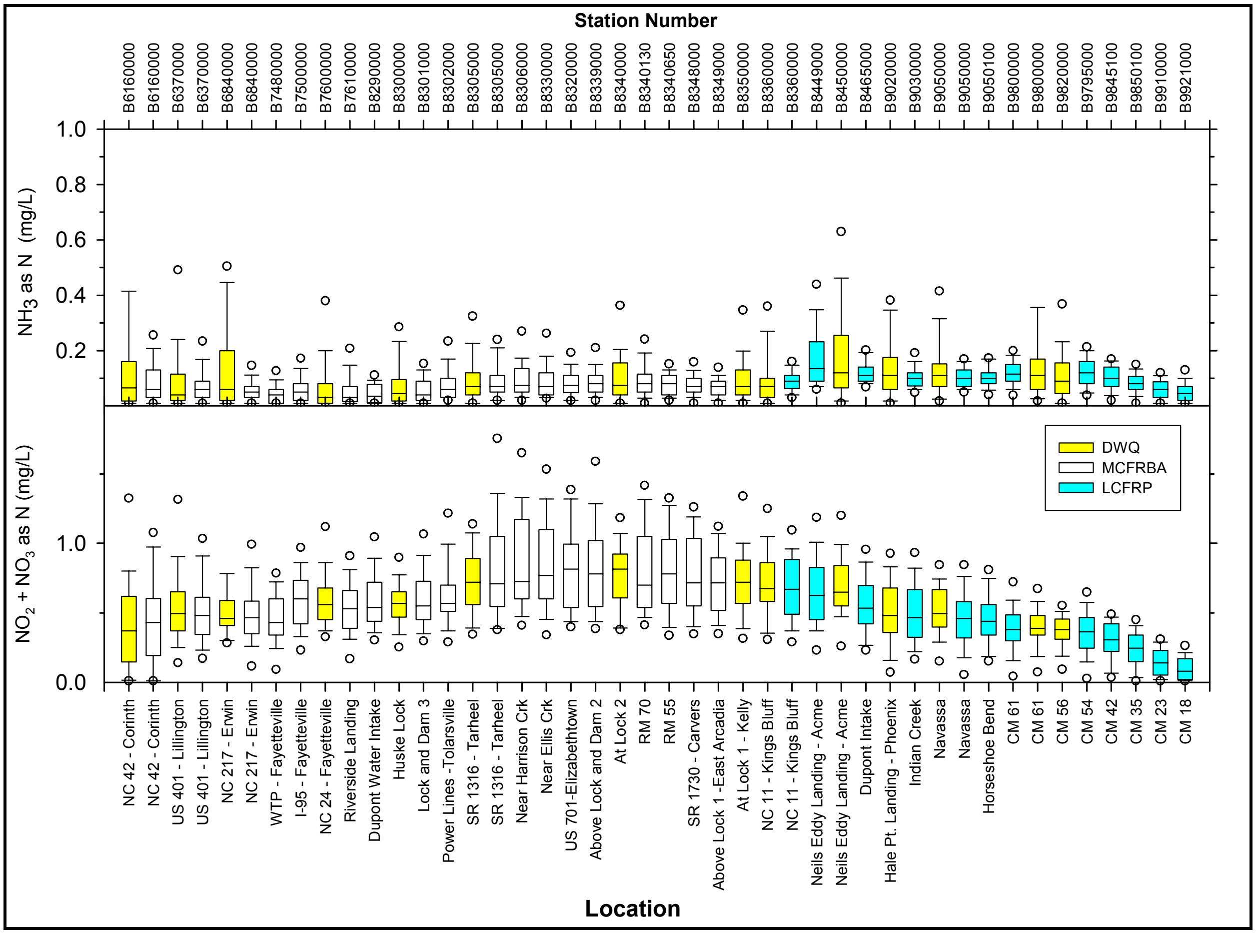


Figure 124. **Upstream (left) to downstream (right) ammonia nitrogen (NH_3 as N) and nitrite+nitrate nitrogen (NO_2+NO_3 as N) patterns along the Cape Fear River, September 01, 1998 – August 31, 2003.**

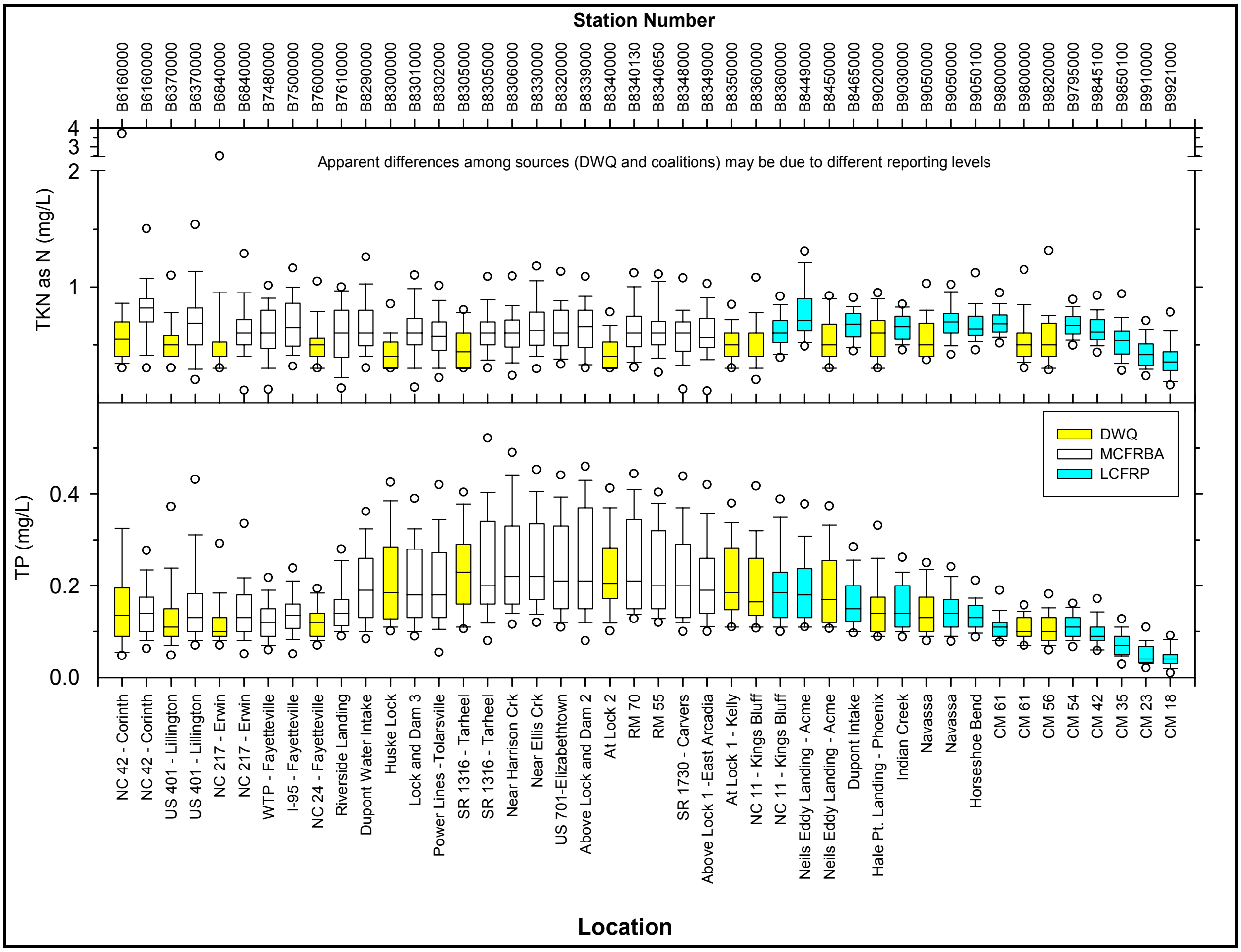


Figure 125. **Upstream (left) to downstream (right) total Kjeldahl nitrogen (TKN as N) and total phosphorus patterns along the Cape Fear River, September 01, 1998 – August 31, 2003.**

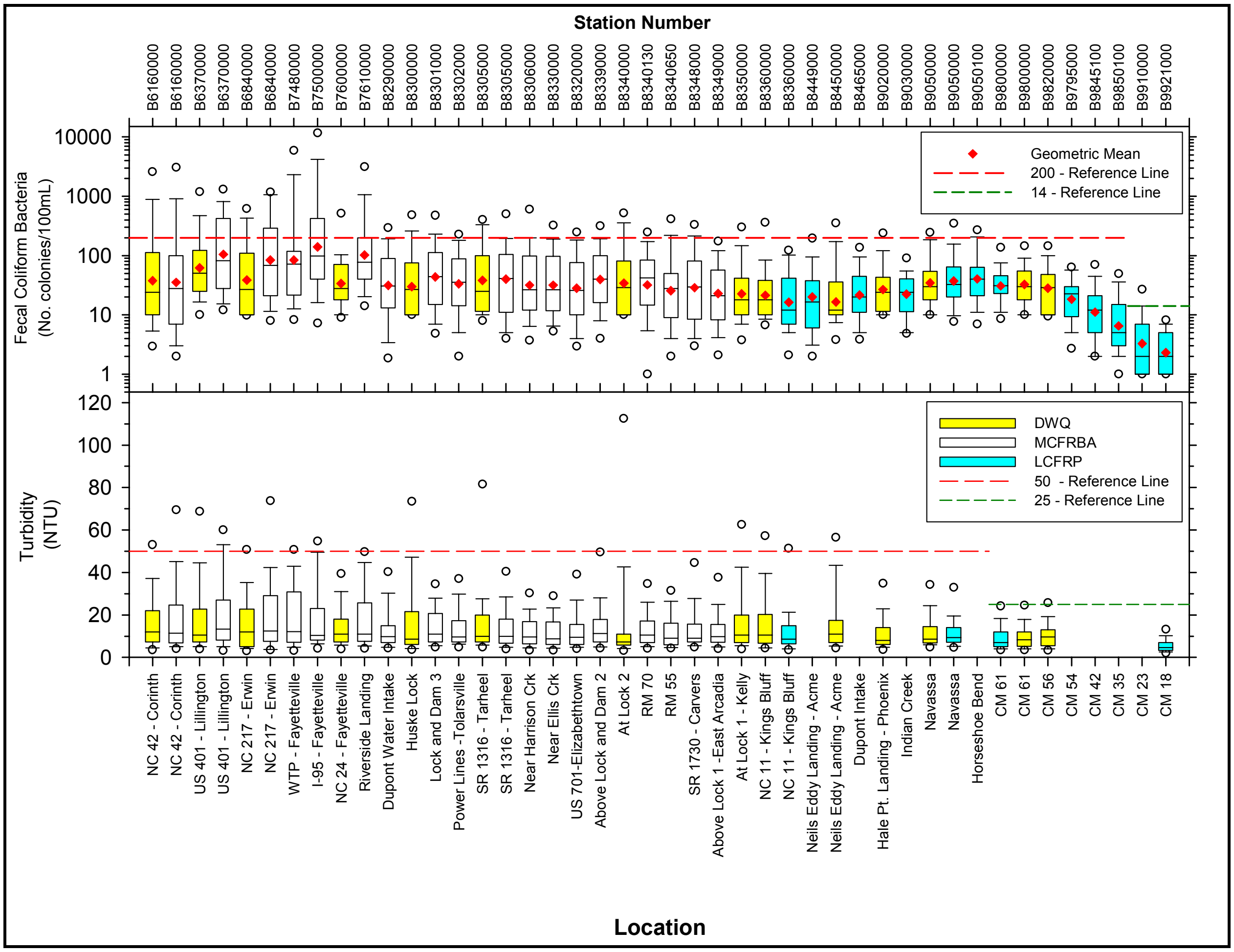


Figure 126. **Upstream (left) to downstream (right) fecal coliform bacteria and turbidity patterns along the Cape Fear River, September 01, 1998 – August 31, 2003.**

AQUATIC TOXICITY MONITORING

One hundred nineteen facility permits in the basin currently require whole effluent toxicity (WET) monitoring (Figure 127 and Table 65). Ninety-four facility permits have a WET limit; the other 25 facility permits specify monitoring with no limit.

The number of facilities in this basin monitoring whole effluent toxicity has increased steadily since 1985, the first year that monitoring was required (Figure 128). Whole effluent toxicity limits were written into permits in North Carolina beginning in 1987. The compliance rate of those facilities has generally risen since the inception of the program. Since 1999 the compliance rate has stabilized at approximately 90 to 95 percent (Figure 128 and Table 66).

The BP Oil Company groundwater remediation site in Guilford County (Subbasin 02) experienced numerous failures from 2000 - 2002. In December 2002, the facility management shut down the facility until such time as more effective treatment options could be tested and installed.

Brenntag Southeast, Inc. (Subbasin 05) failed five WET tests between October 2001 and September 2002. Facility personnel determined that the composite sample was being contaminated with chlorine during its collection. The facility isolated its compositor from the contamination and has since passed each WET test.

The UNC-Chapel Hill Power Plant facility (Subbasin 06) has not been consistently compliant with its WET limit since it began discharging in 1994. The facility had connected to the OWASA-Mason Farm WWTP as of April 2001. UNC-CH continues to maintain the permit and has the option to discharge during high flow conditions.

Dynea USA, Inc. (Subbasin 07) failed seven toxicity tests during the period February 2000 through March 2001. The noncompliances appear to have been operationally related. The facility's activated sludge process was upset, with complete die-out of its microorganisms. There have been no WET noncompliances since March 2001.

The Town of Star (Subbasin 10) has had ongoing effluent toxicity problems since it began monitoring in 1987. The facility's effluent is dominated by textile waste and thus the source of toxicity is total dissolved solids (salts). The facility has worked with consultants and its industries over the years with varying results, at times meeting its limit for as long as three consecutive months. Town officials have requested a Special Order by Consent. The Town passed a resolution to explore sewer regionalization with the towns of Biscoe and Troy. Under this plan, Star and Biscoe would connect their sewer systems to Troy and eliminate their discharges. An engineering analysis is underway as of April 2004.

The industrial wastewater facility operated by the Archer Daniels Midland Company (Subbasin 17) has detected some level of toxicity in nine monitoring tests conducted since the beginning of 2000. The facility's current draft permit includes a chronic toxicity limit.

The Leland Industrial Park WWTP (Subbasin 17) has experienced 10 WET test failures since March 2000. Toxicity appeared to be associated with ammonia. As of July 2003, its wastewater was diverted to the new Northeast Brunswick County WWTP.

The Environmental Management Commission granted Mt. Olive Pickle Co. (Subbasin 21) and Charles F. Cates & Sons (Subbasin 22) variances from the State's action level standard for chloride and water quality standard for WET. These variances were granted effective 1996 based on material presented by the facility describing the technical and economic impracticability of treating the waste and the subsequent adverse economic impact on the region should these two facilities relocate.

The industrial WWTP operated by Guilford Mills (Subbasin 22) experienced numerous noncompliances during the January 2000 through August 2002. The facility signed a Special Order by Consent for the period May 2002 through June 2003. The facility used this period to investigate the toxicity problem. Based on operator and engineer investigations, the facility substituted an industrial polymer with a similar product that was less toxic. There have been no noncompliances since August 2002.

The Rose Hill WWTP (Subbasin 22) has had sporadic noncompliances since 1999. The facility signed a Special Order by Consent for the period August 1999 through June 2001. The facility used this period to investigate the toxicity problem. Its contractors determined that use of a biocide at a local turkey plant was the likely cause of toxicity failures. Facility personnel believe that failures since June 2001 were due to unusually high chlorine at the WWTP and unauthorized dumping to the wastewater collection system.

The Town of Holly Ridge (Subbasin 24) has experienced ongoing problems with effluent toxicity since 1991. The Town at one time explored installation of a land application system in order to ultimately cease discharge. However, most recently, the Town has submitted plans and specification to expand and upgrade the present facility. Inspections by regional office staff have identified operational problems at the plant.

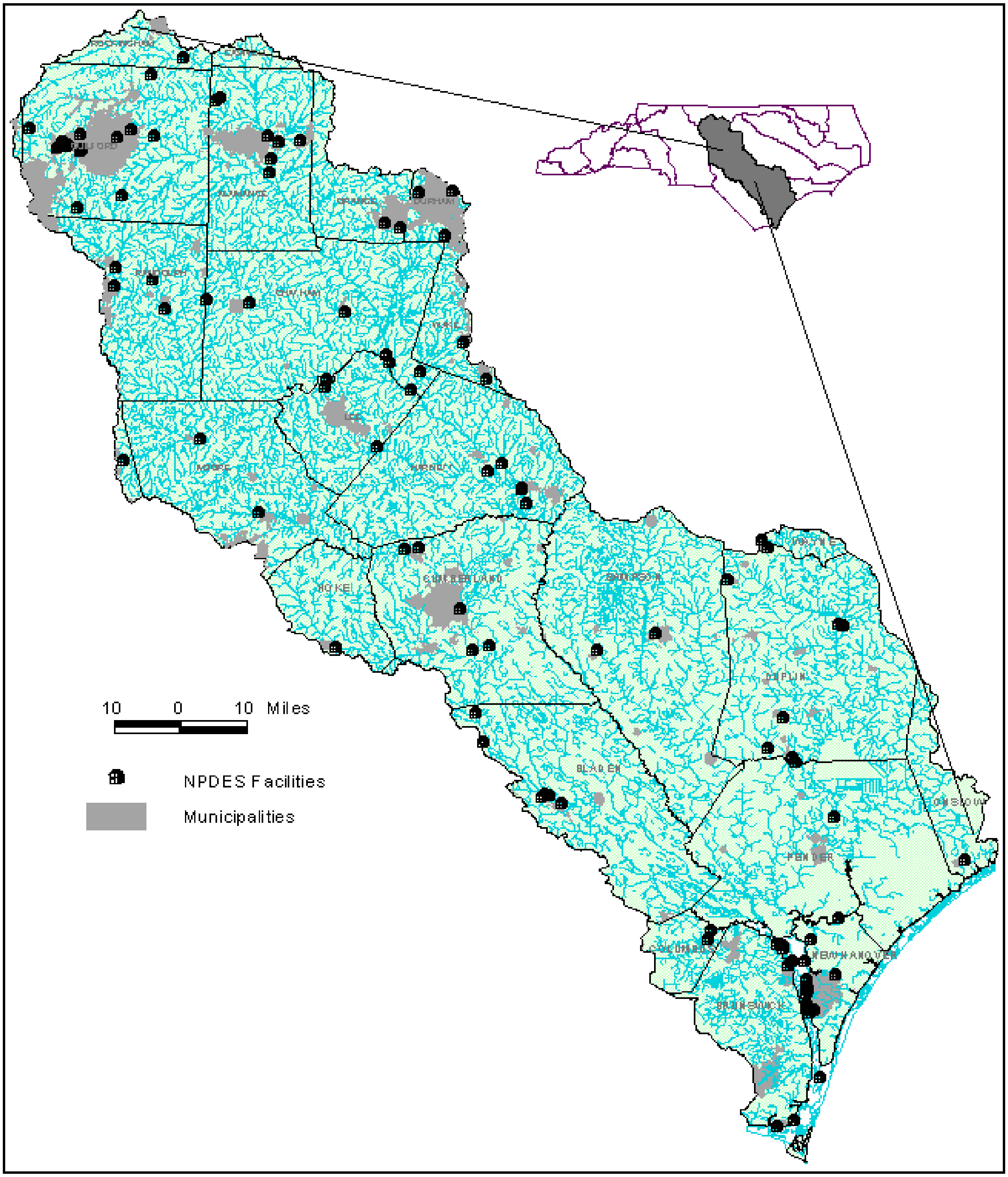


Figure 127. Facilities required to perform toxicity testing in the Cape Fear River basin.

Table 65. Facilities in the Cape Fear River basin required to perform whole effluent toxicity testing.

Subbasin/Facility	NPDES Permit No.	Receiving Stream	County	Flow (MGD)	IWC (%)	$7Q_{10}$ (cfs)
030601						
Glen Raven Inc.	NC0003913/001	Haw R	Alamance	0.15	2.6	8.7
Pentecostal Holiness Church	NC0046809/001	UT Benaja Cr	Guilford	0.02	30.6	0.07
Reidsville WWTP	NC0024881/001	Haw R	Rockingham	7.5	61	7.4
030602						
Apex Oil Company	NC0071463/001	UT Horsepen Cr	Guilford	NA	100	0.0
BP Oil Company	NC0086380/001	UT Horsepen Cr	Guilford	NA	100	0.0
Brenntag Southeast, Inc.	NC0078000/001	UT S. Buffalo Cr	Guilford	0.216	21.8	1.2
Burlington East WWTP	NC0023868/001	Haw R	Alamance	12.0	36	33.6
Burlington-South WWTP	NC0023876/001	Big Alamance Cr	Alamance	12.0	86	3.0
Graham WWTP	NC0021211/001	Haw R	Alamance	3.5	14	34
Greensboro N Buffalo Cr WWTP	NC0024325/001	N. Buffalo Cr	Guilford	16.0	96.5	0.90
Greensboro Osborne WWTP	NC0047384/001	S. Buffalo Cr	Guilford	30.0	95.7	2.1
Harvin Reaction Technology	NC0084778/001	UT N. Buffalo Cr	Guilford	0.110	100	0.0
Haw River Realty, Inc.	NC0084328/001	UT Haw R	Alamance	0.15	100	0.0
Mebane WWTP	NC0021474/001	Moadams Cr	Alamance	2.5	100	0.0
Monarch Hosiery	NC0001210/001	Reedy Fork Cr	Alamance	0.05	0.16	47.8
Sears Logistic Services, Inc.	NC0086860/001	UT Philadelphia Lake	Guilford	0.072	100	0.0
TYCO Electronics Corp.	NC0085821/001	UT N. Buffalo Cr	Guilford	0.0288	100	0
Williams Terminals Holdings-G'boro	NC0003671/001	UT Horsepen Cr	Guilford	NA	100	0.0
030604						
Pittsboro WWTP	NC0020354/001	Roberson Cr	Chatham	0.75	100	0.000
030605						
Brenntag Southeast, Inc.	NC0086827/001	UT Third Fork Cr	Durham	0.0144	100	0.0
Durham Co.-Triangle WWTP	NC0026051/001	Northeast Cr	Durham	6.0	100	0.0
South Durham WRF	NC0047597/001	New Hope Cr	Durham	20.0	99.5	0.15
030606						
OWASA/Mason Farm	NC0025241/001	Morgan Cr	Orange	12	90	1.0
UNC-Chapel Hill Power Plant	NC0025305/001	UT Morgan Cr	Orange	0.048	100	0.0
030607						
Buies Creek WWTP	NC0030091/001	Cape Fear R	Harnett	0.50	0.13	600
CP&L-Cape Fear S.E./007	NC0003433/007	UT Cape Fear R	Chatham	NA	100	0.0
CP&L-Shearon Harris E&E Center	NC0039586/007	Harris L.	Wake	0.02	NA	LAKE
CP&L-Shearon Harris/006	NC0039586/006	Harris Reservoir	Chatham	18.6	NA	LAKE
Dunn/Blackriver WWTP	NC0043176/001	Cape Fear R	Harnett	3.75	1.0	586.6
DYNEA USA, Inc.	NC0000892/001	Haw R	Chatham	0.10	0.39	40.0
Erwin WWTP	NC0064521/001	Cape Fear R	Harnett	1.2	0.32	586
Fuquay-Varina/ Kenneth Cr WWTP	NC0028118/001	Kenneth Cr	Wake	1.2	100	0.0
Holly Springs WWTP	NC0063096/001	Utley Cr	Wake	1.5	95	0.11
Honeywell International, Inc.	NC0001899/002	UT Shaddox Cr	Chatham	NA	100	0.0
Honeywell International, Inc.	NC0001899/001	Haw R	Chatham	0.244	0.94	40
North Harnett Regional WWTP	NC0021636/001	Cape Fear R	Harnett	0.6	0.17	550.0
Swift Textiles	NC0001406/001	Cape Fear R	Harnett	2.5	0.66	586
030608						
Charter-Triad Terminals, LLC	NC0042501/001	UT E Fork Deep R	Guilford	VAR	100	0.0
Colonial Pipeline/001	NC0031046/001	UT E Fork Deep R	Guilford	NA	100	0.0
Colonial Pipeline/002	NC0031046/002	UT E Fork Deep R	Guilford	NA	100	0.0
Colonial Pipeline/003	NC0031046/003	UT E Fork Deep R	Guilford	NA	100.0	0.0
Colonial Pipeline/004	NC0031046/004	UT E Fork Deep R	Guilford	NA	100.0	0.0
Colonial Pipeline/005	NC0031046/005	UT E Fork Deep R	Guilford	NA	100.0	0.0
Exxon/Greensboro Marketing Term	NC0000795/001	UT E Fork Deep R	Guilford	NA	100	0.0
High Point Eastside WWTP	NC0024210/001	Richland Cr	Guilford	16.0	96	1.0
HRS Terminals. Inc.	NC0074241/001	UT E. Fork Deep R	Guilford	VAR	100	0.0
LCP Plastics, Inc.	NC0036366/001	UT W Fork Deep R	Guilford	NA	100	0.00
Motiva Enterprises LLC-Greensboro	NC0022209/001	UT Long Br.	Guilford	VAR	100	0.0
Plantation Pipeline Co. (001)	NC0051161/001	UT E Fork Deep R	Guilford	NA	100	0.0
Plantation Pipeline Co. (002)	NC0051161/002	UT E Fork Deep R	Guilford	NA	100	0.0
Randleman WWTP	NC0025445/001	Deep R	Randolph	1.745	35	5.0
TransMontaigne-Piedmont Terminal	NC0069256/001	UT E Fork Deep R	Guilford	NA	100	0.0
Transmontaigne-Southeast Terminal	NC0026247/001	UT E Fork Deep R	Guilford	NA	100	0.0
Williams Terminals Holdings, L.P.	NC0074578/002	UT Long Br	Guilford	0.0067	100	0.0

Table 65 (continued).

Subbasin/Facility	NPDES Permit No.	Receiving Stream	County	Flow (MGD)	IWC (%)	$7Q_{10}$ (cfs)
030609						
Asheboro WWTP	NC0026123/001	Hasketts Cr	Randolph	9.0	100	0.0
Hancock Country Hams	NC0084077/001	UT Sandy Cr	Randolph	0.10	100	0.0
Ramseur WWTP	NC0026565/001	Deep R	Randolph	0.48	6.3	11.0
S.S. Mobile Home Park	NC0038300/001	UT Brush Cr	Chatham	0.01	100	0.0
Thomasville Furniture	NC0084816/001	UT Polecat Cr	Guilford	0.0288	100	0.0
030610						
Robbins WWTP	NC0062855/001	Deep R	Moore	1.3	10	15.9
Star WWTP	NC0058548/001	Cotton Cr	Montgomery	0.60	100	0.0
030611						
Gold Kist WWTP	NC0072575/001	Deep R	Lee	1.0	9.1	17.0
Sanford-Big Buffalo WWTP	NC0024147/001	Deep R	Lee	6.8	39	16.8
030612						
Siler City WWTP	NC0026441/001	Loves Cr	Chatham	4.0	96.1	0.25
030613						
Carolina Trace Subdivision WWTP	NC0038831/001	Upper Little R	Lee	1.0	76.0	0.49
030614						
Fort Bragg WWTP/001	NC0003964/001	Little R	Cumberland	8.0	26	35.8
Spring Lake WWTP	NC0030970/001	Lower Little R	Cumberland	1.5	5.5	40.0
030615						
Fayetteville-Cross Creek WWTP	NC0023957/001	Cape Fear R	Cumberland	25.0	6.0	657.0
Fayetteville-Rockfish WWTP	NC0050105/001	Cape Fear R	Cumberland	16.0	3.5	675.0
Monsanto/001,002	NC0003719/002	Cape Fear R	Cumberland	1.3	0.25	791.0
Raeford WWTP	NC0026514/001	Rockfish Cr	Hoke	3.0	8.67	49.0
030616						
Alamac Knit Fabrics-E'town Plant	NC0003522/001	Cape Fear R	Bladen	2.5	0.47	814.0
Cogentrix Eastern Carolina Corp.	NC0058297/003	Cape Fear R	Bladen	NA	0.03	740.0
Dupont De Nemours /Fayetteville	NC0003573/001	Cape Fear R	Bladen	17	3.3	791.0
Elizabethtown WWTP	NC0026671/001	Cape Fear R	Bladen	1.225	4.6	815
Smithfield Packing Co., Tarheel Div.	NC0078344/001	Cape Fear R	Bladen	3.0	0.58	795
Veeder Root Corp/004	NC0001121/004	Cape Fear R	Bladen	NA	NA	812.5
030617						
AAF/McQuay, Inc.-001	NC0083658/001	UT Barnards Cr	New Hanover	0.288	100	0.0
AAF/McQuay, Inc.-002	NC0083658/002	UT Barnards Cr	New Hanover	0.36	100	0.0
Amerada Hess Corp.	NC0066711/001	UT Cape Fear R	New Hanover	NA	100	0
Archer Daniels Midland Co./001	NC0027065/001	Cape Fear R	Brunswick	3.502	NA	Tidal
Arteva Specialties-Wilmington-001	NC0001112/001	NE Cape Fear R	New Hanover	1.4	7.4	Tidal
Arteva Specialties-Wilmington-002	NC0001112/002	Cape Fear R	New Hanover	1.25	NA	Tidal
BASF	NC0059234/001	Cape Fear R	New Hanover	.33	1.0	Tidal
Carolina Beach WWTP	NC0023256/001	Cape Fear R	New Hanover	3.0	NA	Tidal
CP&L-Sutton/001 Progress Energy	NC0001422/001	Cape Fear R	New Hanover	NA	NA	Tidal
CTI Of North Carolina	NC0082970/001	Cape Fear R	New Hanover	VAR	NA	Tidal
CTI of North Carolina	NC0082970/003	Cape Fear R	New Hanover	VAR	NA	Tidal
DAK Americas, LL	NC0000663/001	Cape Fear R	Brunswick	2.3	0.38	918
Exxon USA Wilmington Terminal	NC0073181/001	Cape Fear R	New Hanover	VAR	NA	Tidal
Flint Hills Resources, LLP	NC0076732/001	Cape Fear R	New Hanover	0.1	NA	Tidal
Fortron Industries/001	NC0082295/001	Cape Fear R	New Hanover	0.245	1.16	910
Global Nuclear Fuel-Americas, LLC	NC0001228/001	NE Cape Fear R	New Hanover	1.8	9.37	27.0
International Paper Co.	NC0003298/001	Cape Fear R	Columbus	50	8.3	856
International Paper Co.	NC0081507/001	Burnt Mill Cr	New Hanover	0.05	37	0.13
JLM Terminals/Cape Fear Terminal	NC0028568/001	Cape Fear R	New Hanover	NA	NA	Tidal
Leland Industrial Park WWTP	NC0065676/001	Cape Fear R	Brunswick	0.25	0.065	600
NE Brunswick County WWTP	NC0086819/001	Cape Fear R	Brunswick	1.65	NA	Tidal
New Hanover Co. Landfill	NC0049743/001	NE Cape Fear R	New Hanover	0.05	NA	Tidal
New Hanover County Airport WWTP	NC0081736/001	Cape Fear R	New Hanover	4.0	NA	Tidal
Southport WWTP	NC0021334/001	ICW	Brunswick	0.80	NA	Tidal
Vopak Terminal Wilmington	NC0073172/001	Cape Fear R	New Hanover	NA	NA	Tidal
Wilmington Northside WWTP	NC0023965/001	Cape Fear R	New Hanover	8.0	NA	Tidal
Wilmington Southside WWTP	NC0023973/001	Cape Fear R	New Hanover	12.0	1.59	1149
Wright Chemical Corp/001	NC0003395/001	Livingston Cr	Columbus	0.2	34	0.6

Table 65 (continued).

Subbasin/Facility	NPDES Permit No.	Receiving Stream	County	Flow (MGD)	IWC (%)	$7Q_{10}$ (cfs)
030619						
Clinton-Larkins WPCF	NC0020117/001	Williams Old Mill Br.	Sampson	5.0	100	0.0
Roseboro WWTP	NC0026816/001	Little Coharie Cr	Sampson	0.49	52	1.0
030621						
Mt. Olive Pickle	NC0001074/001	Barlow Branch	Wayne	0.40	100	0.0
Mt. Olive WWTP	NC0020575/001	NE Cape Fear R	Wayne	1.0	100	0.0
030622						
Charles F. Cates & Sons	NC0001970/001	UT Panther Br.	Duplin	0.50	100	0.0
Cogentrix Leasing Corporation-003	NC0058271/003	UT NE Cape Fear R	Duplin	NA	90	0.0
Guilford Mills East	NC0002305/001	NE Cape Fear R	Duplin	1.5	27	6.5
Rose Hill WWTP	NC0056863/001	Reedy Branch	Duplin	0.45	100	0.0
Swift-Eckrich, Inc. - Circle S Foods	NC0003344/001	Rockfish Cr	Duplin	1.5	57	1.77
Wallace-L. Rockfish WWTP	NC0003450/001	Little Rockfish Cr	Duplin	4.42	98.70	0.09
Wallace-Rockfish WWTP	NC0020702/001	Rockfish Cr	Duplin	1.0	20.53	4.20
030623						
Burgaw WWTP	NC0021113/001	Osgood Canal	Pender	0.75	100	0.0
Occidental Chemical Corp/001	NC0003875/001	NE Cape Fear R	New Hanover	0.785	4.6	25
030624						
Holly Ridge WWTP	NC0025895/001	UT King Cr	Onslow	0.1	100	0.0

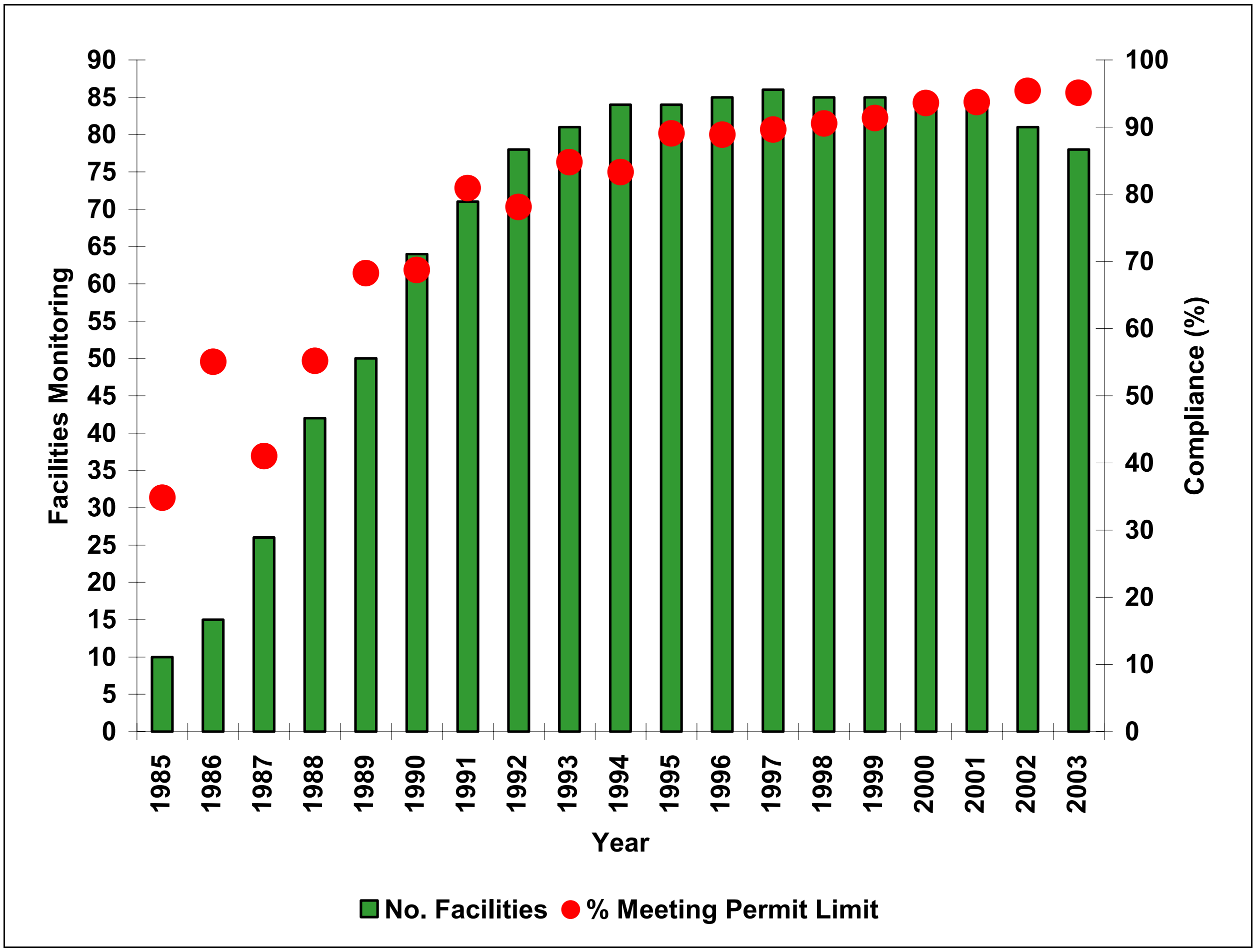


Figure 128. **NPDES facility whole effluent toxicity compliance in the Cape Fear River basin, 1985 - 2003. The compliance values were calculated by determining whether facilities with WET limits were meeting their ultimate permit limits during the given time period, regardless of any SOCs in force.**

Table 66. **Compliance record of facilities performing whole effluent toxicity testing in the Cape Fear River basin.**

Subbasin/Facility	NPDES Permit No.	Pre 2003 Passes[1]	Pre 2003 Fails	2003 Passes	2003 Fails
030601					
Glen Raven Inc	NC0003913/001	17	1	4	0
Pentecostal Holiness Church	NC0046809/001	16	0	4	0
Reidsville WWTP	NC0024881/001	20	13	6	2
030602					
Apex Oil Company	NC0071463/001	4	0	1	0
BP Oil Company	NC0086380/001	10	17	0	0
Brenntag Southeast, Inc.	NC0078000/001	17	0	4	0
Burlington East WWTP	NC0023868/001	16	0	4	0
Burlington-South WWTP	NC0023876/001	19	4	5	1
Graham WWTP	NC0021211/001	17	2	5	0
Greensboro N Buffalo Cr WWTP	NC0024325/001	17	2	5	1
Greensboro Osborne WWTP	NC0047384/001	17	2	4	0
Harvin Reaction Technology	NC0084778/001	16	0	1	0
Haw River Realty, Inc.	NC0084328/001	16	2	4	0
Mebane WWTP	NC0021474/001	17	1	4	0
Monarch Hosiery	NC0001210/001	14	2	0	0
Sears Logistic Services, Inc.	NC0086860/001	0	5	0	0

Table 66 (continued).

Subbasin/Facility	NPDES Permit No.	Pre 2003 Passes[1]	Pre 2003 Fails	2003 Passes	2003 Fails
Williams Terminals Holdings-G'boro	NC0003671/001	2	1	1	0
030604					
Pittsboro WWTP	NC0020354/001	16	1	4	0
030605					
Brenntag Southeast, Inc.	NC0086827/001	6	5	4	0
Durham Co.-Triangle WWTP	NC0026051/001	16	0	5	1
South Durham WRF	NC0047597/001	17	0	4	0
030606					
OWASA/Mason Farm	NC0025241/001	18	2	4	0
UNC-Chapel Hill Power Plant	NC0025305/001	9	10	0	0
030607					
Buies Creek WWTP	NC0030091/001	16	1	4	0
CP&L-Cape Fear S.E./007	NC0003433/007	16	0	5	1
CP&L-Shearon Harris E&E Center	NC0039586/007	16	1	4	0
CP&L-Shearon Harris/006	NC0039586/006	17	0	5	0
Dunn/Blackriver WWTP	NC0043176/001	16	0	3	0
Dynea USA Inc.	NC0000892/001	15	9	4	0
Erwin WWTP	NC0064521/001	17	0	4	0
Fuquay-Varina/ Kenneth Cr WWTP	NC0028118/001	16	0	4	0
Holly Springs WWTP	NC0063096/001	17	2	4	0
Honeywell International, Inc.	NC0001899/002	4	0	1	0
Honeywell International, Inc.	NC0001899/001	17	3	4	0
North Harnett Regional WWTP	NC0021636/001	16	0	4	1
Swift Textiles	NC0001406/001	16	0	4	0
030608					
Charter-Triad Terminals, LLC	NC0042501/001	2	1	1	0
Colonial Pipeline/001	NC0031046/001	5	0	1	0
Colonial Pipeline/002	NC0031046/002	4	0	1	0
Colonial Pipeline/003	NC0031046/003	4	0	1	0
Colonial Pipeline/004	NC0031046/004	4	0	1	0
Colonial Pipeline/005	NC0031046/005	4	0	1	0
Exxon/Greensboro Marketing Terminal	NC0000795/001	4	0	1	0
High Point Eastside WWTP	NC0024210/001	19	2	4	0
HRS Terminals. Inc.	NC0074241/001	4	0	0	0
LCP Plastics, Inc.	NC0036366/001	3	1	0	0
Motiva Enterprises LLC-Greensboro	NC0022209/001	4	0	2	0
Plantation Pipeline Co. (001)	NC0051161/001	8	0	0	0
Plantation Pipeline Co. (002)	NC0051161/002	8	0	1	0
Randleman WWTP	NC0025445/001	16	0	4	0
TransMontaigne-Piedmont Terminal	NC0069256/001	4	0	1	0
Transmontaigne-Southeast Terminal	NC0026247/001	4	0	2	0
Williams Terminals Holdings, L.P.	NC0074578/002	4	0	1	0
030609					
Asheboro WWTP	NC0026123/001	16	0	4	0
Ramseur WWTP	NC0026565/001	17	0	4	2
S.S. Mobile Home Park	NC0038300/001	16	6	4	0
Thomasville Furniture	NC0084816/001	4	2	0	0
030610					
Star WWTP	NC0058548/001	5	39	0	12
030611					
Gold Kist WWTP	NC0072575/001	16	0	4	0
Sanford-Big Buffalo WWTP	NC0024147/001	17	1	7	1
030612					
Siler City WWTP	NC0026441/001	16	0	4	0
03-0614					
Fort Bragg WWTP/001	NC0003964/001	16	0	4	0
Spring Lake WWTP	NC0030970/001	16	0	4	0
03-0615					
Fayetteville-Cross Creek WWTP	NC0023957/001	16	0	4	0
Fayetteville-Rockfish WWTP	NC0050105/001	17	1	4	0
Monsanto/001,002	NC0003719/002	18	1	4	1
Raeford WWTP	NC0026514/001	17	1	5	2

Table 66 (continued).

Subbasin/Facility	NPDES Permit No.	Pre 2003 Passes[1]	Pre 2003 Fails	2003 Passes	2003 Fails
030616					
Alamac Knit Fabrics-Elizabethtown Plant	NC0003522/001	13	0	1	0
Cogentrix Eastern Carolina Corp.	NC0058297/003	16	0	4	0
Dupont - Fayetteville Works	NC0003573/001	18	0	4	0
Elizabethtown WWTP	NC0026671/001	16	0	4	0
Smithfield Packing Co., Tarheel Div.	NC0078344/001	17	0	4	0
Veeder Root Corp/004 (comb 01, 02, 03)	NC0001121/004	16	2	4	0
030617					
AAF/McQuay, Inc.-001	NC0083658/001	14	0	4	0
Amerada Hess Corp.	NC0066711/001	5	0	1	0
Archer Daniels Midland Co./001	NC0027065/001	5	11	3	2
Arteva Specialties-Wilmington-001	NC0001112/001	17	1	4	0
Arteva Specialties-Wilmington-002	NC0001112/002	16	2	4	0
BASF (formerly Takeda)	NC0059234/001	17	0	4	0
Carolina Beach WWTP	NC0023256/001	14	0	4	0
CP&L-Sutton/001 Progress Energy	NC0001422/001	20	0	11	0
CTI Of North Carolina	NC0082970/001	3	0	1	0
CTI of North Carolina	NC0082970/003	0	0	1	0
DAK Americas, LLC (DuPont)	NC0000663/001	15	0	4	0
Exxon USA Wilmington Terminal	NC0073181/001	2	0	0	0
Flint Hills Resources, LLP	NC0076732/001	17	0	4	0
Fortron Industries/001	NC0082295/001	17	0	4	0
International Paper Co.	NC0003298/001	16	0	4	0
JLM Terminals/Cape Fear Terminal	NC0028568/001	4	0	0	0
Leland Industrial Park WWTP	NC0065676/001	13	10	1	4
NE Brunswick County WWTP	NC0086819/001	0	0	3	0
New Hanover Co. Landfill	NC0049743/001	15	0	4	1
Southport WWTP	NC0021334/001	16	0	4	2
Vopak Terminal Wilmington	NC0073172/001	3	0	1	0
Wilmington Northside WWTP	NC0023965/001	16	2	4	0
Wilmington Southside WWTP	NC0023973/001	16	1	4	0
Wright Chemical Corp/001	NC0003395/001	17	1	5	1
030619					
Clinton-Larkins WPCF	NC0020117/001	19	2	4	0
Roseboro WWTP	NC0026816/001	16	0	4	0
030621					
Mt. Olive Pickle	NC0001074/001	0	16	0	4
Mt. Olive WWTP	NC0020575/001	16	0	4	0
030622					
Charles F. Cates & Sons	NC0001970/001	0	16	0	4
Cogentrix Leasing Corporation-003	NC0058271/003	17	1	4	0
Guilford Mills East	NC0002305/001	17	24	12	1
Rose Hill WWTP	NC0056863/001	21	15	4	1
Swift-Eckrich, Inc. - Circle S Foods	NC0003344/001	16	0	5	1
Wallace-L. Rockfish WWTP	NC0003450/001				
Wallace-Rockfish WWTP	NC0020702/001	15	2	4	0
030623					
Burgaw WWTP	NC0021113/001	17	2	4	0
Global Nuclear Fuel-Americas, LLC	NC0001228/001	16	0	4	0
Occidental Chemical Corp/001	NC0003875/001	16	0	4	0
030624					
Holly Ridge WWTP	NC0025895/001	17	9	4	0

Note that “pass” denotes meeting a permit limit or, for those facilities with a monitoring requirement, meeting a target value. The actual test result may be a “pass” (from a pass/fail acute or chronic test), LC_{50}, or chronic value. Conversely, “fail” means failing to meet a permit limit or target value.

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GLOSSARY

$7Q_{10}$	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. $7Q_{10}$ flow (in cfs) is used to allocate the discharge of toxic substances to streams.
Bioclass or Bioclassification	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 *a*	Chlorophyll *a*.
Class C Waters	Freshwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. All freshwaters shall be classified to protect these uses at a minimum.
Conductivity	In this report, synonymous with specific conductance and reported in the units of µmhos/cm at 25 ^{o}C. Conductivity is a measure of the resistance of a solution to electrical flow. Resistance is reduced with increasing content of ionized salts.
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, vegetation, and soil type. Examples include Mountains, Piedmont, Coastal Plain, Sand Hills, and Carolina 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. Waters which are rated Excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and all Class SA waters.
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. Waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs.
NTU	Nephelometric Turbidity Unit.
ORW	Outstanding Resource Waters. Unique and special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses.
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

Appendix 1. Flow measurement and flow conditions and their influence on the interpretation of benthic macroinvertebrate data in the Cape Fear River basin, 2002 - 2003.

The Cape Fear River basin experienced a long lasting and severe drought throughout 2002, followed by a prolonged wet period throughout much of 2003 (Figures 1 – 3), culminating with Hurricane Isabelle in late September 2003. Prior to the severe drought in 2002, eastern North Carolina experienced severe flooding from Hurricanes Dennis, Floyd, and Irene during September and October 1999. The lower Cape Fear River basin received more than 25 inches of rainfall during September and October 1999. Flooding was at record levels and 500 year or greater floods occurred in all the State's river basins east of Raleigh with the exception of the Lumber River basin (Bales *et al*. 2000).

Changes in the benthic macroinvertebrate community are often used to help assess between-year changes in water quality. Some between-year changes in the communities, however, may be due to changes in flow. High flows magnify the potential effects of nonpoint source runoff, leading to scour, substrate instability, and reduced periphyton. Low flows accentuate the effect of point source dischargers by providing less dilution of wastes. Flow-related changes are decided on a site-by-site basis by looking at:

- *Flow*. In the three months prior to collection, daily flow patterns are examined from gauge sites. Areas affected by nonpoint source runoff are expected to have a decline in water quality after high flow, but may improve during low flow. An exception is in smaller headwater streams, which may cease flowing during extreme droughts. Streams affected by point source dischargers may improve after high flow (with dilution of the effluent) and decline after low flows. These changes, however, usually produce a between-year change of only one bioclassification.
- *Changes throughout the subbasin*. Flow-related changes usually affect several sites, not just a single site.
- *Changes in species composition*. Real changes in water quality are usually reflected in a significant change in the composition of the invertebrate community.

All between-year changes are considered in light of flow conditions for one month prior to the sampling date. Flow information is obtained from gauge sites and compared to the long-term median flows. High flow is defined as a median flow greater than 140 percent of the long-term median for that time period, low flow is a median flow less than 60 percent of the long-term median; and normal flow is 60 to 140 percent of the median. Although regional patterns are often observed, there may be large geographical variation within the state and a single sampling period.

In September 2002, DWQ initiated a drought impact study to assess the effects of the severe drought of 2002 on benthic macroinvertebrate communities. Study sites were selected in the Cape Fear, Catawba, and Neuse River basins. Results of this study measured a substantial decline in EPT S and EPT N in nearly all study sites (excluding very large water bodies such as the Cape Fear River) resulting in drastically lowered bioclassifications (often from Excellent to Poor). These declines were first documented in September and October 2002, and persisted until late winter and early spring of 2003 when these communities began to recover. The less drastic drop in bioclassification at larger waterbodies such as the Cape Fear River was attributed to the much larger drainage areas and the resulting flow permanence. An exceptionally wet spring and summer in 2003 followed the severe drought of 2002. Those high flows may have increased scour and nonpoint source runoff. The combination of severe drought followed by high flows prior to and during the basinwide monitoring period made data interpretation difficult for the 2003 monitoring cycle.

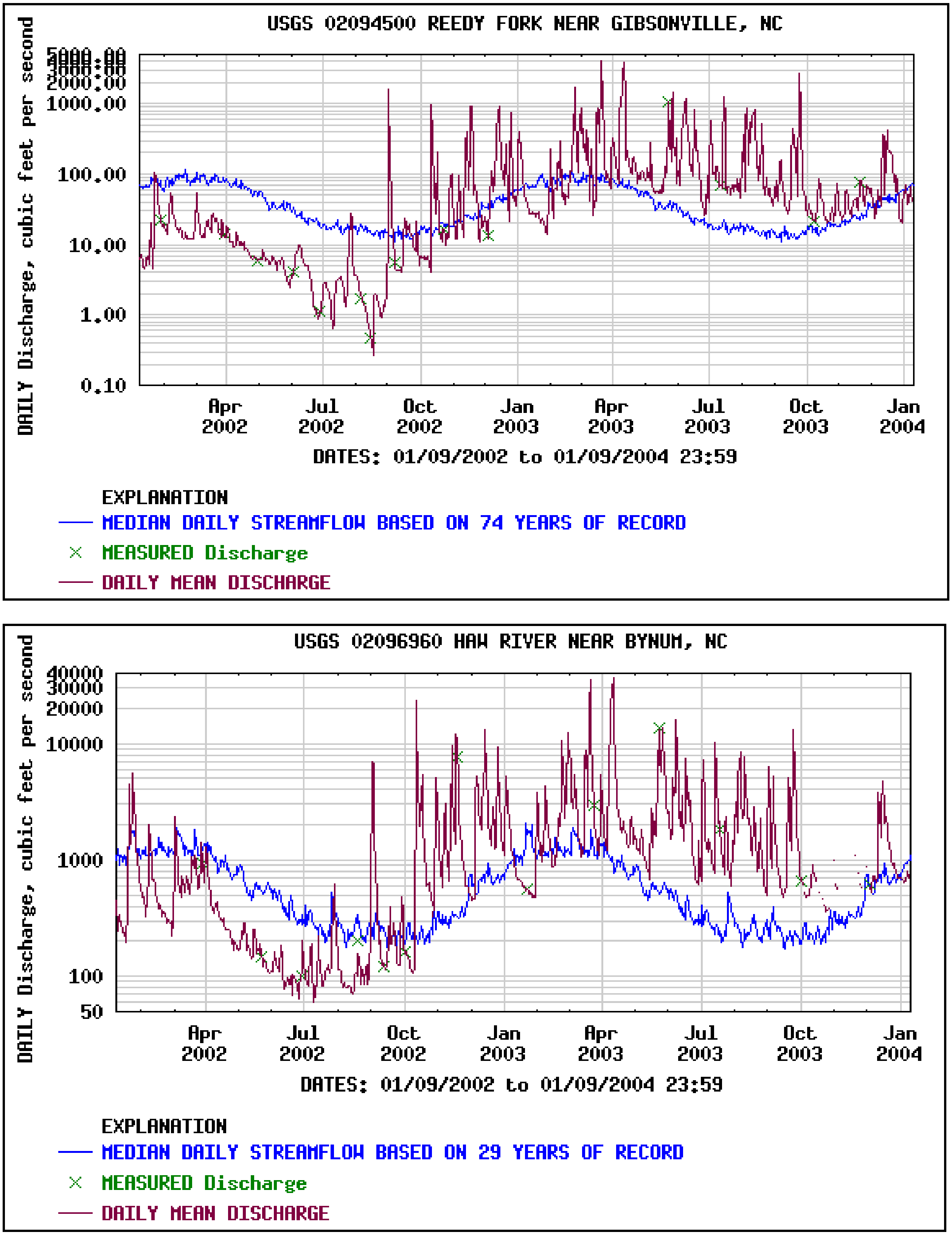
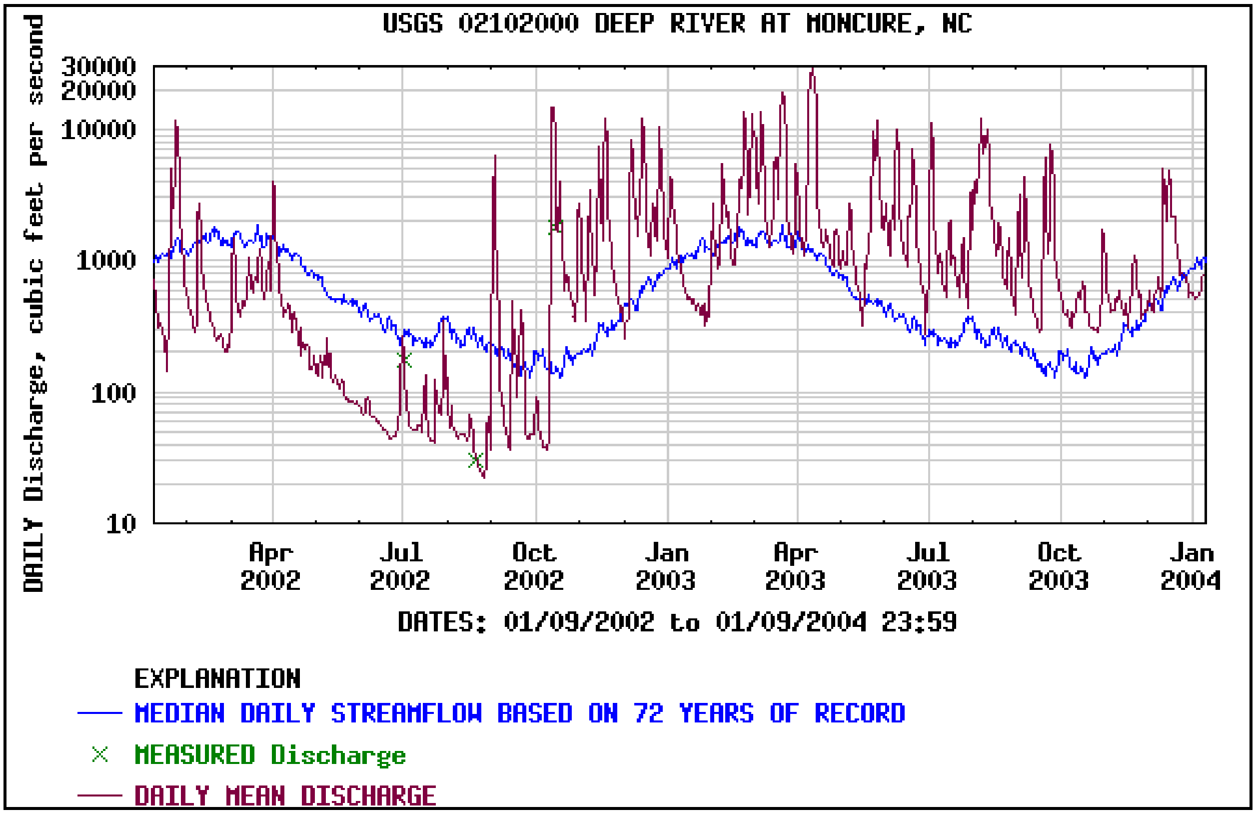


Figure 1. **Flows of Reedy Fork (top) and the Haw River (bottom), January 09, 2002 – January 9, 2004.**



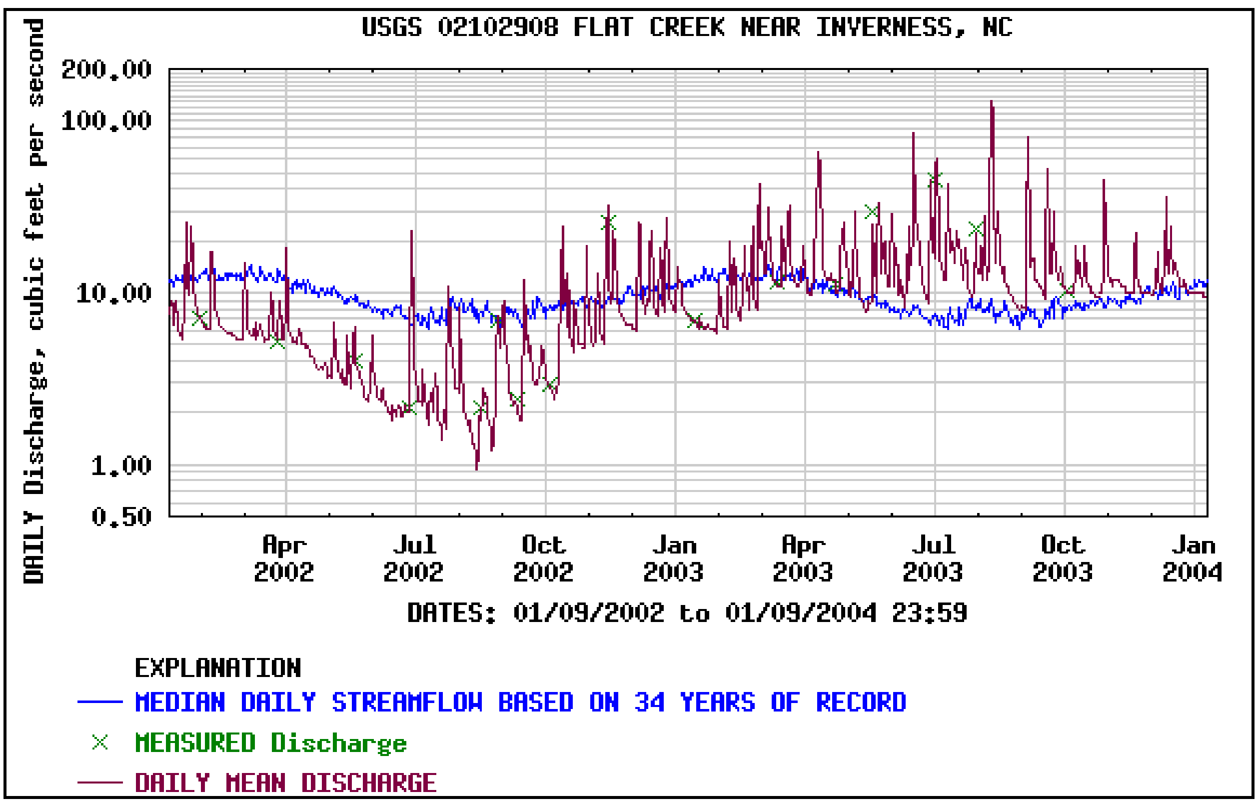
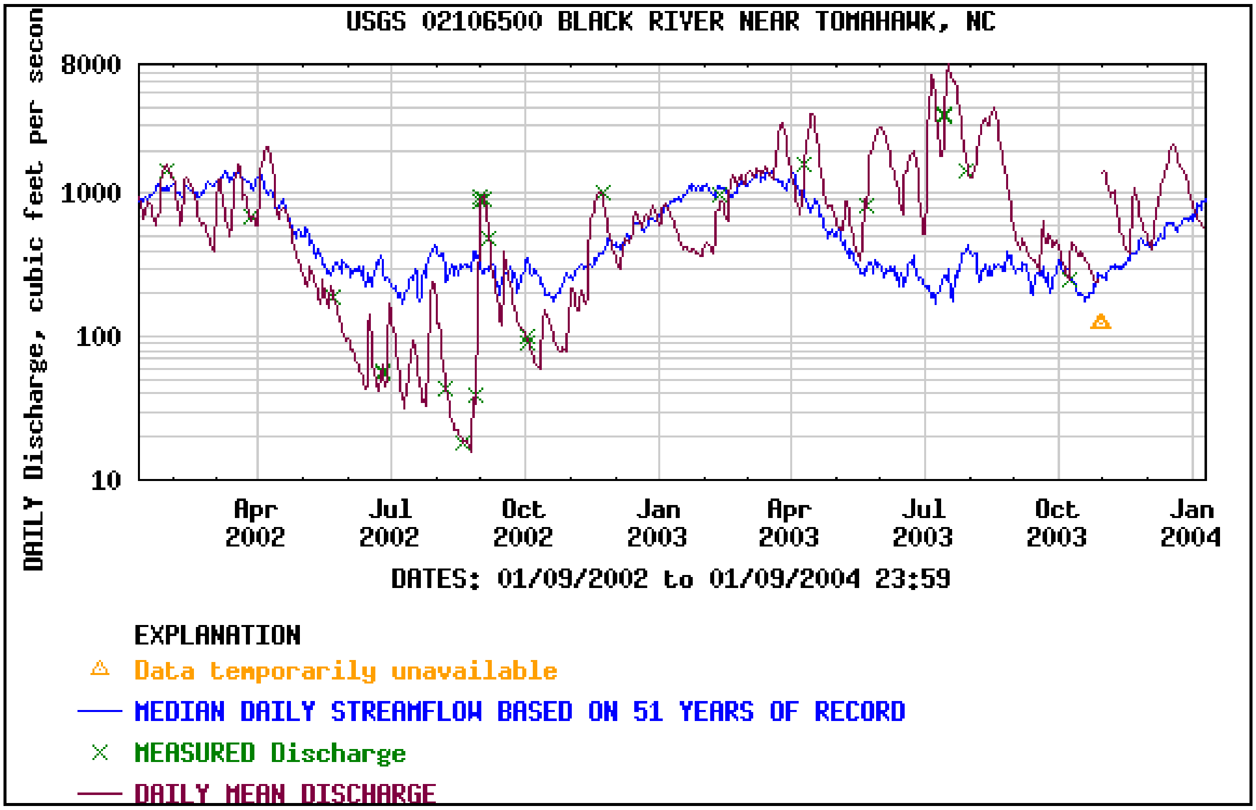


Figure 2. **Flows of the Deep River (top) and Flat Creek (bottom), January 09, 2002 – January 9, 2004.**



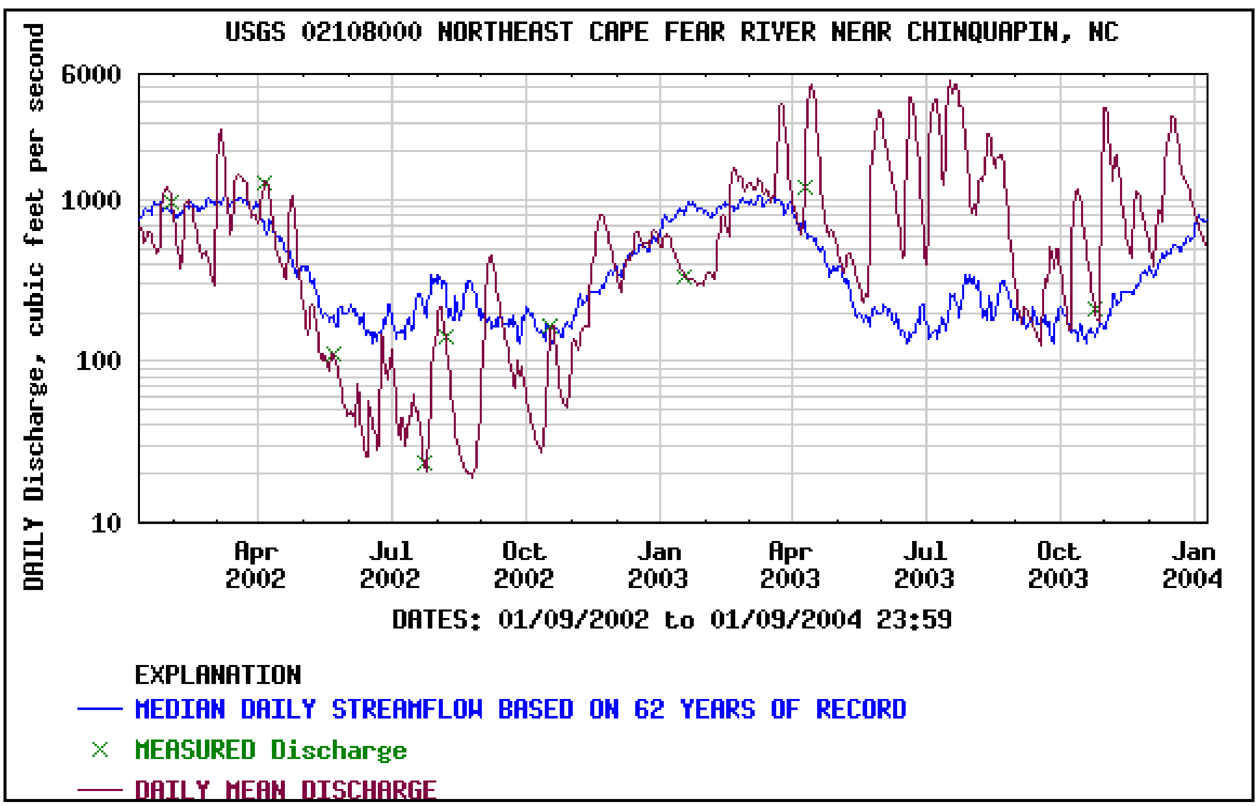


Figure 3. **Flows of the Black River (top) and the North East Cape Fear River (bottom), January 09, 2002 – January 9, 2004.**

Appendix 2. Habitat evaluations and stream and riparian habitats at fish community monitoring sites in the Cape Fear River basin.

Habitat Assessments

A method has been developed by the Biological Assessment Unit to evaluate the physical habitats of a stream (NCDENR 2001a). The habitat score, which ranges between 1 and 100, is based on the 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 criteria have not been developed to assign impairment ratings. Habitat metric scores for all fish community sites in the Cape Fear River basin which were evaluated in 2003 and 1998 are listed in Appendices 3 - 6.

Fish community sampling was conducted in 2003 at 55 sites; 38 within the Piedmont, 16 within the Sand Hills, and 1 within the Coastal Plain. Wet Creek and Gum Log Canal, were in transitional areas between the Piedmont and Sand Hills. Habitat scores ranged from 32 (South Buffalo Creek) to the low to upper 90s (Bear, Fork, Wet, and Terrells Creeks) (Appendices 3 and 4).

In the Piedmont, 21 streams had overall moderate to high quality habitats (score ≥ 65); whereas 17 streams had overall low to poor quality habitats (score < 65) (Table 1). Major differences between the two types were in the instream habitats, substrates, riffles, and bank stabilities (Table 2). Differences were not as pronounced in the abundance of pools, extent of canopy cover, or width of riparian zones. Low scores were attributable to erosion and nonpoint source sedimentation.

Table 2. Mean habitat scores for 38 fish community sites in the Piedmont portion of the Cape Fear River basin, 2003.

Habitat characteristics	Low - Poor Quality Habitat	Moderate - High Quality Habitat	Max. score
Instream habitat	12.4	17.4	20
Substrate	3.7	9.4	15
Riffle	3.2	10.2	16
Bank stability (right and left)	5.5	11.1	14

Characteristics of moderate to high quality habitat Piedmont streams are:

- instream habitats composed of rocks, sticks, leafpacks, snags and logs, and undercut banks and root mats (Figure 1);
- a substrate of cobble and gravel with low embeddedness;
- frequent pools and riffles of varying depths and widths; and
- stable banks with a good tree canopy and a medium to wide riparian zone with no or rare breaks in the riparian zone (Figure 2).

Table 1. Rankings of waterbodies in the Piedmont region of the Cape Fear River basin according to the total habitat scores, 2003. Sub = subbasin.

Sub	Waterbody	Location	County	Score
	Moderate to High Quality Habitats			
10	Bear Cr	SR 1405	Moore	96
9	Fork Cr	SR 1003	Randolph	93
4	Terrells Cr	NC 87	Chatham	91
2	Haw Cr	SR 2158	Alamance	89
7	Avents Cr	SR 1418	Harnett	88
10	Buffalo Cr	NC 22	Moore	88
9	Sandy Cr	SR 2481	Randolph	88
12	Loves Cr	SR 2229	Chatham	85
4	Robeson Cr	off SR 1943	Chatham	84
12	Bear Cr	SR 2187	Chatham	81
2	N Buffalo Cr	off 16th St & US 29	Guilford	81
7	Hector Cr	SR 1412	Harnett	79
9	Brush Cr	SR 1102	Chatham	76
4	Collins Cr	SR 1539	Chatham	76
7	Kenneth Cr	SR 1441	Harnett	76
4	Ferrells Cr	SR 1525	Chatham	74
10	Cabin Cr	SR 1275	Moore	73
2	Reedy Fork	SR 2728	Guilford	72
3	L Alamance Cr	SR 2309	Alamance	68
2	Stony Cr	SR 1104	Caswell	65
3	S Pr Stinking Quarter Cr	SR 1117	Alamance	65
	Low to Poor Quality Habitats			
8	Bull Run Cr	SR 1144	Guilford	63
2	N Buffalo Cr	SR 2770	Guilford	62
3	Big Alamance Cr	SR 3088	Guilford	61
8	Hickory Cr	SR 1140	Guilford	59
10	Indian Cr	SR 2306	Chatham	56
12	Rocky R	SR 1300	Chatham	56
11	Big Buffalo Cr	SR 1403	Lee	54
3	N Pr Stinking Quarter Cr	SR 1113	Alamance	53
8	Muddy Cr	SR 1929	Randolph	52
5	New Hope Cr	SR 2220	Durham	52
8	Richland Cr	SR 1154	Guilford	52
12	Tick Cr	US 421	Chatham	51
2	Jordan Cr	SR 1754	Alamance	50
9	Polecat Cr	SR 2114	Randolph	44
3	L Alamance Cr	SR 3039	Guilford	43
1	L Troublesome Cr	SR 2600	Rockingham	38
2	S Buffalo Cr	US 70	Guilford	32

Figure 1. Instream habitats composed of rocks, sticks, leafpacks, snags and logs, and root mats, Bear Creek, SR 1405, Moore County.

Figure 2. Stable banks with a good tree canopy and a wide riparian zone, Wet Creek, NC 24/27, Moore County.

Characteristics of low to poor quality habitat Piedmont streams are:

- a substrate of primarily sand (Figure 3);
- an absence of riffles (Figure 3); if present, they are usually caused by embedded, coarse woody debris in the current; and
- entrenched channel with unstable, vertical, and sparsely vegetated banks (Figures 4 and 5)

Figure 3. Sandy substrate without riffles, Jordan Creek, SR 1754, Alamance County.

Figure 4. Eroding vertical banks, Rocky River, SR 1300, Chatham County.

Figure 5. Sparsely vegetated and narrow riparian zone, South Buffalo Creek, US 70, Guilford County.

Some streams in Subbasin 10 and all streams in Subbasin 14 and 15 drain the Sand Hills ecoregion. Except for two streams, Cross Creek and Gum Log Canal, the instream and riparian habitats of these streams were of particularly high quality (habitat scores > 85, some sites ~ 95) (Table 3 and Appendix 4).

Table 3. Rankings of waterbodies in the Sand Hills region of the Cape Fear River basin according to the total habitat scores, 2003. Sub = subbasin.

Sub	Waterbody	Location	County	Score
		High Quality Habitats		
10	Wet Cr	NC 24/27	Moore	96
14	Anderson Cr	SR 2031	Harnett	94
15	Juniper Cr	Plank Rd	Hoke	94
15	Puppy Cr	SR 1406	Hoke	92
14	Flat Cr	Manchester Rd	Hoke	90
14	Muddy Cr	SR 1001	Cumberland	90
15	Bones Cr	SR 1400	Cumberland	89
14	Buffalo Cr	SR 1001	Moore	89
15	L Rockfish Cr	Plank Rd	Hoke	89
15	Nicholson Cr	SR 1301	Hoke	89
14	Jumping Run	NC 210	Cumberland	88
14	Little R	NC 22	Moore	88
14	Nicks Cr	NC 22	Moore	88
14	James Cr	off SR 2026	Moore	84
		Low to Poor Quality Habitats		
15	Gum Log Canal	SR 1728	Cumberland	57
15	Cross Cr	NC 87/210/24	Cumberland	31

Characteristics of these streams are:

- a natural channel with darkly colored water, and strong, permanent flow (Figures 6 and 7);
- instream habitats composed of sticks, leafpacks, macrophytes and macroalgae (such as *Vallisneria, Fissidens,* and *Batrachospermum*) in sun-light areas near the bridges, snags and logs, and undercut banks and root mats (Figure 8);
- a mixed substrate of gravel, sand, detritus, and silt; and
- stable banks with at times a dense tree canopy, and a wide riparian zone with no or rare breaks in the zone (Figure 9).

Figure 6. Darkly stained water and strong flow at Jumping Run, NC 210, Cumberland County.

Figure 7. Darkly stained water and strong flow at Buffalo Creek, SR 1001, Moore County.

Figure 8. Coarse woody debris, stable banks with root masses, Puppy Creek, SR 1406, Hoke County.

Figure 9. Wide riparian habitats and stable banks at James Creek, off SR 2026, Moore County.

Cross Creek (Cumberland County) is a very degraded and altered Sand Hills stream that drains the metropolitan area of the City of Fayetteville. Unlike other Sand Hills streams that drain forested watersheds and have high quality instream and riparian habitats, the habitat score for Cross Creek was only 31 (Appendix 4). Altered habitat characteristics include channelization, a uniform sandy substrate and stream depth, a lack of wide and stable riparian zones, and a lack of canopy (Figures 10 and 11).

Figure 10. Channelization and poor riparian habitat at Cross Creek, NC 87/210/24, Cumberland County.

Figure 11. Channelization and poor riparian habitat at Cross Creek, NC 87/210/24, Cumberland County.

Another atypical stream in Cumberland County is Gum Log Canal – a tannin stained stream that does not show typical Sand Hills characteristics (low fish species diversity and abundance, low pH, low conductivity, and riparian vegetative characteristics). According to Fels (1997), the stream is in the Inner Coastal Plain; but according to Griffith, *et al*. (2002) the stream straddles the Southeastern Floodplains and Low Terraces and the Rolling Coastal Plain. Evaluated with Sand Hills/Coastal Plain habitat criteria, The habitat score was 57 (Appendix 4); evaluated with Piedmont criteria, the habitat score was 48 (Appendix 3).

Characteristics of altered habitats at this site included unstable banks, very narrow riparian zones, a sparse canopy, and embedded riffles (Figures 12 - 14). Cattle have access to the stream and the stream flows through pastures. Appearance wise and based upon characteristics of its fish community, it is possible that this stream is located in an isolated finger of the Northern Outer Piedmont (see Subbasin 15 Section).

Figure 12. **Natural channel and sparsely vegetated riparian zones, Gum Log Canal, SR 1728, Cumberland County.**

Figure 13. **Eroding and sparsely vegetated banks, Gum Log Canal, SR 1728, Cumberland County.**

Figure 14. **Stained waters and narrow riparian zones, Gum Log Canal, SR 1728, Cumberland County.**

Habitat and NCIBI Relationships

Since 1993, 122 fish community samples have been collected from the Piedmont portion of the basin, 94 of these samples (all since 1998) have associated habitat measurements. This data set showed that as instream and riparian habitat deteriorated, so did the fish community ratings (Figure 15). Median habitat scores for Excellent and Good sites were 79 and 76, respectively. No site that rated Excellent had a habitat score less than 65. Good-Fair, Fair, and Poor sites had median habitat scores between 57 and 63. Note that some of the sites rated Poor had habitat characteristics similar to those at sites rated Good or Excellent. In such instances, these sites were below wastewater treatment plants (e.g., South Buffalo Creek at SR 2821, Guilford County). At Little Troublesome Creek (SR 2600, Rockingham County), the wastewater treatment plant discharge was relocated and the fish community recovered despite low quality habitat.

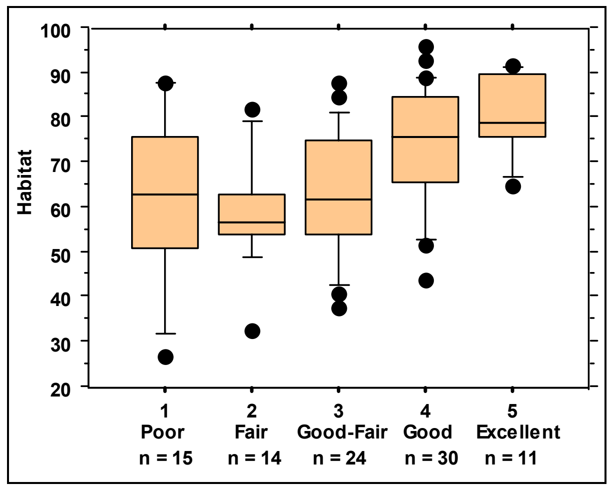


Figure 15. **Relationships between habitat scores and NCIBI ratings in the Cape Fear River basin, 1998 - 2003.**

Analyzing a smaller dataset from 2003, fish communities in the Piedmont which were rated Excellent were found where the habitats were of moderate to high quality (Table 3 and Appendix 3). Communities rated Fair or Poor were found where the habitats were of lower quality.

Table 3. NCIBI ratings and habitat quality for 38 streams in the Piedmont region of the Cape Fear River basin, 2003.[1]

NCIBI Rating	Waterbodies with Low to Poor Quality Habitat (Score < 65)	Waterbodies with Moderate to High Quality Habitat (Score ≥ 65)
Excellent	---	Terrells, Hector, S Pr Stinking Quarter
Good	N Pr Stinking Quarter, Hickory, Muddy, Polecat	Haw, Reedy, L Alamance (SR 2309), Ferrells, Robeson, Kenneth, Brush, Fork, Sandy, Bear (SR 1405), Buffalo (NC 22)
Good-Fair	L Troublesome, Jordan, Big Alamance, L Alamance (SR 3039), New Hope, Bull Run, Rocky R	N Buffalo (16th St & US 29), Stony, Avents, Bear (SR 2187), Loves, Cabin
Fair	Richland, Indian, Big Buffalo, Tick	---
Poor	N Buffalo (SR 2770), S Buffalo	Collins

[1]Blue denotes streams with moderate to high quality habitats and fish communities rated Good or Excellent. Red denotes streams with low to poor quality habitats and fish communities rated Fair or Poor.

Some of the streams with moderate to high quality habitats but rated less than Good continued to be suffering from the 2003 drought or flash floods of 2003. These streams include Stony, Avents, Bear (at SR 2187, Chatham County), Cabin, and Collins Creeks. Recovery of Avents Creek may be further impeded by a natural waterfall downstream of the site.

Appendix 3. Habitat evaluations at 38 basinwide fish community sites in the Piedmont region of the Cape Fear River basin, 2003.

Subbasin	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030601															
	L Troublesome Cr	SR 2600	Rockingham	7	4	11	2	3	3	3	3	5	2	2	38
030602															
	Reedy Fork	SR 2728	Guilford	14	4	16	8	8	10	5	5	8	3	5	72
	N Buffalo Cr	off US29 and 16th St	Guilford	9	5	16	8	9	12	6	6	10	5	4	81
	N Buffalo Cr	SR 2770	Guilford	14	4	12	5	8	5	5	5	10	5	3	62
	S Buffalo Cr	US 70	Guilford	12	3	9	3	2	1	2	2	4	3	3	32
	Stony Cr	SR 1104	Caswell	8	5	15	6	8	5	3	3	10	5	5	65
	Jordan Cr	SR 1754	Alamance	8	5	11	3	10	0	2	2	7	5	5	50
	Haw Cr	SR 2158	Alamance	12	5	20	10	10	12	6	6	10	5	5	89
030603															
	Big Alamance Cr	SR 3088	Guilford	10	5	16	4	10	4	3	3	9	4	3	61
	L Alamance Cr	SR 3039	Guilford	7	5	13	3	6	0	2	2	4	4	4	43
	N Pr Stinking Quarter Cr	SR 1113	Alamance	11	5	12	4	10	0	2	2	10	5	3	53
	S Pr Stinking Quarter Cr	SR 1117	Alamance	12	5	13	4	9	3	6	6	10	5	4	65
	L Alamance Cr	SR 2309	Alamance	11	5	18	6	8	9	4	4	10	2	2	68
030604															
	Collins Cr	SR 1539	Chatham	8	5	18	8	10	5	3	7	10	5	5	76
	Terrells Cr	NC 87	Chatham	11	5	18	12	10	14	6	6	10	5	5	91
	Ferrells Cr	SR 1525	Chatham	9	5	16	4	10	7	6	6	10	5	5	74
	Robeson Cr	off SR 1943	Chatham	10	5	16	10	10	14	6	6	7	5	5	84
030605															
	New Hope Cr	SR 2220	Durham	10	5	12	3	10	1	2	2	7	5	5	52
030607															
	Avents Cr	SR 1418	Harnett	10	5	18	11	10	12	6	6	10	5	5	88
	Hector Cr	SR 1412	Harnett	10	5	18	7	10	7	6	6	10	5	5	79
	Kenneth Cr	SR 1441	Harnett	8	5	18	4	10	7	6	6	10	5	5	76
030608															
	Bull Run Cr	SR 1144	Guilford	4	5	14	7	4	7	3	3	10	5	5	63
	Richland Cr	SR 1154	Guilford	8	5	16	3	4	5	2	2	7	4	4	52
	Hickory Cr	SR 1140	Guilford	10	5	14	4	6	4	4	4	10	5	3	59
	Muddy Cr	SR 1929	Randolph	10	5	12	3	6	2	2	2	10	5	5	52
030609															
	Polecat Cr	SR 2114	Guilford	7	5	11	2	6	2	2	2	10	2	2	44
	Sandy Cr	SR 2481	Randolph	14	5	20	10	8	14	6	6	10	5	4	88
	Brush Cr	SR 1102	Chatham	8	4	18	12	6	14	6	3	7	4	2	76
	Fork Cr	SR 1003	Randolph	9	5	20	15	8	16	6	6	8	5	4	93
030610															
	Bear Cr	SR 1405	Moore	9	4	20	15	10	16	6	6	10	5	4	96
	Cabin Cr	SR 1275	Moore	12	4	12	11	8	7	5	6	10	5	5	73
	Wet Cr[1]	NC 24/27	Moore	9	5	20	12	6	16	7	7	10	5	5	93
	Buffalo Cr	NC 22	Moore	9	4	20	15	10	10	6	6	7	5	5	88
	Indian Cr	SR 2306	Chatham	12	5	11	4	8	5	5	5	7	3	3	56

Appendix 3 (continued).

Subbasin	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030611															
	Big Buffalo Cr	SR 1403	Lee	9	4	11	3	8	2	3	3	10	5	5	54
030612															
	Rocky R	SR 1300	Chatham	7	5	14	6	8	10	1	3	4	0	5	56
	Loves Cr	SR 2229	Chatham	8	5	18	11	10	14	5	5	10	3	4	85
	Tick Cr	US 421	Chatham	11	5	12	4	8	3	3	3	7	3	3	51
	Bear Cr	SR 2187	Chatham	12	5	18	11	9	7	6	6	9	5	5	81
030615															
	Gum Log Canal[1]	SR 1728	Cumberland	7	5	16	6	6	5	2	2	4	1	1	48
Maximum possible scores					**5**	**20**	**15**	**10**	**16**	**7**	**7**	**10**	**5**	**5**	**100**

[1]also evaluated with Sand Hills habitat criteria (Appendix 4).

Appendix 4. Habitat evaluations at 17 basinwide fish community sites in the Sand Hills and Coastal Plain region of the Cape Fear River basin, 2003.

Subbasin	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030607														
	Buies Cr	off SR 1514	Harnett	6	14	18	9	8	10	10	10	5	5	89
030610														
	Wet Cr[1]	NC 24/27	Moore	9	15	20	15	6	10	10	10	5	5	96
030611														
	Little R	NC 22	Moore	6	15	18	14	8	9	9	10	3	2	88
	Nicks Cr	NC 22	Moore	8	15	18	13	4	9	9	10	5	5	88
	James Cr	off SR 2026	Moore	7	15	15	10	4	10	10	10	5	5	84
	Flat Cr	Manchester Road	Hoke	6	15	18	13	4	10	10	10	5	5	90
	Buffalo Cr	SR 1001	Moore	7	15	18	14	4	9	9	10	5	5	89
	Jumping Run	NC 210	Cumberland	9	15	20	13	10	9	5	8	5	3	88
	Muddy Cr	SR 1001	Cumberland	7	15	18	13	4	10	10	10	5	5	90
	Anderson Cr	SR 2031	Harnett	8	15	20	13	10	9	9	10	3	5	94
030615														
	Cross Cr	NC 87/210/24	Cumberland	10	2	10	7	4	3	2	2	1	0	31
	Gum Log Canal[1]	SR 1728	Cumberland	7	15	15	13	6	1	1	4	1	1	57
	Juniper Cr	Plank Road	Hoke	5	15	20	13	6	10	10	10	5	5	94
	Nicholson Cr	SR 1301	Hoke	5	15	20	8	6	10	10	10	5	5	89
	Puppy Cr	SR 1406	Hoke	8	15	20	13	6	9	9	10	5	5	92
	L Rockfish Cr	Plank Road	Hoke	5	15	20	8	6	10	10	10	5	5	89
	Bones Cr	SR 1400	Cumberland	6	15	18	8	10	10	10	10	5	3	89
Maximum possible scores					**15**	**20**	**15**	**10**	**10**	**10**	**10**	**5**	**5**	**100**

[1]also evaluated with Piedmont habitat criteria (Appendix 3).

Appendix 5. Habitat evaluations at 34 basinwide fish community sites in the Piedmont region of the Cape Fear River basin, 1998.

Subbasin	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030601															
	Haw R	SR 2109	Guilford	5	5	16	3	10	14	5	5	10	4	4	76
	Haw R	SR 2426	Rockingham	12	5	15	3	10	3	5	6	10	4	4	65
	Haw R	SR 2426	Rockingham	12	5	15	3	10	3	6	6	10	4	4	66
	Troublesome Cr	SR 1001	Rockingham	10	4	16	3	10	3	5	5	10	4	4	64
	L Troublesome Cr	SR 2600	Rockingham	6	4	15	3	10	3	3	3	10	4	1	56
	L Troublesome Cr	SR 2600	Rockingham	6	4	15	3	10	3	3	3	10	4	1	56
030602															
	Reedy Fork	SR 2728	Guilford	17	4	20	12	10	14	6	6	10	1	4	87
	Reedy Fork	SR 2728	Guilford	14	4	20	12	4	14	4	4	10	1	4	77
	N Buffalo Cr	SR 2770	Guilford	16	4	16	8	10	8	6	6	10	4	3	75
	S Buffalo Cr	US 70	Guilford	14	2	11	3	4	3	3	2	7	4	4	43
	S Buffalo Cr	SR 2821	Guilford	15	5	20	12	10	10	6	6	10	4	4	87
030603															
	Big Alamance Cr	SR 3088	Guilford	9	5	20	3	10	3	2	2	10	4	3	62
	Little Alamance Cr	SR 3039	Guilford	6	4	12	9	10	10	2	3	10	0	4	64
	Stinking Quarter Cr	SR 1136	Alamance	14	4	15	3	4	7	3	3	10	2	2	53
	Little Alamance Cr	SR 2309	Alamance	7	4	16	2	10	7	3	3	10	2	4	61
030604															
	Collins Cr	SR 1539	Chatham	11	5	18	10	10	10	3	5	10	5	3	79
	Terrells Cr	NC 87	Chatham	10	5	19	12	10	10	5	5	9	3	5	83
	Ferrells Cr	SR 1525	Chatham	7	5	13	8	10	7	5	6	10	5	5	74
030605															
	New Hope Cr	SR 2220	Durham	10	5	16	3	10	2	3	3	10	4	4	60
030606															
	Bolin Cr	off SR 1750	Orange	7	3	12	4	4	7	2	2	7	2	2	45
	Morgan Cr	off SR 1900	Orange	8	4	15	3	10	3	5	5	10	5	5	65
030607															
	Avents Cr	SR 1418	Harnett	7	4	18	11	10	7	5	5	10	5	5	80
	Hector Cr	SR 1412	Harnett	7	5	12	7	6	12	6	6	9	5	4	72
	Kenneth Cr	SR 1441	Harnett	6	5	12	5	6	3	6	6	10	4	4	61
030608															
	Richland Cr	SR 1154	Guilford	8	5	13	5	10	8	2	3	4	1	4	55
	Muddy Cr	SR 1929	Randolph	12	5	12	3	10	5	5	5	10	4	4	63
030609															
	Sandy Cr	SR 2481	Randolph	18	5	20	12	7	16	6	6	10	5	3	90
030610															
	Bear Cr	SR 1405	Moore	8	4	18	12	10	7	6	6	8	5	4	80
	Cabin Cr	SR 1275	Moore	13	4	20	12	5	7	6	6	10	4	4	78
	Falls Cr	SR 1606	Moore	6	4	20	15	6	14	7	7	9	5	5	92
	McLendons Cr[1]	SR 1210	Moore	6	4	16	5	4	7	6	6	8	5	5	66
	Richland Cr[1]	SR 1640	Moore	5	5	16	3	10	2	5	5	10	5	3	64
	Indian Cr	SR 2306	Chatham	10	5	19	8	10	7	5	6	10	4	4	78
030611															
	Big Buffalo Cr	SR 1403	Lee	8	4	16	8	8	3	5	3	9	4	3	63

Appendix 5. (continued).

Subbasin	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030612															
	Rocky R	SR 1300	Chatham	5	5	15	6	10	10	2	3	4	1	3	59
	Loves Cr	SR 2229	Chatham	4	3	16	12	7	16	6	6	10	4	3	83
	Bear Cr	SR 2187	Chatham	7	5	17	12	10	12	6	5	10	5	3	85
Maximum possible scores					**5**	**20**	**15**	**10**	**16**	**7**	**7**	**10**	**5**	**5**	**100**

[1]also evaluated with Sand Hills habitat criteria (Appendix 6).

Appendix 6. Habitat evaluations at 17 basinwide fish community sites in the Sand Hills and Coastal Plain region of the Cape Fear River basin, 1998.

Subbasin	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030610														
	McLendons Cr[1]	SR 1210	Moore	6	13	19	15	6	9	9	7	4	4	86
	Richland Cr[1]	SR 1640	Moore	5	15	15	7	10	7	7	10	5	3	79
030614														
	Crane Cr	US 1	Moore	8	11	16	11	6	7	7	9	5	5	77
	Buffalo Cr	SR 1001	Moore	6	15	16	13	6	9	9	10	5	5	88
	Anderson Cr	SR 2031	Harnett	8	15	15	15	6	10	10	10	5	5	91
030615														
	Cross Cr	NC 87/210/24	Cumberland	6	5	11	13	4	7	2	7	3	0	52
	Puppy Cr	SR 1406	Hoke	8	15	15	13	6	10	10	9	5	4	87
030616														
	Harrison Cr	SR 1318	Bladen	9	9	13	13	6	7	4	10	5	1	68
	Browns Cr	NC 87	Bladen	7	15	11	10	10	7	7	10	4	4	78
	Turnbull Cr	NC 242	Bladen	7	8	20	8	6	10	10	10	5	5	82
	Whites Cr	SR 1704	Bladen	6	15	15	13	6	7	7	10	5	5	83
030620														
	Colly Cr	US 701	Bladen	7	11	15	11	8	10	10	10	5	5	85
	White Oak Br	SR 1206	Pender	5	15	19	6	9	10	10	8	3	5	85
030621														
	Mathews Cr	NC 111/NC 903	Duplin	5	15	16	7	6	10	10	10	5	5	84
030622														
	Grove Cr	NC 11/903	Duplin	11	15	16	10	6	10	10	7	5	5	84
	Duff Cr	SR 1170	Duplin	6	13	12	13	10	10	10	10	5	5	88
030623														
	Burgaw Cr	US 117	Pender	7	7	11	1	0	7	7	5	5	5	48
Maximum possible scores					**15**	**20**	**15**	**10**	**10**	**10**	**10**	**5**	**5**	**100**

[1]also evaluated with Piedmont habitat criteria (Appendix 5).

Appendix 7. Habitat evaluations at basinwide benthic macroinvertebrate community sites in the Cape Fear River basin, 2002 - 2003.

Subbasin/ Ecoregion	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030601															
M/P	Haw R	NC 87	Alamance	12	4	15	12	6	14	3	3	7	3	2	69
M/P	Troublesome Cr*	SR 2422	Rockingham	5	5	15	12	8	12	7	7	10	5	5	86
M/P	L Troublesome Cr	SR 2600	Rockingham	6	5	14	3	4	0	3	3	10	3	4	49
030602															
M/P	Reedy Fk	SR 2128	Guilford	8	5	13	3	6	0	3	4	10	5	5	54
M/P	Brush Cr	SR 2136	Guilford	4	5	15	3	3	0	3	3	8	3	3	43
M/P	Horsepen Cr	US 220	Guilford	5	5	15	3	10	0	2	2	10	5	5	57
M/P	Reedy Fk	SR 2728	Guilford	15	5	12	8	6	7	4	4	8	4	3	61
M/P	N. Buffalo Cr	SR 2832	Guilford	14	5	16	5	10	7	3	3	10	5	5	69
M/P	S. Buffalo Cr	US 70	Guilford	12	2	11	3	2	0	2	2	4	3	3	32
M/P	S. Buffalo Cr	SR 2821	Guilford	17	5	16	12	8	7	4	4	10	5	4	75
M/P	Stony Cr	SR 1100	Caswell	7	5	14	3	8	7	3	3	10	5	5	63
M/P	Jordan Cr	SR 1002	Alamance	6	5	12	3	6	0	3	3	10	3	4	49
M/P	Haw Cr	SR 2158	Alamance	8	5	20	11	10	14	2	2	10	5	5	84
030603															
M/P	Big Alamance Cr	NC 49	Alamance	12	5	11	3	6	0	3	3	7	3	3	44
M/P	Stinking Quarter Cr	SR 1136	Alamance	13	5	16	8	6	7	3	2	10	5	4	66
M/P	Little Alamance Cr	SR 2309	Alamance	7	5	16	8	10	7	5	5	10	3	4	73
030604															
M/P	Haw R	SR 1005	Alamance	35	4	12	10	4	3	6	6	2	5	4	56
M/P	Marys Cr	SR 2174	Alamance	7	5	16	12	6	7	5	5	10	5	5	76
M/P	Cane Cr	SR 1114	Orange	7	5	16	15	6	14	5	5	10	5	5	86
M/P	Collins Cr	SR 1539	Chatham	6	5	12	13	10	14	4	5	10	5	5	83
M/P	Terrells Cr	SR 1520	Chatham	7	5	15	13	6	14	6	6	10	5	5	85
M/P	Dry Cr	SR 1520	Chatham	7	5	13	12	6	7	5	5	10	5	5	73
M/P	Haw R	US 64	Chatham	26	4	20	15	6	9	6	6	2	5	5	78
M/P	Pokeberry Cr	SR 1711	Chatham	8	5	14	15	10	14	4	5	10	5	5	87
030605															
M/P	New Hope Cr	SR 1107	Durham	10	8	10	1	0	0	5	5	7	5	5	43
030606															
M/P	Morgan Cr	off SR 1900	Orange	15	12	12	3	0	0	6	6	10	5	4	51
030607															
M/P	Parkers Cr	SR 1450	Harnett	6	4	12	10	6	12	2	4	10	3	4	63
M/P	Neills Cr	SR 1441	Harnett	6	5	16	6	10	14	5	5	10	4	4	79
M/P	Kenneth Cr	SR 1441	Harnett	10	8	14	3	4	0	3	3	7	4	4	47
M/P	Cape Fear R[1]	US 401	Harnett	---	4	12	4	10	1	6	6	2	8	5	53
030608															
M/P	W Fk Deep R	SR 1850	Guilford	8	5	11	3	0	0	6	6	10	5	5	51
M/P	Deep R	US 220 Bus	Randolph	30	25	16	12	0	14	6	6	5	4	5	73
M/P	Richland Cr	SR 1145	Guilford	15	10	11	3	0	0	6	6	10	5	5	51
M/P	Muddy Cr	SR 1929	Randolph	9	6	11	3	0	0	5	5	10	4	5	48

Appendix 7 (continued).

Subbasin/ Ecoregion	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030609															
M/P	Deep R	SR 2615	Randolph	35	30	16	12	0	7	6	6	7	5	5	69
M/P	Sandy Cr	SR 2481	Randolph	18	15	16	10	5	16	7	7	10	4	5	85
M/P	Brush Cr	NC 22/42	Randolph	15	10	16	12	6	14	6	6	10	5	5	85
030610															
M/P	Deep R	SR 1456	Moore	45	40	16	10	0	7	6	6	5	5	2	64
M/P	Mill Cr	SR 1275	Moore	8	6	12	12	6	7	6	6	7	5	5	71
M/P	Wet Cr	NC 24/27	Moore	12	7	16	12	0	15	6	6	10	5	5	78
M/P	Bear Cr	NC 705	Moore	20	15	20	12	6	10	6	6	10	5	5	85
M/P	Buffalo Cr	NC 22	Moore	10	7	16	12	6	12	6	6	10	5	5	83
030611															
M/P	Georges Cr	SR 2142	Chatham	5	5	20	12	4	16	6	6	10	5	3	87
CA	L Buffalo Cr	SR 1420	Lee	5	5	9	3	4		2	2	10	3	3	44
030612															
M/P	Rocky R	US 64	Chatham	8	5	14	10	6	14	6	6	7	4	4	76
M/P	Rocky R	SR 2170	Chatham	17	4	15	14	6	14	7	7	2	5	4	78
M/P	Rocky R	US 15/501	Chatham	26	4	12	15	4	16	6	6	2	4	4	73
M/P	Tick Cr	SR 2120	Chatham	8	5	16	12	8	10	3	3	10	0	2	69
M/P	Harlands Cr	NC 902	Chatham	5	5	14	14	6	12	6	6	9	5	5	82
M/P	Bear Cr	SR 2155	Chatham	10	5	20	8	4	16	6	6	10	5	5	85
030613															
CA	Upper Little R	SR 1222	Harnett	15	12	10	13	6	---	4	4	10	5	3	70
030614															
CA	Nicks Cr	NC 22	Moore	12	5	15	13	4	---	8	8	9	4	3	76
CA	Lower Little R	SR 2023	Moore	15	7	20	15	4	---	10	10	10	5	5	94
CA	Anderson Cr	SR 2031	Harnett	15	7	16	13	2	---	9	9	10	3	5	82
030615															
CA	Rockfish Cr	SR 1432	Hoke	15	15	20	10	6	---	10	10	10	5	5	90
CA	L Rockfish Cr	NC 59	Cumberland	8	15	17	7	4	---	4	4	10	3	3	67
CA	Gum Log Canal	SR 1728	Cumberland	7	15	15	13	6	---	1	1	4	1	1	57
CA	Bones Cr	SR 1400	Cumberland	6	15	18	8	10	---	10	10	10	5	3	89
CA	Nicholson Cr	SR 1301	Hoke	5	15	20	8	6	---	10	10	10	5	5	89
CA	Cross Cr	NC 87/210/24	Cumberland	10	2	10	7	4	---	3	2	2	1	0	31
030616															
CA	Harrison Cr	SR 1318	Bladen	8	13	16	13	4	---	9	7	10	3	5	80
CA	Browns Cr	NC 87	Bladen	5	15	15	7	3	---	10	10	7	5	3	75
CA	Ellis Cr	NC 53	Bladen	6	13	15	13	4	---	9	7	10	4	3	78
CA	Turnbull Cr	SR 1518	Bladen	6	13	13	13	4	---	6	9	10	5	2	76

Appendix 7 (continued).

Subbasin/ Ecoregion	Stream	Location	County	Width (m)	Channel	Instream Habitat	Substrate	Pools	Riffles	Bank Stability-L	Bank Stability-R	Shade	Riparian Zone-L	Riparian Zone-R	Total Score
030617															
CA	Lewis Swp	SR 1410	Brunswick	0	15	15	6	10	---	10	10	10	2	5	83
CA	Hood Cr	US 74/76	Brunswick	10	15	15	13	6	---	10	10	10	5	5	89
CA	Barnards Cr	US 421	New Hanover	3	15	15	10	4	---	5	5	2	5	5	66
CA	Livingston Cr	NC 74	Columbus	5	15	10	10	4	---	9	9	10	5	5	77
030618															
	South R	SR 1502	Bladen	8	15	18	7	4	---	10	10	10	5	5	84
030619															
CA	L Coharie Cr	SR 1214	Sampson	10	15	10	13	6	---	10	10	7	2	4	77
CA	Six Runs Cr	SR 1960	Sampson	15	15	10	7	6	---	9	9	7	4	5	72
CA	Stewarts Cr	SR 1943	Sampson	6	15	13	7	4	---	9	9	9	5	5	76
CA	Stewarts Cr	SR 1943	Sampson	6	13	15	13	9	---	7	9	7	4	4	81
CA	Black R	NC 411	Sampson	15	15	17	7	4	---	10	10	2	5	5	75
030620															
CA	Moore Cr	SR 1128	Pender	0	15	17	6	10	---	10	10	7	5	5	85
030622															
CA	Rockfish Cr	I 40	Duplin	11	10	10	7	8	---	4	7	7	1	5	59
CA	Rockfish Cr	SR 1165	Duplin	12	15	15	7	6	---	7	9	7	1	2	69
CA	Muddy Cr	NC 41	Duplin	3	10	13	7	4	---	10	10	8	5	5	72
CA	Stockinghead Cr	SR 1953	Duplin	8	15	10	10	10	---	7	7	7	5	2	73
CA	Limestone Cr	SR 1702	Duplin	4	15	6	7	0	---	2	2	6	3	4	45
CA	Goshen Swamp	SR 1725	Sampson	5	15	15	7	4	---	10	10	9	5	5	80
CA	Little Rockfish Cr	NC 11	Duplin	4	5	10	7	4	---	7	7	5	4	4	53
030623															
CA	Lillington Cr	SR 1520	Pender	10	15	18	10	6	---	10	10	10	5	5	89
CA	Merricks Cr	NC 210	Pender	10	15	13	7	8	---	10	10	10	5	5	83
CA	Long Cr	NC 53	Pender	10	5	5	3	8	---	10	10	5	5	5	46
CA	Cypress Swp	NC53	Pender	8	15	15	10	8	---	9	9	10	5	5	86
CA	Angola Cr	NC 53	Pender	0	15	17	7	10	---	10	10	7	5	5	86
CA	Moores Cr	NC 50	Pender	6	15	12	7	4	---	10	10	9	5	5	77
CA	Smith Cr	I-40	New Hanover	0	10	10	7	2	---	4	4	7	5	5	54
CA	Island Cr	SR 1336	New Hanover	20	15	18	10	10	---	10	10	10	5	5	93

[1]habitat assessments do not accurately characterize large river habitats.

Appendix 8. Fish community sampling methods and criteria.

In 2003, fish community assessments were performed at 55 sites in the basin, 38 in the Piedmont, 16 in the Sand Hills, and 1 in the Coastal Plain. Twenty-seven of the 38 Piedmont sites which had been previously sampled in 1998 or 1999 were sampled again in 2003, including some which were on the impaired streams list (Table 1).

The 19 new sites (Haw, Buies, Bull Run, Hickory, Polecat, Brush, Fork, Wet, Buffalo, James, Flat, Muddy, Juniper, Nicholson, Little Rockfish, and Bones Creeks, Gum Log Canal, Jumping Run, and Little River,) all represented unassessed fish community watersheds. Fork Creek was added as a basin site at the request of the US Fish and Wildlife Service as part of their management studies of the Cape Fear shiner. Some of these unassessed sites were also selected as potential candidates for regional reference sites.

Other sites were sampled at more appropriately-sized locations (North and South Prong Stinking Quarter Creeks) or at a site further downstream in the watershed (Jordan Creek). Finally, some sites were sampled because of the removal or relocation of NPDES discharge (Little Troublesome Creek and North Buffalo Creek off 16th Street and US 29) or due to issues surrounding WWTP and poultry processing facilities (Robeson Creek).

Some sites that were sampled during the first or second cycles of basinwide monitoring in 1994 and 1998 were not resampled in 2003 because:

- continuous high flows in Subbasins 13 and 16 - 23 that prevented sampling;
- high and turbid flows (Haw River and Troublesome Creek);
- no change in the community was anticipated (South Buffalo, Northeast, Third Fork, McLendons, and Richland Creeks) and resources could be used to evaluate other streams;
- there were already sufficient data collected since 1999 to assess these streams (Bolin, Morgan, and Crane Creeks); and
- the stream was considered Collection Sensitive Waters by the NC Wildlife Resources Commission where sampling is strictly controlled (Falls Creek).

Table 1. Fish community sites monitored in 2003 that are on the state's 303(d) list of impaired waters (NCDENR 2003).

Subbasin/ Waterbody	Reach Affected	Suspected Cause (s)
030601		
Little Troublesome Cr	Reidsville WWTP to Haw R	Historical listing for “sediment” based upon biological impairment
030602		
N Buffalo Cr	Source to above WWTP	Historical listing for “sediment” based upon biological impairment
N Buffalo Cr	WWTP to Buffalo Cr	Ammonia, habitat degradation
S Buffalo Cr	McConnell Road to US 70	Historical listing for “sediment” based upon biological impairment
030603		
Little Alamance Cr	Source to Big Alamance Cr	Cause unknown
030604		
Robeson Cr	From a point 0.7 mi downstream of SR 2159 to a point 0.3 mi above mouth	Historical listing for “sediment” based upon biological impairment
030605		
New Hope Cr	From a point 0.3 mi upstream of SR 2220 to a point 0.8 mi downstream of SR 1107	Fecal coliform, historical listing for “sediment” based upon biological impairment
030607		
Kenneth Cr	Wake-Harnett County line to Neills Cr	Cause unknown
030608		
Richland Cr	From a point 0.4 mi upstream of SR 1154 to Randleman Reservoir	Fecal coliform, historical listing for “sediment” based upon biological impairment
Muddy Cr	Source to a point 0.5 mi above mouth	Fecal coliform
Hickory Cr	From a point 0.6 mi upstream of mouth to Randleman Res	Habitat degradation
030612		
Rocky R	Source to Rocky River Res	Habitat degradation
Loves Cr	US 421 to Siler City WWTP	Cause unknown
030615		
Cross Cr	Water supply intake at Murchison Rd to Cape Fear R	Historical listing for “sediment based upon biological impairment

Sampling Methods

At each sample site, a 600 ft. section of stream was selected and measured. The fish in the delineated stretch of stream were then collected using two backpack electrofishing units and two persons netting the stunned fish. After collection, all readily identifiable fish were examined for sores, lesions, fin damage, or skeletal anomalies, measured (total length to the nearest 1 mm), and then released. Those fish that were not readily identifiable were preserved and returned to the laboratory for identification, examination, and total length measurement. Detailed descriptions of the sampling methods may be found at: http://www.esb.enr.state.nc.us/BAU.html. Raw data for the fish community monitoring program may be found at: http://www.esb.enr.state.nc.us/NCIBI.htm.

NCIBI Analysis

The assessment of biological integrity using the North Carolina Index of Biotic Integrity (NCIBI) is provided by the cumulative assessment of 12 parameters or metrics. The values provided by the metrics are converted into scores on a 1, 3, or 5 scale. A score of 5 represents conditions which would be expected for undisturbed reference streams in the specific river basin or ecoregion, while a score of 1 indicates that the conditions deviate greatly from those expected in undisturbed streams of the region. Each metric is designed to contribute unique information to the overall assessment. The scores for all metrics are then summed to obtain the overall NCIBI score. Finally, the score (an even number between 12 and 60) is then used to determine the ecological integrity class of the stream from which the sample was collected.

The NCIBI has recently been revised (NCDENR 2001b). Currently, the focus of using and applying the NCIBI has been restricted to wadeable streams that can be sampled by a crew of four persons. The bioclassifications and criteria have also been recalibrated against regional reference site data (Biological Assessment Unit Memorandum F-010105) (Tables 2 – 5).

Table 2. Revised scores and classes for evaluating the fish community of a wadeable stream using the North Carolina Index of Biotic Integrity in the Outer Piedmont (Cape Fear, Neuse, Roanoke, and Tar River basins).

NCIBI Scores	NCIBI Classes
54, 56, 58, or 60	Excellent
46, 48, 50, or 52	Good
40, 42, or 44	Good-Fair
34, 36, or 38	Fair
≤ 32	Poor

Table 3. Regional reference sites/samples used in calibrating the North Carolina Index of Biotic Integrity in the Cape Fear River basin.

Subbasin/ Waterbody	Station	County	Date
030604			
Ferrells Cr	SR 1525	Chatham	04/21/1998
030607			
Avents Cr	SR 1418	Harnett	09/21/1998
Hector Cr	SR 1403	Harnett	02/09/1994
Hector Cr	SR 1412	Harnett	05/06/1998
030610			
Bear Cr	SR 1405	Moore	09/21/1998
Falls Cr	SR 1606	Moore	05/05/1998
Indian Cr	SR 2306	Chatham	04/23/1998

Criteria and ratings are applicable only to wadeable streams in the Piedmont region of the basin and are the same as those for the Tar, Neuse, and Roanoke River basins. The definition of the Piedmont for these basins is based on a map of North Carolina watersheds by Fels (1997). Metrics and ratings should not be applied to non-wadeable streams and streams in the Coastal Plain region in each of these basins, nor in the Sand Hills region. These streams are currently not rated.

Blackspot and Other Diseases

Blackspot disease is a naturally occurring, common infection of fish by an immature stage of flukes. The life cycle involves fish, snails, and piscivorous birds. Although heavy, acute infections can be fatal, especially to small fish, fish can carry amazingly high worm burdens without any apparent ill effects (Noga 1996). The infections may often be disfiguring and render the fish aesthetically unpleasing (Figure 1).

Figure 1. **Heavy infestation of blackspot disease in Creek chub.**

Figure 2. **Popeye caused by nematode infection in Bluegill, Hardee Creek (Pitt County, Tar River basin).**

Although some researchers incorporate the incidence of black spot incidence into indices of biotic integrity (e.g., Steedman 1991), others, because of a lack of a consistent, inverse relationship to environmental quality, do not (e.g., Sanders *et al*. 1999). The disease is not considered in the NCIBI because it is widespread, affecting fish in all types of streams. This disease was noted in Cabin Creek on highfin shiner and coastal shiner; in Robeson Creek on white shiner, and spottail shiner; and in Fork Creek on white shiner and redlip shiner.

Other diseases observed in 2003 included:

- fungus on some bluehead chub in Haw Creek and on redbreast sunfish in South Prong Stinking Quarter Creek;
- scoliosis in bluehead chub in Bull Run and Buffalo Creek (NC 22, Moore County) and in dusky shiner in Flat Creek;
- ulcers on yellow bullhead in Flat Creek and Bluegill in Gum Log Canal;
- "Ich' on margined madtom in Flat Creek;
- abdominal tumors in spottail shiner in Ferrells Creek; and
- "Popeye" or exophthalmos in some bluegill from Haw, Ferrells, New, and Hector Creeks. The disease can be caused by bacterial and viral infections as well as nematode infections (Figure 2).

Sand Hills Streams

The Sand Hills is a rolling to hilly region of sandy, low nutrient soils where stream flow is stable and streams seldom flood or dry up (Griffith *et al* 2002). In the Cape Fear River basin the region encompasses parts of Harnett, Lee, Moore, Hoke, and Cumberland counties.

Sixteen streams were sampled in 2003 to obtain additional data for future derivation of metrics and criteria by which to rate the community. The process is ongoing and until completed, these communities will be considered "Not Rated". However, some generalities may be teased from the 2003 sampling efforts:

- Streams draining relatively undisturbed watersheds had high instream and riparian habitat characteristics and many qualified as future regional reference sites (Appendix 2).
- Streams draining relatively undisturbed watersheds had characteristically very darkly stained and low pH water; conversely a stream draining a modified watershed had clearer and greater pH water than that of a reference site. In 2003 the pH ranged from 4.4 s.u. at Muddy Creek to 7.3 s.u. at Cross Creek (Appendix 14)
- Similar to pH, the conductivity of waters draining relatively undisturbed watersheds was characteristically low; conversely a stream draining any modified watershed had a greater conductivity than that of a reference site. In 2003 the lowest conductivity was 11 µmhos/cm at Little Rockfish Creek and the greatest conductivities were 54 µmhos/cm at Cross

Creek, 65 µmhos/cm at Little River, and 75 µmhos/cm at Gum Log Canal (Appendix 14).

- Streams draining relatively undisturbed watersheds had characteristically low species diversity and low abundance; conversely streams draining a modified watershed had greater species diversity and fish abundance. In 2003 only 14 fish and 7 species were collected from Buffalo Creek contrasted to 304 fish and 22 species collected from Gum Log Canal.
- Species that are characteristic of Sand Hills streams in the Cape Fear River basin include the American eel, redfin pickerel, chain pickerel, dusky shiner, coastal shiner, Sand Hills chub, creek chubsucker, spotted sucker, yellow bullhead, margined madtom, pirate perch, bluespotted sunfish, blackbanded sunfish, redbreast sunfish, warmouth, bluegill, dollar sunfish, banded pygmy sunfish, tessellated darter, sawcheek darter, and Piedmont darter.

Despite naturally low fish abundances and species diversity, most of the communities sampled in 2003 seemed to be characteristic of unimpacted and fully functioning streams.

Table 4. Scoring criteria for the NCIBI for wadeable streams in the Outer Piedmont of the Cape Fear, Neuse, Roanoke, and Tar River basins ranging between 3.1 and 328 mi^2.

No.	Metric		Score
1	**No. of species**		
	≥ 16 species		5
	10-15 species		3
	< 10 species		1
2	**No. of fish**		
	≥ 225 fish		5
	150-224 fish		3
	< 150 fish		1
3	**No. of species of darters**		
	Cape Fear	Neuse, Roanoke, and Tar	
	≥ 2 species	≥ 3 species	5
	1 species	1 or 2 species	3
	0 species	0 species	1
4	**No. of species of sunfish**		
	≥ 4 species		5
	3 species		3
	0, 1, or 2 species		1
5	**No. of species of suckers**		
	Cape Fear	Neuse, Roanoke, and Tar	
	≥ 2 species	≥ 3 species	5
	1 species	1 or 2 species	3
	0 species	0 species	1
6	**No. of intolerant species**		
	Cape Fear	Neuse, Roanoke, and Tar	
	≥ 1 species	≥ 3 species	5
	no middle score	1 or 2 species	3
	0 species	0 species	1
7	**Percentage of tolerant individuals**		
	≤ 35%		5
	36-50%		3
	> 50%		1
8	**Percentage of omnivorous and herbivorous individuals**		
	10-35%		5
	36-50%		3
	> 50%		1
	< 10%		1
9	**Percentage of insectivorous individuals**		
	65-90%		5
	45-64%		3
	< 45%		1
	> 90%		1
10	**Percentage of piscivorous individuals**		
	≥ 1.4-15%		5
	0.4-1.3%		3
	< 0.4%		1
	> 15%		1
11	**Percentage of diseased fish (DELT = diseased, fin erosion, lesions, and tumors)**		
	≤ 1.75%		5
	1.76-2.75%		3
	> 2.75%		1
12	**Percentage of species with multiple age groups**		
	≥ 50% of all species have multiple age groups		5
	35-49% all species have multiple age groups		3
	< 35% all species have multiple age groups		1

Table 5. Tolerance ratings and adult trophic guild assignments for fish in the Cape Fear River basin.

Family/ Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Petromyzontidae	**Lampreys**		
Petromyzon marinus	Sea lamprey	Intermediate	Parasitic
Acipenseridae	**Sturgeons**		
Acipenser brevirostrum	Shortnose sturgeon	Intermediate	Insectivore
A. oxyrinchus	Atlantic sturgeon	Intermediate	Insectivore
Lepisosteidae	**Gars**		
Lepisosteus osseus	Longnose gar	Tolerant	Piscivore
Amiidae	**Bowfins**		
Amia calva	Bowfin	Tolerant	Piscivore
Anguillidae	**Eels**		
Anguilla rostrata	American eel	Intermediate	Piscivore
Clupeidae	**Herrings and shads**		
Alosa aestivalis	Blueback herring	Intermediate	Insectivore
A. mediocris	Hickory shad	Intermediate	Insectivore
A. pseudoharengus	Alewife	Intermediate	Insectivore
A. sapidissima	American shad	Intermediate	Insectivore
Dorosoma cepedianum	Gizzard shad	Intermediate	Omnivore
D. petenense	Threadfin shad	Intermediate	Omnivore
Umbridae	**Mudminows**		
Umbra pygmaea	Eastern mudminnow	Intermediate	Insectivore
Esocidae	**Pikes**		
Esox americanus americanus	Redfin pickerel	Intermediate	Piscivore
E. niger	Chain pickerel	Intermediate	Piscivore
Cyprinidae	**Minnows**		
Clinostomus funduloides	Rosyside dace	Intermediate	Insectivore
Ctenopharyngodon idella	Grass carp	Tolerant	Herbivore
Cyprinella analostana	Satinfin shiner	Tolerant	Insectivore
C. lutrensis	Red shiner	Tolerant	Insectivore
C. nivea	Whitefin shiner	Intermediate	Insectivore
C. zanema	Thinlip chub	Intolerant	Insectivore
Cyprinus carpio	Common carp	Tolerant	Omnivore
Hybognathus regius	Silvery minnow	Intermediate	Herbivore
Luxilus albeolus	White shiner	Intermediate	Insectivore
L. cerasinus	Crescent shiner	Intermediate	Insectivore
Lythrurus ardens	Rosefin shiner	Intermediate	Insectivore
Nocomis leptocephalus	Bluehead chub	Intermediate	Omnivore
N. raneyi	Bull chub	Intermediate	Omnivore
Notemigonus crysoleucas	Golden shiner	Tolerant	Omnivore
Notropis alborus	Whitemouth shiner	Intermediate	Insectivore
N. altipinnis	Highfin shiner	Intermediate	Insectivore
N. amoenus	Comely shiner	Intermediate	Insectivore
N. chalybaeus	Ironcolor shiner	Intolerant	Insectivore
N. chiliticus	Redlip shiner	Intermediate	Insectivore
N. cummingsae	Dusky shiner	Intermediate	Insectivore
N. hudsonius	Spottail shiner	Intermediate	Omnivore
N. maculatus	Taillight shiner	Intolerant	Insectivore
N. mekistocholas	Cape Fear shiner	Intermediate	Omnivore
N. petersoni	Coastal shiner	Intermediate	Insectivore
N. procne	Swallowtail shiner	Intermediate	Insectivore
N. scepticus	Sandbar shiner	Intermediate	Insectivore
Phoxinus oreas	Mountain redbelly dace	Intermediate	Herbivore
Pimephales promelas	Fathead minnow	Tolerant	Omnivore
Semotilus atromaculatus	Creek chub	Tolerant	Insectivore
S. lumbee	Sand Hills chub	Intolerant	Insectivore

Table 5 (continued).

Family/ Species	Common Name	Tolerance Rating	Trophic Guild of Adults
Catostomidae	**Suckers**		
C. velifer complex	Highfin carpsucker	Intermediate	Insectivore
Catostomus commersoni	White sucker	Tolerant	Omnivore
Erimyzon oblongus	Creek chubsucker	Intermediate	Omnivore
E. sucetta	Lake chubsucker	Intermediate	Insectivore
Minytrema melanops	Spotted sucker	Intermediate	Insectivore
Moxostoma collapsum	Notchlip redhorse	Intermediate	Insectivore
M. macrolepidotum	Shorthead redhorse	Intermediate	Insectivore
M. pappillosum	V-lip redhorse	Intermediate	Insectivore
M. sp. cf. *erythrurum*	Carolina redhorse	Intermediate	Insectivore
Scartomyzon sp. cf. *lachneri*	Brassy jumprock	Intermediate	Insectivore
Ictaluridae	**Catfishes**		
Ameiurus brunneus	Snail bullhead	Intermediate	Insectivore
A. catus	White catfish	Tolerant	Omnivore
A. natalis	Yellow bullhead	Tolerant	Omnivore
A. nebulosus	Brown bullhead	Tolerant	Omnivore
A. platycephalus	Flat bullhead	Tolerant	Insectivore
Ictalurus furcatus	Blue catfish	Intermediate	Piscivore
I. punctatus	Channel catfish	Intermediate	Omnivore
Noturus gyrinus	Tadpole madtom	Intermediate	Insectivore
N. insignis	Margined madtom	Intermediate	Insectivore
N. sp. cf. *leptacanthus*	Broadtail madtom	Intolerant	Insectivore
Pylodictis olivaris	Flathead catfish	Intermediate	Piscivore
Amblyopsidae	**Cavefishes**		
Chologaster cornuta	Swampfish	Intermediate	Insectivore
Aphredoderidae	**Pirate perches**		
Aphredoderus sayanus	Pirate perch	Intermediate	Insectivore
Fundulidae	**Topminnows**		
Fundulus diaphanus	Banded killifish	Intermediate	Insectivore
F. lineolatus	Lined topminnow	Intermediate	Insectivore
F. rathbuni	Speckled killifish	Intermediate	Insectivore
Poeciliidae	**Livebearers**		
Gambusia holbrooki	Eastern mosquitofish	Tolerant	Insectivore
Atherinidae	**Silversides**		
Labidesthes sicculus	Brook silverside	Intermediate	Insectivore
Menidia beryllina	Inland silverside	Intermediate	Insectivore
Moronidae	**Temperate basses**		
Morone americana	White perch	Intermediate	Piscivore
M. chrysops	White bass	Intermediate	Piscivore
M. saxatilis	Striped bass	Intermediate	Piscivore
Centrarchidae	**Sunfishes and Black Basses**		
Acantharchus pomotis	Mud sunfish	Intermediate	Insectivore
Ambloplites cavifrons	Roanoke bass	Intermediate	Piscivore
Centrarchus macropterus	Flier	Intermediate	Insectivore
Enneacanthus chaetodon	Blackbanded sunfish	Intermediate	Insectivore
E. gloriosus	Bluespotted sunfish	Intermediate	Insectivore
E. obesus	Banded sunfish	Intermediate	Insectivore
Lepomis auritus	Redbreast sunfish	Tolerant	Insectivore
L. cyanellus	Green sunfish	Tolerant	Insectivore
L. gibbosus	Pumpkinseed	Intermediate	Insectivore
L. gulosus	Warmouth	Intermediate	Insectivore
L. macrochirus	Bluegill	Intermediate	Insectivore
L. marginatus	Dollar sunfish	Intermediate	Insectivore
L. microlophus	Redear sunfish	Intermediate	Insectivore
L. punctatus	Spotted sunfish	Intermediate	Insectivore
Lepomis sp.	Hybrid sunfish	Tolerant	Insectivore
Micropterus punctulatus	Spotted bass	Intermediate	Piscivore

Table 5 (continued).

Family/ Species	Common Name	Tolerance Rating	Trophic Guild of Adults
M. salmoides	Largemouth bass	Intermediate	Piscivore
Pomoxis annularis	White crappie	Intermediate	Piscivore
P. nigromaculatus	Black crappie	Intermediate	Piscivore
Elassomatidae	**Pygmy sunfishes**		
Elassoma evergladei	Everglades pygmy sunfish	Intermediate	Insectivore
E. zonatum	Banded pygmy sunfish	Intermediate	Insectivore
Percidae	**Darters and Perches**		
Etheostoma collis	Carolina darter	Intermediate	Insectivore
E. flabellare	Fantail darter	Intermediate	Insectivore
E. fusiforme	Swamp darter	Intermediate	Insectivore
E. olmstedi	Tessellated darter	Intermediate	Insectivore
E. serrifer	Sawcheek darter	Intolerant	Insectivore
Perca flavescens	Yellow perch	Intermediate	Piscivore
Percina crassa	Piedmont darter	Intolerant	Insectivore

Appendix 9. Fish community data collected in the Cape Fear River basin, 1993 - 2003. Current basinwide sites are in bold font.

Subbasin/Waterbody	Location	County	Index No.	Date	NCIBI Score	NCIBI Rating
030601						
Haw R	SR 2109	Guilford	16-(1)	04/06/98	42	Good-Fair
Haw R	SR 2426	Rockingham	16-(1)	10/12/98	52	Good
				04/06/98	32	Poor
Troublesome Cr	SR 1001	Rockingham	16-6-(0.3)	04/06/98	30	Poor
				11/03/93	34	Fair
Little Troublesome Cr	SR 2600	Rockingham	16-7	04/21/03	44	Good-Fair
				10/12/98	24	Poor
				04/06/98	36	Fair
030602						
Reedy Fork	SR 2728	Guilford	16-11-(9)	06/25/03	52	Good
				10/12/98	52	Good
				04/07/98	48	Good
				11/03/93	46	Good
Brush Cr	SR 3820	Guilford	16-11-4-(1)	09/24/99	46	Good
Horsepen Cr	US 220	Guilford	16-11-5-(0.5)	10/27/99	42	Good-Fair
Reedy Fork	SR 2128	Guilford	16-11-(1)	09/20/99	34	Fair
N Buffalo Cr	SR 2628	Guilford	16-11-14	10/27/99	28	Poor
N Buffalo Cr	SR 1400	Guilford	16-11-14	09/20/99	32	Poor
N Buffalo Cr	off 16th St and US 29	Guilford	16-11-14	04/22/03	42	Good-Fair
				04/21/99	22	Poor
N Buffalo Cr	SR 2770	Guilford	16-11-14	06/23/03	28	Poor
				04/07/98	32	Poor
				05/10/94	24	Poor
S Buffalo Cr	off SR 3300	Guilford	16-11-14-2	04/21/99	36	Fair
S Buffalo Cr	US 70	Guilford	16-11-14-2	06/23/03	26	Poor
				04/21/99	22	Poor
				04/07/98	26	Poor
				05/10/94	30	Poor
S Buffalo Cr	SR 2821	Guilford	16-11-14-2	04/07/98	20	Poor
				05/10/94	22	Poor
Stony Cr	SR 1104	Caswell	16-14-(1)	04/21/03	44	Good-Fair
				05/19/94	54	Excellent
Jordan Cr	SR 1002	Alamance	16-14-6-(0.5)	11/04/93	40	Good-Fair
Jordan Cr	SR 1754	Alamance	16-14-6-(0.5)	04/23/03	40	Good-Fair
Haw Cr	SR 2158	Alamance	16-20-(4)	04/23/03	52	Good
030603						
Big Alamance Cr	SR 3088	Guilford	16-19-(1)	04/22/03	42	Good-Fair
				10/26/99	36	Fair
				04/20/99	48	Good
				04/08/98	52	Good
Big Alamance Cr	SR 2309	Alamance	16-19-(4.5)	11/04/93	54	Excellent
Little Alamance Cr	SR 3039	Guilford	16-19-3-(0.5)	04/22/03	44	Good-Fair
				04/22/98	44	Good-Fair
Stinking Quarter Cr	SR 1136	Alamance	16-19-8	04/08/98	52	Good
				05/19/94	58	Excellent
N Pr Stinking Quarter Cr	SR 1113	Alamance	16-19-8-1	04/24/03	46	Good
S Pr Stinking Quarter Cr	SR 1117	Alamance	16-19-8-2-(2)	04/24/03	54	Excellent
Rock Cr	off SR 2409	Alamance	16-19-8-3	07/30/92	48	Good
Rock Cr	off SR 2409	Alamance	16-19-8-3	07/30/92	52	Good
Little Alamance Cr	SR 2309	Alamance	16-19-11	04/23/03	52	Good
				04/08/98	38	Fair
				11/04/93	48	Good
030604						
Cane Cr	SR 1114	Orange	16-27-(2.5)	03/24/94	50	Good
Collins Cr	SR 1539	Chatham	16-30-(1.5)	05/02/03	28	Poor
				04/21/98	38	Fair
Terrells Cr	NC 87	Chatham	16-31-(2.5)	04/24/03	56	Excellent
				04/21/98	52	Good
				04/19/94	50	Good

Appendix 9 (continued).

Subbasin/Waterbody	Location	County	Index No.	Date	NCIBI Score	NCIBI Rating
Ferrells Cr	SR 1525	Chatham	16-32	05/02/03	48	Good
				04/21/98	44	Good-Fair
Robeson Cr	off SR 1943	Chatham	16-38-(3)	05/05/03	52	Good
030605						
New Hope Cr	SR 2220	Durham	16-41-1-(11.5)	05/03/03	40	Good-Fair
				05/18/98	40	Good-Fair
Third Fork Cr	NC 751	Durham	16-41-1-12-(2)	06/16/93	22	Poor
Northeast Cr	SR 1102	Durham	16-41-1-17-(0.7)	06/16/93	42	Good-Fair
Northeast Cr	SR 1100	Durham	16-41-1-17-(0.7)	06/16/93	38	Fair
030606						
Bolin Cr	SR 1777	Orange	16-41-1-15-1-(0.5)	10/22/01	46	Good
Bolin Cr	NC 86	Orange	16-41-1-15-1-(0.5)	10/22/01	50	Good
Bolin Cr	off SR 1750	Orange	16-41-1-15-1-(0.5)	10/22/01	44	Good-Fair
				05/18/98	40	Good-Fair
Morgan Cr	NC 54	Orange	16-41-2-(1)	03/24/94	46	Good
Morgan Cr	off SR 1900	Orange	16-41-2-(5.5)	04/20/99	38	Fair
				05/18/98	36	Fair
030607						
Gulf Cr	off SR 1924	Chatham	18-5-(2)	04/22/93	38	Fair
Gulf Cr	off SR 1916	Chatham	18-5-(2)	04/22/93	30	Poor
Avents Cr	SR 1418	Harnett	18-13-(2)	06/06/03	44	Good-Fair
				09/21/98	48	Good
Hector Cr	SR 1403	Harnett	18-15-(0.7)	02/09/94	46	Good
Hector Cr	SR 1412	Harnett	18-15-(0.7)	06/06/03	56	Excellent
				05/06/98	46	Good
Kenneth Cr	SR 1441	Harnett	18-16-1-(2)	06/06/03	46	Good
				05/06/98	44	Good-Fair
				02/09/94	34	Fair
Buies Cr	off SR 1519	Harnett	18-18	06/06/03		Not Rated
030608						
Bull Run Cr	off SR 1549	Guilford	17-5-(1)	09/20/99	40	Good-Fair
Bull Run Cr	SR 1144	Guilford	17-5-(2)	06/24/03	42	Good-Fair
Richland Cr	SR 1154	Guilford	17-7-(4)	04/22/03	36	Fair
				04/22/98	26	Poor
Hickory Cr	SR 1140	Guilford	17-8.5-(3)	06/23/03	46	Good
Muddy Cr	SR 1929	Randolph	17-9-(1)	06/24/03	50	Good
				04/22/98	38	Fair
				03/22/94	46	Good
030609						
Polecat Cr	SR 2114	Randolph	17-11-(1)	06/24/03	46	Good
Sandy Cr	SR 2481	Randolph	17-16-(3.5)	06/24/03	52	Good
				06/01/99	56	Excellent
				05/04/98	60	Excellent
				03/22/94	52	Good
Brush Cr	SR 1102	Chatham	17-23	06/26/03	52	Good
Fork Cr	SR 1003	Randolph	17-25	06/26/03	50	Good
030610						
Bear Cr	SR 1405	Moore	17-26-(1)	06/27/03	48	Good
				09/21/98	56	Excellent
Bear Cr	NC 705	Moore	17-26-(6)	05/20/94	52	Good
Cabin Cr	SR 1275	Moore	17-26-5-(1)	06/27/03	42	Good-Fair
				10/27/99	50	Good
				06/14/99	58	Excellent
				04/07/99	54	Excellent
				05/05/98	58	Excellent
Wet Cr	NC 24/ 27	Moore	17-26-5-5	06/27/03		Not Rated
Falls Cr	SR 1606	Moore	17-27	05/05/98	54	Excellent
Buffalo Cr	NC 22	Moore	17-28	06/26/03	52	Good
McLendons Cr	SR 1210	Moore	17-30	05/05/98		Not Rated
Richland Cr	SR 1640	Moore	17-30-5-(1)	04/24/98		Not Rated
				05/20/94		Not Rated

Appendix 9 (continued).

Subbasin/Waterbody	Location	County	Index No.	Date	NCIBI Score	NCIBI Rating
Indian Cr	SR 2306	Chatham	17-35	06/13/03	36	Fair
				04/23/98	56	Excellent
030611						
Cedar Cr	SR 2145	Chatham	17-39	04/11/94	38	Fair
Big Buffalo Cr	SR 1403	Lee	17-40	06/16/03	36	Fair
				04/24/98	26	Poor
				04/11/94	42	Good-Fair
030612						
Rocky R	SR 1300	Chatham	17-43-(1)	05/06/03	40	Good-Fair
				05/04/98	44	Good-Fair
Loves Cr	SR 2229	Chatham	17-43-10	05/05/03	44	Good-Fair
				05/04/98	52	Good
Tick Cr	US 421	Chatham	17-43-13	06/13/03	38	Fair
				04/19/94	56	Excellent
Bear Cr	SR 2187	Chatham	17-43-16	06/13/03	44	Good-Fair
				10/29/99	36	Fair
				04/07/99	40	Good-Fair
				04/23/98	50	Good
030614						
Nicks Cr	NC 22	Moore	18-23-3-(3)	09/15/03		Not Rated
				05/31/96		Not Rated
Little R	NC 22	Moore	18-23-(1)	09/15/03		Not Rated
Lower Little R	SR 2023	Moore	18-23-(10.7)	04/20/94		Not Rated
James Cr	off SR 2026	Moore	18-23-13	09/16/03		Not Rated
Flat Cr	Manchester Road	Hoke	18-23-15	09/16/03		Not Rated
Crane Cr	SR 1810	Moore	18-23-16	04/23/02		Not Rated
Crane Cr	US 1	Moore	18-23-16	04/22/02		Not Rated
				05/07/98		Not Rated
Crane Cr	SR 2005	Moore	18-23-16	04/22/02		Not Rated
Crane Cr	SR 1001	Moore	18-23-16	04/20/94		Not Rated
Herds Cr	NC 24/27	Moore	18-23-16-3	04/23/02		Not Rated
Beaver Cr	SR 1825	Moore	18-23-16-8	04/22/02		Not Rated
Cypress Cr	SR 1103	Harnett	18-23-16-10	04/22/02		Not Rated
Buffalo Cr	SR 1001	Moore	18-23-18	09/15/03		Not Rated
				05/07/98		Not Rated
Jumping Run	NC 210	Cumberland	18-23-20	10/02/03		Not Rated
Muddy Cr	SR 1001	Cumberland	18-23-26	09/16/03		Not Rated
Anderson Cr	SR 2031	Harnett	18-23-32	10/02/03		Not Rated
				05/06/98		Not Rated
030615						
Cross Cr	NC 87/210	Cumberland	18-27-(3)	05/03/94		Not Rated
Cross Cr	NC 87/210/24	Cumberland	18-27-(3)	10/20/03		Not Rated
				05/21/98		Not Rated
Gum Log Canal	SR 1728	Cumberland	18-28-1	10/02/03		Not Rated
Juniper Cr	Plank Road	Hoke	18-31-10	10/21/03		Not Rated
Nicholson Cr	SR 1301	Hoke	18-31-14	10/20/03		Not Rated
Puppy Cr	SR 1406	Hoke	18-31-19	10/21/03		Not Rated
				05/21/98		Not Rated
Bones Cr	SR 1400	Cumberland	18-31-24-2	10/20/03		Not Rated
L Rockfish Cr	Plank Road	Hoke	18-31-24-(3)	10/20/03		Not Rated
030616						
Harrison Cr	SR 1318	Bladen	18-42	05/20/98		Not Rated
				05/03/94		Not Rated
Browns Cr	NC 87	Bladen	18-45	05/20/98		Not Rated
				08/11/92		Not Rated
Turnbull Cr	NC 242	Bladen	18-46	05/20/98		Not Rated
Whites Cr	SR 1704	Bladen	18-50-5	05/20/98		Not Rated
030620						
Colly Cr	US 701	Bladen	18-68-17	05/19/98		Not Rated
White Oak Branch	SR 1206	Pender	18-68-18-5	05/19/98		Not Rated

Appendix 9 (continued).

Subbasin/Waterbody	Location	County	Index No.	Date	NCIBI Score	NCIBI Rating
030621						
Mathews Cr	NC 111/NC 903	Duplin	18-17-13	05/22/98		Not Rated
030622						
Grove Cr	NC 11/903	Duplin	18-74-2-1	05/22/98		Not Rated
				06/01/94		Not Rated
Halls Marsh Run	SR 1306	Duplin	18-74-19-11	11/18/92		Not Rated
Herrings Marsh Run	SR 1306	Duplin	18-74-19-16	11/18/92		Not Rated
Duff Cr	SR 1170	Duplin	18-74-29-2-(2)	05/22/98		Not Rated
030623						
Burgaw Cr	US 117	Pender	18-74-39	05/19/98		Not Rated

Appendix 10. Fish community metric values from 38 wadeable streams in the Piedmont region of the Cape Fear River basinwide monitoring program, 2003.[1] Ratable streams are only those in the Piedmont ecoregion.

Subbasin Waterbody	Location	County	Eco-region	d. a. (mi^2)	Date	No. Species	No. Fish	No. Sp. Darters	No. Sp. Sunfish	No. Sp. Suckers	No. Intol. Sp.	% Tolerant	% Omni. +Herb.	% Insect.	% Pisc.	% DELT	% MA
030601																	
Little Troublesome Cr	SR 2600	Rockingham	P	12.1	04/21/03	14	219	1	5	0	0	18	32	64	3.7	0.00	64
030602																	
Reedy Fork	SR 2728	Guilford	P	125	06/25/03	15	452	3	4	0	1	13	27	73	0.4	0.00	60
N Buffalo Cr	off 16th St and US 29	Guilford	P	22.1	04/22/03	11	244	1	3	2	0	68	26	74	0.0	0.00	64
N Buffalo Cr	SR 2770	Guilford	P	43.7	06/23/03	10	109	0	3	1	0	28	61	39	0.0	0.00	40
S Buffalo Cr	US 70	Guilford	P	39.5	06/23/03	7	293	1	3	0	0	95	3	97	0.0	0.00	43
Stony Cr	SR 1104	Caswell	P	12.4	04/21/03	14	121	1	4	2	0	22	25	74	0.8	0.00	36
Jordan Cr	SR 1754	Alamance	P	24.1	04/23/03	12	73	1	4	1	0	15	7	89	4.1	0.00	42
Haw Cr	SR 2158	Alamance	P	27.8	04/23/03	22	384	1	6	1	0	22	24	74	1.8	0.52	64
030603																	
Big Alamance Cr	SR 3088	Guilford	P	30.5	04/22/03	15	170	1	3	2	0	5	9	85	5.9	0.00	40
Little Alamance Cr	SR 3039	Guilford	P	10.1	04/22/03	13	216	1	4	1	0	31	29	71	0.0	0.00	69
N Pr Stinking Quarter Cr	SR 1113	Alamance	P	27.0	04/24/03	16	199	1	6	2	0	47	10	90	0.0	0.00	56
S Pr Stinking Quarter Cr	SR 1117	Alamance	P	33.6	04/24/03	20	442	2	4	1	1	26	19	81	0.2	0.23	50
Little Alamance Cr	SR 2309	Alamance	P	14.8	04/23/03	20	515	1	4	2	0	19	17	82	0.4	0.00	65
030604																	
Collins Cr	SR 1539	Chatham	P	19.4	05/02/03	8	56	0	2	1	0	59	16	84	0.0	0.00	38
Terrells Cr	NC 87	Chatham	P	20.9	04/24/03	16	176	3	4	1	1	12	18	80	1.7	0.00	50
Ferrells Cr	SR 1525	Chatham	P	15.7	05/02/03	14	310	1	5	1	0	10	15	84	1.0	1.29	79
Robeson Cr	off SR 1943	Chatham	P	24.5	05/05/03	19	763	2	4	3	1	16	38	62	0.3	0.00	63
030605																	
New Hope Cr	SR 2220	Durham	P	52.2	05/03/03	17	65	1	5	1	0	55	29	63	7.7	1.54	47
030607																	
Avents Cr	SR 1418	Harnett	P	14.2	06/06/03	15	300	1	3	1	0	17	45	50	5.0	0.00	73
Hector Cr	SR 1412	Harnett	P	17.4	06/06/03	20	191	2	4	3	1	13	32	64	3.7	0.52	65
Kenneth Cr	SR 1441	Harnett	P	15.2	06/06/03	15	244	1	3	1	0	20	22	74	4.5	0.00	47
030608																	
Bull Run Cr	SR 1144	Guilford	P	7.8	06/24/03	12	213	1	5	0	0	34	32	68	0.0	0.94	58
Richland Cr	SR 1154	Guilford	P	12.5	04/22/03	9	410	0	3	1	0	67	16	84	0.0	0.00	56
Hickory Cr	SR 1140	Guilford	P	20.1	06/23/03	14	178	1	5	2	0	17	49	47	3.4	0.00	64
Muddy Cr	SR 1929	Randolph	P	16.8	06/24/03	20	240	1	5	2	0	31	20	79	1.3	0.00	45
030609																	
Polecat Cr	SR 2114	Randolph	P	29.1	06/24/03	16	168	1	2	3	0	23	18	76	6.0	0.00	38
Sandy Cr	SR 2481	Randolph	P	45.1	06/24/03	15	179	2	6	2	1	16	38	55	6.7	0.00	53
Brush Cr	SR 1102	Chatham	P	19.1	06/26/03	16	434	1	4	1	0	21	27	71	1.4	0.23	63
Fork Cr	SR 1003	Randolph	P	31.2	06/26/03	23	437	3	2	1	1	20	28	72	0.2	0.00	52

Appendix 10 (continued).

Subbasin Waterbody	Location	County	Eco-region	d. a. (mi^2)	Date	No. Species	No. Fish	No. Sp. Darters	No. Sp. Sunfish	No. Sp. Suckers	No. Intol. Sp.	% Tolerant	% Omni. +Herb.	% Insect.	% Pisc.	% DELT	% MA
030610																	
Bear Cr	SR 1405	Moore	P	25.2	06/27/03	20	345	2	4	1	1	7	9	90	0.3	0.00	45
Cabin Cr	SR 1275	Moore	P	46.9	06/27/03	18	270	1	4	1	0	4	5	93	2.6	0.00	39
Buffalo Cr	NC 22	Moore	P	21.4	06/26/03	21	727	2	3	2	2	7	9	90	0.6	0.28	57
Indian Cr	SR 2306	Chatham	P	25.4	06/13/03	15	110	0	6	0	0	36	10	82	8.2	0.00	33
030611																	
Big Buffalo Cr	SR 1403	Lee	P	19.7	06/16/03	14	76	1	3	0	1	49	7	88	5.3	0.00	29
030612																	
Rocky R	SR 1300	Chatham	P	7.4	05/06/03	15	222	1	6	1	0	15	48	51	0.5	0.00	40
Loves Cr	SR 2229	Chatham	P	7.9	05/05/03	21	507	1	6	1	0	55	15	84	0.2	0.00	62
Tick Cr	US 421	Chatham	P	15.5	06/13/03	15	206	1	5	1	0	33	6	93	0.5	0.00	53
Bear Cr	SR 2187	Chatham	P	42.4	06/13/03	13	61	3	3	1	1	46	15	80	4.9	0.00	31

[1]Abbreviations are d. a. = drainage area, No. = number, Sp. = species, Intol. = intolerants, Omni. + Herb. = omnivores+herbivores, Insect. = insectivores, Pisc. = piscivores, DELT = disease, erosion, lesions, and tumors, and MA = species with multiple age groups.

Appendix 11. Fish community metric values from 17 wadeable streams in the Sand Hills and Coastal Plain region of the Cape Fear River basinwide monitoring program, 2003.[1] Ratable streams are only those in the Piedmont ecoregion.

Subbasin Waterbody	Location	County	Eco-region	d. a. (mi^2)	Date	No. Species	No. Fish	No. Sp. Darters	No. Sp. Sunfish	No. Sp. Suckers	No. Intol. Sp.	% Tolerant	% Omni. +Herb.	% Insect.	% Pisc.	% DELT	% MA
030607																	
Buies Cr	off SR 1519	Harnett	CA	7.6	06/06/03	6	26	0	3	0	0	31	0	38	61.5	0.00	33
030610																	
Wet Cr	NC 24/ 27	Moore	SH	15.9	06/27/03	11	94	1	1	1	0	9	28	67	5.3	0.00	45
030614																	
Little R	NC 22	Moore	SH	27.3	09/15/03	13	121	3	4	0	2	3	0	95	5.0	0.00	46
Nicks Cr	NC 22	Moore	SH	26.8	09/15/03	15	36	3	5	1	2	14	0	86	13.9	0.00	27
James Cr	off SR 2026	Moore	SH	12.8	09/16/03	7	20	1	1	1	1	0	5	70	25.0	0.00	29
Flat Cr	Manchester Rd	Hoke	SH	7.6	09/16/03	12	73	1	2	0	1	11	1	89	9.6	2.74	42
Buffalo Cr	SR 1001	Moore	SH	18.3	09/15/03	7	14	1	2	1	1	0	7	57	35.7	0.00	14
Jumping Run	NC 210	Cumberland	SH	29.0	10/02/03	11	51	1	3	2	0	37	2	76	21.6	0.00	36
Muddy Cr	SR 1001	Cumberland	SH	16.1	09/16/03	14	38	1	4	1	1	26	3	87	10.5	0.00	14
Anderson Cr	SR 2031	Harnett	SH	34.7	10/02/03	14	69	3	2	2	2	20	1	77	21.7	0.00	43
030615																	
Cross Cr	NC 87/210/24	Cumberland	SH	15.4	10/20/03	10	118	1	4	0	0	55	1	71	28.0	0.00	60
Gum Log Canal	SR 1728	Cumberland	SH	30.8	10/02/03	22	304	2	6	2	1	33	12	79	8.6	0.33	55
Juniper Cr	Plank Rd	Hoke	SH	11.3	10/21/03	10	49	2	3	0	1	6	2	92	6.1	0.00	30
Nicholson Cr	SR 1301	Hoke	SH	16.2	10/20/03	10	30	2	3	0	1	7	7	83	10.0	0.00	20
Puppy Cr	SR 1406	Hoke	SH	26.0	10/21/03	11	24	1	3	1	0	13	4	71	25.0	8.33	45
L Rockfish Cr	Plank Rd	Hoke	SH	11.2	10/20/03	9	29	1	2	1	1	7	14	72	13.8	0.00	22
Bones Cr	SR 1400	Cumberland	SH	12.2	10/20/03	13	49	2	7	0	1	6	4	92	4.1	0.00	31

[1]Abbreviations are d. a. = drainage area, No. = number, Sp. = species, Intol. = intolerants, Omni. + Herb. = omnivores+herbivores, Insect. = insectivores, Pisc. = piscivores, DELT = disease, erosion, lesions, and tumors, and MA = species with multiple age groups.

Appendix 12. Fish distributional records for the Cape Fear River basin.

Based upon Menhinick (1991), NC DWQ's data, and data from other researchers, 104 species of predominantly freshwater fish have been collected from the Cape Fear River basin in North Carolina (Table 5 in Appendix 8). At least 17 of these species (16 percent of the total fauna) are exotics that were introduced either as sportfish, baitfish, or for reasons unknown, into waters of the basin. The known species assemblage includes 30 species of minnows, 10 species of suckers, 18 species of sunfish and bass, and 6 species of darters.

Eight of these species have been given special protection status by the U. S. Department of the Interior, the NC Wildlife Resources Commission, or the NC Natural Heritage Program under the NC State Endangered Species Act (G.S. 113-331 to 113-337) (LeGrand *et al*. 2001; Menhinick and Braswell 1997) (Table 1).

In 2003, as part of the NC DWQ's fish community monitoring program, the Carolina darter was collected from Jordan Creek, Terrells Creek, and Bear Creek (Chatham County); the sandhills chub was collected from Flat Creek, and the Cape Fear shiner was collected from Buffalo Creek (NC 22, Moore County).

As in 1998, the most commonly collected species in 2003 in the Piedmont was the redbreast sunfish (collected at all 38 sites); the most abundant species were the bluehead chub and the redbreast sunfish (~30 percent of all the fish collected were of these two species). In the Sand Hills, the most commonly collected species were the American eel, pirate perch, tessellated darter, redbreast sunfish, dusky shiner, and bluegill.

Table 1. Species of freshwater fish listed as endangered, rare, threatened, special concern, or significantly rare in the Cape Fear River Basin in North Carolina.

Species	Common Name	State or Federal Status	State Rank[1]
Acipenser brevirostrum	Shortnose sturgeon	Federal-Endangered	S1
Acipenser oxyrhynchus	Atlantic sturgeon	State-Special Concern	S3
Carpiodes velifer	Highfin carpsucker	State-Special Concern	S2
Cyprinella zanema	Thinlip chub	State-Special Concern	S2
Notropis mekistocholas	Cape Fear shiner	Federal-Endangered	S1
Semotilus lumbee	Sandhills chub	State-Special Concern	S3
Noturus sp. cf leptacanthus	Broadtail madtom	State-Special Concern	S2
Etheostoma collis	Carolina darter	State-Special Concern	S3

[1]S1 = 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 *et al*. 2001).

Appendix 13. Water quality at fish community sites in the Cape Fear River basin, 2003.

In 2003 water quality data were collected at every site during fish community assessments (Appendix 14). Conductivity ranged from 11 to 254 µmhos/cm at Little Rockfish Creek and North Buffalo Creek at SR 2770, respectively. Measurements were the greatest below wastewater treatment facilities or in streams draining urban areas. Conductivity was the lowest in Sand Hills streams and streams draining least impacted watersheds. Dissolved oxygen saturation ranged from 58 percent at Kenneth Creek and Bear Creek (at SR 2187, Chatham County) to 114 percent at Terrells Creek. The pH ranged from 4.4 to 7.5 s.u. at Muddy Creek (Cumberland County) and Terrells Creek, respectively.

Conductivity measurements at sites below wastewater treatment plants showed the greatest decreases between 2003 and 1998/1999. For example, 25 – 75 percent decreases were noted at North Buffalo Creek (both sites) and at Little Troublesome Creek (Figure 1). Increases (greater than 30 percent) were noted in Bear Creek at SR 2187 (which is below three small NPDES permitted dischargers and what appeared to be a grey water discharge in an unnamed tributary at the end of the sampling reach) and Little Alamance Creek at SR 3039 which drains a triangular area south and east of I-85, US 421, and NC 22 in Guilford County.

Since 1993, 122 fish community samples have been collected from the Piedmont portion of the basin; 114 of these samples have associated conductivity measurements. [One data point – Cabin Creek at SR 1275, Moore County, June 14, 1999 was not included in this data set because of the atypical, low-flow related measurement.] This data set showed that median conductivity was not substantially different among the NCIBI ratings, except for sites rated Poor (Figure 2).

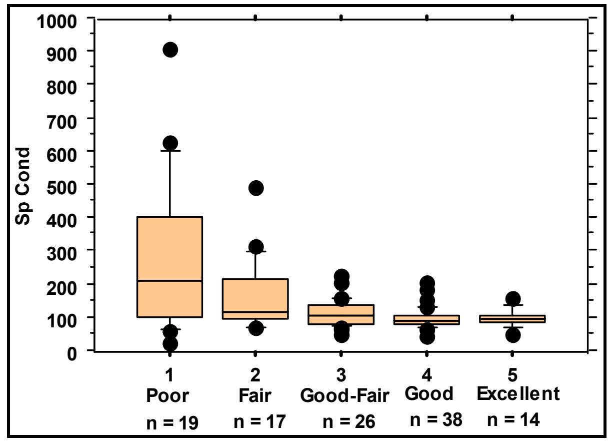


Figure 2. Relationships between conductivity (µmhos/cm) and NCIBI ratings in the Cape Fear River basin, 1993 - 2003.

Median measurements for Excellent, Good, Good-Fair, Fair, and Poor sites were 98, 92, 109, 118, and 212 µmhos/cm, respectively. However, the standard deviation progressively decreased from Poor to Excellent sites. The range in conductivities at sites rated Good or Excellent was much smaller than the range at sites rated Poor or Fair. Poorly rated sites with elevated conductivity were usually below large wastewater treatment plants.

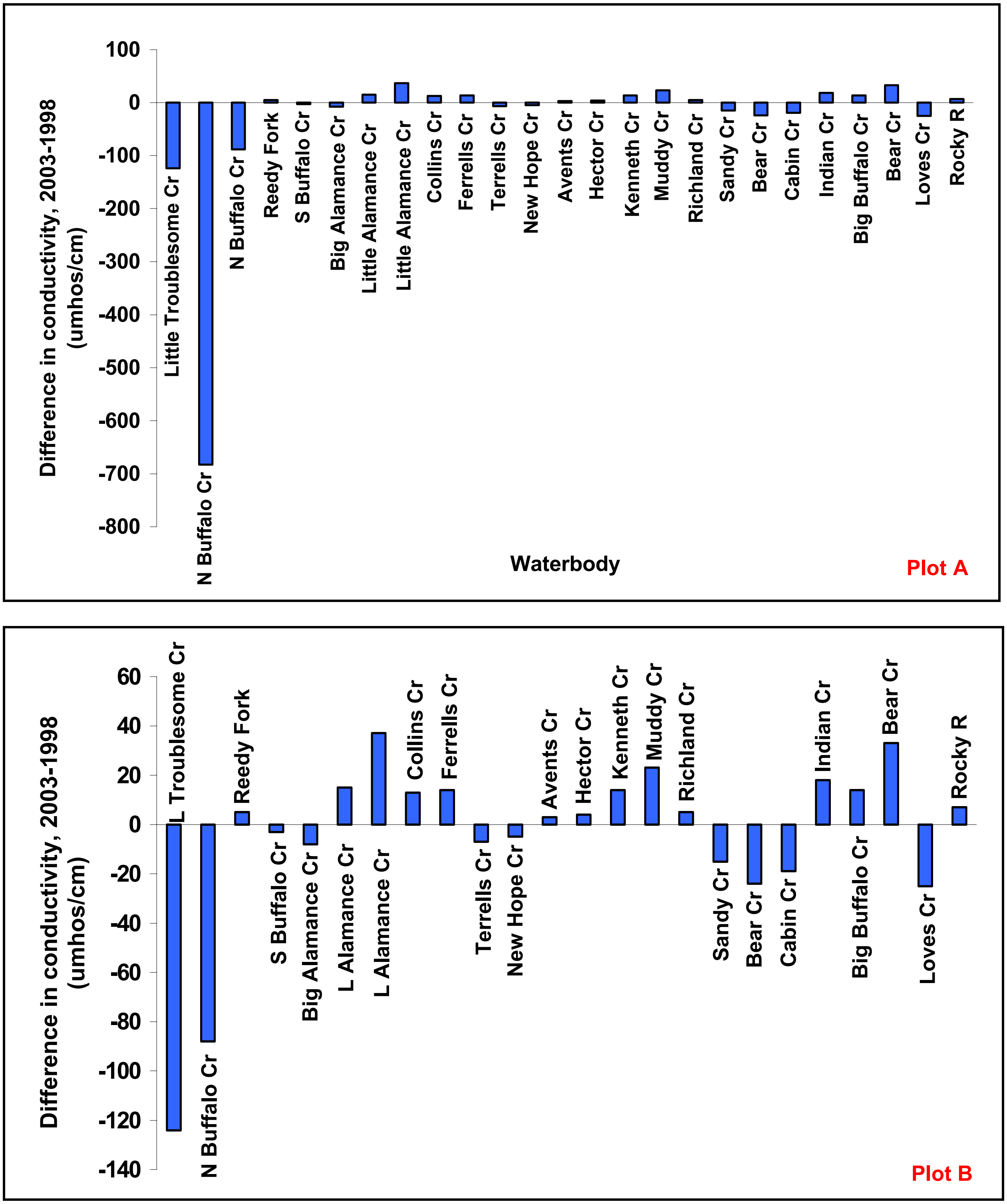


Figure 1. A comparison of the conductivity at 24 fish community sites in the Piedmont region of the Cape Fear River basin, 1998 *vs.* 2003. A positive difference meant that conductivity was greater in 2003 than in 1998; a negative difference meant that conductivity was greater in 1998 than in 2003. Plot B is the same as Plot A except for excluding the datum from North Buffalo Creek off 16th Street and US 29, Guilford County.

Appendix 14. Water quality measurements at 55 fish community sites in the Cape Fear River basin, 2003.

Subbasin/ Waterbody	Location	County	Date	Temperature (˚C)	Specific conductance (µmhos/cm)	Dissolved oxygen (mg/L)	Saturation (%)	pH (s.u.)
030601								
Little Troublesome Cr	SR 2600	Rockingham	04/21/03	14.0	112	7.6	73.8	6.8
030602								
Reedy Fork	SR 2728	Guilford	06/25/03	21.3	85	6.8	76.7	6.9
N Buffalo Cr	off 16th St and US 29	Guilford	04/22/03	16.0	228	6.8	68.9	7.1
N Buffalo Cr	SR 2770	Guilford	06/23/03	20.1	254	8.2	90.4	7.3
S Buffalo Cr	US 70	Guilford	06/23/03	19.3	197	6.9	74.9	7.1
Stony Cr	SR 1104	Caswell	04/21/03	14.0	84	8.5	82.5	7.3
Jordan Cr	SR 1754	Alamance	04/23/03	12.7	82	7.7	72.6	6.6
Haw Cr	SR 2158	Alamance	04/23/03	15.0	86	6.6	65.5	7.1
030603								
Big Alamance Cr	SR 3088	Guilford	04/22/03	15.5	91	6.4	64.2	7.1
Little Alamance Cr	SR 3039	Guilford	04/22/03	16.2	160	6.8	69.2	7.3
N Pr Stinking Quarter Cr	SR 1113	Alamance	04/24/03	13.2	86	7.4	70.6	6.7
S Pr Stinking Quarter Cr	SR 1117	Alamance	04/24/03	14.1	84	9.5	92.4	6.5
Little Alamance Cr	SR 2309	Alamance	04/23/03	14.0	186	7.0	67.9	7.3
030604								
Collins Cr	SR 1539	Chatham	05/02/03	17.7	84	7.0	73.5	6.6
Terrells Cr	NC 87	Chatham	04/24/03	14.5	73	11.6	113.8	7.5
Ferrells Cr	SR 1525	Chatham	05/02/03	17.7	97	5.8	60.9	6.7
Robeson Cr	off SR 1943	Chatham	05/05/03	15.5	119	7.4	74.2	7.0
030605								
New Hope Cr	SR 2220	Durham	05/03/03	20.2	111	6.5	71.8	7.1
030607								
Avents Cr	SR 1418	Harnett	06/06/03	17.0	50	6.3	65.2	7.2
Hector Cr	SR 1412	Harnett	06/06/03	17.5	52	5.7	59.6	7.2
Kenneth Cr	SR 1441	Harnett	06/06/03	18.8	97	5.4	58.0	6.4
Buies Cr	off SR 1519	Harnett	06/06/03	22.0	66	5.4	61.8	6.3
030608								
Bull Run Cr	SR 1144	Guilford	06/24/03	22.1	137	5.8	66.5	7.3
Richland Cr	SR 1154	Guilford	04/22/03	17.5	163	7.4	77.4	7.4
Hickory Cr	SR 1140	Guilford	06/23/03	18.8	107	8.4	90.2	7.3
Muddy Cr	SR 1929	Randolph	06/24/03	19.6	123	6.5	70.9	6.9
030609								
Polecat Cr	SR 2114	Randolph	06/24/03	20.1	109	6.0	66.1	7.1
Sandy Cr	SR 2481	Randolph	06/24/03	19.5	79	9.0	98.0	6.6
Brush Cr	SR 1102	Chatham	06/26/03	21.0	103	6.7	75.2	6.5
Fork Cr	SR 1003	Randolph	06/26/03	21.0	89	8.0	89.8	7.1
030610								
Bear Cr	SR 1405	Moore	06/27/03	21.0	84	7.6	85.3	6.8
Cabin Cr	SR 1275	Moore	06/27/03	21.6	75	7.9	89.7	7.3
Wet Cr	NC 24/ 27	Moore	06/27/03	21.3	37	8.3	93.7	6.6
Buffalo Cr	NC 22	Moore	06/26/03	23.0	83	7.5	87.5	7.3
Indian Cr	SR 2306	Chatham	06/13/03	23.0	109	6.0	70.0	7.1
030611								
Big Buffalo Cr	SR 1403	Lee	06/16/03	22.5	100	6.0	69.3	6.1
030612								
Rocky R	SR 1300	Chatham	05/06/03	15.4	88	7.0	70.0	6.8
Loves Cr	SR 2229	Chatham	05/05/03	15.4	107	7.8	78.0	7.2
Tick Cr	US 421	Chatham	06/13/03	21.5	121	7.8	88.4	6.6
Bear Cr	SR 2187	Chatham	06/13/03	22.7	124	5.0	58.0	6.8

Appendix 14 (continued).

Subbasin/ Waterbody	Location	County	Date	Temperature (˚C)	Specific conductance (µmhos/cm)	Dissolved oxygen (mg/L)	Saturation (%)	pH (s.u.)
030614								
Little R	NC 22	Moore	09/15/03	21.1	65	6.5	73.1	6.2
Nicks Cr	NC 22	Moore	09/15/03	22.0	24	5.3	60.6	4.7
James Cr	off SR 2026	Moore	09/16/03	21.0	26	6.3	70.7	5.6
Flat Cr	Manchester Road	Hoke	09/16/03	21.0	15	7.6	85.3	4.8
Buffalo Cr	SR 1001	Moore	09/15/03	21.0	26	7.0	78.5	4.9
Jumping Run	NC 210	Cumberland	10/02/03	17.0	30	7.6	78.7	5.2
Muddy Cr	SR 1001	Cumberland	09/16/03	23.0	22	7.0	81.6	4.4
Anderson Cr	SR 2031	Harnett	10/02/03	16.1	49	7.8	79.2	5.0
030615								
Cross Cr	NC 87/210/24	Cumberland	10/20/03	18.0	54	9.1	96.2	7.3
Gum Log Canal	SR 1728	Cumberland	10/02/03	16.9	75	9.4	97.1	6.3
Juniper Cr	Plank Road	Hoke	10/21/03	16.0	13	8.7	88.2	4.8
Nicholson Cr	SR 1301	Hoke	10/20/03	17.4	14	8.2	85.6	5.6
Puppy Cr	SR 1406	Hoke	10/21/03	16.0	17	9.0	91.2	5.4
L Rockfish Cr	Plank Road	Hoke	10/20/03	14.0	11	8.6	83.5	5.7
Bones Cr	SR 1400	Cumberland	10/20/03	14.1	14	8.4	81.7	5.8

Appendix 15 Fish tissue criteria.

In evaluating fish tissue analysis results, several criteria are used. Human health concerns related to fish consumption are screened by comparing results with federal Food and Drug Administration (FDA) action levels (USFDA 1980), Environmental Protection Agency (EPA) recommended screening values, and criteria adopted by the state Health Director (Table 1). Results which seem to be of potential human health concern are evaluated by the N.C. Division of Occupational and Environmental Epidemiology by request from the DWQ.

The FDA levels were developed to protect people from the chronic effects of toxic substances consumed in foodstuffs and thus employ a "safe level" approach to fish consumption. Presently, the FDA has developed metals criteria only for mercury.

The EPA has recommended screening values for target analytes formulated from a risk assessment procedure (USEPA 1995). These are the concentrations of analytes in edible fish tissue that are of potential public health concern. The DWQ compares fish tissue results with EPA screening values to evaluate the need for further intensive site specific monitoring.

The North Carolina State Health Director has adopted a selenium limit of 5 µg/g and a mercury limit of 0.4 µg/g for issuing an advisory. Although the EPA has suggested a screening value of 0.7 ppt (pg/g) for dioxins, the North Carolina currently uses a value of 4.0 ppt in issuing an advisory.

Table 1. Fish tissue criteria. All wet weight concentrations are reported in parts per million (ppm, µg/g)

Contaminant	FDA Action Levels	US EPA Screening Values Recreational Fishermen	US EPA Screening Values Subsistence Fishermen	NC Health Director
Metals				
Arsenic (Inorganic)		0.026	0.00327	
Cadmium		4.0	0.491	
Mercury	1.0	0.4	0.049	0.4
Selenium		20	2.457	5.0
Tributyltin		1.2	0.147	
Organics				
Aldrin	0.3			
Chlorpyrifos		1.2	0.147	
Total chlordane		0.114	0.014	
Cis-chlordane	0.3			
Trans-chlordane	0.3			
Total DDT[1]		0.117	0.0144	
o, p DDD	5.0			
p, p DDD	5.0			
o, p DDE	5.0			
p, p DDE	5.0			
o, p DDT	5.0			
p, p DDT	5.0			
Diazinon		2.8	0.344	
Dicofol		1.6	0.196	
Dieldrin		0.0025	3.07×10^{-4}	
Dioxins (total)		2.56×10^{-7}	3.15×10^{-8}	4.0 (ppt)
Disulfoton		0.16	0.019	
Endosulfan (I and II)		24	2.949	
Endrin	0.3	1.2	0.147	
Ethion		2.0	0.245	
Heptachlorepoxide		0.00439	5.40×10^{-4}	
Hexachlorobenzene		0.025	0.00307	
Lindane		0.0307	0.00378	
Mirex		0.8	0.098	
Oxyfluorfen		0.546	0.0671	
Total PCBs		0.02	0.00245	
PCB-1254	2.0			
Terbufos		0.08	0.009	
Toxaphene		0.0363	0.00446	

[1] Total DDT includes the sum of all its isomers and metabolites (i.e. p, p DDT, o, p DDT, DDE, and DDD).
[2] Total chlordane includes the sum of cis-and trans- isomers as well as nonachlor and oxychlordane.

Appendix 16. Wet weight concentrations of mercury (Hg), arsenic (As), total chromium (Crt), cadmium (Cd), copper (Cu), nickel (Ni), lead (Pb) and zinc (Zn) in fish tissue from the Cape Fear River basin, 1999 - 2003.[1]

Subbasin/Location/Species	Date	Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Crt (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
030616										
Cape Fear River at Elizabethtown										
Amia calva	06/08/00	42.5	588	0.53	ND	ND	0.33	0.16	ND	4.2
Ictalurus furcatus	06/08/00	60.0	2538	0.26	ND	0.15	0.19	ND	ND	2.9
		53.2	2215	0.19	ND	0.17	0.54	0.99	1.2	27
		51.5	1556	0.2	ND	0.18	0.14	ND	ND	3.5
Lepomis macrochirus	06/08/00	18.9	142.6	0.1	ND	ND	0.24	ND	0.39	8.4
		19.6	142.6	0.15	ND	0.12	0.38	0.18	ND	9
		17.0	101.3	0.11	ND	ND	0.28	ND	ND	5
Lepomis microlophus	06/08/00	28.4	165	0.18	0.1	ND	0.51	ND	ND	8.1
Micropterus punctulatus	06/08/00	26.2	218	0.35	ND	0.1	0.33	0.24	ND	5.9
Micropterus salmoides	06/08/00	29.0	361	0.19	ND	0.19	0.32	ND	ND	4.6
		38.0	673	0.54	ND	ND	0.2	ND	ND	3.4
030617										
Cape Fear River at Riegelwood										
Amia calva	06/07/00	60.0	2233	1.8	0.22	0.17	0.18	ND	ND	4.1
		56.5	2104	1.4	0.29	0.18	0.16	ND	ND	4.4
	05/08/01	59.0	2194	1.3	0.27	0.17	0.23	ND	ND	4.9
		42.6	679	0.81	0.18	0.17	0.27	ND	ND	4.9
Cyprinus carpio	06/07/00	55.0	2679	0.43	0.12	0.23	0.62	ND	ND	15
Ictalurus furcatus	05/08/01	64.5	3460	0.35	1.4	0.17	0.29	ND	ND	3.1
Lepomis macrochirus	06/07/00	20.7	213.3	0.43	ND	0.18	0.29	ND	ND	6.9
		18.1	136.2	0.37	ND	0.18	0.98	ND	ND	7.3
		25.5	341	0.31	0.14	0.21	0.27	0.23	ND	5.7
	05/08/01	15.2	72	0.24	ND	0.19	0.2	0.1	ND	8.9
		14.9	68	0.22	ND	0.16	0.2	ND	ND	8.2
		15.3	79.6	0.16	ND	0.12	0.22	ND	ND	8
	09/12/02	15.8	82.2	0.06	ND	ND	0.17	ND	ND	4.9
		16.1	78.2	0.14	ND	ND	0.16	0.1	ND	6.4
Micropterus salmoides	06/07/00	27.5	311	0.54	ND	0.16	0.33	0.51	ND	4.4
		48.1	1577	1.5	ND	0.18	0.19	ND	ND	2.7
		43.0	1284	1.3	ND	0.19	0.16	ND	ND	3.1
	05/08/01	25.9	222	0.39	0.22	ND	0.32	ND	ND	7
		28.5	326	0.17	0.11	0.17	0.29	ND	ND	5
		34.2	626	0.38	0.14	ND	0.28	ND	ND	4.2
		37.0	621	0.82	0.11	0.19	0.24	ND	ND	5.5
		25.8	251	0.36	0.24	ND	0.29	ND	ND	7.2
		40.8	895	0.55	ND	0.18	0.21	ND	ND	3.9
		24.2	209	0.49	0.12	ND	0.33	ND	ND	7.2
		31.8	515	0.33	0.14	0.17	0.26	ND	ND	9.5
		27.9	286	0.61	ND	0.18	0.3	ND	ND	6
	09/12/02	31.7	460	0.15	ND	ND	0.14	ND	ND	2.5
		37.8	850	0.18		ND	0.17	ND	ND	4.1
		32.3	534	0.19		ND	0.13	ND	ND	2.7
		31.5	465	0.21		ND	0.11	ND	ND	2.4
		39.1	369	0.01	ND	ND	0.11	ND	ND	2.5
		28.6	328	0.14	ND	ND	0.14	ND	ND	2.9
		27.8	266	0.07	ND	ND	0.11	ND	ND	3.6
		27.1	252	0.23	ND	ND	0.46	0.15	ND	4.4
		24.7	214	0.04	ND	ND	0.37	ND	ND	4
		52.1	1300	0.15	0.11	ND	ND	ND	ND	2.9
		47.0	924	0.18	ND	ND	0.12	ND	ND	2.5
		31.5	275	0.09	ND	ND	0.27	ND	ND	2.6
		34.6	585	0.23	ND	ND	0.14	ND	ND	2.7
Pylodictis olivaris	06/07/00	54.0	1821	0.52	ND	0.16	0.15	ND	ND	3.2

Appendix 16 (continued).

Subbasin/Location/Species	Date	Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Crt (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
Town Creek near NC 17										
Amia calva	05/03/01	51.0	1377	0.57	0.23	ND	0.12	ND	ND	3
		46.9	1012	0.59	0.14	ND	0.16	ND	ND	3.5
	09/12/02	56.7	1612	3	0.36	ND	0.14	ND	ND	2.2
		53.2	1267	1.6	0.28	ND	0.15	ND	ND	2.1
		40.8	662	0.73	0.2	ND	0.12	ND	ND	2
		42.0	658	0.71	0.14	ND	ND	ND	ND	2.3
Erimyzon oblongus	05/03/01	29.0	371.5	0.14	ND	ND	0.17	ND	ND	5.8
Esox niger	05/03/01	35.3	283	0.63	ND	ND	ND	ND	ND	4.9
		35.9	279	0.51	ND	0.27	0.76	ND	ND	6.7
		37.1	325	0.57	ND	0.1	ND	ND	ND	4.7
		38.3	430	0.57	ND	0.12	ND	ND	ND	5
Lepomis gulosus	05/03/01	19.8	158.5	0.43	ND	0.28	0.33	0.39	ND	8.9
Lepomis microlophus	05/03/01	20.8	177	0.29	ND	0.15	0.12	ND	ND	8.8
Lepomis microlophus	05/03/01	20.9	160	0.51	ND	0.14	ND	ND	ND	4.4
Micropterus salmoides	05/03/01	32.5	420	0.68	ND	0.54	0.19	0.33	0.1	3.2
		34.4	572	1	ND	0.18	0.22	ND	ND	3.7
		45.2	1419	1.4	ND	0.15	0.14	ND	ND	4
		34.2	561	0.74	ND	0.12	0.18	ND	ND	3.8
		34.2	526	0.78	ND	ND	0.18	ND	ND	3.3
		34.7	578	0.92	ND	0.12	0.18	ND	ND	3.8
Micropterus salmoides	09/12/02	29.6	284	0.74	ND	ND	0.19	ND	ND	4.2
		28.8	328	0.97	ND	ND	0.26	0.45	ND	4.8
		30.5	353	1	ND	ND	0.26	ND	ND	5.9
		29.6	338	0.97	ND	ND	ND	ND	ND	2.4
		28.4	290	1.2	ND	ND	0.25	0.14	ND	4.6
030618										
South River at NC 701										
Amia calva	08/10/99	46.3	760	1.8	ND					
		57.0	1723	2.7	ND					
		47.3	926	2.2	ND					
		45.6	857	2	ND					
		46.3	748	0.93	ND					
	05/15/03	40.0	642	0.84						
		56.0	1569	2.3						
Esox niger	08/10/99	49.8	735	1.7	ND					
		48.5	798	1.8	ND					
	05/15/03	29.0	186	0.34						
		31.0	193	0.36						
Lepomis auritus	05/15/03	18.6	153	0.37						
		15.4	97.5	0.3						
		20.0	201	0.4						
		20.1	249	0.34						
Lepomis gulosus	08/10/99	14.6	72.5	0.46	ND					
Lepomis macrochirus	08/10/99	24.2	388	0.41	ND					
		22.0	274	0.55	ND					
Micropterus salmoides	08/10/99	37.0	762	1.5	ND					
		31.0	424	1.6	ND					
		27.0	274	0.89	ND					
		26.3	235	1.4	ND					
		49.5	1565	2.1	ND					
	05/15/03	26.5	283	0.75						
Minytrema melanops	08/10/99	36.5	547	0.63	ND					
		34.8	454	0.59	ND					
		42.8	829	0.73	ND					
		37.6	610	0.65	ND					
		45.5	769	0.9	ND					
	05/15/03	42.0	816	0.86						
		42.0	856	0.76						
		41.0	845	0.79						

Appendix 16 (continued).

Subbasin/Location/Species	Date	Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Crt (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
Perca flavescens	08/10/99	25.3	191	0.95	ND					
	05/15/03	26.5	269	0.59						
		21.2	130	0.5						
Pylodictis olivaris	08/10/99	40.0	660	2.3	ND					
		48.5	1528	1.3	ND					
		33.5	388	0.95	ND					
Minytrema melanops	05/15/03	40.0	724	0.95						
		35.0	560	0.29						
030619										
Black R. near Ivanhoe										
Amia calva	06/28/00	50.0	1162	0.94	0.36	0.13	ND	ND	ND	5.2
Esox niger	06/28/00	36.0	307	0.65	ND	0.11	0.12	ND	ND	6.8
		32.7	214	0.64	ND	0.13	0.1	ND	ND	5.2
		37.0	384	0.75	ND	0.11	0.13	ND	ND	16
		40.0	436	0.52	ND	0.16	0.15	ND	ND	6.9
Lepomis macrochirus	06/28/00	21.5	271	0.33	ND	0.19	0.26	ND	ND	6.9
		22.0	292	0.49	ND	0.13	0.53	ND	ND	9.4
		23.5	363	0.48	ND	0.16	0.3	ND	ND	8.1
		23.0	339	0.42	ND	0.23	0.34	0.12	ND	7.2
		23.0	352	0.4	ND	0.16	0.4	ND	ND	10
Lepomis microlophus	06/28/00	25.0	345	0.43	ND	0.18	0.35	0.12	ND	8.2
		24.0	286.5	0.34	ND	0.73	0.29	0.37	ND	7.7
		25.2	347	0.48	ND	0.11	0.3	ND	ND	8.4
		26.5	403	0.29	ND	0.17	0.31	ND	ND	5.3
		28.0	508	0.56	ND	0.13	0.28	0.11	ND	11
		27.0	444	0.51	ND	0.16	0.25	0.12	ND	6
Micropterus salmoides	06/28/00	31.0	381	0.81	ND	ND	ND	ND	ND	4.9
		35.6	653	0.99	ND	0.12	ND	ND	ND	3.4
		30.6	254	0.76	ND	0.13	ND	ND	ND	5.4
		31.7	480	0.72	ND	0.13	ND	ND	ND	6.5
		31.5	435	0.74	ND	0.13	ND	ND	ND	4.3
		32.0	454	0.85	ND	0.14	ND	ND	ND	5.6
		33.5	553	0.85	ND	ND	ND	ND	ND	4
		33.2	617	1.6	ND	0.14	ND	ND	ND	3.5
		35.0	615	1.3	ND	0.13	ND	ND	ND	3.6
		36.2	742	1.5	ND	0.12	ND	ND	ND	3.8
		27.2	310.5	0.63	ND	0.13	ND	ND	ND	4.1
		39.2	818	1.4	ND	0.12	0.15	ND	ND	4.6
		39.2	818	1.4	ND	ND	0.16	ND	ND	3.6
		35.2	659	0.77	ND	0.13	ND	ND	ND	4
Minytrema melanops	06/28/00	38.0	874	0.49	ND	0.1	0.21	ND	ND	4.8
		42.8	940	0.43	ND	0.16	0.22	ND	ND	8.2
		43.1	979	0.61	ND	0.23	0.22	ND	ND	7.8
Perca flavescens	06/28/00	23.0	150	0.53	ND	0.15	ND	ND	ND	5.2
		25.0	212	0.46	ND	0.12	0.24	ND	ND	8.8
		36.2	246	0.47	ND	0.13	0.31	0.1	ND	8.2
		30.8	395	0.82	ND	ND	0.21	0.11	ND	6.5
		31.8	470	0.89	ND	0.12	0.11	0.39	ND	6.5
		20.5	107	0.46	ND	0.15	0.2	ND	ND	8.5
		18.0	66	0.42	ND	0.13	0.33	ND	ND	7.2
		21.0	119	0.5	ND	0.11	0.25	ND	ND	8.1
		16.1	50.5	0.41	ND	0.12	0.25	ND	ND	6.3
Black River at NC 41										
Amia calva	05/15/03	37.0	352	0.23						
		43.2	816	0.72						
Ictalurus punctatus	05/15/03	35.9	456	0.14						
Lepomis macrochirus	05/15/03	16.2	100	0.09						
		15.1	84	0.26						
		14.3	68	0.09						

Appendix 16 (continued).

Subbasin/Location/Species	Date	Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Crt (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
Micropterus salmoides	05/15/03	16.4	61.3	0.23						
		20.0	97	0.32						
		26.2	248	0.43						
Minytrema melanops	05/15/03	44.1	1060	0.42						
		43.2	1033	0.2						
		46.0	1190	0.36						
		45.0	1003	0.32						
		46.1	1072	0.54						
Pomoxis nigromaculatus	05/15/03	25.0	213	0.26						
Great Coharie Creek at NC 701										
Amia calva	06/28/00	42.5	788	0.63	0.15	0.21	0.16	ND	ND	2.7
		49.2	1234	1.5	0.29	0.17	0.18	ND	ND	4.3
		51.5	1582	1.5	ND	0.16	0.18	ND	ND	4.1
		38.0	515	0.56	0.21	0.17	0.22	ND	ND	3.5
Esox niger	06/28/00	28.5	163	0.5	ND	0.22	0.24	ND	ND	6.9
Lepomis auritus	06/28/00	15.7	90	0.28	ND	0.17	0.21	ND	0.11	7.4
		18.1	149.5	0.38	ND	0.17	0.2	ND	ND	5.4
Lepomis macrochirus	06/28/00	14.1	63.5	0.3	ND	0.16	0.2	0.1	ND	8.5
Micropterus salmoides	06/28/00	27.8	351	0.69	ND	0.17	0.21	ND	ND	3.7
		34.8	670	0.97	ND	0.15	0.28	ND	ND	3.8
		42.0	1227	1.7	ND	0.14	0.18	ND	ND	3.8
		42.0	1227	1.8	ND	0.17	0.21	ND	ND	5.4
Minytrema melanops	06/28/00	36.8	1221	0.71	ND	0.16	0.21	ND	0.11	7.8
		39.5	841	0.55	ND	0.14	0.19	ND	ND	7.4
		37.2	656	0.34	ND	0.2	0.19	ND	0.52	9.2
Perca flavescens	06/28/00	25.2	197	1.2	ND	0.22	0.28	0.15	ND	6.5
		23.8	152	0.52	ND	0.23	0.16	ND	ND	4.5
030620										
Black River near Longview										
Amia calva	08/10/99	53.2	1362	1.3	ND					
		45.5	99	1.3	ND					
		47.5	149	1.5	ND					
		51.5	1249	0.6	ND					
		49.0	1120	1.7	ND					
Esox niger	05/03/01	38.6	338	0.64	ND	ND	0.11	ND	ND	5.8
		43.0	657	0.65	ND	ND	0.13	ND	ND	5.8
Ictalurus furcatus	05/03/01	59.0	2513	0.19	ND	ND	0.22	ND	ND	4.5
Ictalurus punctatus	05/03/01	35.1	368	0.26	ND	ND	0.18	ND	ND	3.6
		47.3	1153	0.26	ND	ND	0.27	ND	ND	5.2
Lepomis microlophus	08/10/99	24.1	267	0.33	ND					
		20.8	167	0.41	ND					
		20.5	170	0.29	ND					
		22.0	204	0.47	ND					
		21.5	248	0.49	ND					
		24.3	292	0.25	ND					
		26.5	333	0.57	ND					
		30.8	627	0.62	ND					
Lepomis microlophus	05/03/01	26.3	403	0.28	ND	ND	0.16	ND	ND	4.9
		26.1	407	0.31	ND	ND	0.22	0.12	ND	7.7
		23.8	278	0.23	ND	ND	0.13	ND	ND	5.6
		20.5	169	0.21	ND	ND	0.12	ND	ND	4.9
		26.4	410	0.34	ND	ND	0.14	ND	ND	3.5
		26.5	441	0.36	ND	ND	0.12	ND	ND	3.4
Lepomis punctatus	08/10/99	31.5	357	0.2	ND					
		39.3	857	0.41	ND					

Appendix 16 (continued).

Subbasin/Location/Species	Date	Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Crt (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
Micropterus salmoides	08/10/99	33.0	495	0.9	ND					
		35.6	497	1.7	ND					
		36.0	598	1.9	ND					
		22.0	134	0.61	ND					
	05/03/01	36.3	602	0.81	ND	0.3	0.28	0.2	ND	5.3
		32.1	525	0.7	ND	ND	0.2	ND	ND	4.9
		28.7	341.5	0.77	ND	ND	0.4	0.16	0.15	5.8
Moores Creek near mouth										
Amia calva	05/08/01	53.0	1407	1.1	0.28	ND	0.26	ND	ND	3.5
		52.0	1370	1.3	0.38	ND	0.32	ND	ND	4.3
		51.8	1315	1.3	0.28	ND	0.2	ND	ND	12
		39.0	606	0.53	0.19	ND	0.21	ND	ND	3.2
Ictalurus furcatus	05/08/01	31.5	232	0.29	0.1	ND	0.22	ND	ND	3
Ictalurus punctatus	05/08/01	52.0	1296	0.54	ND	0.16	0.32	0.1	ND	5.4
		31.5	239	0.23	ND	ND	0.28	ND	ND	4.6
Lepomis gulosus	05/08/01	16.5	102	0.49	ND	ND	0.31	0.26	ND	6.3
		17.5	142	0.45	ND	0.32	0.42	0.42	ND	7.4
Lepomis macrochirus	05/08/01	20.6	207	0.33	ND	ND	0.23	ND	ND	6.2
Lepomis microlophus	05/08/01	23.5	263.6	0.27	ND	ND	0.29	ND	ND	7.4
		25.0	331	0.39	ND	ND	0.25	ND	ND	6.5
Micropterus salmoides	05/08/01	42.5	1146	0.9	ND	ND	0.24	ND	ND	4.1
		37.0	820	1.5	ND	ND	0.28	ND	ND	5.4
		31.5	544	0.75	ND	ND	0.23	ND	ND	5.7
		26.5	295	0.65	ND	ND	0.24	ND	ND	4
Pomoxis nigromaculatus	05/08/01	30.0	447	0.8	ND	ND	0.7	0.1	ND	8.4
030623										
Long Creek near Clark's Landing										
Ameiurus catus	08/22/02	31.5	261	0.23	ND	ND	0.11	ND	ND	3.5
Amia calva	05/02/01	51.0	1186	2	0.34	ND	0.21	ND	ND	2.3
		52.0	1507	0.62	0.13	ND	0.17	ND	ND	1.1
		50.0	1071	0.69	0.37	0.1	0.16	ND	ND	1.5
	08/22/02	46.0	999	0.53	0.75	ND	0.13	ND	ND	3.6
		51.3	1271	0.45	0.55	ND	0.15	ND	ND	4.5
		51.5	1276	0.48	0.41	ND	0.12	ND	ND	4.4
		59.0	2260	0.8	0.34	ND	0.42	ND	ND	4.1
		52.0	1538	0.82	0.49	ND	0.16	ND	ND	4.3
		50.0	1280	0.31	0.76	ND	0.17	ND	ND	4.2
Esox niger	05/02/01	31.6	189.5	0.26	0.11	0.1	0.14	ND	ND	7.7
Lepomis gibbosus	05/02/01	16.4	190	0.26	0.18	0.14	0.66	0.35	ND	5.9
Lepomis macrochirus	05/02/01	19.4	162.3	0.29	ND	ND	0.18	ND	ND	5
		16.7	200	0.21	ND	0.15	0.78	0.38	0.13	14
		19.9	164	0.24	ND	ND	0.46	0.12	ND	11
	08/22/02	14.3	56.3	0.09	ND	ND	0.19	0.28	ND	6.7
		17.9	103.3	0.18	ND	ND	0.18	0.4	ND	5.8
Lepomis microlophus	05/02/01	21.3	217.5	0.19	ND	0.2	0.52	0.92	ND	5.4
	08/22/02	21.1	187	0.13	ND	0.15	0.23	0.19	ND	3.2
Micropterus salmoides	05/02/01	34.5	591	0.53	ND	ND	0.19	ND	ND	1.5
		40.0	1122	0.53	ND	0.13	0.18	ND	ND	2.2
Pylodictis olivaris	08/22/02	37.5	519	0.28	ND	ND	0.16	ND	ND	4.2
		29.8	263.3	0.29	ND	ND	0.3	0.15	ND	4.4

Appendix 16 (continued).

Subbasin/Location/Species	Date	Length (cm)	Weight (g)	Hg (µg/g)	As (µg/g)	Crt (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
Northeast Cape Fear at Castle Hayne										
Amia calva	06/07/00	60.0	2211	0.79	0.2	0.14	ND	ND	ND	3.8
		55.0	1841	0.62	0.17	ND	0.13	ND	ND	5
	05/02/01	47.0	1002	0.43	0.17	ND	0.21	ND	ND	3
		53.0	1446	0.65	0.24	ND	0.28	ND	ND	3.2
		54.5	1632	0.94	0.32	ND	0.3	ND	ND	3.5
	08/22/02	61.0	2300	1.6	0.37	ND	0.2	ND	ND	4.8
		47.5	1078	0.44	0.44	ND	0.32	ND	ND	3.4
		54.5	1594	1	0.5	ND	0.31	ND	ND	3.6
		56.0	1747	1.1	0.49	ND	0.46	ND	ND	3.4
Esox niger	06/07/00	31.1	209.5	0.43	0.11	ND	0.15	ND	ND	6.9
Ictalurus furcatus	08/22/02	42.8	625	0.31	ND	ND	0.37	ND	ND	3.5
		34.8	337	0.2	ND	ND	0.32	ND	ND	4.5
Lepomis gulosus	06/07/00	19.2	179	0.29	ND	ND	0.4	ND	ND	6.4
	05/02/01	19.2	176	0.26	ND	0.19	0.39	0.28	ND	5.4
	08/22/02	17.0	85	0.28	ND	ND	0.28	0.18	ND	5.4
Lepomis macrochirus	06/07/00	18.8	146.5	0.25	ND	ND	0.26	ND	ND	9.9
		17.5	119	0.24	ND	ND	0.14	ND	ND	9.5
	05/02/01	18.5	136	0.18	ND	ND	0.25	ND	ND	6.3
	08/22/02	17.9	114	0.16	ND	ND	0.21	ND	ND	5.5
		16.4	80.6	0.15	ND	ND	0.24	0.14	ND	5.6
Lepomis microlophus	06/07/00	22.1	227.6	0.29	ND	0.13	0.19	0.18	ND	6.1
		19.3	153.3	0.17	ND	0.11	0.21	ND	ND	7.9
	05/02/01	22.0	233.5	0.17	ND	ND	0.19	ND	ND	4.1
		22.8	272	0.24	ND	0.24	0.2	ND	ND	3.7
	08/22/02	20.2	146	0.23	ND	ND	0.21	0.12	ND	5
		19.0	119.3	0.12	ND	ND	0.16	0.13	ND	4.6
Micropterus salmoides	06/07/00	39.0	786	0.36	ND	ND	ND	ND	ND	4.1
		35.0	712	1.2	ND	0.45	0.17	0.22	ND	3.9
		26.0	258	0.31	0.21	0.16	0.23	0.12	ND	4.4
		23.0	178	0.3	ND	ND	0.24	ND	ND	5
		41.0	911	0.47	ND	ND	ND	ND	ND	3.6
		34.0	537	0.66	ND	0.11	0.14	ND	ND	3.5
		28.0	318	0.38	ND	0.12	0.41	0.3	0.3	12
		41.5	947	0.37	ND	ND	0.1	ND	ND	4.1
	05/02/01	28.5	326	0.33	ND	ND	0.19	ND	ND	4.6
		27.1	273.5	0.29	ND	ND	0.28	ND	ND	6.1
		33.9	541	0.35	ND	0.13	0.4	0.16	ND	5.2
		35.0	701	0.67	ND	ND	0.33	ND	ND	3.7
		34.2	606	0.4	ND	0.12	0.4	0.11	ND	3.9
		35.2	621	0.55	ND	ND	0.33	ND	ND	3.4
		34.0	492	0.42	ND	ND	0.15	ND	ND	3.9
	08/22/02	45.0	1067	0.85	ND	ND	0.11	ND	ND	5
		33.1	505	0.76	ND	ND	0.11	ND	ND	4.4
		25.0	199.1	0.23	ND	ND	0.15	ND	ND	3.8
Pylodictis olivaris	08/22/02	57.5	254	0.56	ND	ND	0.22	ND	ND	4

[1]cadmium was non-detectable in all samples.

Appendix 17. Benthic macroinvertebrate sampling methods and criteria.

Standard Qualitative (Full Scale) or EPT Methods

Benthic macroinvertebrates can be collected from wadeable, freshwater, flowing waters using two sampling procedures. The Biological Assessment Unit's standard qualitative (Full Scale) 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 (NCDENR 2001a). The samples are picked on-site. 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).

Benthic macroinvertebrates can also be collected using the EPT sampling procedure. Four rather than 10 composite qualitative samples are taken at each site: 1 kick, 1 sweep, 1 leafpack and visual collections. Only EPT taxa are collected and identified and only EPT criteria are used to assign a bioclassification.

Swamp Stream Method

The Biological Assessment Unit defines "swamp streams" as those streams that are within the coastal plain ecoregion and that normally have no visible flow during a part of the year. This low flow period usually occurs during the summer, but flowing water should be present in swamp streams during the winter. Sampling during winter, high flow periods provides the best opportunity for detecting differences in communities from what is natural, and only winter (February to early March) benthos data can be used when evaluating swamp streams. The swamp stream must have visible flow in this winter period, with flow comparable to a coastal plain stream that would have acceptable flow for sampling in summer. Swamp streams with pH values of 4 s.u. or lower cannot be rated, and even those below 4.5 s.u. are difficult to evaluate.

The swamp sampling method utilizes a variety of collection techniques to inventory the macroinvertebrate fauna at a site. Nine sweep samples (1 series of 3 by each field team member) are collected from each of the following habitats: macrophytes, root mats/undercut banks, and detritus deposits. If one of these habitat types is not present, a sweep from one of the other habitats is substituted. A sweep is defined as the area that can be reached from a given standing location. Each sweep should be emptied into a tub before the next sweep is collected, to prevent clogging of the net, but all three sweeps can be combined in the same tub. Three log/debris washes are also collected. Visual collections are the final technique used at each site. Samples are picked on site. The primary output for this sampling method is a taxa list with an indication of relative abundance (Rare, Common, Abundant) for each taxon.

Data Analysis

Criteria for bioclassifications for standard qualitative and EPT samples are given in Tables 1 - 3. Bioclassifications for EPT samples are based solely on EPT S. For standard qualitative samples, EPT S and the NCBI are used.

Table 1. EPT taxa richness criteria for EPT samples.

	Region	
Bioclassification	**Piedmont**	**Coastal Plain (CA)**
Excellent	> 27	> 23
Good	21 - 27	18 - 23
Good-Fair	14 - 20	12 - 17
Fair	7 - 13	6 - 11
Poor	≤ 6	≤ 5

Table 2. Criteria for Standard Qualitative (Full Scale) samples.

	BI Values		EPT Values	
Score	**Piedmont**	**Coastal Plain (CA)**	**Piedmont**	**Coastal Plain (CA)**
5	< 5.14	< 5.42	> 33	> 28
4.6	5.14 - 5.18	5.42 - 5.46	32 - 33	28
4.4	5.19 - 5.23	5.47 - 5.51	30 - 31	27
4	5.24 - 5.73	5.52 - 6.00	26 - 29	22 - 26
3.6	5.74 - 5.78	6.01 - 6.05	24 - 25	21
3.4	5.79 - 5.83	6.06 - 6.10	22 - 23	20
3	5.84 - 6.43	6.11 - 6.67	18 - 21	15 - 19
2.6	6.44 - 6.48	6.68 - 6.72	16 - 17	14
2.4	6.49 - 6.53	6.73 - 6.77	14 - 15	13
2	6.54 - 7.43	6.78 - 7.68	10 - 13	8 - 12
1.6	7.44 - 7.48	7.69 - 7.73	8 - 9	7
1.4	7.49 - 7.53	7.74 - 7.79	6 - 7	6
1	> 7.53	> 7.79	≤ 5	≤ 5

Table 3. Biotic Index corrections for non-summer data. Summer = Jun – Sep; Fall = Oct – Nov; Winter = Dec – Feb; and Spring = Mar – May.

Region	Season: Fall	Winter	Spring
Piedmont	+0.1	+0.1	+0.2
Coastal A	+0.2	+0.2	+0.3

Tolerance values for individual species and biotic index values have a range of 0 - 10, with higher numbers indicating more tolerant species or more polluted conditions. Water quality scores (5 = Excellent, 4 = Good, 3 = Good-Fair, 2 = Fair and 1 = Poor) assigned with the biotic index numbers are averaged with EPT taxa richness scores to produce a final bioclassification. Criteria for piedmont and coastal plain streams are used for the Cape Fear River basin. EPT abundance and Total taxa richness calculations also are used to help examine between-site differences in water quality.

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

Swamp Stream Criteria
Swamp stream criteria evaluate a stream based on three benthic macroinvertebrate metrics (Total taxa richness, EPT taxa richness, and Biotic Index) and the coastal plain form habitat value. The values for each of these metrics is used to derive a score for each metric, using the tables and graphs below. There are only three possible scores for each metric. A score of 5 is assigned if the metric value falls within the range for Natural, a score of 3 is assigned to values in the range for Moderate and a score of 1 is assigned to values in the range given for Severe. The final site score is derived by the formula:

Site Score = [(2xBI score + Habitat Score + EPT S score + Taxa Richness Score) – 5]/2

Stress ratings based on the scores are: Natural (9 - 10), Moderate (4 - 8) and Severe (1 - 3).

Appendix 18. Benthic macroinvertebrate data collected in the Cape Fear River basin, 1983 - 2003. Current basinwide sites are in bold font.

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
030601									
Haw R	SR 2109	Guilford	16-(1)	07/08/98	---	11	---	5.31	Fair
				07/14/93	---	9	---	5.68	Fair
				05/01/85	59	11	6.53	4.86	Fair
Haw R	US 29 Bus	Rockingham	16-(1)	07/06/98	69	21	6.13	5.21	Good-Fair
				07/14/93	56	20	5.88	5.12	Good-Fair
Haw R	NC 150	Rockingham	16-(1)	07/06/98	---	17	---	4.91	Good-Fair
Haw R	NC 87	Alamance	16-(1)	09/15/03	57	15	6.29	5.40	Good-Fair
				07/07/98	57	17	6.69	5.98	Fair
				07/13/93	69	22	5.86	5.14	Good-Fair
				07/09/90	63	12	7.13	5.57	Fair
				07/09/87	65	14	6.42	5.94	Good-Fair
				05/02/85	65	23	6.50	4.92	Good-Fair
UT Brooks Lake	Scout Camp	Guilford	16-4-1-(1)	06/11/90	53	15	4.31	2.39	Not Rated
				06/05/85	79	20	4.95	2.47	Not Rated
Candy Cr	SR 2700	Guilford	16-(5)	06/11/90	59	10	6.61	5.72	Not Rated
				06/05/85	69	11	6.97	6.17	Not Rated
Troublesome Cr	SR 2344	Rockingham	16-6-(0.3)	04/09/02	74	25	5.89	5.02	Good-Fair
Troublesome Cr	SR 2351	Rockingham	16-6-(0.3)	04/09/02	59	21	5.51	4.44	Good-Fair
Troublesome Cr	SR 1001	Rockingham	16-6-(0.3)	04/10/02	61	18	6.17	5.01	Good-Fair
Troublesome Cr	SR 2422	Rockingham	16-6-(0.7)	04/09/02	58	26	5.69	4.86	Good-Fair
				07/06/98	---	14	---	4.85	Good-Fair
				07/14/93	---	18	---	5.11	Good-Fair
L Troublesome Cr	Scales St	Rockingham	16-7	04/12/01	41	8	5.94	5.66	Not Rated
L Troublesome Cr	US 29 Bus	Rockingham	16-7	08/23/00	76	12	7.27	6.46	Fair
L Troublesome Cr	Industrial Dr.	Rockingham	16-7	08/23/00	38	7	6.68	6.46	Not Rated
UT L Troublesome Cr	Turner Rd	Rockingham	16-7	04/11/01	19	3	7.61	7.48	Not Rated
L Troublesome Cr	above WWTP	Rockingham	16-7	11/16/94	59	18	6.49	5.58	Fair
				01/08/92	42	8	6.74	5.64	Fair
				12/01/87	69	18	6.72	5.22	Fair
L Troublesome Cr	below WWTP	Rockingham	16-7	11/16/94	39	8	7.17	5.80	Fair
				01/08/92	33	7	6.84	5.16	Fair
				12/01/87	37	11	6.92	4.17	Fair
L Troublesome Cr	NC 87	Rockingham	16-7	07/09/01	57	6	7.34	5.88	Fair
L Troublesome Cr	SR 2598	Rockingham	16-7	05/02/85	36	3	7.73	5.63	Poor
L Troublesome Cr	SR 2600	Rockingham	16-7	08/26/03	---	12	---	5.83	Fair
				07/09/01	55	10	6.84	5.58	Fair
				04/11/01	62	14	6.45	4.66	Fair
				08/22/00	59	12	6.67	5.61	Fair
				07/06/98	42	3	7.60	7.03	Poor
				07/14/93	41	3	7.22	7.22	Poor
030602									
Haw R	NC 49	Alamance	16-(1)	05/03/85	58	10	6.86	5.76	Fair
				08/01/84	36	12	6.58	5.70	Fair
Haw R	NC 54	Alamance	16-(1)	07/10/98	73	21	6.01	4.69	Good-Fair
				07/12/93	64	19	6.12	5.34	Good-Fair
				08/08/89	58	14	6.16	5.56	Good-Fair
				08/06/87	---	13	---	5.43	Fair
				07/09/87	74	20	6.29	5.50	Good-Fair
				09/05/85	60	14	6.49	5.55	Fair
				05/04/84	64	16	6.97	5.45	Fair
				08/04/83	73	15	7.07	5.51	Fair
Haw R	above Alamance Cr	Alamance	16-(1)	05/01/84	66	16	7.05	5.03	Fair
Haw R	below Alamance Cr	Alamance	16-(1)	05/01/84	68	20	7.13	4.62	Fair
Reedy Fk	SR 2269	Guilford	16-11-(1)	06/19/03	14	14	4.44	4.44	Good-Fair
Reedy Fk	SR 2128	Guilford	16-11-(1)	07/10/03	---	15	---	4.68	Good-Fair
				07/13/01	59	21	5.40	4.78	Good
				07/08/98	---	19	---	4.06	Good-Fair
				07/14/93	---	19	---	4.88	Good-Fair
				07/25/88	68	21	5.55	4.44	Good-Fair
				04/28/86	77	24	5.50	4.48	Good

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Brush Cr	SR 2136	Guilford	16-11-4-(1)	06/19/03	46	7	6.81	6.42	Fair
				10/25/99	---	5	---	5.08	Poor
				09/03/98	72	15	6.81	5.75	Fair
Horsepen Cr	Radar Rd	Guilford	16-11-5-(0.5)	04/19/01	23	3	7.90	6.78	Not Rated
				06/14/00	31	3	7.97	7.00	Not Rated
Horsepen Cr	SR 2145	Guilford	16-11-5-(0.5)	07/12/01	48	5	7.29	6.88	Not Rated
				06/14/00	40	7	7.82	6.98	Not Rated
Horsepen Cr	Bledsoe Rd	Guilford	16-11-5-(0.5)	06/06/00	43	4	7.35	6.72	Poor
UT Horsepen Cr	Chance Rd	Guilford	16-11-5-(0.5)	07/12/01	60	13	5.41	4.18	Not Impaired
UT Horsepen Cr	Crosstimbers Dr	Guilford	16-11-5-(0.5)	07/12/01	37	5	6.43	6.85	Poor
Horsepen Cr	US 220	Guilford	16-11-5-(0.5)	07/10/03	---	6	---	5.99	Poor
				07/12/01	56	6	6.76	5.68	Not Rated
				06/06/00	59	7	7.13	6.42	Fair
				07/08/98	---	7	---	6.46	Fair
				07/14/93	---	9	---	6.11	Fair
				04/29/86	82	22	6.53	5.13	Good-Fair
UT Horsepen Cr	Friendly Rd	Guilford	16-11-5-1-(2)	04/19/01	39	6	7.12	6.90	Not Rated
				09/03/98	51	6	6.80	6.58	Not Rated
				09/28/92	43	4	7.58	7.05	Not Rated
Reedy Fk	SR 2728	Guilford	16-11-(9)	07/11/03	---	8	---	6.27	Fair
				07/07/98	---	18	---	5.64	Good-Fair
				07/13/93	---	16	---	5.99	Good-Fair
Reedy Fk	NC 87	Alamance	16-11-(9)	07/07/98	53	11	7.11	6.16	Fair
				07/13/93	68	20	6.41	5.59	Good-Fair
				08/08/89	67	14	6.88	6.03	Fair
				07/07/86	59	10	6.75	6.03	Fair
				05/02/85	49	12	7.70	5.98	Fair
				08/13/83	52	13	7.66	6.70	Fair
N Buffalo Cr	above Cone Mills	Guilford	16-11-14-1	07/29/97	43	5	7.49	6.99	Poor
N Buffalo Cr	below Cone Mills	Guilford	16-11-14-1	07/08/98	5	5	7.09	7.09	Poor
				07/29/97	50	4	7.81	6.50	Poor
N Buffalo Cr	above WWTP	Guilford	16-11-14-1	07/29/97	50	3	7.75	7.01	Poor
				11/09/88	37	3	7.80	7.43	Poor
N Buffalo Cr	SR 2832	Guilford	16-11-14-1	07/10/03	40	3	7.72	6.80	Poor
				07/08/98	37	3	8.01	7.00	Poor
				07/13/93	40	4	8.11	6.68	Poor
				11/09/88	32	1	8.50	7.79	Poor
				05/01/85	28	2	8.67	6.06	Poor
S Buffalo Cr	McConnell Rd	Guilford	16-11-14-2	07/08/98	---	7	---	6.90	Fair
S Buffalo Cr	US 70	Guilford	16-11-14-2	07/11/03	40	6	7.04	6.56	Fair
				07/07/98	48	6	7.68	6.48	Poor
				07/12/93	59	8	7.41	6.06	Fair
				08/25/88	63	9	7.87	4.69	Poor
S Buffalo Cr	SR 2821	Guilford	16-11-14-2	07/11/03	38	4	7.13	7.00	Poor
				07/07/98	26	1	8.55	7.79	Poor
				07/12/93	50	2	8.23	6.20	Poor
				08/25/88	34	1	7.62	7.79	Poor
				05/01/85	36	2	8.48	6.89	Poor
Mile Run Cr	SR 1400	Guilford	16-11-14-2-4	04/28/86	25	1	8.71	7.00	Poor
Stony Cr	SR 1100	Caswell	16-14-(1)	07/10/03	---	11	---	6.34	Fair
				07/06/98	---	21	---	5.40	Good
				07/13/93	---	21	---	4.69	Good
				02/10/93	---	27	---	4.04	Good
Jordan Cr	SR 1002	Alamance	16-14-6-(0.5)	08/26/03	---	16	---	4.90	Good-Fair
				07/06/98	---	16	---	5.03	Good-Fair
				02/10/93	---	23	---	4.79	Good-Fair
Back Cr	SR 1936	Alamance	16-18-(6)	11/04/99	---	8	---	6.20	Not Rated
Moadams Cr	above Mebane WWTP	Alamance	16-18-7	11/04/99	21	4	7.26	5.80	Not Rated
Moadams Cr	SR 1940	Alamance	16-18-7	11/04/99	36	5	7.26	7.04	Not Rated

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Haw Cr	SR 2158	Alamance	16-20-(1)	07/07/03	---	14	---	5.47	Good-Fair
				11/04/99	---	12	---	4.87	Not Rated
				07/10/98	---	22	---	4.81	Good
				02/10/93	---	19	---	4.77	Good-Fair
Varnals Cr	SR 2116	Alamance	16-21	09/20/00	80	22	5.57	5.25	Good
Varnals Cr	SR 2328	Alamance	16-21	09/20/00	46	13	6.54	5.74	Fair
030603									
Big Alamance Cr	NC 49	Alamance	16-19-(4.5)	08/26/03	---	12	---	6.23	Fair
				07/10/98	---	18	---	5.82	Good-Fair
				07/12/93	---	19	---	5.24	Good-Fair
				02/11/93	---	20	---	4.28	Good-Fair
Big Alamance Cr	SR 2309	Alamance	16-19-(4.5)	10/11/89	95	31	5.87	4.47	Good
				08/11/89	79	22	6.11	5.27	Good-Fair
				04/27/89	79	26	5.77	4.42	Good-Fair
				02/09/89	65	22	5.84	4.58	Good-Fair
				07/07/86	80	22	6.02	5.06	Good-Fair
L Alamance Cr	SR 3056	Guilford	16-19-3-(4.5)	02/15/93	69	24	5.48	4.72	Good
UT Back Cr	off 1149	Alamance	16-19-5	04/03/95	70	28	4.85	3.95	Excellent
UT Back Cr	below Triangle Paving	Alamance	16-19-5	04/03/95	54	22	5.49	4.77	Good
Gum Cr	SR 1148	Alamance	16-19-7	04/30/86	67	14	7.52	5.98	Fair
Stinking Quarter Cr	SR 1136	Alamance	16-19-8	11/11/03	---	21	---	4.85	Good-Fair
				07/07/03	---	13	---	5.59	Fair
				07/10/98	---	23	---	5.07	Good
				07/12/93	---	16	---	5.02	Good-Fair
				02/11/93	---	25	---	4.02	Good-Fair
				04/30/86	---	30	---	5.10	Good
UT Rock Cr	SR 2808	Guilford	16-19-8-3.5-(1)	11/09/88	---	20	---	4.53	Not Rated
Coble Br	Engleman Ave.	Alamance	16-19-11	06/24/03	27	4	6.96	7.00	Not Rated
L Alamance Cr	Overbrook Rd.	Alamance	16-19-11	06/24/03	30	5	7.25	6.85	Poor
L Alamance Cr	I 85 frontage road	Alamance	16-19-11	06/23/03	33	4	7.60	6.48	Poor
L Alamance Cr	NC 49	Alamance	16-19-11	06/23/03	33	4	6.85	6.67	Poor
L Alamance Cr	SR 2309	Alamance	16-19-11	06/23/03	41	5	6.69	6.70	Fair
				07/10/98	---	6	---	6.85	Poor
				07/29/85	45	8	7.33	6.63	Fair
030604									
Haw R	SR 2158	Alamance	16-(1)	08/04/83	54	7	6.90	5.63	Fair
Haw R	SR 1005	Alamance	16-(1)	10/03/02	---	20	---	4.82	Good-Fair
				11/09/98	47	15	5.68	4.49	Good-Fair
				07/07/98	65	20	6.17	4.76	Good-Fair
				07/28/93	60	18	5.91	5.27	Good-Fair
				07/09/90	71	20	6.11	5.01	Good-Fair
				08/08/89	60	18	6.23	5.42	Good-Fair
				07/13/88	74	21	6.26	5.11	Good-Fair
				07/10/87	71	21	5.90	5.15	Good-Fair
				07/08/87	---	21	---	5.05	Good
				07/07/86	67	19	6.18	5.07	Good-Fair
				09/05/85	64	23	5.63	5.21	Good
				05/06/85	73	24	6.30	5.01	Good-Fair
				09/06/84	61	13	6.53	5.17	Fair
				05/04/84	85	27	6.01	4.76	Good-Fair
Marys Cr	SR 2174	Alamance	16-26	07/15/03	---	18	---	5.03	Good-Fair
				03/10/03	---	18	---	4.05	Not Rated
				10/19/00	76	25	5.71	4.59	Good-Fair
				02/10/98	---	17	---	3.88	Fair
Cane Cr	SR 1114	Orange	16-27-(2.5)	08/14/03	---	15	---	4.94	Good-Fair
				07/15/03	---	18	---	5.19	Good-Fair
				07/07/98	---	27	---	4.30	Good
				02/26/98	77	37	4.88	3.49	Excellent
				02/02/98	---	25	---	4.08	Good
				07/28/93	---	20	---	4.06	Good-Fair
				02/11/93	---	28	---	3.57	Good
				04/28/86	110	33	5.63	4.54	Good

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Cane Cr	SR 1100	Orange	16-27-(2.5)	11/06/84	88	27	5.89	4.87	Good-Fair
Cane Cr	NC 54	Orange	16-27-(7)	04/11/94	91	28	5.86	4.17	Good-Fair
Cane Cr	SR 1958	Orange	16-27-(7)	04/11/94	110	37	5.85	4.59	Good
Cane Cr	SR 2351	Alamance	16-28	08/17/98	---	10	---	4.43	Not Rated
				12/09/86	---	12	---	5.75	Fair
Cane Cr	off SR 2351	Alamance	16-28	08/17/98	66	15	5.61	4.41	Good-Fair
Cane Cr	NC 87	Alamance	16-28	02/08/93	---	20	---	4.36	Good-Fair
				12/09/86	---	5	---	4.86	Poor
UT Collins Cr	above WWTP	Orange	16-30-(1)	08/22/91	52	17	5.73	4.75	Good-Fair
UT Collins Cr	below WWTP	Orange	16-30-(1)	08/22/91	63	15	5.83	5.03	Good-Fair
Collins Cr	SR 1539	Chatham	16-30-(1.5)	07/15/03	---	14	---	5.33	Good-Fair
				02/02/98	---	19	---	4.53	Good-Fair
				12/10/86	44	4	7.17	4.13	Poor
Terrells Cr	NC 87	Chatham	16-31-(2.5)	11/21/03	---	18	---	4.41	Good-Fair
				07/15/03	---	12	---	5.26	Fair
				07/10/98	---	15	---	4.53	Good-Fair
				02/08/93	---	30	---	3.32	Excellent
Terrells Cr	SR 1520	Chatham	16-31-(2.5)	12/09/86	---	13	---	5.07	Fair
Dry Cr	SR 1520	Chatham	16-34-(0.7)	11/21/03	---	13	---	5.05	Fair
				07/15/03	---	9	---	5.62	Fair
				02/02/98	---	21	---	3.79	Good-Fair
				02/08/93	---	31	---	4.62	Good
				12/09/86	---	5	---	6.02	Poor
Haw R	US 64	Chatham	16-(36.7)	10/03/02	---	23	---	4.01	Good
				07/10/98	65	25	5.40	4.34	Good
				07/29/93	63	24	5.19	4.42	Good
				07/17/90	60	24	5.47	4.29	Good
				07/13/88	81	28	5.97	4.70	Good
				07/08/86	69	24	5.73	4.43	Good
				06/17/83	48	14	5.52	4.44	Good-Fair
				06/14/83	51	19	5.49	4.49	Good
				06/14/83	61	19	5.63	4.53	Good
				09/06/84	56	20	5.77	4.69	Good-Fair
				05/03/85	84	27	5.74	4.32	Good
Brooks Cr	SR 1521	Chatham	16-36	01/19/01	56	16	5.57	4.73	Not Impaired
Pokeberry Cr	SR 1711	Chatham	16-37	07/15/03	---	19	---	5.28	Good-Fair
				03/05/03	---	21	---	4.66	Good-Fair
				02/02/98	---	30	---	3.93	Good
				02/08/93	---	23	---	4.68	Good-Fair
				12/10/86	94	26	5.91	4.24	Good
				10/09/85	86	21	6.06	4.74	Good-Fair
Robeson Cr	US 15/501	Chatham	16-38-(3)	03/06/97	---	12	---	5.94	Fair
UT Robeson Cr	US 64	Chatham	16-38-(3)	03/06/97	24	3	7.66	4.03	Not Rated
Robeson Cr	above Pittsboro WWTP	Chatham	16-38-(3)	09/19/01	62	7	6.61	6.59	Fair
Robeson Cr	below UT A, above Pittsboro WWTP	Chatham	16-38-(3)	03/06/97	52	7	6.44	6.26	Fair
				09/04/90	66	7	7.58	7.00	Poor
Robeson Cr	below WWTP	Chatham	16-38-(3)	09/19/01	41	6	7.13	6.73	Fair
				09/04/90	54	7	7.10	5.90	Fair
				04/28/86	82	11	7.26	5.89	Fair
Robeson Cr	above Turkey Cr	Chatham	16-38-(3)	01/19/01	51	8	6.41	5.85	Fair
Robeson Cr	off SR 1943	Chatham	16-38-(3)	09/12/01	59	16	6.01	5.84	Good-Fair
				01/19/01	51	11	5.84	5.06	Fair
Turkey Cr	US 15/501	Chatham	16-38-4	01/19/01	56	14	6.44	5.39	Not Rated
Turkey Cr	SR 1012	Chatham	16-38-4	01/19/01	33	7	7.56	5.32	Not Rated
				01/19/01	65	15	6.16	4.71	Not Rated
Camp Cr	SR 1012	Chatham	16-38-4	01/19/01	27	4	6.30	3.87	Not Rated
UT Camp Cr	above SR 1012	Chatham	16-38-4	01/19/01	25	2	7.57	4.72	Not Rated
030605									
New Hope Cr	SR 1734,	Orange	16-41-1(0.5)	3/1/93	94	29	5.02	3.84	Good
New Hope Cr	SR 1730	Orange	16-41-1-(0.5)	6/12/03	79	16	5.74	5.20	Good-Fair
New Hope Cr	SR 2220	Durham	16-41-1-(11.5)	3/12/87	53	14	6.70	5.71	Fair

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
New Hope Cr	I-40	Durham	16-41-1-(11.5)	10/9/85	49	10	7.66	6.47	Fair
New Hope Cr	SR 1107	Durham	16-41-1-(11.5)	7/7/03	32	6	6.64	6.32	Fair
				7/7/98	38	10	6.78	5.76	Fair
				10/9/85	32	5	7.58	6.69	Poor
Third Fork Cr	NC 751	Durham	16-41-1-12-(2)	2/9/93	39	8	7.62	6.64	Poor
				4/30/85	40	3	8.10	6.83	Poor
Northeast Cr	SR 1102,	Durham	16-41-1-17-(0.7)	2/13/98	---	7	---	6.57	Not Rated
				2/19/93	58	9	6.81	6.04	Not Rated
				3/12/87	29	3	7.71	6.50	Not Rated
Northeast Cr	SR 1100	Durham	16-41-1-17-(0.7)	2/9/93	35	7	6.81	5.83	Not Rated
				3/12/87	27	0	7.96	---	Not Rated
				12/10/86	---	4	---	6.39	Not Rated
				4/30/85	62	7	7.38	6.08	Not Rated
Northeast Cr	SR 1731	Chatham	16-41-1-17-(0.7)	7/28/93	46	8	7.10	6.30	Fair
				12/10/86	---	8	---	5.94	Fair
Burdens Cr	SR 1945	Durham	16-41-1-17-1-(0.7)	4/29/86	60	10	6.96	5.41	Fair
Kit Cr	NC 55	Wake	16-41-1-17-2-(0.3)	4/24/03	---	9	---	6.00	Not Rated
Cub Cr	SR 1008	Chatham	16-41-2-10-(0.5)	12/10/86	---	14	---	5.44	Fair
Beartree Cr	SR 1716	Chatham	16-41-5-(2)	2/13/98	---	22	---	3.93	Not Rated
				7/27/93	---	10	---	6.30	Not Rated
				2/9/93	---	21	---	3.91	Good-Fair
				4/1/86	76	29	4.85	4.05	Good
White Oak Cr	SR 1603	Wake	16-41-6-(0.7)	04/24/03	---	9	---	5.66	Not Rated
				03/05/03	---	5	---	5.70	Not Rated
				02/13/98	---	10	---	5.17	Not Rated
White Oak Cr	NC 751	Chatham	16-41-6-(2)	02/08/93	---	13	---	4.82	Not Rated
030606									
Little Cr	Pinehurst Dr	Orange	16-41-1-15-(0.5)	7/11/01	27	5	6.81	6.36	Not Rated
				3/1/01	45	5	7.33	4.96	Poor
				2/2/98	---	5	---	4.83	Poor
				2/10/93	37	7	7.12	4.69	Fair
Bolin Cr	SR 1777	Orange	16-41-1-15-1-(0.5)	7/10/01	87	24	5.96	5.18	Good-Fair
				2/27/01	82	17	6.40	5.23	Not Rated
				4/6/00	---	26	---	5.05	Good
				3/11/98	---	23	---	4.22	Good
				4/1/93	---	24	---	4.46	Good
Bolin Cr	Village Rd	Orange	16-41-1-15-1-(0.5)	3/14/02	40	7	7.00	6.42	Fair
				7/10/01	52	9	6.61	6.64	Fair
				2/27/01	54	6	7.00	5.82	Poor
				2/26/98	59	26	5.10	3.93	Good
				4/1/93	---	24	---	3.89	Good-Fair
Bolin Cr	E Franklin St	Orange	16-41-1-15-1-(4)	7/10/01	41	4	6.87	6.95	Poor
				3/1/01	53	4	7.05	5.94	Poor
				3/11/98	37	13	6.28	6.00	Fair
				2/2/98	---	4	---	6.65	Poor
				2/10/93	32	8	6.52	5.34	Fair
				4/29/86	89	28	6.08	4.34	Good-Fair
Bolin Cr	Bolinwood Dr	Orange	16-41-1-15-1-(4)	3/14/02	41	5	7.49	6.88	Poor
				3/1/01	46	5	7.32	6.39	Poor
Tanbark Br	Umstead Rd	Orange	16-41-1-15-1-3	3/14/02	16	1	6.99	6.20	Not Rated

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Booker Cr	Piney Mountain Rd	Orange	16-41-1-15-2-(1)	7/11/01	35	4	6.41	6.62	Not Rated
				2/21/01	39	8	6.26	6.36	Not Rated
				3/11/98	---	10	---	5.79	Fair
Booker Cr	Barbara Court	Orange	16-41-1-15-2-(1)	7/10/01	45	3	6.56	7.00	Not Rated
				2/21/01	31	4	7.33	6.62	Not Rated
	Walnut St	Orange	16-41-1-15-2-(1)	7/10/01	51	7	6.91	6.04	Not Rated
				2/21/01	33	3	7.20	5.26	Not Rated
Morgan Cr	NC 54	Orange	16-41-2-(1)	10/1/03	---	22	---	4.22	Good
				7/7/03	---	20	---	4.61	Good-Fair
				5/6/03	---	16	---	4.95	Good-Fair
				3/5/03	---	12	---	3.07	Not Rated
				1/9/03	---	8	---	3.42	Not Rated
				9/24/02	---	2	---	4.10	Not Rated
				4/6/00	---	36	---	4.21	Excellent
				2/26/98	80	33	4.37	3.28	Excellent
				2/2/98	31	31	3.63	3.63	Good
				10/15/96	64	22	5.03	4.12	Good
				7/28/93	61	21	4.92	3.48	Good
				2/11/93	90	36	4.48	3.23	Excellent
				4/30/85	109	32	5.71	4.69	Good
Morgan Cr	Botanical Trail	Orange	16-41-2-(5.5)	3/17/98	46	20	6.08	5.39	Good-Fair
				4/1/93	---	16	---	4.94	Fair
				2/10/93	71	26	6.00	4.63	Good-Fair
Morgan Cr	off SR 1900 above WWTP	Orange	16-41-2-(5.5)	9/19/94	58	9	7.27	6.27	Fair
				9/4/90	63	8	7.16	6.39	Fair
				7/7/88	82	13	6.94	6.34	Fair
Morgan Cr	off SR 1900 below WWTP	Orange	16-41-2-(5.5)	3/17/98	44	11	6.66	5.68	Fair
				9/19/94	47	6	7.60	6.12	Poor
				2/10/93	42	7	7.20	4.93	Fair
				9/4/90	66	8	7.47	5.88	Fair
				7/7/88	52	4	7.80	7.11	Poor
Morgan Cr	off SR 1900	Orange	16-41-2-(5.5)	7/7/03	42	9	6.78	6.46	Fair
Morgan Cr	SR 1726	Chatham	16-41-2-(5.5)	7/7/98	44	11	6.63	5.91	Fair
				7/27/93	38	7	6.88	6.53	Fair
				7/9/90	54	8	7.17	6.53	Fair
				7/8/87	---	5	---	5.97	Poor
				7/6/87	35	6	6.81	6.29	Fair
				4/30/85	40	5	7.71	5.67	Poor
				8/13/84	50	10	7.06	5.89	Fair
Pritchards Mill Cr	Damascus Rd	Orange	16-41-2-3-(0.5)	4/1/93	---	22	---	4.30	Good-Fair
Meeting of the Waters Cr	Laurel Hill Rd	Orange	16-41-2-7	4/1/93	---	2	---	7.28	Not Rated
				3/11/98	---	3	---	7.36	Not Rated
030607									
Hughes Cr	SR 1002	Lee	18-4-7	3/10/03	---	3	---	6.40	Not Rated
Gulf Cr	near SR 1924	Chatham	18-5-(1)	4/22/93	34	6	6.68	5.38	Not Rated
UT Gulf Cr	near SR 1924	Chatham	18-5-(1)	4/22/93	19	4	6.62	4.49	Not Rated
Buckhorn Cr	SR 1117	Wake	18-7-(1)	3/13/03	78	27	5.37	4.80	Good
Little Br	SR 1153	Wake	18-7-6-1-1	3/12/03	28	5	7.37	7.36	Not Rated
Parkers Cr	SR 1450	Harnett	18-9	4/30/03	---	26	---	4.54	Good
				7/8/98	---	19	---	5.43	Good
				2/11/98	---	20	---	4.20	Good
				8/10/93	83	25	5.45	4.51	Good
				3/2/93	---	27	---	4.03	Good
Parkers Cr	SR 1403	Harnett	18-9	3/14/03	64	23	4.44	3.90	Not Impaired
Parkers Cr	off SR 1418	Harnett	18-9	11/29/88	---	28	---	3.42	Excellent
Avents	SR 1418	Harnett	18-13	3/12/03	85	31	4.97	3.85	Excellent
				11/29/88	---	25	3.94	3.94	Excellent
Avents Cr	SR 1403	Harnett	18-13	9/19/00	58	20	5.44	4.57	Good

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Hector Cr	SR 1412	Harnett	18-15	3/13/03	79	29	5.00	4.08	Excellent
				11/29/88	100	29	5.20	3.90	Excellent
Hector Cr	SR 1427	Harnett	18-15	3/12/03	67	26	4.66	3.98	Good
Coopers Br	SR 1403	Harnett	18-15-1	3/12/03	65	24	4.70	3.81	Good
Neills Cr	SR 1441	Harnett	18-16-(0.7)	3/12/03	---	6	---	4.24	Poor
				2/11/98	---	19	---	5.10	Good-Fair
				3/2/93	---	18	---	4.64	Good-Fair
Neills Cr	SR 1403	Harnett	18-16-(0.7)	3/14/03	68	7	7.09	6.16	Fair
				11/30/88	---	16	---	4.32	Good-Fair
Kenneth Cr	US 401	Wake		9/2/98	67	18	5.98	5.14	Not Rated
Kenneth Cr	SR 1441	Harnett	18-16-1-(2)	3/10/03	---	4	---	5.60	Poor
				2/11/98	---	5	---	6.22	Poor
				3/2/93	43	7	6.22	5.29	Poor
Kenneth Cr	SR 1100	Wake	18-16-1-(2)	3/12/03	72	27	5.10	4.41	Good
UT Kenneth Cr	near SR 2772	Wake	18-16-1-(2)	9/2/98	44	6	6.96	5.81	Not Rated
				9/5/90	47	3	7.53	6.50	Not Rated
UT Kenneth Cr	SR 1447	Harnett	18-16-1-(2)	8/28/91	50	16	4.13	2.37	Not Rated
Cape Fear R	US 401	Harnett	18-(16.7)	1/21/03	---	20	---	4.44	Good-Fair
				10/2/02	---	12	---	3.78	Not Rated
				7/8/98	76	33	5.98	4.84	Good
				8/23/93	76	28	5.78	4.70	Good
				9/12/90	107	36	6.09	4.72	Good
				7/12/88	93	30	5.96	4.83	Good
				7/11/88	---	25	---	4.22	Good
				7/8/86	89	29	6.08	4.81	Good
				8/1/85	91	29	6.20	5.04	Good
				9/25/84	94	25	6.01	4.98	Good-Fair
				7/14/83	72	30	5.27	4.54	Good
Cape Fear R	NC 217	Harnett	18-(20.7)	7/13/98	76	34	5.44	4.30	Excellent
				8/18/93	68	30	5.15	4.36	Excellent
030608									
E Fk Deep R	SR 1541	Guilford	17-2-(0.3)	5/20/03	48	8	6.94	6.52	Fair
				7/9/98	---	13	---	6.01	Fair
				2/15/93	---	12	---	5.86	Fair
UT E Fk Deep R	I-40	Guilford	17-2-(0.3)	9/28/92	38	5	6.88	5.20	Not Rated
UT E Fk Deep R #1	UT 1	Guilford	17-2-(0.3)	9/28/00	45	14	5.34	3.94	Not Rated
UT E Fk Deep R #2	below UT 1	Guilford	17-2-(0.3)	9/28/00	35	7	6.48	5.28	Not Rated
UT E Fk Deep R #3	Millhouse School Rd	Guilford	17-2-(0.3)	5/19/03	75	19	5.95	5.17	Not Impaired
Long Br	Jamesford Rd	Guilford	17-2-1-(2)	5/19/03	42	11	6.63	5.81	Fair
W Fk Deep R	SR 1850	Guilford	17-3-(0.3)	7/7/03	---	14	---	5.14	Good-Fair
				4/15/03	50	19	5.59	4.86	Good-Fair
				9/5/98	46	11	5.59	4.57	Good-Fair
				7/9/98	---	12	---	4.35	Good-Fair
				7/15/93	---	15	---	4.66	Good-Fair
				2/15/93	---	27	---	4.61	Good-Fair
UT W Fk Deep R	above LCP	Guilford	17-3-(0.3)	10/13/88	35	8	5.96	5.30	Not Rated
UT W Fk Deep R	below LCP	Guilford	17-3-(0.3)	10/13/88	6	0	8.41	---	Not Rated
Deep R	SR 1113	Guilford	17-(4)	9/8/98	55	12	6.62	6.00	Fair
				8/15/88	81	8	7.29	6.74	Fair
				8/25/87	90	17	7.04	6.12	Fair
				8/4/86	87	13	7.06	6.28	Fair
				7/29/85	67	14	6.72	6.45	Fair
				8/22/83	11	0	8.42	---	Poor
Deep R	SR 1921	Randolph	17-(4)	7/9/90	73	12	7.20	6.12	Fair
				7/26/89	66	16	7.03	6.01	Fair
				8/16/88	78	11	7.28	6.43	Fair
				7/27/88	80	18	7.03	6.42	Good-Fair
				8/25/87	78	16	6.99	5.86	Fair
				7/20/87	---	8	---	6.57	Fair
				8/4/86	56	10	7.67	6.70	Fair
				7/29/85	64	11	7.70	6.60	Fair
				8/13/84	39	7	7.40	6.63	Fair
				8/3/83	56	9	7.86	6.47	Poor

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Deep R	US 220 Bus	Randolph	17-(4)	7/22/03	52	18	5.77	6.12	Good-Fair
				7/9/98	77	20	5.98	5.10	Good-Fair
				7/15/93	74	20	6.07	5.39	Good-Fair
				8/16/88	63	12	6.64	6.22	Fair
				8/25/87	81	17	6.66	6.11	Fair
				8/5/86	74	10	7.14	6.22	Fair
				7/30/85	56	9	7.78	6.67	Poor
				8/23/83	60	9	7.22	6.46	Fair
E Fk Deep R	SR 1556	Guilford	17-(4)	5/19/03	46	6	7.05	6.33	Fair
E Fk Deep R	Thatcher Rd	Guilford	17-(4)	5/19/03	62	20	5.95	5.53	Good-Fair
Richland Cr	above WWTP	Guilford	17-7	8/15/88	55	9	7.28	6.48	Fair
Richland Cr	SR 1145	Guilford	17-7	7/7/03	36	7	7.08	6.89	Fair
				7/9/98	28	5	7.88	6.59	Poor
				7/15/93	53	13	7.09	6.44	Fair
				8/16/88	62	9	7.61	5.78	Poor
				8/25/87	61	9	7.60	6.11	Poor
				8/4/86	40	2	8.19	6.58	Poor
				7/31/85	30	5	8.42	6.81	Poor
				8/22/83	47	9	7.53	6.75	Fair
Reddicks Cr	Bisbee Rd.	Guilford	17-8-(0.5)	4/16/03	45	9	7.49	5.78	Fair
Reddicks Cr	Groomtown Rd	Guilford	17-8-(0.5)	4/15/03	54	16	6.16	5.43	Good-Fair
Jenny Br	Brandy Rd	Guilford	17-8-2	4/15/03	32	7	6.55	4.97	Fair
Hickory Cr	SR 1131	Guilford	17-8-3	4/16/03	35	17	5.01	4.09	Good-Fair
				7/9/98	---	12	---	5.31	Not Rated
				2/17/93	---	18	---	3.33	Fair
Hickory Cr	Bishop Rd	Guilford	17-8-3	4/14/03	34	9	6.68	5.94	Fair
Hickory Cr	SR 1113	Guilford	17-8-3	4/14/03	48	19	6.12	4.90	Good-Fair
Hickory Cr	SR 1132	Guilford	17-8-3	4/16/03	50	19	5.82	4.60	Good-Fair
Muddy Cr	SR 1929	Randolph	17-9	7/8/03	---	7	---	6.25	Fair
				7/8/98	---	13	---	6.07	Not Rated
				2/15/93	---	22	---	4.71	Good-Fair
030609									
Deep R	SR 2122	Randolph	17-(4)	8/17/88	74	10	7.28	6.19	Fair
				8/26/87	57	9	7.14	5.96	Fair
				8/5/86	66	10	7.92	6.40	Fair
				7/31/85	47	5	8.21	6.80	Poor
				8/24/83	46	3	8.20	6.72	Poor
Deep R	SR 2226	Randolph	17-(4)	8/17/88	61	16	6.33	5.29	Good-Fair
				8/26/87	70	17	6.90	5.88	Fair
				8/5/86	61	12	6.89	6.23	Fair
				7/31/85	65	9	7.78	6.69	Poor
				8/24/83	50	5	7.84	6.83	Poor
Deep R	SR 2615	Randolph	17-(4)	7/22/03	57	19	5.72	5.24	Good
				7/6/98	71	20	5.93	4.78	Good-Fair
				7/26/93	67	17	6.22	5.13	Good-Fair
				7/26/89	73	18	6.10	5.43	Good-Fair
				8/26/87	78	23	6.27	4.95	Good-Fair
				8/6/86	75	21	6.46	5.22	Good-Fair
				7/30/85	74	13	6.91	5.95	Fair
				8/3/83	62	15	7.14	5.91	Fair
Deep R	SR 2628	Randolph	17-(4)	8/6/86	89	26	6.68	5.30	Good-Fair
				8/8/85	104	35	5.76	4.54	Good
				8/24/83	71	19	6.92	5.78	Good-Fair
Polecat Cr	SR 1007	Guilford	17-11-(1)	7/18/90	78	21	5.75	5.32	Good
Polecat Cr	SR 2113	Randolph	17-11-(1)	2/10/98	---	31	---	4.03	Good
				2/17/93	---	32	---	4.31	Good
UT Polecat Cr	near SR 3430	Guilford	17-11-2-(2)	7/18/90	33	1	8.86	7.41	Not Rated
L Polecat Cr	SR 2108	Randolph	17-11-3	2/10/98	---	14	---	4.22	Not Rated
L Polecat Cr	SR 2113	Randolph	17-11-3	2/17/93	83	32	4.63	3.43	Excellent
				8/5/86	91	20	5.14	4.21	Good
Hasketts Cr	SR 2149	Randolph	17-12	4/16/03	57	11	7.35	6.14	Fair
				9/9/98	33	4	7.02	6.41	Poor
				2/25/87	58	12	7.01	5.45	Fair

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Hasketts Cr	below SR 2149	Randolph	17-12	2/21/90	58	10	7.11	6.55	Fair
				8/16/88	66	12	7.64	6.63	Fair
Hasketts Cr	SR 2128	Randolph	17-12	4/16/03	34	6	7.43	5.73	Poor
				9/9/98	27	5	7.78	6.85	Poor
				2/25/87	29	3	8.33	5.80	Poor
Hasketts Cr	SR 1504	Randolph	17-12	4/14/03	34	4	7.22	6.69	Poor
Hasketts Cr	US 220	Randolph	17-12	4/14/03	32	2	7.41	4.35	Poor
Hasketts Cr	US 220 BUS	Randolph	17-12	4/15/03	42	4	7.08	6.27	Poor
Penwood Br	SR 2182	Randolph	17-12-1	4/15/03	49	10	6.76	6.11	Fair
Penwood Br	SR 2261	Randolph	17-12-1	4/15/03	48	10	6.62	5.26	Fair
Sandy Cr	SR 2261	Randolph	17-16-(1)	5/15/89	81	19	6.44	4.39	Good-Fair
				5/24/88	69	15	6.10	5.24	Good-Fair
Sandy Cr	SR 2481	Randolph	17-16-(1)	7/8/03	---	21	---	4.91	Good
				4/16/03	71	27	4.98	3.81	Good
				9/30/02	---	21	---	4.73	Good
				4/19/01	124	43	5.33	4.26	Excellent
				7/6/98	---	35	---	4.43	Excellent
				7/26/93	---	22	---	4.06	Good
				2/17/93	---	27	---	3.28	Good
				5/15/89	83	25	5.39	4.40	Good
				5/24/88	94	32	5.41	4.07	Good
UT Sandy Cr	SR 2261	Randolph	17-16-(1)	5/15/89	80	22	5.61	4.19	Good
				5/24/88	76	17	6.16	4.83	Good-Fair
Mt Pleasant Cr	SR 2442	Randolph	17-16-3	5/15/89	80	22	4.99	4.05	Good
				5/24/88	81	27	5.29	3.93	Good
Richland Cr	SR 2873	Randolph	17-22	7/8/03	---	27	---	4.48	Good
				7/6/98	---	29	---	3.92	Excellent
				7/26/93	---	26	---	3.88	Good
				2/18/93	---	23	---	3.60	Good
Brush Cr	SR 1102	Chatham	17-23	5/18/90	---	26	---	4.89	Good
Brush Cr	NC 22	Randolph	17-23	7/8/03	---	18	---	5.29	Good-Fair
				7/6/98	---	26	---	4.26	Good
				2/18/93	---	23	---	3.58	Good
				5/18/90	---	28	---	4.24	Excellent
				8/25/83	95	26	6.02	4.37	Good
UT Little Brush Cr	SR 1100	Chatham	17-23-2	5/18/90	---	23	---	5.01	Good
UT Little Brush Cr	SR 1005	Randolph	17-23-2	5/18/90	---	17	---	4.13	Good-Fair
Flat Cr	SR 2886	Randolph	17-24	2/10/98	---	22	---	4.70	Good-Fair
				2/18/93	17	17	5.07	5.07	Fair
Fork Cr	SR 2873	Randolph	17-25	2/10/98	---	28	---	3.75	Good
				2/18/93	---	22	---	3.37	Good
030610									
Deep R	SR 1456	Moore	17-(4)	7/22/03	66	26	4.99	4.39	Excellent
				10/3/02	26	26	3.63	3.63	Good
				7/6/98	83	34	5.23	4.48	Excellent
				7/26/93	80	32	5.04	4.22	Excellent
				8/17/88	96	34	5.03	4.01	Excellent
				8/27/87	111	38	5.11	4.19	Excellent
				8/8/85	99	33	5.22	4.22	Excellent
				8/6/86	87	32	4.95	3.80	Excellent
				8/25/83	94	33	5.24	4.14	Good
Deep R	NC 22	Moore	17-(25.7)	7/26/89	69	24	5.58	4.83	Good
Wolf Cr	SR 1403	Moore	17-26-4	7/15/88	---	17	---	5.55	Good-Fair
				2/22/84	91	30	5.38	3.77	Good
Cabin Cr	SR 1400	Moore	17-26-5-(1)	4/30/03	---	25	---	4.22	Good
				2/4/03	---	22	---	4.06	Good-Fair
				9/30/02	---	3	---	4.53	Poor
				3/5/98	---	29	---	4.20	Good
				2/23/93	---	27	---	3.62	Good
				9/21/92	---	14	---	4.49	Not Rated
Cabin Cr	below Cotton Cr	Moore	17-26-5-(1)	9/21/92	61	11	6.37	3.71	Fair
Cabin Cr	SR 1275	Moore	17-26-5-(1)	9/21/92	91	27	5.50	3.73	Good

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Cotton Cr	SR 1370	Montgomery	17-26-5-3	9/27/01	55	7	6.08	4.73	Fair
				9/11/98	49	11	6.07	4.39	Fair
				9/16/92	42	7	6.60	5.32	Fair
				2/22/84	33	10	7.16	4.76	Fair
Mill Cr	NR SR 1275	Moore	17-26-5-4	7/9/03	---	26	---	3.55	Good
				7/21/98	---	20	---	4.20	Good-Fair
				3/5/98	76	31	4.79	4.02	Good
				8/9/93	69	22	5.19	3.60	Good
				2/23/93	97	39	4.11	2.90	Excellent
Wet Cr	NC 24/27	Moore	17-26-5-5	7/9/03	---	24	---	4.70	Good
				3/5/98	---	24	---	3.26	Good
				2/23/93	---	34	---	3.95	Good
Bear Cr	NC 705	Moore	17-26-(6)	7/9/03	84	27	5.67	4.47	Good
				7/21/98	82	25	5.70	4.42	Good
				8/9/93	73	22	6.27	4.92	Good-Fair
Falls Cr	SR 1606	Moore	17-27	2/16/98	---	17	---	4.89	Not Rated
				2/23/93	---	18	---	4.61	Not Rated
Buffalo Cr	NC 22	Moore	17-28	7/9/03	---	20	---	4.88	Good-Fair
				2/16/98	---	27	---	3.90	Not Rated
				2/23/93	---	20	---	3.51	Not Rated
McLendons Cr	SR 1210	Moore	17-30	11/1/84	84	28	5.33	4.27	Not Rated
McLendons Cr	SR 1628	Moore	17-30	8/9/93	61	8	6.75	5.15	Not Rated
Haystack Cr	off SR 1261	Moore	17-30-1-2	3/6/86	63	21	4.86	2.72	Good
				2/14/84	65	25	4.20	2.31	Good
Big Governors Cr	SR 1625	Moore	17-32	2/16/98	45	11	6.64	5.44	Not Rated
				2/24/93	49	10	6.26	4.48	Not Rated
Crawley Cr	near SR 1625	Moore	17-32-2	2/11/98	---	10	---	5.47	Not Rated
UT Deep R	near SR 2140	Chatham	17-(33.5)	9/4/87	64	13	6.49	5.27	Good-Fair
Indian Cr	SR 2306	Chatham	17-35	3/1/93	---	10	---	5.17	Not Rated
				2/24/93	---	13	---	5.59	Not Rated
Deep	SR1007	Chatham	17-(36.5)	7/8/98	61	23	5.92	4.65	Good-Fair
				8/9/93	74	25	5.77	4.89	Good
				9/1/87	99	32	5.75	4.32	Good
030611									
L Pocket Cr	NC 42	Lee	11-37-4-(2)	2/3/98	---	14	---	4.56	Not Rated
				2/25/93	---	16	---	5.04	Not Rated
Cedar Cr	SR 2142	Chatham	17-39	2/3/98	---	16	---	4.87	Not Rated
				2/25/93	---	13	---	5.28	Not Rated
Big Buffalo Cr	SR 1403	Lee	17-40	8/9/93	---	4	---	6.19	Not Rated
				2/25/93	---	12	---	5.12	Not Rated
Georges Cr	SR 2142	Chatham	17-41	3/10/03	---	17	---	4.51	Not Rated
				2/25/93	---	15	---	4.83	Not Rated
Georges Cr	SR 2150	Chatham	17-41	2/3/98	---	4	---	4.25	Not Rated
Deep R	NC 15/501-NC 87	Chatham		7/8/98	72	21	6.38	4.96	Good-Fair
				8/11/93	78	27	5.94	4.69	Good
				9/1/87	88	25	6.09	4.62	Good-Fair
L Buffalo Cr	SR 1420	Lee	17-42	3/5/03	---	3	---	6.74	Not Rated
				2/25/93	---	5	---	7.08	Not Rated
UT Cape Fear R	off NC 42	Lee	18-(1)	3/12/03	8	3	5.87	4.26	Not Rated
030612									
Rocky R	US 64	Chatham	17-43-(8)	7/21/03	70	15	6.51	5.44	Not Rated
				7/9/98	78	17	6.42	4.63	Good-Fair
				6/27/97	76	20	6.74	5.72	Good-Fair
				7/27/93	69	12	6.94	5.68	Fair
				8/1/89	57	16	6.73	5.81	Fair
Rocky R	SR 2170	Chatham	17-43-(8)	7/22/03	72	15	5.87	4.99	Good-Fair
				9/30/02	---	8	---	4.87	Not Rated
				7/9/98	66	18	6.28	5.07	Good-Fair
				6/27/97	80	19	6.48	5.60	Good-Fair
				7/27/93	66	19	6.54	5.38	Good-Fair
				8/2/89	56	11	6.74	6.13	Fair
Rocky R	NC 902	Chatham	17-43-(8)	6/27/97	22	22	4.76	4.62	Good
				8/2/89	73	24	5.84	4.77	Good-Fair

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
UT Rocky R	SR 2158	Chatham	17-43-(8)	1/19/01	50	17	5.70	4.62	Not Impaired
Rocky R	US 15/501	Chatham	17-43-(8)	7/21/03	78	28	5.57	4.75	Good
				7/9/98	77	26	5.26	3.99	Good
				7/27/93	84	29	5.44	4.21	Good
				7/3/90	96	29	5.54	4.50	Good
Loves Cr	SR 1006	Chatham	17-43-10	6/23/03	39	3	7.63	7.10	Not Rated
Loves Cr	below Golf Course	Chatham	17-43-10	6/23/03	48	13	6.31	4.34	Not Rated
UT Loves Cr	Greensboro Rd	Chatham	17-43-10	6/23/03	36	4	7.32	6.43	Not Rated
Loves Cr	Second Ave	Chatham	17-43-10	6/24/03	50	7	7.14	6.42	Fair
Loves Cr	SR 2229 (WWTP Rd)	Chatham	17-43-10	6/24/03	48	7	7.37	6.95	Fair
				6/27/97	55	8	7.25	6.61	Fair
				8/1/89	52	7	7.50	6.85	Fair
Loves Cr	below outfall	Chatham	17-43-10	6/24/03	40	6	6.72	7.04	Fair
				6/27/97	36	4	7.41	6.06	Poor
Loves Cr	near SR 2203, below WWTP	Chatham	17-43-10	8/1/89	27	2	8.41	6.62	Poor
Meadow Cr	SR 2170	Chatham	17-43-12	6/25/03	67	14	6.96	6.32	Not Rated
Tick Cr	US 421	Chatham	17-43-13	2/3/98	18	18	4.86	4.81	Good-Fair
				7/27/93	---	5	---	6.57	Not Rated
				8/1/85	80	19	6.60	5.41	Good-Fair
Tick Cr	SR 2120	Chatham	17-43-13	7/22/03	61	20	6.46	5.93	Good-Fair
				7/9/98	---	15	---	5.93	Good-Fair
Landrum Cr	NC 902	Chatham	17-43-14	7/3/90	---	19	---	3.53	Good-Fair
Harlands Cr	NC 902	Chatham	17-43-15	7/21/03	---	16	---	4.97	Good-Fair
				7/10/98	---	23	---	4.45	Good
				2/3/98	---	22	---	4.68	Good-Fair
				7/3/90	---	15	---	3.85	Good-Fair
Bear Cr	SR 2333	Chatham	17-43-16	8/26/91	73	16	6.78	5.80	Not Rated
Bear Cr	SR 2189	Chatham	17-43-16	8/26/91	69	15	6.51	5.58	Not Rated
Bear Cr	SR 2155	Chatham	17-43-16	3/10/03	---	16	---	5.05	Not Rated
				7/3/90	---	15	---	4.86	Not Rated
030613									
Juniper Cr	SR 1144	Lee	18-20-6-(1)	11/30/88	---	9	---	4.20	Fair
Upper Little R	SR 1222	Harnett	18-20-(8)	7/22/03	61	17	6.25	5.60	Good-Fair
				7/13/98	72	21	6.38	5.26	Good-Fair
				8/10/93	56	13	6.16	4.81	Good-Fair
				12/28/88	77	19	5.94	4.22	Good-Fair
Upper Little R	NC 27	Harnett	18-20-(8)	7/13/98	81	27	5.51	3.92	Good
				8/10/93	81	26	5.51	3.85	Good
Barbeque Cr	SR 1209	Harnett	18-20-13	7/13/98	---	20	---	3.67	Good
				8/10/93	14	14	3.62	3.54	Good-Fair
				11/30/88	---	19	---	4.10	Good-Fair
Upper Little R	above SR 2016, above Becker mineral spill	Harnett	18-20-(24.5)	7/23/91	---	23	---	3.97	Good
Upper Little R	below SR 2016, below Becker mineral spill	Harnett	18-20-(24.5)	7/23/91	---	17	---	3.04	Good-Fair
Upper Little R	SR 2021	Harnett	18-20-(24.5)	7/13/98	88	35	5.13	3.69	Excellent
				8/10/93	67	25	5.35	3.87	Good
				7/23/91	---	25	---	3.47	Excellent
				7/12/88	83	27	5.26	3.79	Excellent
030614									
Nicks Cr	NC 22	Moore	18-23-3-(3)	7/23/03	---	15	---	4.76	Good-Fair
				7/15/98	---	23	---	3.98	Good
				8/24/93	---	20	---	3.25	Good
				11/28/88	---	22	---	2.99	Good
Lower Little R	SR 2023	Moore	18-23-(10.7)	1/21/03	---	22	---	3.56	Good-Fair
				10/2/02	---	13	---	2.64	Good-Fair
				7/14/98	75	31	4.70	3.56	Excellent
				8/24/93	70	33	4.55	3.24	Excellent
				4/23/90	---	35	---	3.94	Excellent
				12/28/88	85	35	4.38	2.64	Excellent

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
UT McDeeds Cr	off SR 2029	Moore	18-23-11-4	7/21/93	15	0	8.45	---	Not Rated
James Cr	near Weymouth Springs	Moore	18-23-13	3/5/86	49	11	5.01	2.99	Good
				2/23/84	55	16	4.46	2.68	Good
James Cr	near SR 2023	Hoke	18-23-13	4/20/90	---	24	---	3.94	Good
James Cr	at confluence with Little R	Moore	18-23-13	11/28/88	---	22	---	2.76	Good
Horse Cr	Manchester Rd	Hoke	18-23-14	4/19/90	---	18	---	3.40	Good-Fair
Flat Cr	Manchester Rd	Hoke	18-23-15	4/20/90	---	21	---	3.53	Good
				12/12/84	74	24	5.01	4.04	Good
Crane Cr	SR 1810	Moore	18-23-16	4/3/03	---	19	---	3.90	Good-Fair
				4/23/02	79	23	5.36	4.09	Good
Crane Cr	US 1	Moore	18-23-16	4/23/02	62	25	5.93	5.09	Good
Crane Cr	SR 2005	Moore	18-23-16	4/22/02	60	15	6.01	4.99	Good-Fair
Crane Cr	SR 2018	Moore	18-23-16	4/22/02	70	24	5.63	4.77	Good
Herds Cr	NC 24/27	Moore	18-23-16-3	4/23/02	69	26	5.15	4.12	Not Impaired
Little Crane Cr	NC 24/27	Moore	18-23-16-4	4/30/03	48	13	5.98	4.20	Not Rated
Little Crane Cr	off US 1	Moore	18-23-16-4	4/30/03	67	19	5.59	4.20	Good-Fair
Beaver Cr	SR 1825	Moore	18-23-16-8	4/23/02	58	17	6.15	4.89	Good-Fair
Cypress Cr	SR 1103	Harnett	18-23-16-10	4/22/02	59	14	5.55	3.62	Not Impaired
Deep Cr	NC 210	Hoke	18-23-17	4/19/90	---	13	---	3.65	Good-Fair
Mill Cr	SR 1853	Moore	18-23-17-1	7/11/00	---	26	---	3.78	Excellent
				7/21/98	68	30	4.84	3.52	Excellent
Jumping Run Cr	NC 210	Cumberland	18-23-20	7/14/98	---	26	---	4.09	Excellent
				8/24/93	---	16	---	3.25	Good-Fair
				4/19/90	---	13	---	4.37	Good-Fair
UT Sicily Drop Zone	Sicily Drop Zone	Cumberland	18-23-20	4/19/90	---	2	---	2.37	Not Rated
McPherson Cr	Manchester Rd	Cumberland	18-23-23.7	4/19/90	---	12	---	4.71	Good-Fair
Lower Little R	NC 87/24	Cumberland	18-23-(24)	7/14/98	83	40	4.80	3.72	Excellent
				8/23/93	63	18	5.62	4.48	Good-Fair
				7/12/90	73	19	6.11	4.80	Good-Fair
				7/12/88	50	7	7.23	5.24	Fair
				6/26/86	57	8	6.75	3.04	Fair
				9/26/84	81	25	5.35	3.74	Good
Lower Little R	US 401	Cumberland	18-23-(24)	7/14/98	87	38	4.65	3.96	Excellent
				8/23/93	70	26	5.07	3.90	Excellent
Anderson Cr	SR 2031	Harnett	18-23-32	7/23/03	---	20	---	3.78	Good
				9/19/00	58	20	4.75	3.01	Good
				7/14/98	---	18	---	3.62	Good-Fair
				8/24/93	---	13	---	2.95	Good-Fair
030615									
Cape Fear R	above Cross Cr	Cumberland	18-(26)	1/22/86	79	32	5.58	4.13	Good
Cape Fear R	below Cross Cr	Cumberland	18-(26)	1/22/86	82	24	6.10	4.10	Good-Fair
Cape Fear R	Person St	Cumberland	18-(26)	7/20/98	40	14	6.14	4.74	Not Rated
				8/18/93	48	19	5.36	4.61	Good-Fair
Cape Fear R	below Monsanto	Cumberland	18-(26)	1/22/86	78	28	5.78	4.46	Good
Cross Cr	above UT	Cumberland	18-27-(1)	4/20/90	---	7	---	5.04	Not Rated
Cross Cr	below UT	Cumberland	18-27-(1)	4/20/90	---	10	---	5.12	Not Rated
UT Cross Cr	Rosehill Rd	Cumberland	18-27-2-(2)	8/4/03					
Cross Cr	Country Club Rd	Cumberland	18-27-(2.5)	8/8/03					
Cross Cr	Langdon Rd	Cumberland	18-27-(3)	8/8/03					
Cross Cr	off NC 87/210, Green St	Cumberland	18-27-(3)	8/8/03	38	9	6.21	5.94	Good-Fair
L Cross Cr	above Glenville Lake nr Bragg Blvd	Cumberland	18-27-4-(1)	9/10/98	48	12	5.98	4.58	Not Rated
UT L Cross Cr	Above Glenville Lake	Cumberland	18-27-4-(1)	9/10/98	---	8	---	2.93	Not Impaired
L Cross Cr	US 401 Bypass	Cumberland	18-27-4-(1)	8/4/03					
L Cross Cr	below Glenville Lake	Cumberland	18-27-4-(2)	8/4/03	41	7	7.37	6.82	Fair
				3/3/98	37	7	6.90	6.09	Fair
Rockfish Cr	Chicken Rd	Hoke	18-31-(1)	7/17/01	---	20	---	3.23	Good
Rockfish Cr	Plank Rd	Hoke	18-31-(1)	4/23/90	---	16	---	3.78	Good-Fair

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Juniper Cr	Plank Rd	Hoke	18-31-10	10/23/03	---	15	---	3.22	
				4/23/90	---	19	---	3.85	Good
Pedler Br	NC 20	Hoke	18-31-16	2/1/90	36	2	8.29	6.33	Not Rated
Pedler Br	US 401	Hoke		2/1/90	16	0	8.46	---	Not Rated
Puppy Cr	Plank Rd	Hoke	18-31-19	10/23/03	---	10	---	3.39	Not Rated
				4/23/90	---	15	4.35	4.35	Good-Fair
Rockfish Cr	SR 1300	Hoke	18-32-(12)	5/19/94	66	25	5.10	4.08	Good
L Rockfish Cr	Plank Rd	Hoke	18-31-24-(1)	10/23/03	---	14	---	2.45	Not Rated
				4/24/90	---	12	3.50	3.50	Good-Fair
UT Bones Cr	near SR 1400	Cumberland	18-31-24-2	1/30/89	44	17	6.75	5.15	Not Rated
UT Bones Cr	below Sunset MHP	Cumberland	18-31-24-2	1/30/89	6	0	9.49	---	Not Rated
L Rockfish Cr	NC 59	Cumberland	18-31-24-(4)	9/3/03	---	23	---	4.48	Good
				7/20/98	---	22	---	4.06	Good
				8/25/93	---	23	---	3.97	Good
Buckhead Cr	off Glenwick Rd	Cumberland	18-31-24-6	5/5/97	39	1	7.68	6.22	Not Rated
L Rockfish Cr	SR 1131	Cumberland	18-31-24-(7)	6/13/90	---	13	---	4.78	Good-Fair
Rockfish Cr	SR 1432	Hoke	18-32-(23)	9/3/03	---	23	---	3.72	Good
				7/15/98	60	25	5.34	3.89	Good
				5/19/94	---	24	3.72	3.68	Good
				8/24/93	61	25	4.84	3.53	Good
				6/13/90	---	16	---	4.26	Good-Fair
Rockfish Cr	SR 1115	Cumberland	18-32-(23)	6/13/90	---	17	---	4.53	Good-Fair
				5/19/94	76	23	5.40	3.80	Good
Rockfish Cr	US 301 Bus	Cumberland	18-32-(23)	7/27/83	60	25	5.03	4.11	Excellent
Rockfish Cr	I-95	Cumberland	18-32-(23)	6/13/90	---	24	---	4.16	Excellent
				7/11/88	77	31	5.17	4.14	Excellent
Rockfish Cr	NC 87	Cumberland	18-32-(23)	7/15/98	68	32	4.56	3.82	Excellent
				8/25/93	60	23	4.95	3.65	Good
030616									
Cape Fear R	SR 1355	Bladen	18-(26)	8/3/98	48	16	6.74	5.82	Good-Fair
				8/12/93	50	10	6.37	4.69	Fair
Cape Fear R	above Carolina Foods	Bladen	18-(26)	9/9/92	47	14	6.19	4.73	Good-Fair
Cape Fear	SR 1316	Bladen	18-(26)	9/9/92	45	11	6.56	4.77	Fair
				6/24/87	41	7	7.24	5.22	Fair
Cape Fear R	below Lock #2	Bladen	18-(26)	8/3/98	39	14	6.57	5.37	Good-Fair
				8/12/93	53	15	6.74	4.91	Good-Fair
Harrison Cr	SR 1318	Bladen	18-42	8/23/03	---	14	---	3.91	Good-Fair
				8/4/98	17	17	3.39	3.39	Good-Fair
				8/26/93	---	11	---	3.62	Fair
Ellis Cr	NC 53	Bladen	18-44	8/26/03	---	15	---	3.88	Good-Fair
				8/3/98	---	16	---	3.93	Good-Fair
				8/26/93	---	16	---	3.88	Good-Fair
Browns Cr	NC 87	Bladen	18-45	2/20/03	63	15	6.58	5.1	Not Rated
Turnbull Cr	NC 242	Bladen	18-46	11/17/99	25	5	6.14	5.80	Not Rated
Turnbull Cr	SR 1511	Bladen	18-46	8/26/03	---	14	---	4.00	Good-Fair
				8/4/98	---	18	---	3.96	Good
Cape Fear R	SR 1730	Bladen	18-(53.5)	8/4/98	49	15	6.72	4.82	Good-Fair
				8/11/93	48	11	6.51	4.62	Fair
				8/8/90	44	12	7.42	4.28	Fair
				7/11/88	69	12	7.14	6.35	Fair
				6/25/86	51	6	7.25	6.83	Fair
				6/9/84	52	7	7.20	5.66	Fair
030617									
Cape Fear R	above Federal Paper	Pender	18-(59)	7/21/98	51	13	6.36	5.06	Excellent
				8/10/93	45	8	6.61	4.81	Good-Fair
Cape Fear R	below Federal Paper	Pender	18-(63)	7/21/98	34	4	7	5.21	Fair
				8/10/93	32	5	7.21	5.34	Fair
UT Cape Fear R (be landfill)	Sampson St at RR Tracks	New Hanover	18-(63)	5/1/01	19	0	8.74	---	Not Rated

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Livingston Cr	US 74	Columbus	18-64	9/4/03	57	16	5.93	5.37	Good-Fair
				7/20/98	83	20	6.30	5.31	Good-Fair
				8/9/93	68	9	7.30	5.50	Fair
Livingston Cr	off SR 1878, above Wright	Columbus	18-64	8/16/90	39	4	7.07	4.00	Not Rated
Livingston Cr	off SR 1878, below Wright	Columbus	18-64	8/16/90	24	0	7.97	-	Not Rated
Hood Cr	US 74/76	Brunswick	18-66	2/25/03	42	12	6.16	5.13	Moderate
				11/17/99	---	16	---	5.31	Not Rated
				9/21/98	54	13	6.09	4.68	Not Rated
				7/20/98	---	18	---	3.66	Not Rated
				3/4/98	69	20	6	4.78	Natural
Jumping Run Br	17th St above pond	New Hanover	18-76-1-3	9/28/94	43	3	7.52	6.96	Not Rated
Jumping Run Br	16th St below Pond	New Hanover	18-76-1-3	9/28/94	58	4	7.46	7.11	Not Rated
Barnards Cr	US 421	New Hanover	18-80	2/12/03	30	4	7.23	6.83	Moderate
				2/19/98	44	5	7.70	6.57	Moderate
Town Cr	above SR 1413	Brunswick	18-81	11/17/99	---	17	---	5.79	Not Rated
				2/18/99	77	23	6.01	4.78	Natural
				9/21/98	62	16	6.08	4.34	Not Rated
				7/21/98	24	15	5.22	5.02	Not Rated
				3/4/98	71	24	5.87	4.79	Natural
Lewis Swp	SR 1410	Brunswick	18-81-2	2/25/03	55	12	6.60	5.09	Natural
				3/4/98	63	14	6.36	5.05	Natural
Beaverdam Cr	above Upper Trib	Brunswick	18-88-9-1-(0.5)	3/18/99	40	13	6.32	5.51	Not Rated
Beaverdam Cr	below Upper Trib	Brunswick	18-88-9-1-(0.5)	3/18/99	40	12	6.56	5.90	Not Rated
Beaverdam Cr	Player Club Rd	Brunswick	18-88-9-1-(0.5)	3/18/99	40	15	5.52	4.54	Not Rated
UT Beaverdam Cr	off NC 211	Brunswick	18-88-9-1-(0.5)	3/18/99	28	8	5.74	4.49	Not Rated
Jump and Run Cr	off NC 211	New Hanover	18-88-9-3-2	3/17/99	23	4	6.84	5.06	Not Rated
Jump and Run Cr	above NC 133 & Shopping Ctr	New Hanover	18-88-9-3-2	5/17/95	43	9	6.28	4.08	Not Rated
Jump and Run Cr	below NC 133 & Shopping Ctr	New Hanover	18-88-9-3-2	5/17/95	28	1	7.73	4.10	Not Rated
030618									
South R	NC 13	Sampson	18-68-12 (0.5)	10/17/89	---	5	---	5.78	Not Rated
South R	NC 242	Sampson	18-68-12 (0.5)	10/19/89	---	26	---	3.91	Excellent
South R	SR 1502	Bladen	18-68-12 (0.5)	10/9/02	---	12	---	4.40	Fair
				8/4/98	68	25	5.91	4.46	Good
				8/25/93	75	25	5.36	3.75	Good
				6/7/87	84	29	5.46	3.85	Excellent
				9/4/85	93	30	5.49	3.81	Excellent
				7/26/83	76	25	5.49	4.16	Good
Black R	SR 1780	Harnett	18-68-12-1	7/8/84	53	13	6.79	5.93	Fair
Black R	US 421	Harnett	18-68-12-1	10/17/89	---	11	---	5.47	Not Rated
Mingo Swp	NC 55	Harnett	18-68-12-2	8/3/94	18	0	7.78	---	Poor
Mingo Swp	US 421	Harnett	18-68-12-2	8/3/94	50	10	7.28	6.33	Fair
Beaverdam Swp	SR 1005	Sampson	18-68-12-2-4-1	6/1/98	---	6	---	5.22	Not Rated
Big Cr	SR 1851	Cumberland	18-68-12-5	6/1/98	---	12	---	4.69	Good-Fair
Big Swp	SR 1246	Sampson	18-68-12-8	12/7/89	---	14	---	5.38	Good-Fair
030619									
Black R	NC 411	Sampson	18-68	10/9/02	---	26	---	4.33	Excellent
				10/29/98	58	19	5.70	4.50	Good
				8/5/98	77	30	5.42	4.35	Excellent
				8/23/93	96	31	5.49	3.92	Excellent
				10/18/89	---	31	---	3.67	Excellent
				7/12/88	107	37	5.51	4.26	Excellent
				9/4/85	94	30	5.33	3.98	Excellent

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Great Coharie Cr	SR 1214	Sampson	18-68-1	8/5/98	39	12	5.88	4.06	Good-Fair
				8/23/93	77	26	5.51	4.23	Good
				10/19/89	---	19	---	4.53	Good
				9/27/88	69	20	5.89	4.47	Good
				7/27/83	62	19	5.53	3.66	Good-Fair
L Coharie Cr	NC 24	Sampson	18-68-1-17	8/23/93	---	20	---	4.69	Good
L Coharie Cr	SR 1207	Sampson	18-68-1-17	9/27/88	---	17	---	3.94	Good-Fair
L Coharie Cr	SR 1214	Sampson	18-68-1-17	9/17/03	---	18	---	3.93	Good
				8/5/98	---	16	---	4.41	Good-Fair
				8/23/93	---	17	---	4.08	Good-Fair
				10/17/89	---	23	---	3.86	Good
Six Runs Cr	SR 1003	Sampson	18-68-2	9/27/88	---	25	---	4.07	Excellent
Six Runs Cr	SR 1004	Sampson	18-68-2	11/20/96	---	9	---	5.43	Fair
				12/7/89	---	21	---	3.78	Good
Six Runs Cr	SR 1130	Sampson	18-68-2	10/18/89	---	26	---	3.39	Excellent
Six Runs Cr	SR 1960	Sampson	18-68-2	9/17/03	---	21	---	4.54	Good
				9/21/98	13	13	5.49	5.49	Good-Fair
				8/5/98	---	23	---	4.78	Good
				8/23/93	28	28	3.52	3.39	Excellent
Tenmile Swp	SR 1740	Sampson	18-68-2-4	12/17/86	58	6	7.45	5.92	Fair
Stewarts Cr	SR 1943	Sampson	18-68-2-10	8/26/03	---	20	---	5.05	Good
				3/5/03	86	20	6.06	5.32	Good-Fair
				11/20/96	8	8	5.20	5.20	Fair
				12/7/89	17	17	4.73	4.73	Good-Fair
UT Stewarts Cr	SR 1107	Duplin	18-68-2-10-1	4/11/00	38	1	6.97	2.52	Not Rated
UT Millers Cr	below Magnolia WWTP	Duplin	18-68-2-10-3	4/11/00	34	1	8.40	7.41	Not Rated
Crane Cr	SR 1004	Sampson	18-68-2-12	6/1/98	---	14	---	5.16	Good-Fair
030620									
Black R	NC 11	Bladen	18-68	7/20/98	92	30	5.84	4.50	Excellent
				8/11/93	73	28	5.52	4.12	Good
				9/5/91	100	28	5.79	4.16	Good
				8/8/90	48	18	6.19	4.56	Good-Fair
				10/18/89	28	28	3.89	3.89	Excellent
				9/27/88	72	22	5.59	4.09	Good
				6/25/86	78	23	6.18	4.71	Good-Fair
Moores Cr	SR 1128	Pender	18-68-18	2/26/03	38	10	6.89	6.6	Moderate
Moores Cr	NC 53	Pender	18-68-18	3/17/98	41	11	6.65	5.29	Moderate
White Oak Br	SR 1209	Pender	18-68-18-5	12/10/87	---	7	---	5.01	Good-Fair
Lyons Swp Canal	NC 11	Bladen	18-68-22-1-1	3/17/98	36	5	7.37	7.1	Not Rated
030621									
NE Cape Fear R	NC 403	Duplin	18-74-(1)	5/17/93	68	13	6.96	5.27	Good-Fair
NE Cape Fear R	SR 1937	Wayne	18-74-(1)	5/17/93	54	4	7.85	6.84	Not Rated
NE Cape Fear R	SR 1948	Wayne	18-74-(1)	5/17/93	67	15	6.16	4.88	Good-Fair
NE Cape Fear R	SR 1937	Wayne	18-74-(2)	6/30/86	13	0	8.08	---	Not Rated
Barlow Br	Bell St	Wayne	18-74-2	5/17/93	26	0	8.86	---	Not Rated
				6/30/86	8	0	9.63	---	Not Rated
Polly Run Cr	SR 1501	Duplin	18-74-5	7/2/86	67	11	6.70	5.52	Fair
Buck Marsh Br	NC 111	Duplin	18-74-8	8/25/93	16	16	3.84	3.84	Good-Fair
Grove Cr	NC 11	Duplin	18-74-21	3/26/01	76	19	6.22	4.88	Natural
				5/3/94	63	9	6.99	5.05	Not Rated
	SR 1301	Duplin	18-74-21	3/26/01	78	14	6.72	5.65	Moderate
				5/3/94	61	13	6.35	4.79	Not Rated
030622									
Goshen Swp	NC 403	Duplin	18-74-19	5/19/93	56	10	6.67	5.57	Not Rated
Goshen Swp	SR 1302	Duplin	18-74-19	5/19/93	62	8	6.66	5.30	Not Rated
Goshen Swp	SR 1725	Sampson	18-74-19	2/19/03	42	4	8.00	6.58	Severe
Goshen Swp	US 117	Duplin	18-74-19	5/18/93	51	11	6.68	5.44	Not Rated
Panther Br	below confl w/ discharge	Duplin	18-74-19-3	5/18/93	35	1	8.25	6.20	Not Rated
Panther Br	below Cates pickle effluent	Duplin	18-74-19-3	12/17/86	10	0	8.05	---	Not Rated
	NC 50, above Cates pickle effluent	Duplin	18-74-19-3	12/17/86	64	11	6.59	5.10	Not Rated

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Halls Marsh	SR 1306	Duplin	18-74-19-11	9/20/96	---	4	---	5.51	Not Rated
				9/12/95	67	13	6.55	5.53	Not Rated
				9/1/94	76	9	6.82	5.23	Not Rated
				9/20/93	68	12	6.55	5.27	Not Rated
				9/28/92	69	9	6.36	4.98	Not Rated
				9/20/91	54	7	6.55	4.88	Not Rated
				9/25/90	68	11	6.56	4.92	Not Rated
Herrings Marsh Run	SR1306	Duplin	18-74-19-16	9/20/96	48	4	7.03	6.68	Not Rated
				9/12/95	55	9	6.61	5.50	Not Rated
				9/1/94	69	8	7.32	5.77	Not Rated
				9/20/93	71	15	7.02	5.45	Not Rated
				9/28/92	72	13	6.58	5.13	Not Rated
				9/20/91	67	11	6.13	4.87	Not Rated
				9/25/90	74	10	6.79	5.44	Not Rated
				1/4/90	---	13	---	5.12	Not Rated
Herrings Marsh Run	SR 1508	Duplin	18-74-19-16	9/20/93	---	0	---	---	Not Rated
				9/28/92	---	8	---	4.94	Not Rated
				9/20/91	---	14	---	4.43	Not Rated
UT Herrings Marsh Run	SR 1508	Duplin	18-74-19-16	9/20/93	8	8	4.89	4.89	Not Rated
Grove Cr	SR 1376	Duplin	18-74-21	9/25/90	62	15	6.29	4.61	Good-Fair
Maxwell Cr	SR 1921	Duplin	18-74-21-1	6/11/85	55	5	6.89	5.52	Fair
Limestone Cr	NC 111	Duplin	18-74-23	7/14/95	---	3	---	6.64	Not Rated
Limestone Cr	NC 24	Duplin	18-74-23	4/23/86	35	1	7.36	6.23	Poor
Limestone Cr	SR 1702	Duplin	18-74-23	9/17/03	---	12	---	4.79	Good-Fair
				8/5/98	---	14	---	4.85	Good-Fair
				7/14/95	---	4	---	5.48	Poor
				8/25/93	---	26	---	4.50	Excellent
Stockinghead Cr	SR 1953	Duplin	18-74-24	9/17/03	---	16	---	5.13	Good-Fair
				8/5/98	---	12	---	4.72	Good-Fair
				8/25/93	13	13	4.52	3.99	Good-Fair
Beaverdam Br	SR 1915	Duplin	18-74-24-1-1	4/27/87	20	0	9.07	---	Poor
				6/11/85	38	0	8.91	---	Poor
UT Beaverdam Cr	SR 1916	Duplin	18-74-24-1-1	4/27/87	49	4	6.90	5.05	Not Rated
Cabin Br	SR 1911	Duplin	18-74-24-1-1-1	4/27/87	37	0	8.14	---	Poor
				6/11/85	48	2	8.72	8.94	Poor
Cabin Cr	SR 1700	Duplin	18-74-24-1-1-1	7/21/95	---	3	---	6.20	Poor
Muddy Cr	NC 41	Duplin	18-74-25	8/4/03	8	8	6.36	6.36	Fair
				8/12/98	8	8	5.37	5.37	Fair
				8/24/93	4	4	5.59	5.59	Not Rated
NE Cape Fear R	NC 11/903	Duplin	18-74-(25.5)	8/6/98	---	17	---	5.49	Good-Fair
				8/25/93	78	23	5.33	3.86	Excellent
				7/2/86	32	8	5.47	4.34	Fair
NE Cape Fear R	NC 41	Duplin	18-74-(25.5)	9/22/98	40	3	7.00	4.48	Poor
				8/5/98	70	29	5.66	4.93	Good
				8/24/93	82	22	5.43	4.57	Good
				10/26/89	85	28	5.74	3.95	Good
				10/26/89	---	26	---	4.17	Excellent
				8/9/89	83	30	5.40	4.17	Excellent
				8/9/89	---	27	---	4.07	Excellent
				9/4/85	89	31	5.65	4.00	Excellent
Persimmon Br	off SR 1801 above Beulaville WWTP	Duplin	18-74-25-1	9/26/90	45	4	6.98	6.62	Not Rated
	off SR 1801 below Beulaville WWTP	Duplin	18-74-25-1	9/26/90	31	0	7.53	---	Not Rated
Rockfish Cr	SR 1165	Duplin	18-74-29	9/3/03	62	17	6.19	5.39	Good-Fair
				8/6/98	44	8	6.87	5.39	Fair
				8/24/93	81	14	6.31	4.79	Good-Fair

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Rockfish Cr	I-40	Duplin	18-74-29	9/3/03	59	12	6.63	5.39	Good-Fair
				10/29/98	50	6	7.30	6.02	Fair
				8/7/98	62	16	6.97	5.85	Good-Fair
				8/24/93	64	12	6.83	5.26	Fair
Rockfish Cr	NC 41	Duplin	18-74-29	7/12/88	79	17	6.47	4.84	Good-Fair
L Rockfish Cr	NC 11	Duplin	18-74-29-6	2/19/03	36	4	7.33	6.31	Not Rated
				5/3/94	24	0	8.27	---	Not Rated
				9/28/92	7	7	5.22	5.22	Not Rated
				9/20/91	2	2	5.68	5.68	Not Rated
030623									
NE Cape Fear R	above NC 53	Pender	18-74-(29.5)	5/5/94	47	10	7.16	5.45	Not Rated
NE Cape Fear R	below NC 53	Pender	18-74-(29.5)	5/5/94	42	6	6.53	5.02	Not Rated
NE Cape Fear R	near Watha	Pender	18-74-(29.5)	7/27/83	44	5	7.29	4.81	Poor
NE Cape Fear R	White Stocking Ramp	Pender	18-74-(29.5)	5/5/94	40	9	6.91	5.39	Not Rated
Holly Shelter Cr	NC 50	Pender	18-74-33	3/5/03	48	8	7.13	6.49	Moderate
Sandy Run Swp	NC 50	Onslow	18-74-33-2	11/17/93	36	2	7.27	6.34	Not Rated
				8/17/93	31	0	7.41	---	Not Rated
				5/4/93	42	5	6.59	4.89	Not Rated
				3/2/93	38	8	6.40	4.86	Not Rated
Shelter Swp	NC 50	Onslow	18-74-33-2-2	2/19/99	31	5	6.49	5.90	Natural
				3/16/98	28	3	6.75	5.92	Natural
Angola Cr	NC 53	Pender	18-74-33-3	9/4/03	20	20	5.47	5.47	Good
				7/22/98	35	9	6.75	6.24	Not Rated
				11/17/93	56	9	6.33	4.70	Not Rated
				11/17/93	62	10	6.39	4.82	Not Rated
				8/16/93	52	11	6.01	4.33	Not Rated
				5/5/93	68	17	6.23	4.93	Not Rated
				2/17/93	61	18	6.20	5.12	Not Rated
Juniper Swp	NC 50	Onslow	18-74-33-4-2	3/16/98	22	2	6.68	6.21	Natural
				2/25/97	19	1	7.00	6.20	Moderate
				11/17/93	30	2	6.90	6.30	Not Rated
				8/17/93	25	1	7.30	4.46	Not Rated
				5/5/93	34	2	7.07	5.90	Not Rated
				2/17/93	44	5	7.02	5.85	Not Rated
Burgaw Cr	above WWTP at old RR	Pender	18-74-39	12/10/87	37	0	8.85	---	Not Rated
Burgaw Cr	US 117	Pender	18-74-39	12/10/87	14	0	9.44	---	Not Rated
Burgaw Cr	I-40	Pender	18-74-39	7/22/98	40	5	7.19	6.11	Poor
				3/13/98	34	5	7.33	6.46	Poor
Lillington Cr	SR 1520	Pender	18-74-42	2/10/03	41	12	6.24	4.68	Natural
				2/24/97	33	7	5.98	4.74	Moderate
Merricks Cr	NC 210	Pender	18-74-49-2	2/11/03	43	12	5.74	5.51	Natural
				2/19/99	58	15	6.47	5.46	Natural
				3/19/98	43	10	6.21	5.00	Natural
				2/24/97	43	12	6.01	4.65	Moderate
				11/16/93	53	11	6.61	5.50	Not Rated
				11/16/93	52	11	6.49	5.50	Not Rated
				5/4/93	51	13	6.12	4.42	Not Rated
				2/17/93	52	16	6.32	5.20	Natural
Island Cr	SR 1336	New Hanover	18-74-51	02/11/03	24	4	7.01	6.54	Not Rated
NE Cape Fear R	US 117	New Hanover	18-74-(52.5)	7/22/98	44	9	6.40	5.26	Good
				8/9/93	38	7	6.93	4.84	Good-Fair
				6/26/90	45	7	6.51	5.26	Good-Fair
				6/24/87	41	6	7.32	5.34	Fair
				8/11/85	42	5	7.05	3.97	Fair
Long Cr	NC 53	Pender	18-74-55	2/10/03	31	0	7.92	---	Severe
				3/13/98	30	2	6.82	7.00	Not Rated
Cypress Cr	NC 53	Pender	18-74-55-2	2/10/03	54	3	7.93	7.76	Moderate
				3/17/98	53	9	7.36	5.88	Moderate
				3/2/93	---	9	---	5.88	Not Rated

Appendix 18 (continued).

Subbasin/ Waterbody	Location	County	Index No.	Date	Total S	EPT	BI	EPT BI	BioClass
Smith Cr	I-40	New Hanover	18-74-63	2/26/03	30	1	7.43	6.20	Severe
Burnt Mill Cr	Forest Hills Dr	New Hanover	18-74-63-2	3/28/01	34	2	7.84	6.49	Poor
Burnt Mill Cr	Metts Ave	New Hanover	18-74-63-2	7/21/98	11	4	7.36	6.25	Poor
				2/19/98	40	5	7.98	6.67	Moderate
030624									
Hewletts Cr	Pine Grove Rd	New Hanover	18-87-26	2/26/03	32	6	7.12	5.95	Moderate
				7/21/98	13	5	6.16	6.10	Not Rated
				2/19/98	41	6	7.12	5.95	Moderate
UT Hewletts Cr	100 m above pond	New Hanover	18-87-26	9/28/94	26	1	6.82	6.22	Not Rated
UT Hewletts Cr	Beasley Rd below pond	New Hanover	18-87-26	9/28/94	37	1	7.22	6.22	Not Rated

Appendix 19. Water quality measurements at benthic macroinvertebrate basinwide sites in the Cape Fear River basin, 2002 – 2003.

Subbasin/ Waterbody	Location	County	Date	Temperature (ºC)	Specific conductance (µmhos/cm)	Dissolved oxygen (mg/L)	pH (s.u.)
03-06-01							
Haw R	NC 87	Alamance	9/15/03	21	118	7.7	7.6
Troublesome Cr	SR 2422	Rockingham	4/9/02	15	74	7.9	7.1
L Troublesome Cr	SR 2600	Rockingham	8/26/03	22	112	6.8	7.1
03-06-02							
Reedy Fk	SR 2128	Guilford	7/10/03	23	89	7.1	7.3
Brush Cr	SR 2136	Guilford	6/19/03	23	89	7.1	7.2
Horsepen Cr	US 220	Guilford	7/10/03	24	126	6.4	7.2
Reedy Fk	SR 2728	Guilford	7/11/03	27	83	6.2	7.3
N. Buffalo Cr	SR 2832	Guilford	7/10/03	27	252	6.2	7.2
S. Buffalo Cr	US 70	Guilford	7/11/03	25	224	6.3	7.3
S. Buffalo Cr	SR 2821	Guilford	7/11/03	26	776	5.8	7.9
Stony Cr	SR 1100	Caswell	7/10/03	23	123	7.0	7.5
Jordan Cr	SR 1002	Alamance	8/26/03	24	94	7.0	7.1
Haw Cr	SR 2158	Alamance	7/7/03	23	107	6.9	7.1
03-06-03							
Big Alamance Cr	NC 49	Alamance	8/26/03	27	88	5.8	7.6
Stinking Quarter Cr	SR 1136	Alamance	11/21/03	11	110	9.8	6.1
Little Alamance Cr	SR 2309	Alamance	6/03/03	19	181	6.8	7.7
03-06-04							
Haw R	SR 1005	Alamance	10/03/03	24	428	7.1	7.6
Marys Cr	SR 2174	Alamance	7/15/03	22	82	7.9	7.5
Cane Cr	SR 1114	Orange	8/14/03	25	75	8.1	7.0
Collins Cr	SR 1539	Chatham	7/15/03	23	86	6.8	---
Terrells Cr	SR 1520	Chatham	11/21/03	12	128	9.0	6.6
Dry Cr	SR 1520	Chatham	11/21/03	11	120	9.2	6.4
Haw R	US 64	Chatham	10/03/03	24	506	7.4	7.4
Pokeberry Cr	SR 1711	Chatham	7/15/03	26	86	7.8	---
03-06-05							
New Hope Cr	SR 1107	Durham	7/7/03	25	210	5.3	7.8
03-06-06							
Morgan Cr	Finley Rd	Orange	7/7/03	25	237	6.6	7.4
03-06-07							
Parkers Cr	SR 1450	Harnett	4/30/03	22	109	7.5	6.8
Neills Cr	SR 1441	Harnett	3/12/03	8.0	64	10.0	6.2
Kenneth Cr	SR 1441	Harnett	3/10/03	12	82	8.6	5.9
Cape Fear R	US 401	Harnett	1/21/03	5.8	110	12.8	7.6
03-06-08							
W Fk Deep R	SR 1850	Guilford	7/7/03	22	79	7.3	7.4
Deep R	US 220 Bus	Randolph	7/22/03	25	187	7.6	7.5
Richland Cr	SR 1145	Guilford	7/7/03	24	255	6.9	7.1
Muddy Cr	SR 1929	Randolph	7/8/03	23	109	7.1	7.5
03-06-09							
Deep R	SR 2615	Randolph	7/22/03	26	157	7.0	7.3
Sandy Cr	SR 2481	Randolph	7/8/03	23	103	7.9	7.3
Richland Cr	SR 2873	Randolph	7/8/03	27	78	7.3	7.7
Brush Cr	NC22/27	Randolph	7/8/03	26	96	6.7	7.4
03-06-10							
Deep R	SR 1456	Moore	7/22/03	28	128	7.1	7.2
Mill Cr	SR 1275	Moore	7/9/03	26	53	7.5	---
Wet Cr	NC 24/27	Moore	7/9/03	24	37	7.8	---
Bear Cr	NC 705	Moore	7/9/03	25	59	6.0	6.9
Buffalo Cr	NC 22	Moore	7/9/03	25	77	6.6	7.2
03-06-11							
Georges Cr	SR 2142	Chatham	03/10/03	12	62	8.8	7.8
L Buffalo Cr	SR 1420	Lee	03/05/03	12	144	10.6	7.1
03-06-12							
Rocky R	US 64	Chatham	7/21/03	26	81	5.4	6.9
Rocky R	SR 2170	Chatham	7/22/03	27	201	6.0	7.3
Rocky R	US 15/501	Chatham	7/21/03	30	130	10.1	8.4
Tick Cr	SR 2120	Chatham	7/22/03	24	140	6.7	7.3
Harlands Cr	NC 902	Chatham	7/21/03	24	91	6.5	7.2
Bear Cr	SR 2155	Chatham	3/10/03	---	---	--	7.8

Appendix 19 (continued).

Subbasin/ Waterbody	Location	County	Date	Temperature (ºC)	Specific conductance (µmhos/cm)	Dissolved oxygen (mg/L)	pH (s.u.)
03-06-13							
Upper Little R	SR 1222	Harnett	7/22/03	29	53	4.5	6.7
03-06-14							
Nicks Cr	NC 22	Moore	7/23/03	25	25	4.5	5.3
Lower Little R	SR 2023	Moore	1/21/03	4.5	39	12.9	6.2
Anderson Cr	SR 2031	Harnett	7/23/03	24	---	6.1	5.9
03-06-15							
Cross Cr	NC 87/210/24	Cumberland	08/0803	18	54	9.1	7.3
L Rockfish Cr	NC 59	Hoke	09/03/03	14	112	8.6	5.7
Rockfish Cr	SR 1432	Hoke	09/3/03	24	33	6.2	6.2
03-06-16							
Harrison Cr	SR 1318	Bladen	8/26/03	23	64	4.6	4.4
Ellis Cr	NC 53	Bladen	8/26/03	24	52	5.0	4.4
Browns Cr	NC 87	Bladen	2/21/03	8.5	148	11.7	---
Turnbull Cr	SR 1518	Bladen	8/26/03	25	61	4.5	4
03-06-17							
Livingston Cr	NC 74	Columbus	9/4/03	28	142	3.9	6.7
Hood Cr	US 74/76	Brunswick	2/25/03	13	65	9.8	---
Barnards Cr	US 421	New Hanover	2/12/03	8.8	224	7.5	6.8
Lewis Swp	SR 1410	Brunswick	2/25/03	15	54	10.5	5.3
03-06-19							
Black R	NC 411	Sampson	10/9/02	23	157	7.0	6.2
L Coharie Cr	SR 1214	Sampson	9/17/03	23	81	7.0	6.4
Six Runs Cr	SR 1960	Sampson	9/17/03	22	121	7.6	6.9
03-06-20							
Moores Cr	SR 1128	Pender	2/26/03	11	71	10.4	5.7
03-06-22							
Goshen Swp	SR 1725	Sampson	2/19/03	7.0	137	11.7	6.2
Limestone Cr	SR 1702	Duplin	9/17/03	22	85	8.0	6.3
Stockinghead Cr	SR 1953	Duplin	9/17/03	23	120	7.4	6.6
Muddy Cr	NC 41	Duplin	8/4/03	25	124	---	--
Rockfish Cr	SR 1165	Duplin	9/3/03	27	173	2.1	6.4
Rockfish Cr	I 40	Duplin	9/3/03	28	118	4.1	6.5
Little Rockfish Cr	NC 11	Duplin	2/19/03	7.4	76	12.3	---
03-06-23							
Angola Cr	NC 53	Pender	9/4/03	27	104	1.9	6.4
Lillington Cr	SR 1520	Pender	2/10/03	8.7	76	10.9	5.2
Merricks Cr	NC 210	Pender	2/11/03	6.1	73	9.6	4.8
Island Cr	SR 1336	New Hanover	2/11/03	7.9	82	8.5	4
Long Cr	NC 53	Pender	2/10/03	9.0	140	11.6	6.2
Cypress Swp	NC53	Pender	2/10/03	7.7	119	10.0	---
Smith Cr	Above I-40	New Hanover	2/26/03	11	138	10.3	6.3
03-06-24							
Hewletts Cr	Pine Grove Rd	New Hanover	2/26/03	11	203	9.7	---

Appendix 20. New species and distributional records for EPT taxa of the Cape Fear River basin.

Ephemeroptera:

- *Siphlonurus* sp.: collected from Kenneth and Avents Creeks (Harnett County). Since 1983, this organism has been collected approximately 58 times.
- *Stenonema lenati*: collected from the Deep River (US 220 and SR 1456, Randolph County). This species has been collected 78 times. This species is generally restricted to streams located near the Fall Line of the Piedmont.
- *Stenonema vicarium*: collected from Morgan Creek (Orange County). Since 1983, this species has been collected on approximately 52 occasions. Generally considered a Carolina Slate Belt indicator.
- *Eurylophella prudentalis*: a rare species of a widespread genus. Collected from Lillington Creek (Pender County) and Lewis Swamp (Brunswick County). This species has been collected only 15 times since 1983.

Plecoptera:

- *Isoperla richardsoni*: an extremely rare species of a widespread genus. Collected from Crane Creek (Moore County). Represents only the third collection of this species since 1983.
- *Perlinella drymo*: collected from Little Rockfish Creek (Cumberland County). Since 1983, this species has been collected 55 times.
- *Helopicus bogaloosa*: collected from Hector Creek (Harnett County). This intolerant species has been collected 30 times since 1983.
- *Haploperla sp. nov*:: adult and larvae to be described by Dr. Boris Kondratieff (Colorado State University). Collected from Lower Little River (Moore County).

Trichoptera:

- *Rhyacophila lobifera*: rare species of a widespread genus. Collected from Moores Creek (Pender County). Represents only the seventh collection of this species since 1983. Restricted to high quality swamps.
- *Triaenodes mela*: rare species of a very widespread genus. Collected from Kit Creek (Wake County). Only the fourth collection of this species since 1983.
- *Triaenodes marginatus*: another rare species of a very widespread genus. Collected from Bear Creek (Chatham County). Since 1983, this species has been collected on only nine occasions.
- *Ceraclea enodis*: rare species of a widespread genus. Collected from Tick Creek (Chatham County). Collected 10 times since 1983.
- *Ceraclea excisa*: a fairly rare species of a widespread genus. Collected from the Lower Little River (Moore County). Since 1983, this species has been collected 21 times.
- *Ceraclea resurgens*: another rare species of this widespread genus. Collected from Lillington Creek (Pender County). This species has been collected approximately 32 times since 1983.
- *Molanna tryphena*: collected from Ellis Creek (Bladen County). This species is generally restricted to high-quality swamp areas. Since 1983, this species has been collected 45 times.
- *Brachycentrus chelatus*: a rare species of a fairly widespread genus. Restricted to the Sand Hills ecoregion. Collected from Rockfish Creek (Hoke County). This species has been collected 31 times since 1983.
- *Micrasema rusticum*: collected from Hector and Avents Creeks (Harnett County). This species has been collected 34 times since 1983.
- *Matrioptila jeanae*: collected from Sandy Creek (Randolph County). A very rare species and collected on only 13 occasions since 1983. This collection represents a significant range extension as this species was previously restricted to the mountains.

Appendix 21. Lake assessment program.

Lakes Monitored

Thirty-three lakes in the Cape Fear River basin were monitored as part of the Lakes Assessment program in 2003. The morphological data related to these lakes is presented in Table 1. Surface physical data and photic zone chemistry data collected at these lakes from 1998 through 2003 are presented in Appendix 22.

Sampling Methods

Monitoring stations are sited to provide representative samples of lake water quality based on morphology, size, and site-specific features such as coves and tributaries. Dissolved oxygen, pH, water temperature, and conductivity) are made with a calibrated Hydrolab™. Readings are taken at the surface (0.15 meters) and at one-meter increments to the bottom. Secchi depth is measured at each 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 Labline™ 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. The sampler is also used to collect a sample near the bottom for nutrients. Samples are collected and preserved in accordance with specified protocols (NCDEHNR 1996 and subsequent updates).

Data Interpretation

The North Carolina water quality standards (NCAC 2002) are used in determining if a lake is meeting its designated uses. Table 4 lists the standards applicable to the various use classifications (designated uses) associated with lakes and streams. Lake water quality assessments are also based on information obtained from other lake monitoring programs such as those implemented by municipalities and major hydroelectric companies. Observations and comments from citizens, local government personnel, water treatment facility staff, etc. are also considered in the assessment process.

In addition to determining use support, data are used to evaluate the trophic state of lakes. An index was developed specifically for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NCDNRCD 1983). The North Carolina Trophic State Index (NCTSI) is based on total phosphorus (TP in mg/L), total organic nitrogen (TON in mg/L), Secchi depth (SD in inches), and chlorophyll *a* (CHL in µg/L). Lakewide means for these parameters are used to produce a NCTSI score for each lake, using the equations:

TON_{Score} = ((Log (TON) + 0.45)/0.24)*0.90

TP_{Score} = ((Log (TP) + 1.55)/0.35)*0.92

SD_{Score} = ((Log (SD) – 1.73)/0.35)*-0.82

CHL_{Score} = ((Log (CHL) – 1.00)/0.48)*0.83

NCTSI = $TON_{Score} + TP_{Score} + SD_{Score} + CHL_{Score}$

In general, NCTSI scores relate to trophic classifications (Table 2). When scores border between classes, best professional judgment is used to assign an appropriate classification. Scores may be skewed by highly colored water typical of dystrophic lakes. Some variation in the trophic state between years is not unusual because of the variability of data, which usually involve sampling a limited number of times during the growing season.

Table 2. Lakes classification criteria.

NCTSI Score	Trophic classification
< -2.0	Oligotrophic
-2.0 – 0.0	Mesotrophic
0.0 – 5.0	Eutrophic
> 5.0	Hypereutrophic

Oligotrophic lakes are characteristically found in the mountains or in undisturbed watersheds. Many mesotrophic and eutrophic lakes are found in the central piedmont. There are a few hypereutrophic lakes where point or nonpoint sources of pollution contribute to high levels of nutrients.

Table 1. Lakes monitored in the Cape Fear River basin during the 2003 sampling effort.

Subbasin/ Lake	County	Classification	Surface Area (Ac)	Mean Depth (ft)	Volume (x $10^6 m^3$)	Watershed (mi^2)	Retention Time (days)
030601							
Reidsville Lake	Rockingham	WS-III NSW CA	751	20	0.04	53	
Lake Hunt	Rockingham	WS-III B CA	180	33	2.8	5	
030602							
Lake Brandt	Guilford	WS-III NSW CA	709	7	84.0	40	
Lake Townsend	Guilford	WS-III NSW CA	1,611	10	25.0	105	
Lake Higgins	Guilford	WS-III NSW CA	287	12	3.0	11	
Burlington Res	Alamance	WS-II HQW NSW CA	751	13	12.2	28	
Lake Burlington	Alamance	WS-II HQW NSW CA	136	7	1.5	110	40
Graham-Mebane Res	Alamance	WS-II HQW NSW CA	650	10	8.7	66	
030603							
Lake Mackintosh	Alamance	WS-IV NSW CA	1,149	59	29.0	129	
030604							
Cane Creek Res	Orange	WS-II HQW NSW CA	4991	7	11.0	32	
Pittsboro Lake	Chatham	WS-IV NSW	37	3	0.02	8	
030605							
Jordan Lake	Chatham	WS-IV B NSW CA	14,300	16	929.6	1,689	418
030606							
University Lake	Orange	WS-II HQW NSW CA	205	5	2.6	29	
030607							
Harris Lake	Chatham	WS-V	4,151	20	10.1	70	840
030608							
High Point Lake	Guilford	WS-IV CA	299	16	4.8	60	
Oak Hollow Lake	Guilford	WS-IV CA	719	21	11.0	55	
030609							
Sandy Creek Res	Randolph	WS-III CA	126	21	1.5	55	
030610							
Carthage City Lake	Moore	WS-III CA	7	3	0.1	27	
030612							
Rocky River Res	Chatham	WS-III CA	185	18	1.6	23	
030614							
Old Town Res	Moore	WS-III	59	13	0.2		
030615							
Bonnie Doone Lake	Cumberland	WS-IV	27	3	0.1	3	
Kornbow Lake	Cumberland	WS-IV	57	7	0.3	5	
Mintz Pond	Cumberland	WS-IV	15	5	0.3	6	
Glenville Lake	Cumberland	WS-IV CA	27	8	0.2	10	
Hope Mills Lake	Cumberland	B	111	8	0.1	26	
030616							
Salters Lake	Bladen	C	450	7	0.3	3	
Jones Lake	Bladen	B	225	3	0.1	2	
White Lake	Bladen	B	1050	10	9.5		292
030617							
Greenfield Lake	New Hanover	C Sw	114	5	0.1	4	
Boiling Springs Lake	Brunswick	B Sw	1119	7	3.8	10	
030618							
Bay Tree Lake	Bladen	C Sw	1401	3	0.6	4	
030620							
Singletary Lake	Bladen	B Sw	571	5	0.4	2	
030622							
Cabin Lake	Duplin	B Sw	69	4		2	

Appendix 22. Surface physical water data and photic zone chemistry data collected from lakes in the Cape Fear River basin, 1998 – 2002.

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
030601																	
Reidsville Lake																	
8/18/2003	CPF0025A	8.9	27.3	6.5	51	0.7	0.06	0.60	<0.02	<0.02	0.61	0.59	0.02	42	96	8.0	17.0
8/18/2003	CPF002A1	9.0	28.0	7.3	54	1.2	0.04	0.56	<0.02	<0.02	0.57	0.55	0.02	51	110	6.0	11.0
7/16/2003	CPF0025A	9.5	25.7	6.9		1.0	0.05	0.58	<0.02	<0.02	0.59	9.57	0.02	48	64	8.0	11.0
7/16/2003	CPF002A1	9.0	28.0	7.5	51	1.1	0.04	0.56	<0.02	<0.02	0.57	0.55	0.02	58	62	7.0	84.0
6/11/2003	CPF0025A	9.1	25.1	7.2	46	0.5	0.07	0.64	<0.02	0.06	0.70	0.63	0.07	26	84	17.0	34.0
6/11/2003	CPF002A1	9.5	25.4	6.8	43	0.5	0.06	0.55	<0.02	0.08	0.56	0.54	0.02	28	76	9.0	24.0
8/3/1998	CPF0025A	7.3	27.4	7.0	68	0.8	0.02	0.30	<0.02	0.03	0.33	0.30	0.04		71	5.0	7.9
8/3/1998	CPF002A1	7.0	27.0	7.2	69	1.2	0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		59	6.0	3.2
7/1/1998	CPF0025A	7.4	29.0	6.1	66	0.7	0.06	0.60	0.02	<0.01	0.61	0.58	0.03		67	6.0	7.2
7/1/1998	CPF002A1	7.5	29.3	6.5	68	1.6	0.03	0.30	0.04	<0.01	0.31	0.26	0.05		59	2.0	2.6
6/2/1998	CPF0025A	9.6	26.4	7.6	55	0.8	0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		58	8.0	5.4
6/2/1998	CPF002A1	8.7	26.8	7.3	55	1.2	<0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		51	4.0	3.2
Lake Hunt																	
8/18/2003	CPF0021A	8.8	29.5	7.7	49	1.1	0.04	0.60	<0.02	<0.02	0.61	0.59	0.02	42	68	6.0	9.9
8/18/2003	CPF0022A	8.1	29.5	7.4	47	1.2	0.04	0.64	<0.02	<0.02	0.65	0.63	0.02	28	67	4.0	11.0
8/18/2003	CPF0023A	9.0	29.5	7.3	47	1.2	0.03	0.61	<0.02	<0.02	0.62	0.60	0.02	32	64	6.0	8.9
7/16/2003	CPF0021A	8.9	29.7	7.9	47	1.0	0.04	0.67	<0.02	<0.02	0.68	0.66	0.02	35	58	7.0	9.5
7/16/2003	CPF0022A	9.0	29.6	7.9	47	0.9	0.04	0.66	<0.02	<0.02	0.67	0.65	0.02	30	63	5.0	8.2
7/16/2003	CPF0023A	8.8	29.6	8.3	46	1.0	0.04	0.64	<0.02	<0.02	0.65	0.63	0.02	37	59	6.0	8.5
6/11/2003	CPF0021A	8.9	26.6	7.4	48	1.2	0.04	0.64	<0.02	<0.02	0.65	0.63	0.02	22	64	6.0	9.3
6/11/2003	CPF0022A	8.8	26.6	7.4	48	1.3	0.04	0.46	<0.02	<0.02	0.47	0.45	0.02	26	66	10.0	8.1
6/11/2003	CPF0023A	9.1	25.6	7.4	47	1.4	0.03	0.44	<0.02	<0.02	0.45	0.43	0.02	25	75	7.0	7.3
8/3/1998	CPF0021A	7.8	27.5	6.7	58	0.8	0.02	0.30	<0.01	<0.01	0.31	0.30	0.01		61	6.0	6.7
8/3/1998	CPF0022A	8.0	27.6	6.9	57	1.1	0.01	0.30	<0.01	<0.01	0.31	0.30	0.01		59	5.0	4.4
8/3/1998	CPF0023A	8.0	27.5	7.4	59	1.1	0.01	0.20	0.09	0.03	0.23	0.11	0.12		54	5.0	3.8
7/1/1998	CPF0021A	7.7	30.2	5.8	51	0.8	0.06	0.60	<0.01	<0.01	0.61	0.60	0.01		55	6.0	7.0
7/1/1998	CPF0022A	7.8	29.9	6.1	52	1.1	0.06	0.40	<0.01	<0.01	0.41	0.40	0.01		58	4.0	4.2
7/1/1998	CPF0023A	7.1	29.6	7.1	56	1.1	0.05	0.40	0.04	<0.01	0.41	0.36	0.05		61	4.0	3.8
6/2/1998	CPF0021A	8.5	27.4	7.4	49	0.7	0.01	0.20	<0.01	<0.01	0.21	0.20	0.02		66	8.0	6.8
6/2/1998	CPF0022A	8.6	27.2	7.3	48	0.8	0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		70	15.0	9.2
6/2/1998	CPF0023A	8.4	27.1	7.0	49	0.8	0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		62	7.0	8.7
030602																	
Lake Brandt																	
8/27/2003	CPF007A1A	8.9	29.7	7.6	67	1.2	0.04	0.54	<0.02	<0.02	0.55	0.53	0.02	29	66	6.0	6.3
8/27/2003	CPF007A4	9.2	30.4	7.5	75	0.7	0.08	0.51	<0.02	<0.02	0.52	0.50	0.02	27	160	34.0	30.0
8/27/2003	CPF007B	8.9	30.8	7.6	68	1.3	0.04	0.53	<0.02	<0.02	0.54	0.52	0.02	27	67	6.0	6.3
7/10/2003	CPF007A1A	7.9	29.1	7.8	73	1.3	0.03	0.37	<0.02	<0.02	0.38	0.36	0.02	11	68	6.0	4.8
7/10/2003	CPF007A4	7.7	28.8	7.6	75	0.8	0.04	0.39	<0.02	<0.02	0.40	0.38	0.02	16	70	7.0	8.0
7/10/2003	CPF007B	7.8	28.5	7.8	73	1.4	0.03	0.38	<0.02	<0.02	0.39	0.37	0.02	11	63	4.0	5.0
6/12/2003	CPF007A1A	8.7	26.6	8.0	61	0.8	0.06	0.54	<0.02	<0.02	0.55	0.53	0.02	22	160	8.0	14.0
6/12/2003	CPF007A4	8.4	25.8	7.9	73	0.6	0.08	0.46	<0.02	0.02	0.48	0.45	0.03	22	110	27.0	33.0
6/12/2003	CPF007B	8.9	26.7	7.6	64	0.9	0.04	0.51	<0.02	<0.02	0.52	0.50	0.02	23	120	7.0	8.8
8/6/1998	CPF007A1A	8.7	28.4	8.1	87	0.6	0.04	0.50	0.04	<0.01	0.51	0.46	0.05		82	7.0	6.5
8/6/1998	CPF007A4	8.0	28.4	7.9	91	0.4	0.08	0.40	0.04	<0.01	0.41	0.36	0.05		100	19.0	15.0
8/6/1998	CPF007B	8.1	27.8	7.7	91	0.6	0.03	0.40	0.05	<0.01	0.41	0.35	0.06		86	10.0	7.2
7/9/1998	CPF007A1A	8.4	30.6	7.8	82	0.8	0.04	0.40	0.08	<0.01	0.41	0.32	0.09		72	6.0	5.4
7/9/1998	CPF007A4	8.4	30.2	8.1	82	0.8	0.03	0.30	0.11	<0.01	0.31	0.19	0.12		71	5.0	4.7
7/9/1998	CPF007B	8.7	30.2	8.4	83	0.8	0.04	0.30	0.08	<0.01	0.31	0.22	0.09		68	5.0	4.7

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
6/25/1998	CPF007A1A	8.8	30.9	8.2	78	1.2	0.03	0.20	<0.01	<0.01	0.21	0.20	0.01		67	5.0	3.8
6/25/1998	CPF007A4	8.4	32.3	8.1	80	1.2	0.02	0.20	0.07	<0.01	0.21	0.13	0.08		12	3.0	3.6
6/25/1998	CPF007B	8.7	31.3	8.5	79	1.1	0.06	0.30	0.03	<0.01	0.31	0.27	0.04		61	4.0	3.8
Lake Townsend																	
8/28/2003	CPFLT4	8.3	30.9	7.3	68	1.2	0.09	0.62	<0.02	<0.02	0.63	0.61	0.02	27	85	16.0	7.0
8/28/2003	CPFLT6	8.3	30.2	7.6	68	1.2	0.04	0.47	<0.02	<0.02	0.48	0.46	0.02	21	60	3	5.2
8/28/2003	CPFLT8	8.4	30.5	7.8	68	1.3	0.02	0.48	<0.02	<0.02	0.49	0.47	0.02	38	60	4	4.3
7/10/2003	CPFLT4	5.5	28.4	7.5	71	0.6	0.05	0.44	<0.02	<0.02	0.45	0.43	0.02	16	86	20.0	22.0
7/10/2003	CPFLT6	7.7	29.7	7.7	68	1.1	0.04	0.38	<0.02	<0.02	0.39	0.37	0.02	12	64	5.0	5.8
7/10/2003	CPFLT8	8.1	30.1	8.1	65	1.3	0.03	0.42	<0.02	<0.02	0.43	0.41	0.02	7	60	4.0	4.8
6/12/2003	CPFLT4	9.4	27.7	7.8	64	0.8	0.05	0.53	<0.02	<0.02	0.54	0.52	0.02	22	98	10.0	13.0
6/12/2003	CPFLT6	9.7	25.2	7.7	65	1.0	0.03	0.44	<0.02	<0.02	0.45	0.43	0.02	19	90	7.0	7.2
6/12/2003	CPFLT8	9.0	26.9	8.2	63	1.2	0.02	0.42	<0.02	<0.02	0.43	0.41	0.02	14	120	4.0	4.6
8/6/1998	CPFLT4	8.7	29.7	7.9	73	0.4	0.04	0.30	0.03	<0.01	0.31	0.27	0.04		89	18.0	13.0
8/6/1998	CPFLT6	8.6	28.2	7.7	73	0.7	0.03	0.40	0.03	<0.01	0.41	0.37	0.04		68	9.0	6.2
8/6/1998	CPFLT8	7.9	27.5	7.9	82	1.1	0.02	0.30	0.03	<0.01	0.31	0.27	0.04		70	3.0	3.1
7/9/1998	CPFLT4	6.3	30.4	7.4	78	0.5	0.05	0.40	0.06	<0.01	0.41	0.34	0.07		75	14.0	13.0
7/9/1998	CPFLT6	7.2	30.7	7.3	70	0.8	0.04	0.50	0.08	<0.01	0.51	0.42	0.09		62	6.0	5.2
7/9/1998	CPFLT8	8.2	31.1	8.1	70	1.3	0.02	0.30	0.02	<0.01	0.31	0.28	0.03		51	2.0	2.8
6/25/1998	CPFLT4	8.8	32.5	7.5	76	0.6	0.03	0.20	<0.01	0.02	0.22	0.19	0.03		58	8.0	6.2
6/25/1998	CPFLT6	8.6	31.9	8.6	73	1.0	0.02	0.20	<0.01	<0.01	0.21	0.19	0.02		58	4.0	3.5
6/25/1998	CPFLT8	8.3	32.3	8.1	71	1.6	0.01	<0.10	<0.01	<0.01	0.11	0.10	0.01		58	3.0	2.4
Lake Higgins																	
8/27/2003	CPFLH2	7.3	28.3	7.3	60	1.1	0.05	0.47	<0.02	<0.02	0.48	0.46	0.02	26	64	10	11
8/27/2003	CPFLH4	8.1	29.5	7.0	57	1.4	0.05	0.49	<0.02	<0.02	0.50	0.48	0.02	28	<50	7.0	14.0
7/10/2003	CPFLH2	6.8	27.9	7.3	63	1.4	0.04	0.37	<0.02	<0.02	0.38	0.36	0.02	10	60	5.0	4.9
7/10/2003	CPFLH4	7.1	28.7	7.1	63	1.4	0.02	0.37	<0.02	<0.02	0.38	0.36	0.02	9	52	4.0	4.8
6/12/2003	CPFLH2	7.3	25.1	7.1	59	1.3	0.04	0.42	<0.02	<0.02	0.43	0.41	0.02	11	100	<2.5	8.9
6/12/2003	CPFLH4	8.2	25.4	7.2	59	1.4	0.03	0.44	<0.02	<0.02	0.45	0.43	0.02	9	110	5.0	4.6
8/6/1998	CPFLH2	8.0	27.5	7.3	75	0.7	0.04	0.30	0.05	<0.01	0.31	0.25	0.06		72	10.0	6.5
8/6/1998	CPFLH4	7.9	27.3	7.5	75	1.1	0.03	0.30	0.03	<0.01	0.31	0.27	0.04		70	6.0	3.8
7/9/1998	CPFLH2	7.9	29.1	7.6	74	0.8	0.04	0.30	0.11	<0.01	0.31	0.19	0.12		61	7.0	6.4
7/9/1998	CPFLH4	7.9	29.6	8.0	70	1.2	0.03	0.30	0.08	<0.01	0.31	0.22	0.09		51	4.0	3.5
6/25/1998	CPFLH2	8.7	30.3	7.5	76	0.7	0.02	0.30	0.02	<0.01	0.31	0.28	0.03		65	8.0	5.8
6/25/1998	CPFLH4	8.7	30.3	8.3	72	1.3	0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		59	6.0	3.1
Burlington Reservoir																	
8/19/2003	CPF0251A	8.3	27.9	7.6	66	0.7	0.05	0.66	<0.02	<0.02	0.67	0.65	0.02	52	77	8.0	7.9
8/19/2003	CPF025A	8.0	28.6	7.4	63	0.8	0.04	0.70	<0.02	<0.02	0.71	0.69	0.02	31	73	7.0	10.0
7/10/2003	CPF0251A	7.3	28.2	7.5	67	0.6	0.04	0.78	<0.02	<0.02	0.79	0.77	0.02	36	110	7.0	8.0
7/10/2003	CPF025A	5.1	26.8	7.1	65	0.5	0.04	0.70	0.020	<0.02	0.71	0.68	0.03	32	100	6.0	7.6
6/10/2003	CPF0251A	9.2	24.9	7.4	59	0.9	0.05	0.61	<0.02	<0.02	0.62	0.60	0.02	45	84	6.0	6.8
6/10/2003	CPF025A	9.3	24.9	7.4	58	1.0	0.04	0.72	<0.02	<0.02	0.71	0.71	0.02	33	80	6.0	6.6
8/21/1998	CPF0251A	8.0	27.6	7.6	71	1.0	0.03	0.20	<0.01	<0.01	0.21	0.20	0.01		62	<1.0	3.0
8/21/1998	CPF025A	7.7	27.9	7.6	71	1.0	0.02	0.30	0.02	0.03	0.33	0.28	0.05		74	<1.0	3.5
7/9/1998	CPF0251A	8.4	28.6	8.1	74	0.9	0.02	0.30	0.08	<0.01	0.31	0.22	0.09		66	5.0	3.8
7/9/1998	CPF025A	7.8	28.2	7.2	72	1.0	0.03	0.20	0.12	<0.01	0.21	0.08	0.13		67	4.0	4.6
6/9/1998	CPF0251A	7.3	23.1	7.0	78	0.8	0.02	0.30	<0.01	0.03	0.33	0.29	0.04		88	7.0	3.7
6/9/1998	CPF025A	7.7	23.8	7.3	74	1.0	0.02	0.30	<0.01	<0.01	0.31	0.29	0.02		90	7.0	3.4

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
Lake Burlington																	
8/19/2003	CPFSCR2	9.4	23.0	6.5	90	0.7	0.06	0.61	<0.02	0.03	0.64	0.60	0.04	30	94	9.0	15.0
8/19/2003	CPFSCR4	8.9	23.8	6.7	83	0.9	0.05	0.66	<0.02	<0.02	0.67	0.65	0.02	32	91	6.0	12.0
7/23/2003	CPFSCR2	7.7	27.7	7.3	76	0.6	0.08	0.78	<0.02	<0.02	0.79	0.77	0.02	35	110	13.0	18.0
7/23/2003	CPFSCR4	6.7	26.6	7.1	70	0.6	0.06	0.75	<0.02	<0.02	0.76	0.74	0.02	27	110	10.0	
6/16/2003	CPFSCR2	6.3	24.5	7.0	64	0.3	0.13	0.67	0.03	0.07	0.74	0.64	0.10	9	120	39.0	70.0
6/16/2003	CPFSCR4	7.1	25.2	7.2	64	0.5	0.09	0.66	<0.02	0.03	0.69	0.65	0.04	20	94	18.0	30.0
8/21/1998	CPFSCR2	7.4	26.2	7.2	85	0.5	0.07	0.50	0.07	0.02	0.52	0.43	0.09		86	7.0	10.0
8/21/1998	CPFSCR4	5.8	26.3	7.4	85	0.6	0.05	0.50	0.03	<0.01	0.51	0.47	0.04		84	1.0	5.2
7/9/1998	CPFSCR2	8.5	28.6	7.2	89	0.5	0.06	0.30	0.08	<0.01	0.31	0.22	0.09		90	9.0	10.0
7/9/1998	CPFSCR4	8.9	28.2	7.6	87	0.7	0.04	0.50	0.09	<0.01	0.51	0.41	0.10		83	6.0	6.9
6/9/1998	CPFSCR2	7.3	22.4	6.9	93	0.5	0.04	0.20	<0.01	<0.01	0.21	0.20	0.01		110	14.0	11.0
6/9/1998	CPFSCR4	7.7	22.8	7.3	94	0.7	0.02	0.20	<0.01	<0.01	0.21	0.20	0.01		100	10.0	6.4
Graham-Mebane Reservoir																	
8/14/2003	CPFGMR1	8.0	28.9	7.2	64	0.8	0.04	0.65	0.04	<0.02	0.66	0.61	0.05	48	110	9.0	13.0
8/14/2003	CPFGMR2	9.5	29.3	7.5	65	0.7	0.07	0.61	<0.02	<0.02	0.62	0.60	0.02	25	110	11.0	20.0
8/14/2003	CPFGMR3	8.1	28.7	7.4	68	0.7	0.06	0.60	0.05	0.02	0.62	0.55	0.07	33	95	6.0	16.0
8/14/2003	CPFGMR4	8.3	28.7	7.4	64	1.0	0.05	0.73	0.05	<0.02	0.74	0.68	0.06	67	110	7.0	13.0
8/14/2003	CPFGMROA	7.5	27.9	7.4	65	0.5	0.06	0.70	<0.02	0.02	0.72	0.69	0.03	20	100	11.0	19.0
7/30/2003	CPFGMR1	6.9	28.1	7.2	55	0.7	0.06	0.52	0.020	<0.02	0.53	0.50	0.03	66	72	7.0	10.0
7/30/2003	CPFGMR2	6.2	28.2	7.1	72	0.7	0.06	0.62	0.030	<0.02	0.63	0.59	0.04	19	86	12.0	18.0
7/30/2003	CPFGMR3	5.7	27.4	7.0	60	0.7	0.07	0.64	0.070	<0.02	0.65	0.57	0.08	98	76	9.0	16.0
7/30/2003	CPFGMR4	6.9	28.1	7.2	55	0.7	0.05	0.53	0.020	<0.02	0.54	0.51	0.03	60	68	7.0	12.0
7/30/2003	CPFGMROA	4.7	27.3	7.0	66	0.5	0.07	0.60	0.080	0.020	0.62	0.52	0.10	18	80	15.0	21.0
6/16/2003	CPFGMR1	7.5	26.3	7.1	54	0.8	0.06	0.52	0.02	<0.02	0.53	0.50	0.03	14	77	6.0	14.0
6/16/2003	CPFGMR2	6.9	26.9	7.1	63	0.7	0.08	0.63	0.06	0.03	0.66	0.57	0.09	12	92	16.0	28.0
6/16/2003	CPFGMR3	6.8	26.7	7.1	59	0.6	0.07	0.63	0.07	0.03	0.66	0.56	0.10	12	86	12.0	24.0
6/16/2003	CPFGMR4	7.5	26.2	7.1	55	0.8	0.06	0.59	0.04	0.02	0.61	0.55	0.06	14	84	12.0	17.0
6/16/2003	CPFGMROA	6.6	26.5	7.3	60	0.5	0.12	0.83	0.07	0.04	0.87	0.76	0.11	25	100	8.0	29.0
8/13/1998	CPFGMR1	9.3	29.9	8.8	78	0.8	0.02	0.30	<0.01	<0.01	0.31	0.30	0.01		85	7.0	5.5
8/13/1998	CPFGMR2	10.0	30.2	8.2	82	0.3	0.09	0.70	<0.01	<0.01	0.71	0.70	0.01		110	24.0	23.0
8/13/1998	CPFGMR3	8.7	28.9	7.9	80	0.5	0.03	0.40	<0.01	0.03	0.43	0.40	0.04		94	8.0	10.0
8/13/1998	CPFGMR4	9.1	29.1	8.3	78	0.8	0.02	0.30	<0.01	<0.01	0.31	0.30	0.01		85	7.0	6.5
8/13/1998	CPFGMROA	9.9	29.9	8.9	76	0.3	0.11	0.50	<0.01	<0.01	0.51	0.50	0.01		120	29.0	26.0
7/15/1998	CPFGMR1	8.4	30.0	7.5	75	1.0	0.05	0.30	<0.01	<0.01	0.31	0.29	0.02		67	5.0	5.1
7/15/1998	CPFGMR2	9.2	29.4	7.1	89	0.5	0.07	0.40	<0.01	<0.01	0.41	0.39	0.02		79	11.0	8.9
7/15/1998	CPFGMR3	7.9	28.2	6.9	79	0.7	0.06	0.20	0.03	<0.01	0.21	0.17	0.04		79	7.0	6.2
7/15/1998	CPFGMR4	8.6	29.7	7.4	76	0.9	0.04	0.30	0.04	<0.01	0.31	0.26	0.05		71	5.0	5.1
7/15/1998	CPFGMROA	9.0	30.0	7.4	81	0.4	0.10	0.30	0.04	<0.01	0.31	0.26	0.05		99	21.0	18.0
6/3/1998	CPFGMR1	8.8	27.7	7.9	68	0.8	0.02	0.20	<0.01	<0.01	0.21	0.20	0.02		70	7.0	5.2
6/3/1998	CPFGMR2	9.4	30.4	7.9	79	0.4	0.04	0.20	<0.01	<0.01	0.21	0.20	0.02		90	10.0	12.0
6/3/1998	CPFGMR3	8.8	28.5	7.9	72	0.6	0.03	0.20	0.05	0.02	0.22	0.15	0.07		77	6.0	6.7
6/3/1998	CPFGMR4	8.6	27.6	7.9	68	0.7	0.02	<0.10	<0.01	0.02	0.12	0.10	0.03		65	7.0	5.8
6/3/1998	CPFGMROA	8.9	30.4	7.6	73	0.4	0.05	0.30	0.02	0.02	0.32	0.28	0.04		72	15.0	12.0
6/3/1998	CPFGMR1	8.0	28.9	7.2	64	0.8	0.04	0.65	0.04	<0.01	0.66	0.61	0.05	48	110	9.0	13.0

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
030603																	
Lake Mackintosh																	
8/4/2003	CPF038F	9.1	27.1	7.4	81	0.5	0.09	0.77	<0.02	0.03	0.80	0.76	0.04	35	100	26.0	40.0
8/4/2003	CPF038G	9.6	26.8	7.7	74	0.8	0.08	0.73	<0.02	<0.02	0.74	0.72	0.02	65	85	10.0	16.0
8/4/2003	CPF038H	9.5	27.0	7.6	79	0.8	0.12	1.70	0.93	<0.02	1.71	0.77	0.94	41	110	22.0	33.0
8/4/2003	CPF038L	6.4	25.7	6.9	75	0.9	0.05	0.61	<0.02	<0.02	0.62	0.60	0.02	31	80	7.0	11.0
8/4/2003	CPF038J	8.5	26.9	7.1	77	0.9	0.04	0.63	<0.02	<0.02	0.64	0.62	0.02	30	86	7.0	11.0
8/4/2003	CPF038N	8.0	26.7	7.2	75	1.1	0.05	0.61	<0.02	<0.02	0.62	0.60	0.02	36	1210	7.0	9.7
7/24/2003	CPF038F	8.5	26.4	7.3	78	0.4	0.11	0.72	<0.02	0.04	0.76	0.71	0.05	31	110	21.0	39.0
7/24/2003	CPF038G	8.9	26.8	7.2	70	1.0	0.07	0.63	<0.02	0.060	0.69	0.62	0.07	30	86	8.0	13.0
7/24/2003	CPF038H	8.7	26.5	7.4	76	0.6	0.08	0.68	<0.02	0.030	0.71	0.67	0.04	38	90	13.0	20.0
7/24/2003	CPF038L	7.5	26.2	6.9	72	1.0	0.06	0.60	0.020	0.050	0.65	0.58	0.07	29	86	7.0	12.0
7/24/2003	CPF038J	8.2	26.8	7.1	75	1.0	0.06	0.63	<0.02	<0.02	0.64	0.62	0.62	0	74	8.0	11.0
7/24/2003	CPF038N	7.3	26.4	6.8	74	0.9	0.06	0.63	<0.02	0.030	0.66	0.62	0.04	40	83	6.0	9.2
6/5/2003	CPF038F	7.7	21.7	7.7	68	0.1	0.18	0.66	0.02	0.14	0.80	0.64	0.16	12	190	110.0	140.0
6/5/2003	CPF038G	10.8	22.9	7.9	61	0.8	0.08	0.78	<0.02	<0.02	0.79	0.77	0.02	51	67	11.0	16.0
6/5/2003	CPF038H	9.4	22.4	7.5	70	0.4	0.11	0.71	<0.02	0.06	0.77	0.70	0.07	18	110	22.0	40.0
6/5/2003	CPF038L	9.1	21.8	7.1	61	0.8	0.06	0.70	<0.02	0.09	0.79	0.69	0.10	31	77	6.0	17.0
6/5/2003	CPF038J	9.5	21.9	7.5	59	0.7	0.07	0.56	0.02	0.07	0.63	0.54	0.09	30	74	8.0	15.0
6/5/2003	CPF038N	8.9	21.5	7.6	61	0.8	0.06	0.60	<0.02	0.07	0.67	0.59	0.08	31	84	6.0	10.0
8/13/1998	CPF038F	8.7	29.0	7.8	105	1.6	0.03	0.30	<0.02	<0.02	0.31	0.30	0.01		95	<1.0	3.3
8/13/1998	CPF038G	8.5	29.5	8.2	100	1.4	0.04	<0.10	<0.01	<0.01	0.11	0.10	0.01		92	<1.0	3.3
8/13/1998	CPF038H	8.5	28.9	7.8	100	1.8	0.04	0.20	0.03	<0.01	0.21	0.17	0.04		96	4.0	3.5
8/13/1998	CPF038L	8.2	28.9	7.7	92	1.5	0.03	0.40	<0.01	<0.01	0.41	0.40	0.01		85	2.0	5.2
8/13/1998	CPF038J	8.0	28.7	8.1	97	1.9	0.03	0.20	<0.01	<0.01	0.21	0.20	0.01		87	4.0	3.8
8/13/1998	CPF038N	8.3	28.4	7.8	92	1.5	0.03	0.40	<0.01	<0.01	0.41	0.40	0.01		89	3.0	3.5
7/15/1998	CPF038F	8.3	29.2	7.6	108	1.1	0.02	0.20	0.02	0.02	0.22	0.18	0.04		86	5.0	5.2
7/15/1998	CPF038G	8.9	28.8	7.8	103	1.2	0.02	0.20	<0.01	<0.01	0.21	0.19	0.02		84	5.0	4.6
7/15/1998	CPF038H	9.1	28.9	7.8	105	1.3	0.02	0.20	0.03	<0.01	0.21	0.17	0.04		77	2.0	3.9
7/15/1998	CPF038L	8.5	28.4	7.7	95	1.5	0.03	0.20	<0.01	<0.01	0.21	0.20	0.01		75	4.0	3.6
7/15/1998	CPF038J	8.3	28.5	7.8	98	1.7	0.02	0.20	<0.01	<0.01	0.21	0.19	0.02		79	3.0	3.7
7/15/1998	CPF038N	8.3	28.0	7.4	96	1.6	0.03	0.20	0.02	<0.01	0.21	0.18	0.03		77	3.0	3.3
6/3/1998	CPF038F	10.4	28.3	8.8	92	0.8	<0.01	0.40	<0.01	<0.01	0.41	0.40	0.01		90	7.0	6.5
6/3/1998	CPF038G	11.0	27.7	8.8	87	0.6	0.03	0.30	<0.01	<0.01	0.31	0.30	0.02		81	8.0	9.9
6/3/1998	CPF038H	10.6	28.0	8.9	89	0.8	0.02	<0.10	<0.01	<0.01	0.11	0.10	0.01		81	8.0	7.8
6/3/1998	CPF038L	8.6	27.3	7.8	83	0.8	<0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		73	8.0	5.8
6/3/1998	CPF038J	9.0	27.8	8.2	82	1.1	<0.01	<0.10	<0.01	<0.01	0.11	0.10	0.01		71	6.0	4.4
6/3/1998	CPF038N	8.3	27.6	8.0	81	1.0	0.01	<0.10	<0.01	<0.01	0.11	0.09	0.02		82	5.0	4.6
030604																	
Cane Creek Reservoir																	
8/18/2003	CPFCCR2	7.7	29.2	7.1	61	1.4	0.04	0.51	<0.02	<0.02	0.52	0.50	0.02	67	82	4.0	4.1
8/18/2003	CPFCCR4	7.7	28.8	7.4	61	1.8	0.04	0.46	<0.02	<0.02	0.47	0.45	0.02	170	90	4.0	5.3
8/18/2003	CPFCCR6	7.7	28.1	7.2	61	1.7	0.03	0.43	<0.02	<0.02	0.44	0.42	0.02	21	76	3.0	3.6
7/21/2003	CPFCCR2	7.6	29.9	6.8	64	1.6	0.03	0.50	<0.02	<0.02	0.51	0.49	0.02	130	67	6.0	4.9
7/21/2003	CPFCCR4	7.8	29.5	7.0	64	1.8	0.03	0.49	<0.02	<0.02	0.50	0.48	0.02	65	38	4.0	5.6
7/21/2003	CPFCCR6	7.5	29.3	7.0	64	1.9	0.04	0.60	<0.02	<0.02	0.61	0.59	0.02	57	39	4.0	7.2
6/18/2003	CPFCCR2	7.1	24.7	6.3	53	1.0	0.05	0.81	0.04	0.07	0.88	0.77	0.11	29	63	4.0	6.2
6/18/2003	CPFCCR4	7.8	25.1	6.5	55	1.0	0.04	0.73	0.02	0.03	0.76	0.72	0.04	25	68	6.0	8.3
6/18/2003	CPFCCR6	7.9	25.6	6.6	55	1.1	0.04	0.70	<0.01	<0.01	0.71	0.69	0.02	21	68	4.0	7.1
8/13/1998	CPFCCR2	9.3	28.1	8.1	67	1.3	0.02	0.30	<0.01	<0.01	0.31	0.30	0.01		66	1.0	3.2
8/13/1998	CPFCCR4	8.1	28.2	8.1	65	1.4	0.02	0.30	<0.01	<0.01	0.31	0.30	0.01		66	1.0	3.0

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
8/13/1998	CPFCCR6	8.4	28.6	7.7	85	1.4	0.02	0.20	<0.01	<0.01	0.21	0.20	0.01		64	<1.0	2.7
7/16/1998	CPFCCR2	9.1	29.5	8.2	69	0.8	0.04	0.40	<0.01	<0.01	0.41	0.40	0.01		65	5.0	5.3
7/16/1998	CPFCCR4	8.5	29.4	8.1	68	0.9	0.03	0.30	<0.01	<0.01	0.31	0.30	0.01		55	4.0	4.7
7/16/1998	CPFCCR6	8.4	29.6	8.2	69	1.0	0.01	0.30	<0.01	<0.01	0.31	0.30	0.01		62	4.0	4.7
6/18/1998	CPFCCR2	8.7	28.5	6.9	68	1.4	0.02	0.30	0.09	<0.01	0.31	0.21	0.10		68	6.0	3.1
6/18/1998	CPFCCR4	8.4	27.9	6.6	63	1.5	0.01	0.30	0.07	<0.01	0.31	0.23	0.08		66	5.0	3.0
6/18/1998	CPFCCR6	8.4	27.4	5.8	60	1.5	0.01	0.40	0.06	<0.01	0.41	0.34	0.07		59	5.0	2.8
6/18/2003	CPFCCR2	7.7	29.2	7.1	61	1.4	0.04	0.51	<0.01	<0.01	0.52	0.50	0.02	67	82	4.0	4.1
Jordan Lake																	
8/4/2003	CPF055C	7.4	28.1	8.5	94	0.5	0.12	0.97	<0.02	<0.02	0.98	0.96	0.02	61	100	12.0	16.0
8/4/2003	CPF055E	6.4	27.6	8.0	94	0.6	0.07	0.73	<0.02	0.12	0.85	0.72	0.13	50	92	8.0	11.0
8/4/2003	CPF081A1C	5.3	28.2	7.3	112	0.4	0.10	1.10	<0.02	<0.02	1.11	1.09	0.02	62	150	22.0	23.0
8/4/2003	CPF086C	5.3	27.9	7.2	112	0.4	0.10	1.10	<0.02	<0.02	1.11	1.09	0.02	68	120	14.0	18.0
8/4/2003	CPF086F	4.1	27.9	6.8	102	0.5	0.07	0.76	0.02	<0.02	0.77	0.74	0.02	51	99	12.0	13.0
8/4/2003	CPF087B3	5.0	28.1	6.9	89	0.7	0.05	0.58	<0.02	<0.02	0.59	0.57	0.02	34	87	6.0	9.3
8/4/2003	CPF0880A	4.7	28.0	6.8	8.3	0.8	0.04	0.58	<0.02	<0.02	0.59	0.57	0.02	30	<50	5.0	7.5
7/1/2003	CPF055C	10.7	28.6	9.2	133	0.8	0.08	0.75	<0.02	0.28	1.03	0.74	0.29	25	110	6.0	6.3
7/1/2003	CPF055E	9.4	28.2	9.0	94	1.0	0.06	0.74	<0.02	0.07	0.81	0.73	0.08	20	90	6.0	6.2
7/1/2003	CPF081A1C	7.4	28.7	7.8	119	0.4	0.10	0.78	<0.02	<0.02	0.79	0.77	0.02	33	110	16.0	17.0
7/1/2003	CPF086C	8.6	29.0	8.8	123	0.5	0.09	0.93	<0.02	<0.02	0.94	0.92	0.02	33	110	14.0	16.0
7/1/2003	CPF086F	7.0	28.2	7.7	108	0.6	0.07	0.79	0.02	<0.02	0.80	0.77	0.03	26	100	10.0	12.0
7/1/2003	CPF087B3	7.7	28.1	8.2	95	0.9	0.04	0.61	<0.02	<0.02	0.62	0.60	0.02	16	55	6.0	4.9
7/1/2003	CPF0880A	8.7	27.9	8.9	87	1.0	0.04	0.67	<0.02	<0.02	0.68	0.66	0.02	17	79	6.0	6.4
6/2/2003	CPF055C	9.0	22.0	7.1	92	0.4	0.13	0.54	<0.02	0.48	1.02	0.53	0.49	29	94	13.0	24.0
6/2/2003	CPF055E	8.1	21.4	6.7	95	0.8	0.05	0.44	<0.02	0.26	0.70	0.43	0.27	29	78	8.0	9.2
6/2/2003	CPF081A1C	8.6	22.3	6.6	110	0.4	0.13	0.72	<0.02	0.04	0.76	0.71	0.05	45	110	22.0	27.0
6/2/2003	CPF086C	9.5	22.0	7.2	115	0.4	0.09	0.89	<0.02	0.89	1.06	0.88	0.18	58	100	20.0	23.0
6/2/2003	CPF086F	8.2	21.4	6.6	110	0.5	0.09	0.80	0.03	0.10	0.90	0.77	0.13	47	110	18.0	20.0
6/2/2003	CPF087B3	7.5	20.7	6.3	97	0.7	0.05	0.67	0.05	0.16	0.83	0.62	0.21	30	96	8.0	10.0
6/2/2003	CPF0880A	8.8	22.0	6.7	92	0.9	0.04	0.47	<0.02	0.19	0.66	0.46	0.20	34	87	6.0	7.9
11/7/2001	CPF049	12.2	12.9	8.0	568		0.19	1.00	0.02	2.00	3.00	0.98	2.02	2	360	<2.5	
11/7/2001	CPF050	10.6	11.7	7.4	482		0.15	0.87	0.02	1.20	2.07	0.85	1.22	1	320	<3.3	
11/7/2001	CPF055C	11.4	16.2	8.4	219	0.6	0.08	1.10	<0.01	0.02	1.12	1.09	0.03	57	150	12.0	
11/7/2001	CPF055E	9.3	16.2	7.2	183	0.6	0.06	0.79	<0.01	0.04	0.83	0.78	0.05	55	150	11.0	
11/7/2001	CPF081A1C	10.2	14.6	7.9	187	0.3	0.11	1.20	0.02	<0.01	1.21	1.18	0.03	62	180	26.0	
11/7/2001	CPF081A1CUPS	11.3	13.5	8.6	226	0.2	0.21	1.90	0.10	0.64	2.54	1.80	0.74	70	280	81.0	
11/7/2001	CPF086C	10.0	14.3	8.1	188	0.3	0.10	<0.10	0.02	<0.01			0.03	62	170	24.0	
11/7/2001	CPF086CUPS	10.5	12.6	8.1	201	0.3		1.50	0.02	0.02	1.52	1.48	0.04	58	250	69.0	
11/7/2001	CPF086F	8.9	15.0	7.8	178	0.4	0.09	1.10	0.02	<0.01	1.11	1.08	0.03	57	160	23.0	
11/7/2001	CPF087B	8.1	15.1	7.2	164	0.5	0.07	0.80	0.02	<0.01	0.81	0.78	0.03	46	180	18.0	
11/7/2001	CPF087B3	8.4	15.4	6.9	150	0.5	0.05	0.66	0.02	<0.01	0.67	0.64	0.03	40	140	11.0	
11/7/2001	CPF087D	8.8	15.6	6.8	151	0.5	0.05	0.83	0.02	<0.01	0.84	0.81	0.03	41	130	13.0	
11/7/2001	CPF08801A	9.7	16.0	7.1	148	0.7	0.04	0.58	0.02	<0.01	0.59	0.56	0.03	41	110	4.0	
11/7/2001	CPF0880Aa	7.7	15.8	6.7	146	0.6	0.05	0.68	0.02	<0.01	0.69	0.66	0.03	41	120	12.0	
11/7/2001	CPF0880Ab	8.1	16.1	6.8	148	0.6	0.05	0.93	0.02	<0.01	0.94	0.91	0.03	44	110	10.0	
11/7/2001	CPF0880Ac	8.7	16.3	6.9	148	0.6	0.05	0.88	0.02	<0.01	0.89	0.86	0.03	45	120	10.0	
11/7/2001	CPF0884A	9.4	16.4	7.1	170	0.6								50	130	11.0	
10/3/2001	CPF049	11.1	20.9	9.1	309		0.21	0.50	<0.01	2.00	2.50	0.50	2.01	2	200	3.0	
10/3/2001	CPF050	10.1	20.4	8.5	277		0.16	0.43	<0.01	1.30	1.73	0.43	1.31	1	190	<2.5	
10/3/2001	CPF055C	11.0	22.7	8.6	202	0.7	0.06	0.92	<0.01	0.20	1.12	0.92	0.21	60	170	8.0	
10/3/2001	CPF055E	22.0	9.3	7.9	197	0.8	0.05	0.68	<0.01	0.29	0.97	0.68	0.30	40	160	8.0	

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
10/3/2001	CPF081A1C	13.1	20.8	9.1	168	0.4	0.06	1.10	0.06	0.06	1.16	1.04	0.12	54	140	17.0	
10/3/2001	CPF081A1CUPS	13.2	21.8	9.2	179	0.3	0.12	1.40	<0.01	<0.01	1.41	1.40	0.01	71	160	36.0	
10/3/2001	CPF086C	12.4	21.5	9.0	166	0.4	0.04	1.10	<0.01	<0.01	1.11	1.10	0.01	60	140	16.0	
10/3/2001	CPF086CUPS	12.7	22.0	9.0	172	0.4	0.06	1.20	<0.01	<0.01	1.21	1.20	0.01	64	160	27.0	
10/3/2001	CPF086F	10.8	22.0	8.8	150	0.5	0.06	0.98	<0.01	<0.01	0.99	0.98	0.01	61	150	17.0	
10/3/2001	CPF087B	11.7	22.4	8.8	143	0.6	0.04	0.74	<0.01	<0.01	0.75	0.74	0.01	46	120	10.0	
10/3/2001	CPF087B3	10.8	21.4	8.5	142	0.6	0.04	0.76	<0.01	<0.01	0.77	0.76	0.01	51	150	10.0	
10/3/2001	CPF087D	10.7	22.2	8.6	142	0.7	0.03	0.66	<0.01	<0.01	0.67	0.66	0.01	42	130	8.0	
10/3/2001	CPF08801A	11.5	22.3	8.8	144	0.7	0.03	0.74	<0.01	<0.01	0.75	0.74	0.01	40	140	8.0	
10/3/2001	CPF0880Aa	11.5	21.9	8.9	144	0.7	0.04	0.66	<0.01	<0.01	0.67	0.66	0.01	48	140	8.0	
10/3/2001	CPF0880Ab	9.0	21.3	7.7	142	0.7	0.03	0.72	<0.01	<0.01	0.73	0.72	0.01	47	130	8.0	
10/3/2001	CPF0880Ac	10.5	21.7	8.7	141	0.7	0.03	0.67	<0.01	<0.01	0.68	0.67	0.01	44	120	8.0	
10/3/2001	CPF0884A	11.1	22.6	8.6	196	0.7	0.06	0.71	<0.01	0.20	0.91	0.71	0.21	45	170	8.0	
9/18/2001	CPF049	9.0	20.3	8.0	373		0.37	0.73	0.02	1.60	2.33	0.71	1.62	3	250	3.0	
9/18/2001	CPF050	7.7	20.1	7.6	387		0.31	0.95	0.03	1.40	2.35	0.92	1.43	2	270	4.0	
9/18/2001	CPF055C	9.1	24.9	8.3	184	0.7	0.07	0.75	<0.01	0.10	0.85	0.75	0.11	33	140	7.0	
9/18/2001	CPF055E	7.8	25.1	7.5	173	0.6	0.05	0.72	<0.01	0.11	0.83	0.72	0.12	24	130	6.0	
9/18/2001	CPF081A1C	10.9	23.0	8.8	152	0.4	0.11	0.52	<0.01	<0.01	0.53	0.52	0.01	48	140	18.0	
9/18/2001	CPF081A1CUPS	9.8	22.2	8.4	166	0.3	0.18	0.86	0.02	<0.01	0.87	0.84	0.03	58	170	47.0	
9/18/2001	CPF086C	11.1	22.7	8.8	151	0.4	0.11	1.20	<0.01	<0.01	1.21	1.20	0.01	62	140	15.0	
9/18/2001	CPF086CUPS	13.8	23.1	9.1	170	0.4	0.15	1.10	<0.01	0.21	1.31	1.09	0.22	56	150	16.0	
9/18/2001	CPF086F	7.8	22.9	7.2	143	0.5	0.08	1.00	0.06	0.04	1.04	0.94	0.10	38	130	15.0	
9/18/2001	CPF087B	8.9	23.5	7.7	132	0.6	0.05	0.66	<0.01	<0.01	0.67	0.66	0.02	30	110	9.0	
9/18/2001	CPF087B3	7.6	23.9	7.1	132	0.7	0.04	0.57	0.04	<0.01	0.58	0.53	0.05	29	110	6.0	
9/18/2001	CPF087D	7.0	23.9	6.9	132	0.8	0.04	0.55	0.06	<0.01	0.56	0.49	0.07	26	100	6.0	
9/18/2001	CPF08801A	8.6	24.7	7.7	138	0.6	0.04	0.67	<0.01	<0.01	0.68	0.67	0.01	26	96	4.0	
9/18/2001	CPF0880Aa	8.3	24.5	7.5	139	0.7	0.04	0.59	0.03	<0.01	0.60	0.56	0.04	22	110	4.0	
9/18/2001	CPF0880Ab	6.7	24.3	7.1	140	0.6	0.04	0.61	0.08	<0.01	0.62	0.53	0.09	17	110	4.0	
9/18/2001	CPF0880Ac	8.3	24.9	7.6	139	0.7	0.04	0.62	0.02	<0.01	0.63	0.60	0.03	24	110	4.0	
9/18/2001	CPF0884A	7.3	24.9	7.3	164	0.7	0.05	0.61	<0.01	0.12	0.73	0.61	0.13	25	120	6.0	
8/20/2001	CPF049	8.4	27.6	8.0	230		0.26	0.47	0.05	1.10	1.57	0.42	1.15	1	200	4.0	
8/20/2001	CPF050	7.6	26.2	7.6	217		0.26	0.50	0.03	1.00	1.50	0.47	1.03	2	180	5.0	
8/20/2001	CPF055C	7.1	28.4	8.2	202	0.5	0.12	0.75	<0.01	0.37	1.12	0.75	0.38	30	170	8.0	
8/20/2001	CPF055E	6.8	27.9	7.6	166	0.7	0.06	0.66	<0.01	0.04	0.70	0.66	0.05	28	140	6.0	
8/20/2001	CPF081A1C	5.7	28.4	7.2	157	0.3	0.11	1.20	0.12	<0.01	1.21	1.08	0.13	45	170	46.0	
8/20/2001	CPF081A1CUPS	7.1	27.7	7.2	133	0.3	0.18	1.00	<0.01	<0.01	1.01	0.99	0.02	61	190	34.0	
8/20/2001	CPF086C	5.5	28.2	7.2	161	0.3	0.12	1.20	0.11	<0.01	1.21	1.09	0.12	17	180	25.0	
8/20/2001	CPF086CUPS	5.9	28.3	7.3	157	0.3	0.13	1.30	0.03	<0.01	1.31	1.27	0.04	61	190	29.0	
8/20/2001	CPF086F	5.1	28.3	7.1	150	0.5	0.08	1.00	0.16	<0.01	1.01	0.84	0.17	35	150	13.0	
8/20/2001	CPF087B	5.7	28.6	7.2	144	0.5	0.05	0.86	0.06	<0.01	0.87	0.80	0.07	32	140	12.0	
8/20/2001	CPF087B3	5.5	28.2	7.1	140	0.7	0.04	0.76	0.05	<0.01	0.77	0.71	0.06	27	160	6.0	
8/20/2001	CPF087D	6.6	28.2	7.2	136	0.9	0.03	0.67	0.03	<0.01	0.68	0.64	0.04	19	140	4.0	
8/20/2001	CPF08801A	6.7	28.1	7.3	135	0.7	0.04	0.65	<0.01	<0.01	0.66	0.65	0.01	21	110	7.0	
8/20/2001	CPF0880Aa	7.1	28.1	7.5	134	1.0	0.03	0.49	<0.01	<0.01	0.50	0.49	0.01	16	100	5.0	
8/20/2001	CPF0880Ab	6.7	27.9	7.3	134	0.9	0.02		<0.01	<0.01			0.01	16	110	4.0	
8/20/2001	CPF0880Ac	6.2	27.7	7.2	134	1.0	0.02	0.51	<0.01	<0.01	0.52	0.51	0.01	16	100	4.0	
8/20/2001	CPF0884A	7.8	28.2	8.3	153	0.7	0.04	0.69	<0.01	<0.01	0.70	0.69	0.01	25	130	6.0	
8/6/2001	CPF049	9.1	30.1	8.6	182		0.22	0.46	0.08	0.47	0.93	0.38	0.55	2	140	3.0	
8/6/2001	CPF050	9.6	29.4	8.6	177		0.19	0.67	0.08	0.36	1.03	0.59	0.44	2	130	4.0	
8/6/2001	CPF055C	13.4	30.4	9.4	201	0.7	0.09	1.10	<0.01	<0.01	1.11	1.10	0.01	32	140	9.0	
8/6/2001	CPF055E	11.6	30.4	9.2	192	0.9	0.05	0.89	0.03	<0.01	0.90	0.86	0.04	20	130	7.0	

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
8/6/2001	CPF081A1C	10.6	29.8	9.2	159	0.5	0.10	1.30	0.13	<0.01	1.31	1.17	0.14	52	120	11.0	
8/6/2001	CPF081A1CUPS	8.9	30.7	9.0	163	0.3	0.21	1.40	0.02	<0.01	1.41	1.38	0.03	48	170	26.0	
8/6/2001	CPF086C	10.4	19.1	9.2	157	0.5	0.08	1.20	0.04	<0.01	1.21	1.16	0.05	48	120	13.0	
8/6/2001	CPF086CUPS	9.5	30.7	9.2	163	0.4	0.11	1.50	0.03	<0.01	1.51	1.47	0.04	48	140	19.0	
8/6/2001	CPF086F	9.7	29.3	9.1	140	0.7	0.07	1.10	0.09	<0.01	1.11	1.01	0.10	41	110	11.0	
8/6/2001	CPF087B	9.9	29.2	9.0	138	0.8	0.04	0.72	0.03	<0.01	0.73	0.69	0.04	21	100	7.0	
8/6/2001	CPF087B3	9.3	28.4	8.6	135	1.0	0.03	0.60	0.03	<0.01	0.61	0.57	0.04	15	98	5.0	
8/6/2001	CPF087D	8.8	28.3	8.5	135	1.2	0.03	0.64	0.03	<0.01	0.65	0.61	0.04	16	89	5.0	
8/6/2001	CPF08801A	9.5	29.3	8.5	134	1.5	0.02	0.56	0.02	<0.01	0.57	0.54	0.03	10	99	<2.5	
8/6/2001	CPF0880Aa	9.5	29.3	8.6	135	1.4	0.03	0.74	<0.01	<0.01	0.75	0.73	0.02	12	88	4.0	
8/6/2001	CPF0880Ab	9.3	29.6	8.5	136	1.6	0.02	0.50	0.03	<0.01	0.51	0.47	0.04	12	87	3.0	
8/6/2001	CPF0880Ac	9.3	29.7	8.6	135	1.5	0.02	0.54	0.02	<0.01	0.55	0.52	0.03	14	82	3.0	
8/6/2001	CPF0884A	9.5	29.7	8.7	151	1.1	0.04	0.65	<0.01	<0.01	0.66	0.65	0.01	20	92	6.0	
7/23/2001	CPF049	9.1	28.0	8.5	330		0.24	0.59	0.06	0.78	1.37	0.53	0.84	3	210		
7/23/2001	CPF050	7.7	27.5	7.9	299		0.20	0.58	0.04	0.36	0.94	0.54	0.40	3	190	3.0	
7/23/2001	CPF055C	9.3	28.7	8.9	185	0.8	0.06	0.86	0.04	<0.01	0.87	0.82	0.05	3	130	10.0	
7/23/2001	CPF055E	8.6	28.6	8.7	171	0.9	0.03	0.75	0.02	<0.01	0.76	0.73	0.03	24	120	10.0	
7/23/2001	CPF081A1C	11.1	30.1	9.3	165	0.4	0.13	1.30	0.02	<0.01	1.31	1.28	0.03		140	15.0	
7/23/2001	CPF081A1CUPS	10.4	29.9	9.2	173	0.3	0.22	1.80	0.11	<0.01	1.81	1.69	0.12	75	190	26.0	
7/23/2001	CPF086C	11.5	29.5	9.4	156	0.4	0.10	1.20	<0.01	<0.01	1.21	1.19	0.02	61	140	14.0	
7/23/2001	CPF086CUPS	12.5	30.7	9.4	170	0.3	0.11	1.40	0.21	<0.01	1.41	1.19	0.22	71	120	16.0	
7/23/2001	CPF086F	10.0	28.4	9.1	150	0.5	0.08	1.10	<0.01	<0.01	1.11	1.10	0.01	60	110	14.0	
7/23/2001	CPF087B	9.0	29.1	8.6	139	0.7	0.04	1.00	0.14	<0.01	1.01	0.86	0.15	32	100	10.0	
7/23/2001	CPF087B3	8.7	28.9	8.5	136	1.0	0.03	0.58	0.03	<0.01	0.59	0.55	0.04	20	89	4.0	
7/23/2001	CPF087D	8.0	28.2	7.9	136	1.0	0.03	0.73	0.02	<0.01	0.74	0.71	0.03	32	96	6.0	
7/23/2001	CPF08801A	8.0	28.5	7.6	139	1.3	0.03	0.58	0.10	<0.01	0.59	0.48	0.11	11	98	4.0	
7/23/2001	CPF0880Aa	7.8	28.8	7.9	139	1.4	0.03	0.60	0.08	<0.01	0.61	0.52	0.09	12	94		
7/23/2001	CPF0880Ab	7.7	28.1	7.7	138	1.5	0.02	0.59	0.17	<0.01	0.60	0.42	0.18	12	98	6.0	
7/23/2001	CPF0880Ac	7.7	28.0	7.8	137	1.4	0.03	0.52	0.06	<0.01	0.53	0.46	0.07	12	93	3.0	
7/23/2001	CPF0884A	8.0	28.9	7.9	142	1.2	0.03	0.59	0.57	<0.01	0.60	0.02	0.58	15	100		
7/10/2001	CPF049	27.4	8.0	7.9	107		0.22	0.58	0.05	0.85	1.43	0.53	0.90	2	120	9.0	
7/10/2001	CPF055C	30.5	13.6	9.4	222	0.7	0.11	0.69	<0.01	0.05	0.74	0.69	0.06	32	160	8.0	
7/10/2001	CPF055E	29.7	11.3	9.0	179	0.8	0.07	0.51	<0.01	<0.01	0.52	0.51	0.01	24	140	7.0	
7/10/2001	CPF081A1C	28.3	8.3	8.2	146	0.3	0.12	0.43	0.18	<0.01	0.44	0.25	0.19	71	140	29.0	
7/10/2001	CPF081A1CUPS	9.6	9.6	8.7	159	0.2	0.17	0.42	0.09	<0.01	0.43	0.33	0.10	33	150	38.0	
7/10/2001	CPF086C	27.9	7.3	7.7	144	0.4	0.09	0.36	0.02	<0.01	0.37	0.34	0.03	24	120	21.0	
7/10/2001	CPF086CUPS	27.9	8.5	8.5	144	0.4	0.09	0.47	0.34	<0.01	0.48	0.13	0.35	59	120	27.0	
7/10/2001	CPF086F	27.6	6.0	7.3	140	0.5	0.07	0.40	0.14	<0.01	0.41	0.26	0.15	35	99	15.0	
7/10/2001	CPF087B	27.8	6.3	7.3	136	0.6	0.05	0.34	0.14	0.02	0.36	0.20	0.16	27	99	12.0	
7/10/2001	CPF087B3	27.6	6.5	7.3	134	0.9	0.03	0.33	0.08	0.03	0.36	0.25	0.11	19	99	6.0	
7/10/2001	CPF087D	27.5	6.5	7.3	133	1.2	0.03	0.48	0.13	0.04	0.52	0.35	0.17	14	100	5.0	
7/10/2001	CPF08801A	28.0	7.4	7.5	132	1.6	0.03	0.64	0.16	<0.01	0.65	0.48	0.17	8	100	4.0	
7/10/2001	CPF0880Aa	28.2	7.8	7.8	132	1.6	0.03	0.52	<0.01	<0.01	0.53	0.52	0.01	10	99	4.0	
7/10/2001	CPF0880Ab	28.4	7.6	7.7	132	1.6	0.03	0.64	0.38	<0.01	0.65	0.26	0.39	10	98	4.0	
7/10/2001	CPF0880Ac	28.8	7.8	7.7	132	1.5	0.03	0.49	<0.01	<0.01	0.50	0.49	0.01	7	100	5.0	
7/10/2001	CPF0884A	28.5	8.5	8.2	142	1.3	0.04	0.80	0.13	<0.01	0.81	0.67	0.14	10	110	6.0	
6/27/2001	CPF049	8.3	27.8	8.2	283		0.24	0.76	0.14	1.30	2.06	0.62	1.44	2	200	5.0	
6/27/2001	CPF055C	13.2	29.4	9.6	187	0.8	0.08	0.62	0.05	<0.15		0.57		32	130	7.0	
6/27/2001	CPF055E	11.0	29.2	9.3	177	0.9	0.05	0.56	0.04	<0.01		0.52		13	120	5.0	
6/27/2001	CPF081A1C	7.5	28.0	8.0	143	0.2	0.10	1.80	1.80	0.05	1.85	0.00	1.85	25			
6/27/2001	CPF081A1CUPS	7.6	27.4	7.7	138	0.2	0.14	<0.6	0.05	0.07			0.12	33			

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
6/27/2001	CPF086C	8.6	28.2	8.3	142	0.5	0.08	0.63	0.06	0.06	0.69	0.57	0.12	27			
6/27/2001	CPF086CUPS	10.1	27.4	8.6	148	0.3	0.10	0.69	0.03	0.13	0.82	0.66	0.16	31			
6/27/2001	CPF086F	8.1	27.7	8.0	138	0.4	0.07	0.64	0.04	0.05	0.69	0.60	0.09	22			
6/27/2001	CPF087B	6.2	26.9	7.5	131	1.0	0.03	0.80	0.21	0.08	0.88	0.59	0.29	8			
6/27/2001	CPF087B3	6.8	27.2	7.6	132	1.2	0.03	0.57	0.09	0.08	0.65	0.48	0.17	8			
6/27/2001	CPF087D	6.8	27.1	7.8	132	1.0	0.03	0.55	0.08	0.08	0.63	0.47	0.16	7			
6/27/2001	CPF08801A	7.8	28.3	7.8	133	1.2	0.03	0.54	0.06	0.08	0.62	0.48	0.14	10	92	6.0	
6/27/2001	CPF0880Aa	8.4	28.7	8.4	133	1.1	0.03	0.47	0.20	0.04	0.51	0.27	0.24	12	89	2.0	
6/27/2001	CPF0880Ab	8.3	28.4	8.3	133	1.2	0.02	0.36	0.03	0.04	0.40	0.33	0.07	11	91	5.0	
6/27/2001	CPF0880Ac	8.1	28.2	8.3	133	1.3	0.02	0.51	0.04	0.04	0.55	0.47	0.08	11	88	6.0	
6/27/2001	CPF0884A	8.4	28.7	8.5	138	1.2	0.03	0.43	0.12	0.04	0.47	0.31	0.16	15	95	6.0	
6/12/2001	CPF049	7.2	26.8	7.9	259		0.26	0.58	0.06	1.80	2.38	0.52	1.86	2	180	3.0	
6/12/2001	CPF050	7.2	26.5	7.8	264		0.19	0.79	0.11	1.60	2.39	0.68	1.71	3	180	4.0	
6/12/2001	CPF055C	12.8	27.7	9.5	175	0.6	0.09	1.20	0.10	<0.01	1.21	1.10	0.11	43	120	8.0	
6/12/2001	CPF055E	11.3	27.3	9.3	179	0.7					0.00	0.00	0.00				
6/12/2001	CPF081A1C	7.2	27.6	7.6	142	0.3	0.11	0.93	0.06	0.02	0.95	0.87	0.08	30	130	27.0	
6/12/2001	CPF081A1CUPS	8.3	28.1	7.8	140	0.3	0.20	0.95	0.12	<0.01	0.96	0.83	0.13	47	100	54.0	
6/12/2001	CPF086C	7.6	27.3	7.5	154	0.5	0.10	0.96	0.10	0.11	1.07	0.86	0.21	34	130	20.0	
6/12/2001	CPF086CUPS	8.1	27.8	7.8	146	0.4	0.10	1.00	0.03	0.02	1.02	0.97	0.05	34	140	28.0	
6/12/2001	CPF086F	6.3	27.2	7.4	142	0.7	0.06	0.75	0.14	0.10	0.85	0.61	0.24	14	120	8.0	
6/12/2001	CPF087B	7.2	26.7	7.6	140	0.9	0.04	0.69	0.08	0.12	0.81	0.61	0.20	13	100	8.0	
6/12/2001	CPF087B3	7.8	26.5	7.7	137	1.1	0.03	0.57	0.05	0.13	0.70	0.52	0.18	12	100	6.0	
6/12/2001	CPF087D	8.2	26.8	8.5	143	1.1	0.03	0.65	0.05	0.15	0.80	0.60	0.20	13	100	6.0	
6/12/2001	CPF08801A	8.6	27.3	8.6	144	1.1	0.03	0.69	0.02	0.10	0.79	0.67	0.12	15	100	5.0	
6/12/2001	CPF0880Aa	8.8	26.9	8.7	145	1.1	0.03	0.64	0.13	0.09	0.73	0.51	0.22	7	100	6.0	
6/12/2001	CPF0880Ab	8.9	26.9	8.7	151	1.4	0.03	0.59	0.04	0.08	0.67	0.55	0.12	16	110	6.0	
6/12/2001	CPF0880Ac	9.0	27.1	8.7	151	1.1	0.03	0.65	0.02	0.07	0.72	0.63	0.09	15	110	6.0	
6/12/2001	CPF0884A	11.0	27.8	9.3	178	0.8	0.05	0.79	0.11	<0.01	0.80	0.68	0.12	26	120	6.0	
5/30/2001	CPF049	8.7	22.5	7.7	131		0.17	0.30	0.10	0.81	1.11	0.20	0.91	2	120	5.0	
5/30/2001	CPF050	9.3	23.1	7.7	129		0.17	0.30	0.10	0.82	1.12	0.20	0.92	2	120	6.0	
5/30/2001	CPF055C	12.2	23.4	8.9	241	0.7	0.97	0.30	0.10	0.58	0.88	0.20	0.68	46	160	8.0	
5/30/2001	CPF055E	13.8	24.0	9.1	233	0.7	<0.10	0.30	0.10	0.21	0.51	0.20	0.31	52	160	10.0	
5/30/2001	CPF081A1C	11.0	25.6	8.4	166	0.4	0.10	0.30	0.10	0.70	1.00	0.20	0.80	56	160	16.0	
5/30/2001	CPF081A1CUPS	10.4	23.8	8.1	180	0.2	0.18	0.30	0.10	0.70	1.00	0.20	0.80	96	200	36.0	
5/30/2001	CPF086C	8.9	24.0	7.6	152	0.5	<0.10	0.30	0.10	0.70	1.00	0.20	0.80	36	150	23.0	
5/30/2001	CPF086CUPS	10.0	24.2	7.9	160	0.4	<0.10	0.30	0.10	0.70	1.00	0.20	0.80	48	150	18.0	
5/30/2001	CPF086F	8.7	24.0	7.4	146	0.5					0.00	0.00	0.00	34	130	16.0	
5/30/2001	CPF087B	7.8	23.3	7.3	139	0.7	<0.10	0.30	0.10	0.26	0.56	0.20	0.36	20	120	10.0	
5/30/2001	CPF087B3	8.3	23.4	7.3	137	0.9	<0.10	0.30	0.10	0.27	0.57	0.20	0.37	13	120	14.0	
5/30/2001	CPF087D	8.2	23.7	7.9	138	0.8	<0.10	0.30	0.10	0.27	0.57	0.20	0.37	8	110	6.0	
5/30/2001	CPF08801A	8.7	23.5	7.5	140	1.0	<0.10	0.30	0.10	0.24	0.54	0.20	0.34	18	100	5.0	
5/30/2001	CPF0880Aa	9.1	23.3	7.7	145	0.9	<0.10	0.30	0.10	0.21	0.51	0.20	0.31	19	110	5.0	
5/30/2001	CPF0880Ab	9.0	23.4	7.7	144	1.2	<0.10	0.30	0.10	0.22	0.52	0.20	0.32	18	110	5.0	
5/30/2001	CPF0880Ac	9.3	23.4	8.1	146	1.1	<0.10	0.30	0.10	0.21	0.51	0.20	0.31	17	110	5.0	
5/30/2001	CPF0884A	13.0	23.7	9.0	203	0.8	<0.10	0.30	0.10	0.70	1.00	0.20	0.80	48	140	8.0	
5/10/2001	CPF049	9.2	22.1	8.0	284		0.21	0.60	0.20	1.10	1.70	0.40	1.30	2	240	4.0	
5/10/2001	CPF050	11.1	23.0	8.3	278		0.19	0.60	0.20	0.88	1.48	0.40	1.08	2	240	4.0	
5/10/2001	CPF055C	12.5	23.7	8.6	183	0.9	0.11	0.60	0.20	0.30	0.90	0.40	0.50	36	170	7.0	
5/10/2001	CPF055E	12.4	23.2	8.5	164	1.1	0.10	0.60	0.20	0.15	0.75	0.40	0.35	25	160	5.0	
5/10/2001	CPF081A1C	11.1	24.2	8.7	140	0.4	0.10	0.30	0.10	0.70	1.00	0.20	0.80	37	180	23.0	
5/10/2001	CPF081A1CUPS	11.3	24.2	8.4	154	0.3	0.14	0.30	0.10	0.70	1.00	0.20	0.80	45	200	46.0	

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
5/10/2001	CPF086C	11.4	25.8	8.4	131	0.5	0.10	0.30	0.10	0.18	0.48	0.20	0.28	55	180	22.0	
5/10/2001	CPF086CUPS	11.6	25.0	8.4	133	0.4	0.10	0.70	0.10	0.18	0.88	0.60	0.28	42	180	24.0	
5/10/2001	CPF086F	10.5	25.2	8.2	126	0.5	<0.10	0.30	0.10	0.16	0.46	0.20	0.26	24	180	13.0	
5/10/2001	CPF087B	9.4	24.7	7.6	127	0.6	<0.10	0.60	0.10	0.18	0.78	0.50	0.28	20	160	10.0	
5/10/2001	CPF087B3	8.8	23.8	7.5	127	0.8	<0.10	0.70	0.10	0.19	0.89	0.60	0.29	12	150	7.0	
5/10/2001	CPF087D	9.3	24.5	8.0	127	0.9	0.10	0.60	0.20	0.19	0.79	0.40	0.39	10	160	6.0	
5/10/2001	CPF08801A	8.5	22.3	7.3	131	1.1	0.10	0.60	0.20	0.21	0.81	0.40	0.41	13	150	5.0	
5/10/2001	CPF0880Aa	9.4	22.9	7.7	136	1.1	0.10	0.60	0.20	0.20	0.80	0.40	0.40	10	150	3.0	
5/10/2001	CPF0880Ab	9.0	22.3	7.6	136	1.2	0.10	0.60	0.20	0.20	0.80	0.40	0.40	11	150	4.0	
5/10/2001	CPF0880Ac	9.2	22.6	7.5	136	1.1	0.10	0.60	0.20	0.20	0.80	0.40	0.40	12	150	4.0	
5/10/2001	CPF0884A	10.3	22.8	7.9	150	1.1	0.10	0.60	0.20	0.19	0.79	0.40	0.39	23	160	5.0	
4/30/2001	CPF049	9.2	18.7	7.9	267		0.37	0.60	0.20	2.00	2.60	0.40	2.20	3	180	3.0	
4/30/2001	CPF050	10.4	20.1	8.3	247		0.34	0.30	0.10	1.80	2.10	0.20	1.90	3	170	2.0	
4/30/2001	CPF055C	8.8	20.0	7.6	194	1.1	0.16	0.60	0.20	0.64	1.24	0.40	0.84	7	150	4.0	
4/30/2001	CPF055E	11.1	19.8	7.8	147	1.0	0.10	0.60	0.20	0.26	0.86	0.40	0.46	14	120	4.0	
4/30/2001	CPF081A1C	10.9	21.0	8.5	128	0.2	0.10	0.70	0.20	0.26	0.96	0.50	0.46	15	120	3.0	
4/30/2001	CPF081A1CUPS	12.0	21.2	8.8	139	0.2	0.10	0.70	0.20	0.24	0.94	0.50	0.44	16	120	6.0	
4/30/2001	CPF086C	10.2	20.6	8.2	119	0.3	0.10	0.60	0.20	0.25	0.85	0.40	0.45	17	120	6.0	
4/30/2001	CPF086CUPS	10.1	20.7	8.2	122	0.2	0.10	0.60	0.20	0.24	0.84	0.40	0.44	30	140	5.0	
4/30/2001	CPF086F	9.6	20.1	7.6	119	0.3	0.10	0.60	0.20	0.24	0.84	0.40	0.44	11	120	5.0	
4/30/2001	CPF087B	9.1	19.4	7.4	129	0.4	0.10	0.60	0.20	0.20	0.80	0.40	0.40	36	120	7.0	
4/30/2001	CPF087B3	10.0	19.9	7.7	128	0.4	0.10	0.60	0.20	0.19	0.79	0.40	0.39	34	130	9.0	
4/30/2001	CPF087D	10.0	20.2	7.4	129	0.4	0.10	0.60	0.20	0.19	0.79	0.40	0.39	22	120	6.0	
4/30/2001	CPF08801A	9.6	19.0	7.5	130	0.5	0.12	0.60	0.20	0.15	0.75	0.40	0.35	42	140	18.0	
4/30/2001	CPF0880Aa	9.9	18.9	7.7	137	0.8	0.12	0.60	0.20	0.15	0.75	0.40	0.35	59	150	23.0	
4/30/2001	CPF0880Ab	10.0	19.0	7.6	138	0.9	0.10	0.90	0.20	0.18	1.08	0.70	0.38	31	140	22.0	
4/30/2001	CPF0880Ac	10.1	19.0	7.7	137	0.6	0.14	0.60	0.20	0.15	0.75	0.40	0.35				
4/30/2001	CPF0884A	9.8	19.3	7.4	142	1.0	0.19	0.60	0.20	0.15	0.75	0.40	0.35		170	46.0	
2/20/2001	CPF049	11.8	7.3	7.3	109										140	18.0	
2/20/2001	CPF050	11.7	7.4	7.2	109										150	21.0	
2/20/2001	CPF055C	10.8	9.0	7.1	116	0.3									180	30.0	
2/20/2001	CPF055E	10.4	10.0	7.1	174	0.3									190	26.0	
2/20/2001	CPF081A1C	11.1	9.9	7.5	213	0.4									180	24.0	
2/20/2001	CPF081A1CUPS	8.7	8.4	6.7	119	0.2									200	38.0	
2/20/2001	CPF086C	11.4	9.7	7.7	209	0.5									180	20.0	
2/20/2001	CPF086CUPS	11.7	9.6	7.8	216	0.5									190	26.0	
2/20/2001	CPF086F	11.1	10.5	7.5	210	0.5									180	14.0	
2/20/2001	CPF087B	11.7	9.5	7.6	176	0.7									140	13.0	
2/20/2001	CPF087B3	11.6	9.1	7.4	166	0.8									140	9.0	
2/20/2001	CPF087D	12.0	8.8	7.6	173	0.9									140	11.0	
2/20/2001	CPF08801A	12.0	8.6	7.5	172	0.9									140	10.0	
2/20/2001	CPF0880Aa	12.2	8.9	7.6	189	0.8									150	10.0	
2/20/2001	CPF0880Ab	11.6	8.8	7.4	191	0.8									150	10.0	
2/20/2001	CPF0880Ac	11.5	9.0	7.4	199	0.8									160	9.0	
2/20/2001	CPF0884A	10.3	10.5	7.1	187	0.3									190	22.0	
1/11/2001	CPF049	13.9	2.1	7.6	326		0.20	0.80	0.16	2.00	2.80	0.64	2.16		240	1.0	
1/11/2001	CPF050	13.4	0.6	7.0	323		0.20	0.80	0.08	1.80	2.60	0.72	1.88		230	2.0	
1/11/2001	CPF055C	12.9	3.1	7.4	238	1.4	0.11	0.60	0.16	1.60	2.20	0.44	1.76		200	5.0	
1/11/2001	CPF055E	11.0	3.7	7.2	221	1.4	0.10	0.70	0.28	0.70	1.40	0.42	0.98		180	5.0	
1/11/2001	CPF081A1C	16.1	3.4	8.9	208	0.5	0.09	0.50	0.09	0.71	1.21	0.41	0.80		190	21.0	
1/11/2001	CPF081A1CUPS	17.4	4.4	9.1	218	0.4	0.12	0.50	0.17	0.82	1.32	0.33	0.99		210	33.0	

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
1/11/2001	CPF086C	16.1	3.3	8.7	212	0.5	0.09	0.60	0.02	0.85	1.45	0.58	0.87		160	17.0	
1/11/2001	CPF086CUPS	15.3	3.7	9.0	244	0.6	0.09	0.60	0.11	1.50	2.10	0.49	1.61		190	21.0	
1/11/2001	CPF086F	15.1	3.3	8.3	200	0.6	0.07	0.70	0.06	0.61	1.31	0.64	0.67		150	14.0	
1/11/2001	CPF087B	14.0	3.4	7.7	182	0.7	0.09	0.70	0.14	0.38	1.08	0.56	0.52		130	11.0	
1/11/2001	CPF087B3	13.1	3.0	7.1	159	1.1	0.06	0.80	0.35	0.14	0.94	0.45	0.49		130	8.0	
1/11/2001	CPF087D	12.5	3.5	7.2	155	1.1	0.09	0.80	0.37	0.12	0.92	0.43	0.49		130	6.0	
1/11/2001	CPF08801A	12.4	3.4	7.1	155	1.1	0.04	0.70	0.30	0.12	0.82	0.40	0.42		140	5.0	
1/11/2001	CPF0880Aa	11.8	4.0	7.3	155	1.2	0.05	0.80	0.38	0.09	0.89	0.42	0.47		140	6.0	
1/11/2001	CPF0880Ab	11.9	3.8	7.4	152	1.3	0.05	0.70	0.50	0.12	0.82	0.20	0.62		140	7.0	
1/11/2001	CPF0880Ac	12.3	3.7	7.6	154	1.2	0.06	0.80	0.32	0.12	0.92	0.48	0.44		130	7.0	
1/11/2001	CPF0884A	11.0	4.2	7.3	180	1.4	0.05	0.70	0.35	0.31	1.01	0.35	0.66		160	6.0	
12/12/2000	CPF049	13.7	6.5	8.1	348		0.24	0.50	<0.01	1.70	2.20	0.49	1.71		230	4.0	
12/12/2000	CPF050	16.6	7.8	9.1	317		0.20	0.50	0.38	1.40	1.90	0.12	1.78		210	4.0	
12/12/2000	CPF055C	11.4	7.2	7.4	235	0.9	0.12	0.50	0.15	0.55	1.05	0.35	0.70		160	10.0	
12/12/2000	CPF055E	9.7	7.9	7.1	210	0.9	0.09	0.60	0.11	0.37	0.97	0.49	0.48		150	9.0	
12/12/2000	CPF081A1C	11.8	6.6	7.3	207	0.7	0.08	0.70	0.21	0.44	1.14	0.49	0.65		150	15.0	
12/12/2000	CPF081A1CUPS	12.8	7.9	8.0	234	0.4	0.14	0.50	0.07	0.99	1.49	0.43	1.06		200	59.0	
12/12/2000	CPF086C	11.3	6.7	7.2	216	0.7	0.07	0.80	0.26	0.43	1.23	0.54	0.69		150	13.0	
12/12/2000	CPF086CUPS	11.4	7.6	7.3	207	0.6	0.09	0.60	0.21	0.56	1.16	0.39	0.77		200	62.0	
12/12/2000	CPF086F	11.1	6.2	7.3	208	0.7	0.07	0.80	0.38	0.33	1.13	0.42	0.71		140	11.0	
12/12/2000	CPF087B	10.1	6.8	7.3	172	0.8	0.07	0.80	0.24	0.04	0.84	0.56	0.28		120	8.0	
12/12/2000	CPF087B3	10.0	7.3	7.1	151	0.7	0.06	0.70	0.39	<0.01	0.71	0.31	0.40		110	9.0	
12/12/2000	CPF087D	9.7	7.4	7.0	149	0.7	0.06	0.60	0.18	<0.01	0.61	0.42	0.19		110	10.0	
12/12/2000	CPF08801A	9.8	7.7	7.0	149	0.7	0.06	0.50	0.24	<0.01	0.51	0.26	0.25		110	10.0	
12/12/2000	CPF0880Aa	9.7	7.9	7.1	151	0.8	0.04	0.60	0.25	0.05	0.65	0.35	0.30		110	11.0	
12/12/2000	CPF0880Ab	9.8	7.9	7.1	150	0.8	0.06	0.60	0.19	<0.01	0.61	0.41	0.20		110	10.0	
12/12/2000	CPF0880Ac	9.6	8.0	7.1	150	0.7	0.06	0.60	0.21	<0.01	0.61	0.39	0.22		110	10.0	
12/12/2000	CPF0884A	9.9	8.0	7.1	180	0.8	0.06	0.60	0.19	0.24	0.84	0.41	0.43		120	7.0	
11/20/2000	CPF049	11.9	6.9	7.6	332		0.24	0.70	<0.01	1.20	1.90	0.70	1.21		230	<1.0	
11/20/2000	CPF050	14.2	7.6	8.3	380		0.27	0.40	<0.01	1.80	2.20	0.40	1.81		260	<1.0	
11/20/2000	CPF055C	9.9	12.6	7.6	200	0.7	0.07	0.70	<0.01	<0.01	0.71	0.70	0.02		150	12.0	
11/20/2000	CPF055E	8.1	13.1	7.2	217	0.7	0.04	0.60	0.04	0.17	0.77	0.56	0.21		150	9.0	
11/20/2000	CPF081A1C	10.3	8.6	7.4	195	0.4	0.11	0.50	<0.01	0.02	0.52	0.50	0.03		160	25.0	
11/20/2000	CPF081A1CUPS	11.8	6.8	8.0	223	0.4	0.15	0.60	0.08	0.02	0.62	0.52	0.10		210	53.0	
11/20/2000	CPF086C	9.8	9.4	7.3	189	0.5	0.10	0.50	0.04	0.04	0.54	0.46	0.08		200	24.0	
11/20/2000	CPF086CUPS	11.2	6.5	7.5	210	0.4	0.10	0.50	0.05	0.25	0.75	0.45	0.30		220	78.0	
11/20/2000	CPF086F	9.6	10.5	7.3	178	0.5	0.10	0.50	0.23	0.02	0.52	0.27	0.25		140	21.0	
11/20/2000	CPF087B	9.4	11.0	7.1	160	0.6	0.08	0.60	0.38	<0.01	0.61	0.22	0.39		130	16.0	
11/20/2000	CPF087B3	9.0	12.0	7.2	146	0.6	0.06	0.60	0.06	0.02	0.62	0.54	0.08		120	13.0	
11/20/2000	CPF087D	8.8	12.4	7.1	145	0.6	0.05	0.60	0.07	<0.01	0.61	0.53	0.08		120	12.0	
11/20/2000	CPF08801A	8.5	12.7	7.1	146	0.7	0.06	0.50	0.11	0.03	0.53	0.39	0.14		120	14.0	
11/20/2000	CPF0880Aa	8.4	13.1	7.1	148	0.6	0.06	0.50	0.27	0.04	0.54	0.23	0.31		110	17.0	
11/20/2000	CPF0880Ab	8.4	13.3	7.1	149	0.6	0.05	0.50	0.03	0.02	0.52	0.47	0.05		130	15.0	
11/20/2000	CPF0880Ac	8.5	13.0	7.1	147	0.6	0.05	0.40	<0.01	<0.01	0.41	0.39	0.02		120	15.0	
11/20/2000	CPF0884A	7.5	13.2	7.1	206	0.7	0.06	0.50	0.10	0.18	0.68	0.40	0.28		150	11.0	
10/26/2000	CPF049	11.7	18.4	8.8	415		0.19	0.70	<0.01	1.30	2.00	0.70	1.31		260	<1.0	
10/26/2000	CPF050	8.8	15.8	8.0	393		0.14	0.50	<0.01	1.20	1.70	0.50	1.21		240	<1.0	
10/26/2000	CPF055C	10.6	18.8	8.5	154	0.4	0.06	0.60	<0.01	<0.01	0.61	0.60	0.01		110	7.0	
10/26/2000	CPF055E	9.9	19.0	8.2	147	0.6	0.05	0.50	<0.01	<0.01	0.51	0.50	0.01		110	10.0	
10/26/2000	CPF081A1C	9.8	18.7	8.5	176	0.3	0.09	0.60	0.03	<0.01	0.61	0.57	0.04		120	20.0	
10/26/2000	CPF081A1CUPS	10.2	18.6	8.6	190	0.2	0.12	0.60	<0.01	<0.01	0.61	0.60	0.01		150	24.0	

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
10/26/2000	CPF086C	10.7	19.0	8.6	173	0.3	0.07	0.60	<0.01	<0.01	0.61	0.60	0.01		120	9.0	
10/26/2000	CPF086CUPS	11.3	18.7	8.5	211	0.2	0.09	0.60	<0.01	0.25	0.85	0.59	0.26		150	22.0	
10/26/2000	CPF086F	11.4	19.7	8.8	167	0.4	0.06	0.40	<0.01	<0.01	0.41	0.40	0.01		120	10.0	
10/26/2000	CPF087B	7.9	18.6	7.1	155	0.3	0.06	0.30	<0.01	0.04	0.34	0.30	0.05		110	13.0	
10/26/2000	CPF087B3	7.6	18.9	7.1	145	0.4	0.04	0.30	<0.01	<0.01	0.31	0.30	0.01		101	7.0	
10/26/2000	CPF087D	9.9	19.6	8.3	146	0.5	0.05	0.30	0.02	<0.01	0.31	0.28	0.03		94	10.0	
10/26/2000	CPF08801A	7.7	19.0	7.0	143	0.7	0.04	0.40	<0.01	0.02	0.42	0.40	0.03		94	10.0	
10/26/2000	CPF0880Aa	9.3	19.2	7.8	142	0.6	0.05	0.60	<0.01	<0.01	0.61	0.60	0.02		98	1.0	
10/26/2000	CPF0880Ab	7.0	18.9	6.9	143	0.5	0.03	0.40	<0.01	0.05	0.45	0.39	0.06		93	<1.0	
10/26/2000	CPF0880Ac	7.5	18.8	7.0	142	1.0	0.04	0.60	<0.01	<0.01	0.61	0.60	0.01		91	8.0	
10/26/2000	CPF0884A	9.2	19.0	8.0	143	0.6	0.04	0.50	<0.01	<0.01	0.51	0.49	0.02		96	5.0	
9/27/2000	CPF049	9.1	19.1	7.0	104		0.16	0.30	0.03	0.46	0.76	0.27	0.49		160	43.0	
9/27/2000	CPF050	8.8	19.0	7.1	98		0.14	0.40	<0.01	0.43	0.83	0.39	0.44		170	60.0	
9/27/2000	CPF055C	8.3	21.3	7.2	135	0.2	0.09	0.20	<0.01	0.51	0.71	0.20	0.52		130	12.0	
9/27/2000	CPF055E	8.8	22.5	8.0	154	0.6	0.07	0.40	<0.01	0.33	0.73	0.40	0.34		140	7.0	
9/27/2000	CPF081A1C	8.2	21.8	7.5	158	0.5	0.06	0.50	<0.01	<0.01	0.51	0.50	0.01		130	18.0	
9/27/2000	CPF081A1CUPS	7.8	20.3	7.1	178	0.3	0.11	0.40	<0.01	0.26	0.66	0.40	0.27		160	33.0	
9/27/2000	CPF086C	7.7	21.5	7.3	158	0.3	0.06	0.70	<0.01	<0.01	0.71	0.70	0.01		140	20.0	
9/27/2000	CPF086CUPS	9.0	20.3	7.6	170	0.3	0.07	0.60	<0.01	0.12	0.72	0.60	0.13		140	20.0	
9/27/2000	CPF086F	7.4	21.9	7.1	150	0.5	0.05	0.50	<0.01	<0.01	0.51	0.50	0.01		120	15.0	
9/27/2000	CPF087B	7.1	22.0	7.0	144	0.6	<0.01	0.40	<0.01	<0.01	0.41	0.40	0.01		120	9.0	
9/27/2000	CPF087B3	7.2	22.4	7.0	142	0.7	0.01	0.40	<0.01	<0.01	0.41	0.40	0.02		110	7.0	
9/27/2000	CPF087D	7.2	22.4	7.0	143	0.6	0.01	0.50	<0.01	<0.01	0.51	0.50	0.01		110	9.0	
9/27/2000	CPF08801A	5.8	22.2	6.9	146	0.6	0.01	0.60	<0.01	0.13	0.73	0.59	0.14		110	5.0	
9/27/2000	CPF0880Aa	7.5	22.6	7.1	145	0.7	0.03	0.40	<0.01	0.13	0.53	0.40	0.14		120	8.0	
9/27/2000	CPF0880Ab	7.0	22.6	7.1	144	0.7	0.02	0.40	<0.01	0.10	0.50	0.40	0.11		110	4.0	
9/27/2000	CPF0880Ac	7.5	22.6	7.1	145	0.7	0.03	0.40	<0.01	0.11	0.51	0.40	0.12		110	9.0	
9/27/2000	CPF0884A	8.9	22.8	7.9	155	0.6	0.06	0.70	<0.01	0.28	0.98	0.70	0.29		120	8.0	
9/20/2000	CPF049	8.9	20.3	7.6	122		0.14	0.40	<0.01	0.54	0.94	0.39	0.55				
9/20/2000	CPF050	8.6	21.0	7.7	117		0.13	0.30	<0.01	0.66	0.96	0.30	0.67		160	30.0	
9/20/2000	CPF055C	9.0	23.5	7.9	162	0.9	0.06	0.50	<0.01	0.30	0.80	0.50	0.31		130	8.0	
9/20/2000	CPF055E	6.9	23.5	7.4	162	0.9	0.05	0.40	<0.01	0.36	0.76	0.40	0.37		140	1.0	
9/20/2000	CPF081A1C	7.7	22.5	7.5	150	0.5	0.03	0.40	<0.01	<0.01	0.41	0.40	0.01		130	19.0	
9/20/2000	CPF081A1CUPS	9.0	23.0	7.8	162	0.3	0.06	0.40	<0.01	<0.01	0.41	0.40	0.01		160	40.0	
9/20/2000	CPF086C	8.4	22.4	7.6	152	0.5	0.04	0.40	<0.01	<0.01	0.41	0.40	0.01		130	21.0	
9/20/2000	CPF086CUPS	8.3	22.8	7.7	153	0.4	0.05	0.40	<0.01	0.03	0.43	0.40	0.04		150	28.0	
9/20/2000	CPF086F	6.8	22.6	7.5	143	0.5	0.02	0.50	<0.01	<0.01	0.51	0.50	0.01		130	10.0	
9/20/2000	CPF087B	7.0	22.7	7.5	137	0.6	0.02	0.50	<0.01	<0.01	0.51	0.50	0.01		120	7.0	
9/20/2000	CPF087B3	6.9	23.2	7.5	136	0.8	0.01	0.60	<0.01	<0.01	0.61	0.60	0.01		110	6.0	
9/20/2000	CPF087D	6.7	23.2	7.6	141	0.8	0.01	0.50	<0.01	0.04	0.54	0.50	0.05		110	7.0	
9/20/2000	CPF08801A	6.7	23.3	7.9	140	0.8	<0.01	0.50	<0.01	0.05	0.55	0.50	0.06		100	5.0	
9/20/2000	CPF0880Aa	5.8	23.4	7.5	143	0.7	0.01	0.40	<0.01	0.07	0.47	0.40	0.08		110	2.0	
9/20/2000	CPF0880Ab	6.0	23.4	7.4	143	0.9	0.05	0.40	<0.01	0.06	0.46	0.40	0.07		110	7.0	
9/20/2000	CPF0880Ac	6.5	23.6	7.7	140	0.9	0.01	0.40	<0.01	0.06	0.46	0.40	0.07		100	5.0	
9/20/2000	CPF0884A	7.0	24.2	7.3	160	0.7	0.04	<0.10	<0.01	0.38	0.48	0.10	0.39		130	6.0	
8/15/2000	CPF049	9.1	26.5	8.2	246		0.20	0.70	0.04	1.50	2.20	0.66	1.54		180	1.0	
8/15/2000	CPF050	9.6	25.3	8.0	286										870	5.0	
8/15/2000	CPF055C	9.4	28.9	8.6	182	0.7	0.07	0.60	<0.01	0.24	0.84	0.60	0.25		140	6.0	
8/15/2000	CPF055E	7.7	28.8	7.8	142	0.9	0.02	0.40	<0.01	0.03	0.43	0.40	0.04		90	5.0	
8/15/2000	CPF081A1C	6.6	27.5	7.1	141	0.3	0.12	0.60	<0.01	<0.01	0.61	0.60	0.01		120	18.0	
8/15/2000	CPF081A1CUPS	8.6	26.9	7.5	138	0.2	0.18	0.60	<0.01	<0.01	0.61	0.60	0.01		150	21.0	

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
8/15/2000	CPF086C	5.5	27.0	7.0	145	0.4	0.12	0.50	0.06	<0.01	0.51	0.44	0.07		120	18.0	
8/15/2000	CPF086CUPS	7.3	26.7	7.2	151	0.3	0.12	0.80	<0.01	<0.01	0.81	0.80	0.01		120	24.0	
8/15/2000	CPF086F	8.1	28.0	7.7	141	0.4	0.06	0.60	<0.01	<0.01	0.61	0.60	0.01		120	11.0	
8/15/2000	CPF087B	5.7	26.9	7.0	138	0.6	0.05	0.40	<0.01	<0.01	0.41	0.40	0.01		110	8.0	
8/15/2000	CPF087B3	6.9	27.3	7.3	135	0.7	0.03	0.50	<0.01	<0.01	0.51	0.50	0.01		100	6.0	
8/15/2000	CPF087D	7.2	27.8	7.3	135	0.8	0.03	0.40	<0.01	<0.01	0.41	0.40	0.01		87	5.0	
8/15/2000	CPF08801A	7.7	27.5	7.3	136	0.8	0.01	0.60	<0.01	<0.01	0.61	0.59	0.02		83	6.0	
8/15/2000	CPF0880Aa	7.6	27.7	7.4	137	1.0	0.02	0.50	<0.01	0.02	0.52	0.50	0.03		95	4.0	
8/15/2000	CPF0880Ab	7.4	27.8	7.5	137	1.0	0.02	0.60	<0.01	<0.01	0.61	0.60	0.01		86	6.0	
8/15/2000	CPF0880Ac	7.6	27.9	7.4	137	1.0	0.02	0.60	<0.01	<0.01	0.61	0.60	0.01		88	4.0	
8/15/2000	CPF0884A	7.6	27.9	7.4	137	1.0	0.02	0.30	0.18	0.02	0.32	0.12	0.20		86	5.0	
8/3/2000	CPF049	7.6	27.0	7.5	202		0.19	0.60	0.04	1.80	2.40	0.56	1.84		180	8.0	
8/3/2000	CPF050	7.7	26.7	7.9	257		0.18	0.40	0.02	1.10	1.50	0.38	1.12		160	16.0	
8/3/2000	CPF055C	10.3	28.7	9.0	165	0.8	0.09	0.50	0.02	0.06	0.56	0.48	0.08		130	7.0	
8/3/2000	CPF055E	8.9	27.7	8.6	148	0.9	0.05	0.30	<0.01	<0.01	0.31	0.30	0.01		100	5.0	
8/3/2000	CPF081A1C	7.6	28.0	7.7	140	0.5	0.07	0.50	<0.01	<0.01	0.51	0.50	0.01		130	15.0	
8/3/2000	CPF081A1CUPS	8.4	28.1	7.5	135	0.4	0.15	0.70	<0.01	0.07	0.77	0.70	0.08		110	34.0	
8/3/2000	CPF086C	7.7	28.1	7.9	153	0.5	0.07	0.60	<0.01	<0.01	0.61	0.60	0.01		130	17.0	
8/3/2000	CPF086CUPS	7.1	28.5	7.6	154	0.4	0.09	0.80	<0.01	<0.01	0.81	0.80	0.01		140	36.0	
8/3/2000	CPF086F	7.6	27.7	7.9	138	0.6	0.03	0.60	<0.01	<0.01	0.61	0.60	0.01		110	12.0	
8/3/2000	CPF087B	7.9	27.8	8.1	138	0.7	0.04	0.60	<0.01	<0.01	0.61	0.60	0.01		100	8.0	
8/3/2000	CPF087B3	8.2	27.7	8.3	139	0.8	0.02	0.40	<0.01	<0.01	0.41	0.40	0.01		99	6.0	
8/3/2000	CPF087D	7.9	28.0	8.4	140	1.0	0.03	0.40	0.10	<0.01	0.41	0.30	0.11		100	7.0	
8/3/2000	CPF08801A	8.4	28.0	8.5	140	1.0	0.02	0.60	0.05	<0.01	0.61	0.55	0.06		100	6.0	
8/3/2000	CPF0880Aa	8.1	27.4	8.1	139	0.9	0.02	0.30	<0.01	<0.01	0.31	0.30	0.01		110	4.0	
8/3/2000	CPF0880Ab	8.3	27.6	8.3	139	1.0	0.02	0.30	0.02	<0.01	0.31	0.28	0.03		100	5.0	
8/3/2000	CPF0880Ac	8.3	27.7	8.3	139	1.0	0.03	0.40	<0.01	<0.01	0.41	0.39	0.02		100	4.0	
8/3/2000	CPF0884A	9.8	28.3	8.9	147	0.9	0.03	0.40	<0.01	<0.01	0.41	0.40	0.01		100	7.0	
7/19/2000	CPF049	8.8	29.7	8.7	299		0.19	0.50	0.02	1.80	2.30	0.48	1.82		200	4.0	
7/19/2000	CPF050	9.9	29.7	8.6	271		0.16	0.60	<0.01	1.20	1.80	0.59	1.21		190	5.0	
7/19/2000	CPF055C	12.2	29.5	9.5	183	0.6	0.07	0.50	<0.01	<0.01	0.51	0.50	0.01		140	6.0	
7/19/2000	CPF055E	10.3	29.6	9.2	165	0.7	0.04	0.40	0.07	<0.01	0.41	0.33	0.08		120	7.0	
7/19/2000	CPF081A1C	9.0	29.8	8.9	175	0.4	0.09	0.50	0.25	<0.01	0.51	0.25	0.26		130	23.0	
7/19/2000	CPF081A1CUPS	9.1	29.8	8.8	185	0.2	0.14	0.50	0.05	<0.01	0.51	0.45	0.06		170	60.0	
7/19/2000	CPF086C	9.6	29.4	8.9	171	0.4	0.06	0.70	0.03	<0.01	0.71	0.67	0.04		130	10.0	
7/19/2000	CPF086CUPS	9.3	29.8	8.9	172	0.4									130	20.0	
7/19/2000	CPF086F	9.3	29.2	8.8	162	0.6	0.05	0.40	<0.01	<0.01	0.41	0.40	0.01		130	7.0	
7/19/2000	CPF087B	9.1	29.6	8.8	144	0.8	0.03	0.20	<0.01	<0.01	0.21	0.20	0.01		100	4.0	
7/19/2000	CPF087B3	9.2	29.2	8.8	140	1.0	0.02	0.20	0.19	<0.01	0.21	0.01	0.20		100	3.0	
7/19/2000	CPF087D	8.7	29.4	8.6	140	1.1	0.02	0.30	0.13	<0.01	0.31	0.17	0.14		100	2.0	
7/19/2000	CPF08801A	8.8	29.3	8.6	141	1.2									100	5.0	
7/19/2000	CPF0880Aa	8.7	28.6	8.5	138	1.4	0.02	0.20	0.04	<0.01	0.21	0.16	0.05		95	4.0	
7/19/2000	CPF0880Ab	8.6	29.2	8.5	142	1.4	0.02	0.30	<0.01	<0.01	0.31	0.30	0.01		100	3.0	
7/19/2000	CPF0880Ac	8.6	29.5	8.6	141	1.4	0.01	0.20	0.04	<0.01	0.21	0.16	0.05		100	1.0	
7/19/2000	CPF0884A	10.4	29.6	9.3	165	0.6	0.03	0.40	0.18	<0.01	0.41	0.22	0.19		110	6.0	
7/6/2000	CPF049	7.1	27.8	7.3	135		0.17	0.50	0.24	0.64	1.14	0.26	0.88		120	5.0	
7/6/2000	CPF050	8.3	28.1	7.8	129		0.16	0.50	0.20	0.59	1.09	0.30	0.79		130	8.0	
7/6/2000	CPF055C	10.5	28.7	9.3	189	0.3	0.09	0.60	0.15	<0.01	0.61	0.45	0.16		140	7.0	
7/6/2000	CPF055E	11.4	28.6	9.3	193	0.4	0.09	0.50	0.47	<0.01	0.51	0.03	0.48		150	5.0	
7/6/2000	CPF081A1C	8.5	29.8	8.5	180	0.2	0.12	0.70	0.47	<0.01	0.71	0.23	0.48		150		
7/6/2000	CPF081A1CUPS	8.2	29.5	8.5	174	0.2	0.13	0.60	0.17	<0.01	0.61	0.43	0.18		170	25.0	

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
7/6/2000	CPF086C	7.8	29.3	8.2	162	0.2	0.08	0.50	0.10	<0.01	0.51	0.40	0.11		130	17.0	
7/6/2000	CPF086CUPS	7.5	29.7	8.0	163	0.2	0.08	0.40	0.27	<0.01	0.41	0.13	0.28		140	22.0	
7/6/2000	CPF086F	8.8	29.3	8.5	156	0.3	0.07	0.50	0.18	<0.01	0.51	0.32	0.19		130	8.0	
7/6/2000	CPF087B	8.0	29.3	8.2	143	0.3	0.04	0.40	0.39	<0.01	0.41	0.01	0.40		110	13.0	
7/6/2000	CPF087B3	8.0	28.6	8.2	138	0.7	0.03	0.30	0.13	<0.01	0.31	0.17	0.14		100	3.0	
7/6/2000	CPF087D	8.1	28.5	8.3	140	0.8	0.03	0.60	0.54	<0.01	0.61	0.06	0.55		100	6.0	
7/6/2000	CPF08801A	8.0	27.9	8.0	141	0.8	0.02	1.80	0.10	<0.01	1.81	1.70	0.11		110	2.0	
7/6/2000	CPF0880Aa	7.5	27.7	7.9	142	1.0	0.03	0.40	0.02	<0.01	0.41	0.38	0.03				
7/6/2000	CPF0880Ab	7.7	27.8	8.0	143	1.1	0.03	0.50	0.15	<0.01	0.51	0.35	0.16		110	3.0	
7/6/2000	CPF0880Ac	7.7	27.8	7.9	144	1.0	0.02	0.50	0.53	<0.01	0.51	-0.03	0.54		110	6.0	
7/6/2000	CPF0884A	9.4	28.6	8.9	170	0.5	0.04	0.70	0.48	<0.01	0.71	0.22	0.49		130	5.0	
6/22/2000	CPF049	7.8	26.2	7.1	98		0.16	0.60	0.37	0.76	1.36	0.23	1.13		120	19.0	
6/22/2000	CPF050	7.5	26.3	7.0	96		0.19	0.70	0.09	0.78	1.48	0.61	0.87		140	25.0	
6/22/2000	CPF055C	10.3	28.0	8.7	243	0.5	0.14	0.60	0.23	0.48	1.08	0.37	0.71		180	8.0	
6/22/2000	CPF055E	8.5	27.5	8.3	232	0.6	0.11	0.40	0.22	0.50	0.90	0.18	0.72		130	13.0	
6/22/2000	CPF081A1C	7.9	28.1	7.8	160	0.4	0.08	0.60	<0.01	<0.01	0.61	0.60	0.01		120	20.0	
6/22/2000	CPF081A1CUPS	8.6	28.3	8.2	189	0.2	0.17	0.50	<0.01	<0.01	0.51	0.50	0.01		180	54.0	
6/22/2000	CPF086C	8.5	28.0	8.1	165	0.4	0.08	0.70	0.15	<0.01	0.71	0.55	0.16		120	18.0	
6/22/2000	CPF086CUPS	8.7	28.4	8.2	161	0.3	0.09	0.50	<0.01	<0.01	0.51	0.50	0.01		130	23.0	
6/22/2000	CPF086F	6.4	27.4	7.2	150	0.5	0.07	0.60	0.03	<0.01	0.61	0.57	0.04		110	10.0	
6/22/2000	CPF087B	7.8	27.4	7.7	139	0.8	0.05	0.60	0.02	<0.01	0.61	0.58	0.03		96	8.0	
6/22/2000	CPF087B3	7.8	27.4	7.7	139	0.8	0.04	0.50	<0.01	<0.01	0.51	0.50	0.01		93	4.0	
6/22/2000	CPF087D	7.6	27.2	7.6	138	1.1	0.02	0.20	0.05	<0.01	0.21	0.15	0.06		89	3.0	
6/22/2000	CPF08801A	7.4	27.3	7.6	138	1.0	0.15	1.00	0.54	<0.01	1.01	0.46	0.55		86	3.0	
6/22/2000	CPF0880Aa	8.1	27.3	7.8	139	1.0	0.02	1.00	0.28	<0.01	1.01	0.72	0.29		97	3.0	
6/22/2000	CPF0880Ab	7.4	27.2	7.5	144	1.0	0.03	0.40	0.29	<0.01	0.41	0.11	0.30		97	6.0	
6/22/2000	CPF0880Ac	7.6	27.5	7.7	146	0.9	0.03	1.30	0.67	<0.01	1.31	0.63	0.68		98	4.0	
6/22/2000	CPF0884A	11.1	28.8	9.0	229	0.8	0.07	0.60	<0.01	0.05	0.65	0.59	0.06		120	7.0	
6/1/2000	CPF049	8.1	23.5	6.6	277		0.18	0.50	<0.01	1.70	2.20	0.50	1.71		370	1.0	
6/1/2000	CPF050	9.1	23.7	8.2	278		0.16	0.60	<0.01	1.90	2.50	0.59	1.91		190	5.0	
6/1/2000	CPF055C	9.4	24.3	7.4	191	0.8	0.07	0.40	<0.01	0.32	0.72	0.40	0.33		140	3.0	
6/1/2000	CPF055E	9.4	24.6	7.3	188	0.8	0.05	0.60	0.03	0.11	0.71	0.57	0.14		120	1.0	
6/1/2000	CPF081A1C	10.2	24.5	6.7	167	0.3	0.09	0.50	0.03	<0.01	0.51	0.47	0.04		130	16.0	
6/1/2000	CPF081A1CUPS	11.3	24.8	6.6	177	0.2	0.10	0.30	0.08	<0.01	0.31	0.22	0.09		140	11.0	
6/1/2000	CPF086C	11.0	24.9	7.4	169	0.4	0.08	0.60	<0.01	<0.01	0.61	0.60	0.01				
6/1/2000	CPF086CUPS	10.8	25.2	7.3	166	0.3	0.07	0.80	0.12	<0.01	0.81	0.68	0.13		120	13.0	
6/1/2000	CPF086F	8.3	24.3	8.5	150	0.4	0.08	0.70	0.03	<0.01	0.71	0.67	0.04		120	12.0	
6/1/2000	CPF087B	8.7	24.3	6.6	144	0.6	0.04	0.40	0.03	<0.01	0.41	0.37	0.04		100	7.0	
6/1/2000	CPF087B3	8.3	24.0	6.8	143	0.8	0.04	0.50	<0.01	<0.01	0.51	0.50	0.01		100	4.0	
6/1/2000	CPF087D	8.2	24.2	5.6	137	0.9	0.03	0.50	0.23	0.02	0.52	0.27	0.25		100	3.0	
6/1/2000	CPF08801A	8.9	23.4	7.0	125	1.1	0.02	0.40	<0.01	<0.01	0.41	0.40	0.01		76	2.0	
6/1/2000	CPF0880Aa	7.5	22.7	5.3	136	1.2	0.01	0.20	<0.01	<0.01	0.21	0.20	0.02		90	1.0	
6/1/2000	CPF0880Ab	8.0	23.0	6.1	136	1.0	0.03	0.50	<0.01	<0.01	0.51	0.50	0.02		91	3.0	
6/1/2000	CPF0880Ac	8.2	23.4	6.0	136	1.1	0.02	0.40	0.06	<0.01	0.41	0.34	0.07		83	5.0	
6/1/2000	CPF0884A	8.9	24.1	8.0	180	0.8	0.04	0.40	<0.01	0.10	0.50	0.40	0.11		120	1.0	
5/22/2000	CPF049	9.0	24.1	7.3	270		0.19	0.50	0.06	1.20	1.70	0.44	1.26		200	14.0	
5/22/2000	CPF050	8.7	25.0	6.6	304		0.19	0.40	0.03	1.10	1.50	0.37	1.13		230	27.0	
5/22/2000	CPF081A1CUPS	6.7	25.8	6.9	169	0.2	0.17	0.70	0.17	<0.01	0.71	0.53	0.18		160	64.0	
5/22/2000	CPF081A1C	7.5	25.6	7.6	150	0.4	0.10	0.70	0.10	<0.01	0.71	0.60	0.11		130	23.0	
5/22/2000	CPF086CUPS	6.7	25.8	6.9	169	0.2	0.12	0.50	0.12	0.09	0.59	0.38	0.21		160	35.0	
5/22/2000	CPF086C	7.3	25.4	6.8	149	0.4	0.07	0.60	0.10	<0.01	0.61	0.50	0.11		130	18.0	

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
5/22/2000	CPF086F	8.5	25.0	7.1	142	0.6	0.06	0.40	0.03	<0.01	0.41	0.37	0.04		110	13.0	
5/22/2000	CPF087B	8.2	24.1	6.8	132	0.8	0.04	0.60	0.04	<0.01	0.61	0.56	0.05		95	7.0	
5/22/2000	CPF087B3	9.0	24.6	7.1	132	1.0	0.02	0.40	0.03	<0.01	0.41	0.37	0.04		100	9.0	
5/22/2000	CPF087D	9.2	24.9	7.2	130	1.1	0.02	0.50	0.04	<0.01	0.51	0.46	0.05		99	9.0	
5/22/2000	CPF08801A	8.9	24.4	7.1	128	1.1	0.02	0.40	0.04	<0.01	0.41	0.36	0.05		96	7.0	
5/22/2000	CPF0880Aa	9.9	24.9	10.2	123	1.0	0.02	0.30	<0.01	<0.01	0.31	0.30	0.01		85	3.0	
5/22/2000	CPF0880Ab	9.7	24.6	9.4	123	1.1	0.03	0.20	0.03	<0.01	0.21	0.17	0.04		88	27.0	
5/22/2000	CPF0880Ac	9.7	24.8	9.9	123	1.2	0.02	0.30	0.03	<0.01	0.31	0.27	0.04		88	5.0	
5/22/2000	CPF055E	11.7	25.9	12.8	148	0.9	0.04	0.30	0.02	0.04	0.34	0.28	0.06		110	3.0	
5/22/2000	CPF055C	11.8	26.3	11.7	198	0.8	0.07	0.40	<0.01	0.18	0.58	0.40	0.19		140	5.0	
5/22/2000	CPF0884A	10.2	25.8	6.9	126	0.9	0.03	0.40	0.06	<0.01	0.41	0.34	0.07		100	7.0	
8/4/1999	CPF049	7.7	27.9	7.6	280		0.41	0.70	0.04	0.63	1.33	0.66	0.67		190	6.0	
8/4/1999	CPF050	6.3	26.8	7.5	248		0.34	0.60	0.04	0.47	1.07	0.56	0.51		200	33.0	
8/4/1999	CPF055C	8.0	29.0	8.9	269	0.8	0.12	0.80	<0.01	<0.01	0.81	0.80	0.01		180	6.0	
8/4/1999	CPF055E	7.4	29.6	8.9	234	0.8	0.07	0.70	<0.01	<0.01	0.71	0.70	0.01		160	5.0	
8/4/1999	CPF081A1C	5.9	28.5	7.2	188	0.3	0.09	1.40	0.07	<0.01	1.41	1.33	0.08		150	16.0	
8/4/1999	CPF086C	5.9	28.4	7.2	189	0.4	0.09	0.60	<0.01	<0.01	0.61	0.59	0.02		150	22.0	
8/4/1999	CPF086F	5.7	28.7	7.2	190	0.5	0.09	0.70	<0.01	<0.01	0.71	0.69	0.02		140	13.0	
8/4/1999	CPF087B3	6.4	28.3	7.3	161	0.9	0.04	0.70	<0.01	<0.01	0.71	0.70	0.01		110	5.0	
8/4/1999	CPF087D	6.6	28.7	7.5	162	0.7	0.04	0.50	<0.01	<0.01	0.51	0.50	0.01		110	7.0	
8/4/1999	CPF08801A	6.7	28.5	7.4	160	0.8	0.03	0.80	<0.01	<0.01	0.81	0.79	0.02		110	5.0	
8/4/1999	CPF0880A	7.1	28.6	7.6	160	1.0	0.03	0.40	<0.01	0.03	0.43	0.40	0.04		110	11.0	
7/21/1999	CPF049	8.1	29.3	8.0	224		0.40	0.50	0.11	0.89	1.39	0.39	1.00		190	15.0	
7/21/1999	CPF050	6.5	28.1	7.6	249		0.31	0.40	0.10	1.30	1.70	0.30	1.40		180	2.0	
7/21/1999	CPF055C	14.7	30.4	9.8	254	0.5	0.17	0.60	0.05	<0.01	0.61	0.55	0.06		180	14.0	
7/21/1999	CPF055E	13.9	30.7	9.7	240	0.5	0.06	0.50	0.02	<0.01	0.51	0.48	0.03		170	10.0	
7/21/1999	CPF081A1C	8.0	30.7	9.0	181	0.4	0.08	0.60	0.02	<0.01	0.61	0.58	0.03		150	10.0	
7/21/1999	CPF086C	9.0	30.6	9.1	172	0.4	0.06	0.50	0.02	<0.01	0.51	0.48	0.03		130	13.0	
7/21/1999	CPF086F	9.7	31.0	9.2	168	0.5	0.05	0.60	<0.01	0.04	0.64	0.59	0.05		120	11.0	
7/21/1999	CPF087B3	9.4	29.6	9.0	147	0.8	0.01	0.60	0.17	0.03	0.63	0.43	0.20		110	6.0	
7/21/1999	CPF087D	9.6	29.7	8.9	146	1.1	<0.01	0.40	0.05	<0.01	0.41	0.35	0.06		120	6.0	
7/21/1999	CPF08801A	9.1	29.1	8.8	148	1.2	0.01	0.40	0.04	<0.01	0.41	0.36	0.05		120	4.0	
7/21/1999	CPF0880A	9.5	29.9	8.9	156	1.1	0.01	0.40	0.03	<0.01	0.41	0.37	0.04		120	6.0	
6/9/1999	CPF049	8.2	27.1	7.8	373		0.18	0.70	0.03	1.50	2.20	0.67	1.53		240	2.0	
6/9/1999	CPF050	6.2	26.9	7.6	339		0.17	0.60	0.04	1.20	1.80	0.56	1.24		230	5.0	
6/9/1999	CPF055C	11.6	30.6	9.4	209	0.7	0.07	0.50	<0.01	0.05	0.55	0.50	0.06		150	6.0	
6/9/1999	CPF055E	10.1	29.8	9.3	171	1.0	0.03	0.40	<0.01	0.05	0.45	0.40	0.06		120	4.0	
6/9/1999	CPF081A1C	9.1	30.2	8.6	154	0.7	0.07	0.50	<0.01	0.03	0.53	0.50	0.04		120	9.0	
6/9/1999	CPF086C	9.1	30.5	8.7	158	0.6	0.06	0.40	<0.01	0.05	0.45	0.40	0.06		120	9.0	
6/9/1999	CPF086F	8.6	29.3	8.4	149	0.8	0.04	0.40	<0.01	0.03	0.43	0.40	0.04		110	9.0	
6/9/1999	CPF087B3	9.2	29.0	8.7	140	1.0	0.02	0.40	<0.01	0.03	0.43	0.40	0.04		100	6.0	
6/9/1999	CPF087D	9.1	29.0	8.7	141	1.2	0.02	0.40	<0.01	0.04	0.44	0.40	0.05		100	5.0	
6/9/1999	CPF8801A	9.0	29.4	8.6	140	1.0	0.02	0.40	<0.01	0.04	0.44	0.40	0.05		100	5.0	
6/9/1999	CPF0880A	9.4	30.2	8.7	142	0.9	0.03	0.40	<0.01	0.05	0.45	0.40	0.06		98	7.0	
5/18/1999	CPF049	8.9	19.5	7.3	113		0.14	0.60	0.08	0.73	1.33	0.52	0.81		140	15.0	
5/18/1999	CPF050	8.6	20.0	7.3	113		0.15	0.60	0.05	0.74	1.34	0.55	0.79		140	13.0	
5/18/1999	CPF055C	9.7	21.3	8.0	160	0.8	0.07	0.60	<0.01	0.56	1.16	0.60	0.57		130	8.0	
5/18/1999	CPF055E	9.9	21.6	8.4	140	0.8	0.04	0.40	<0.01	0.27	0.67	0.40	0.28		110	9.0	
5/18/1999	CPF081A1C	9.1	20.9	7.0	138	0.5	0.08	0.60	<0.01	<0.01	0.61	0.60	0.01		130	19.0	
5/18/1999	CPF086C	9.4	20.9	7.1	140	0.6	0.06	0.50	0.02	<0.01	0.51	0.48	0.03		230	15.0	
5/18/1999	CPF086F	8.8	20.7	7.0	137	0.6	0.06	0.60	0.02	<0.01	0.61	0.58	0.03		120	15.0	

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
5/18/1999	CPF087B3	8.1	20.4	7.1	133	0.9	0.04	0.60	0.07	0.07	0.67	0.53	0.14		110	7.0	
5/18/1999	CPF087D	8.4	20.7	7.0	132	0.8	0.03	0.60	0.06	0.07	0.67	0.54	0.13		120	7.0	
5/18/1999	CPF08801A	8.3	20.7	7.3	132	0.9	0.03	0.50	0.07	0.11	0.61	0.43	0.18		110	6.0	
5/18/1999	CPF0880A	8.9	21.0	6.9	136	0.9	0.02	0.50	<0.01	0.17	0.67	0.50	0.18		110	7.0	
4/29/1999	CPF049	9.2	15.6	7.7	281		0.25	0.60	0.13	1.80	2.40	0.47	1.93		190	5.0	
4/29/1999	CPF050	9.0	15.7	7.7	272		0.29	0.50	0.11	1.70	2.20	0.39	1.81		200	20.0	
4/29/1999	CPF055C	7.2	17.8	7.4	181	0.7	0.10	0.40	0.17	0.55	0.95	0.23	0.72		140	11.0	
4/29/1999	CPF055E	8.1	18.1	7.5	156	1.0	0.06	0.30	0.12	0.36	0.66	0.18	0.48		120	8.0	
4/29/1999	CPF081A1C	7.9	17.6	7.3	137	0.3	0.09	0.40	0.11	0.09	0.49	0.29	0.20		150	43.0	
4/29/1999	CPF086C	7.6	17.7	7.4	132	0.4	0.11	0.40	0.08	<0.01	0.41	0.32	0.09		130	32.0	
4/29/1999	CPF086F	7.6	17.9	7.4	131	0.4	0.08	0.40	0.08	0.02	0.42	0.32	0.10		130	27.0	
4/29/1999	CPF087B3	7.6	17.8	7.3	129	0.7	0.05	0.50	0.11	0.12	0.62	0.39	0.23		110	16.0	
4/29/1999	CPF087D	7.6	18.0	7.3	128	0.6	0.05	0.40	0.10	0.11	0.51	0.30	0.21		120	20.0	
4/29/1999	CPF08801A	7.2	17.8	7.2	130	0.6	0.02	0.40	0.13	0.13	0.53	0.27	0.26		110	11.0	
4/29/1999	CPF0880A	8.2	17.4	7.3	136	0.6	0.04	0.40	0.17	0.17	0.57	0.23	0.34		100	20.0	
8/5/1998	CPF055C	8.3	27.8	7.7	235	0.5	0.05	0.50	<0.01	0.02	0.52	0.50	0.03		170	9.0	
8/5/1998	CPF055E	8.1	28.2	7.8	164	0.7	0.02	0.30	<0.01	<0.01	0.31	0.30	0.01		120	5.0	
8/5/1998	CPF081A1C	7.7	26.9	7.5	151	0.2	0.11	0.30	<0.01	<0.01	0.31	0.30	0.02		150	40.0	
8/5/1998	CPF086C	8.7	26.7	8.0	146	0.2	0.06	0.50	<0.01	<0.01	0.51	0.50	0.01		140	33.0	
8/5/1998	CPF086F	8.8	26.9	8.0	139	0.3	0.03	0.50	<0.01	<0.01	0.51	0.50	0.01		120	18.0	
8/5/1998	CPF087B3	7.5	27.1	7.3	105	0.8	0.01	0.30	<0.01	<0.01	0.31	0.30	0.01		81	5.0	
8/5/1998	CPF0880A	7.7	27.6	7.4	97	0.7	0.01	0.40	<0.01	<0.01	0.41	0.40	0.01		76	6.0	
7/7/1998	CPF055C	8.7	30.2	8.7	205	0.6	0.07	0.40	<0.01	0.02	0.42	0.40	0.03		150	9.0	
7/7/1998	CPF055E	7.7	29.9	8.1	160	0.8	0.05	0.40	<0.01	<0.01	0.41	0.40	0.01		120	9.0	
7/7/1998	CPF081A1C	7.1	29.2	7.3	141	0.3	0.10	0.30	<0.01	<0.01	0.31	0.30	0.01		120	22.0	
7/7/1998	CPF086C	6.4	28.9	7.1	132	0.3	0.07	0.20	<0.01	<0.01	0.21	0.20	0.01		120	19.0	
7/7/1998	CPF086F	6.8	29.0	7.0	129	0.4	0.06	0.30	<0.01	<0.01	0.31	0.30	0.01		100	10.0	
7/7/1998	CPF087B3	7.0	28.9	7.0	103	0.8	0.03	0.30	<0.01	<0.01	0.31	0.30	0.01		83	7.0	
7/7/1998	CPF0880A	7.5	29.5	7.5	98	1.0	0.03	0.20	<0.01	<0.01	0.21	0.20	0.01		73	6.0	
6/17/1998	CPF055C	8.8	27.6	8.8	176	0.8	0.07	0.50	<0.01	0.35	0.85	0.50	0.36		150	12.0	
6/17/1998	CPF055E	8.1	26.6	8.5	157	0.7	0.05	0.50	<0.01	0.27	0.77	0.50	0.28		134	3.0	
6/17/1998	CPF081A1C	7.2	28.4	7.8	127	0.4	0.09	0.30	<0.01	<0.01	0.31	0.30	0.01		130	33.0	
6/17/1998	CPF086C	7.4	27.8	7.9	120	0.4	0.04	0.30	<0.01	<0.01	0.31	0.30	0.01		110	28.0	
6/17/1998	CPF086F	6.9	27.4	7.6	114	0.4	0.06	0.30	<0.01	<0.01	0.31	0.30	0.01		120	23.0	
6/17/1998	CPF087B3	7.3	26.8	7.8	87	0.9	0.03	0.20	<0.01	<0.01	0.21	0.20	0.02		100	13.0	
6/17/1998	CPF0880A	6.6	26.0	7.4	89	1.1	0.02	0.20	<0.01	<0.01	0.21	0.20	0.01		90	10.0	
Pittsboro Lake																	
8/11/2003	CPF050A9	5.9	25.4	6.4	74	0.5	0.08	0.76	<0.01	0.02	0.78	0.75	0.03	66	100	13.0	18.0
8/11/2003	CPF050B	4.6	23.5	6.3	83	0.6	0.07	0.65	0.06	0.17	0.82	0.59	0.23	5	120	18.0	30.0
7/16/2003	CPF050A9	8.3	27.6	7.2	76	0.8	0.07	0.68	<0.02	<0.02	0.69	0.67	0.02	63	79	10.0	12.0
7/16/2003	CPF050B	8.6	28.4	7.5	85	0.8	0.06	0.56	<0.02	<0.02	0.57	0.55	0.02	16	85	8.0	11.0
6/17/2003	CPF050A9	7.3	24.4	6.7	94	0.6	0.06	0.80	<0.02	0.02	0.82	0.79	0.03	56	96	13.0	12.0
6/17/2003	CPF050B	6.3	24.5	6.8	95	0.6	0.05	0.59	0.03	0.04	0.63	0.56	0.07	9	100	14.0	15.0
8/6/1998	CPF050A9	6.6	25.8	7.4	75	0.4	0.08	0.40	<0.01	<0.01	0.41	0.39	0.02		96	11.0	28.0
8/6/1998	CPF050B	6.4	25.6	7.1	79	0.4	0.16	0.40	0.06	0.11	0.51	0.34	0.17		150	64.0	55.0
7/8/1998	CPF050A9	9.3	28.7	8.6	104	0.6	0.03	0.40	0.06	<0.01	0.41	0.34	0.07		80	7.0	7.2
7/8/1998	CPF050B	9.5	29.1	8.6	106	0.4	0.03	0.30	0.06	<0.01	0.31	0.24	0.07		84	7.0	6.9

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
030606																	
University Lake																	
8/18/2003	CPFUL4	8.1	29.0	7.2	85	0.6	0.07	0.70	<0.02	<0.02	0.71	0.69	0.02	58	110	9	7.0
8/18/2003	CPFUL6	8.5	29.0	7.9	80	0.8	0.06	0.64	<0.02	<0.02	0.65	0.63	0.02	38	100	6	4.6
7/21/2003	CPFUL4	9.0	30.1	7.4	86	0.8	0.08	0.80	<0.02	<0.02	0.81	0.79	0.02	99	91	8.0	9.3
7/21/2003	CPFUL6	9.3	29.9	8.0	83	1.0	0.06	0.71	<0.02	<0.02	0.72	0.70	0.02	160	92	8.0	7.9
6/18/2003	CPFUL4	10.0	25.2	7.7	80	0.5	0.09	0.99	<0.02	<0.02	1.00	0.98	0.02	73	94	13.0	21.0
6/18/2003	CPFUL6	9.7	25.1	7.3	75	0.6	0.07	0.95	<0.02	<0.02	0.96	0.94	0.02	62	90	10.0	13.0
8/13/1998	CPFUL4	8.5	28.6	8.0	88	0.5	0.08	0.40	<0.01	<0.01	0.41	0.40	0.01		100	8.0	9.0
8/13/1998	CPFUL6	10.1	28.9	8.4	89	0.6	0.05	0.50	<0.01	<0.01	0.51	0.50	0.01		100	4.0	5.5
7/20/1998	CPFUL4	9.0	29.4	8.1	91	0.4	0.08	0.40	0.10	<0.01	0.41	0.30	0.11		84	14.0	10.0
7/20/1998	CPFUL6	10.5	29.5	8.7	92	0.6	0.05	0.30	0.10	<0.01	0.31	0.20	0.11		61	8.0	5.7
6/3/1998	CPFUL4	7.8	27.4	7.3	87	0.8	0.04	0.40	<0.01	<0.01	0.41	0.40	0.01		88	16.0	9.0
6/3/1998	CPFUL6	8.0	28.0	7.5	90	1.0	0.03	0.30	<0.01	<0.01	0.31	0.29	0.02		81	8.0	5.1
030607																	
Harris Lake																	
8/5/2003	CPF126A2	7.6	28.7	6.9	64	1.3	0.03	0.47	<0.02	<0.02	0.48	0.46	0.02	31	<50	13.0	4.7
8/5/2003	CPF126A4	7.4	28.0	6.7	64	1.5	0.03	0.49	<0.02	<0.02	0.50	0.48	0.02	24	64	6.0	3.3
8/5/2003	CPF126A6	6.3	27.6	6.3	65	1.3	0.03	0.45	<0.02	<0.02	0.46	0.44	0.02	38	66	5.0	3.9
7/1/2003	CPF126A2	8.1	28.7	7.6	71	1.5	0.03	0.54	<0.02	<0.02	0.55	0.53	0.02	12	72	4.0	4.2
7/1/2003	CPF126A4	7.2	28.4	7.6	71	1.8	0.03	0.49	<0.02	<0.02	0.50	0.48	0.02	7	72	<2.5	2.5
7/1/2003	CPF126A6	8.4	27.7	7.7	71	1.6	0.03	0.47	<0.02	<0.02	0.48	0.46	0.02	11	66	4.0	3.2
6/3/2003	CPF126A2	9.1	22.8	6.7	76	1.8	0.03	0.52	<0.02	<0.02	0.53	0.51	0.02	15	56	<2.5	2.8
6/3/2003	CPF126A4	9.4	22.4	6.8	76	2.0	0.04	<0.02	0.54	<0.02	0.55	0.53	0.02	16	57	3.0	2.2
6/3/2003	CPF126A6	9.2	22.0	6.8	77	1.8	0.04	<0.02	0.50	<0.02	0.51	0.49	0.02	14	54	3.0	2.2
9/11/2001	CPF126A2	8.3	27.5	7.2	74	1.9	0.03	0.52	<0.01	<0.01	0.53	0.52	0.01	19	70	2.5	1.6
9/11/2001	CPF126A4	8.5	27.1	6.8	75	1.3	0.02	0.48		<0.01	0.49			15	69	<3.3	1.4
9/11/2001	CPF126A6	6.4	26.9	6.5	75	1.8	0.03	0.65	<0.01	<0.01	0.66	0.65	0.01	18	72	<2.5	1.6
8/15/2001	CPF126A2	8.1	29.0	7.4	78	1.6	0.03	0.68	<0.01	<0.01	0.69	0.67	0.02	17	65	3.0	2.3
8/15/2001	CPF126A4	7.9	29.0	7.4	79	0.9	0.03	0.73	0.15	<0.01	0.74	0.58	0.16	17	65	2.5	2.2
8/15/2001	CPF126A6	8.2	29.2	7.8	80	1.7	0.03	0.53	0.03	<0.01	0.54	0.50	0.04	20	59	3.0	2.2
7/30/2001	CPF126A2	6.1	25.8	7.7	87	1.0	0.03	0.59	0.12	<0.01	0.60	0.47	0.13	18	110	3.0	2.7
7/30/2001	CPF126A4	6.2	25.4	7.7	81	1.2	0.02	0.50	0.12	<0.01	0.51	0.38	0.13	13	76	<2.5	2.3
7/30/2001	CPF126A6	5.7	25.6	7.6	88	1.2	0.03	0.57	0.06	<0.01	0.58	0.51	0.07	9	110	<2.5	2.1
7/30/2001	White Oak Creek Arm	7.1	24.7	7.5	81	0.8	0.04	0.56	0.05	<0.01	0.57	0.51	0.06	8	86	6.0	10.0
7/16/2001	CPF126A2	8.5	28.7	7.9	83	1.5	0.03	0.42	0.02	<0.01	0.43	0.40	0.03	17	74	4.0	2.8
7/16/2001	CPF126A4	8.4	28.6	8.0	85	2.0	0.03	0.34	<0.01	<0.01	0.35	0.34	0.01	13	72	3.0	2.2
7/16/2001	CPF126A6	8.3	28.1	8.1	87	1.5	0.03	0.45	0.11	<0.01	0.46	0.34	0.12	13	73	2.0	1.9
030608																	
High Point Lake																	
8/5/2003	CPF089E2	10.0	27.1	7.8	91	0.7	0.07	0.69	<0.02	<0.02	0.70	0.68	0.02	81	90	10.0	14.0
8/5/2003	CPF089E4	7.0	26.6	7.5	80	0.5	0.07	0.57	0.080	0.090	0.66	0.49	0.17	30	90	16.0	31.0
7/8/2003	CPF089E2	10.1	28.5	8.3	89	0.9	0.06	0.71	<0.02	<0.02	0.72	0.70	0.02	45	83	7.0	6.7
7/8/2003	CPF089E4	9.1	28.0	7.8	88	0.8	0.06	0.66	0.03	0.06	0.72	0.63	0.09	29	84	11.0	12.0
6/2/2003	CPF089E2	9.9	20.9	7.4	88	0.7	0.04	0.61	<0.02	0.16	0.77	0.60	0.17	86	65	9.0	9.4
6/2/2003	CPF089E4	8.1	20.6	7.3	88	0.6	0.10	0.44	0.06	0.16	0.6	0.38	0.22	36	82	9.0	13.0
8/8/2002	CPF089E2	7.1	28.7	7.6	121	0.8	<0.02	0.27	<0.02	0.02	0.29	0.26	0.03	28	87	10.0	12.0
8/8/2002	CPF089E4	6.6	28.6	7.2	121	0.7											
7/17/2002	CPF089E2	7.6	27.8	7.7	120	1.1	<0.02	0.20	0.02	0.04	0.24	0.18	0.06	19	100	7.0	9.3
7/17/2002	CPF089E4	6.5	27.4	7.1	121	0.7	<0.02	0.25	0.09	0.07	0.32	0.16	0.16	15	100	8.0	12.0

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
6/19/2002	CPF089E2	9.3	26.5	7.9	134	1.0	0.01	<0.20	<0.02	<0.02	0.11	0.09	0.02	35	100	6.0	9.2
6/19/2002	CPF089E4	7.2	26.1	7.4	134	0.7	0.01	0.22	0.09	0.02	0.24	0.13	0.11	22	110	8.0	13.0
9/5/2001	CPF089E2	6.9	26.5	7.3	114	0.8	0.03	0.53	0.02	0.02	0.55	0.51	0.04	18	100	7.0	ns
9/5/2001	CPF089E4	5.5	26.3	7.1	114	0.7	0.03	0.59	0.11	0.06	0.65	0.48	0.17	10	ns	10.0	???
8/23/2001	CPF089E2	8.4	27.9	7.6	114	1.0	0.02	0.48	0.03	<0.01	0.49	0.45	0.04	15	88	7.0	4.4
8/23/2001	CPF089E4	7.0	28.0	7.4	114	0.8	0.03	0.50	0.11	0.03	0.53	0.39	0.14	13	100	10.0	7.2
8/9/2001	CPF089E2	8.7	28.8	8.2	115	1.5	0.02	0.37	0.03	0.02	0.39	0.34	0.05	16	76	5.0	2.9
8/9/2001	CPF089E4	7.7	29.3	7.9	115	1.3	0.03	0.40	0.05	0.05	0.45	0.35	0.10	14	79	7.0	3.4
7/17/2001	CPF089E2	10.1	27.8	8.0	117	1.2	0.03	0.32	0.10	0.04	0.36	0.22	0.14	23	84	8.0	5.4
7/17/2001	CPF089E4	6.8	26.1	7.3	118	0.8	0.05	0.42	0.21	0.06	0.48	0.21	0.27	20	89	10.0	8.1
8/22/2000	CPF089E2	7.8	27.3	7.6	119	0.8	0.04	0.30	0.06	<0.01	0.31	0.24	0.07		100	5.0	6.1
8/22/2000	CPF089E4	7.5	27.3	7.8	122	0.6	0.05	0.40	0.15	<0.01	0.41	0.25	0.16		110	10.0	8.7
8/3/2000	CPF089E2	10.3	27.0	7.8	120	1.1	0.04	0.30	<0.01	<0.01	0.31	0.30	0.01		88	5.0	3.6
8/3/2000	CPF089E4	8.7	26.5	7.4	121	0.9	0.04	0.40	<0.01	<0.01	0.41	0.39	0.02		90	6.0	4.7
7/26/2000	CPF089E2	6.4	24.5	7.2	122	1.0	0.04	0.40	0.12	0.02	0.42	0.28	0.14		180	9.0	8.8
7/26/2000	CPF089E4	5.8	24.7	7.1	119	0.5	0.04	0.50	0.11	0.06	0.56	0.39	0.17		95	14.0	16.0
7/13/2000	CPF089E2	6.3	27.6	7.4	127	0.8	0.02	0.40	0.05	0.02	0.42	0.35	0.07		92	9.0	6.2
7/13/2000	CPF089E4	5.2	27.4	7.3	128	0.8	0.02	0.40	0.24	<0.01	0.41	0.16	0.25		90	8.0	6.4
6/27/2000	CPF089E2	8.9	29.2	8.1	131	0.9	0.01	0.50	0.13	<0.01	0.51	0.37	0.14		94	8.0	5.7
6/27/2000	CPF089E4	6.8	28.6	7.6	131	0.8	0.01	0.40	0.17	<0.01	0.41	0.23	0.18		93	8.0	6.3
6/13/2000	CPF089E2	9.4	29.2	8.0	132	1.2	0.04	0.30	<0.01	<0.01	0.31	0.30	0.01		110	7.0	6.1
6/13/2000	CPF089E4	8.6	28.3	7.8	131	0.9	0.04	0.40	0.11	<0.01	0.41	0.29	0.12		110	12.0	8.8
8/20/1998	CPF089E2	7.6	27.8	7.3	80	0.6	0.04	0.30	<0.01	0.02	0.32	0.29	0.03		66	8.0	6.9
8/20/1998	CPF089E4	7.3	27.9	7.5	80	0.6	0.04	0.40	0.05	0.03	0.43	0.35	0.08		68	6.0	7.6
7/9/1998	CPF089E2	8.6	30.1	7.6	90	0.9	0.04	0.20	0.10	<0.01	0.21	0.10	0.11		82	6.0	4.6
7/9/1998	CPF089E4	5.3	29.0	7.2	92	0.7	0.04	0.40	0.23	<0.01	0.41	0.17	0.24		97	8.0	8.2
6/9/1998	CPF089E2	8.1	23.9	7.2	99	0.6	0.04	0.30	0.04	0.06	0.36	0.26	0.10		100	11.0	7.0
6/9/1998	CPF089E4	7.2	23.7	7.2	93	0.6	0.04	0.30	0.07	0.07	0.37	0.23	0.14		110	13.0	8.9
High Point Reservoir																	
8/5/2003	CPF089D3	8.5	27.3	7.7	80	0.8	0.09	0.54	<0.02	0.02	0.56	0.53	0.03	27	74	4.0	11.0
8/5/2003	CPF089D4	6.3	26.6	7.2	80	0.8	0.04	0.55	0.08	0.04	0.59	0.47	0.12	19	78	10.0	11.0
8/5/2003	CPF089D5	5.4	26.4	7.2	80	0.5	0.05	0.60	0.12	0.05	0.65	0.48	0.17	22	82	13.0	21.0
7/8/2003	CPF089D3	8.2	27.9	7.4	75	1.1	0.04	0.58	0.02	<0.02	0.59	0.56	0.03	16	71	8.0	7.4
7/8/2003	CPF089D4	6.4	26.4	7.1	75	0.9	0.04	0.61	0.08	0.03	0.64	0.53	0.11	13	69	7.0	8.0
7/8/2003	CPF089D5	5.9	26.3	7.2	76	0.7	0.05	0.53	0.12	0.04	0.57	0.41	0.16	12	71	10.0	12.0
6/2/2003	CPF089D3	7.6	19.4	7.2	76	0.8	0.04	0.55	0.03	0.11	0.66	0.52	0.14	17	68	7.0	12.0
6/2/2003	CPF089D4	7.5	19.4	7.2	76	0.7	0.05	0.48	0.03	0.11	0.59	0.45	0.14	19	64	7.0	12.0
6/2/2003	CPF089D5	8.0	19.9	7.2	76	0.8	0.04	0.46	<0.02	0.09	0.55	0.45	0.10	13	66	6.0	9.4
8/8/2002	CPF089D3	5.8	27.6	7.3	117	1.0	0.02	0.30	<0.02	<0.02	0.31	0.29	0.02	14	83	7.0	9.2
8/8/2002	CPF089D4	7.0	28.0	7.6	119	0.8	0.02	0.28	<0.02	<0.02	0.29	0.27	0.02	16	87	7.0	10.0
8/8/2002	CPF089D5	6.7	27.9	7.5	118	1.3	<0.02	0.38	<0.02	<0.02	0.39	0.37	0.02	14	83	4.0	7.2
7/17/2002	CPF089D3	8.1	27.5	8.0	119	1.3	<0.02	0.20	<0.02	<0.02	0.21	0.19	0.02	9	100	7.0	10.0
7/17/2002	CPF089D4	8.0	27.9	8.0	120	1.3	<0.02	0.22	<0.02	<0.02	0.23	0.21	0.02	8	93	5.0	6.4
7/17/2002	CPF089D5	7.8	27.9	8.0	119	1.3	<0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	8	97	5.0	6.2
6/19/2002	CPF089D3	8.0	26.5	8.5	131	1.4	0.01	<0.20	<0.02	<0.02	0.11	0.10	0.01	8	100	4.0	6.6
6/19/2002	CPF089D4	7.9	26.6	8.0	126	1.1	0.01	<0.20	<0.02	<0.02	0.11	0.10	0.01	11	110	6.0	9.1
6/19/2002	CPF089D5	7.6	26.2	7.9	126	1.3	0.01	<0.20	<0.02	<0.02	0.11	0.10	0.01	7	100	3.0	6.2
9/5/2001	CPF089D3	6.3	25.9	7.3	106	1.2	0.03	0.40	0.04	<0.01	0.41	0.36	0.05	8	82	5.0	
9/5/2001	CPF089D4	5.8	25.6	7.6	107	1.7	0.03	0.33	0.05	<0.01	0.34	0.28	0.06	7	83	4.0	
9/5/2001	CPF089D5	6.1	25.8	7.2	106	1.8	0.02	0.36	0.06	<0.01	0.37	0.30	0.07	<1	81	4.0	
8/23/2001	CPF089D3	9.1	27.3	7.7	106	1.4	0.01	0.43	0.02	<0.01	0.44	0.41	0.03	6	98	4.0	2.5

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
8/23/2001	CPF089D4	7.6	27.4	7.7	106	1.4	0.01	0.48	<0.01	<0.01	0.49	0.47	0.02	7	90	4.0	2.6
8/23/2001	CPF089D5	8.3	27.5	7.7	106	1.8	0.03	2.00	1.50	<0.01	2.01	0.50	1.51	7	74	4.0	2.6
8/9/2001	CPF089D3	8.3	29.3	8.3	109	1.3	0.03	0.38	0.03	<0.01	0.39	0.35	0.04	11	81	7.0	4.6
8/9/2001	CPF089D4	8.0	30.1	8.3	110	1.8	0.02	0.42	0.02	<0.01	0.43	0.40	0.03	10	75	4.0	2.7
8/9/2001	CPF089D5	8.0	30.0	8.3	109	2.8	0.02	0.40	0.04	<0.01	0.41	0.36	0.05	11	74	4.0	3.2
7/17/2001	CPF089D3	9.1	27.5	8.1	109	1.4	0.02	0.37	<0.01	<0.01	0.38	0.36	0.02	12	83	5.0	3.8
7/17/2001	CPF089D4	8.9	26.7	8.0	110	1.5	0.02	0.28	<0.01	<0.01	0.29	0.27	0.02	10	79	4.0	4.3
7/17/2001	CPF089D5	9.3	26.9	8.2	109	1.5	0.02	0.36	<0.01	<0.01	0.37	0.36	0.01	11	79	4.0	3.0
8/22/2000	CPF089D3	7.8	26.0	7.4	121	1.1	0.03	0.40	0.10	<0.01	0.41	0.30	0.11		99	6.0	5.5
8/22/2000	CPF089D4	6.9	25.9	7.7	123	1.3	0.02	0.40	0.15	<0.01	0.41	0.25	0.16		94	4.0	4.1
8/22/2000	CPF089D5	7.1	25.8	7.4	122	1.3	0.02	0.40	0.11	<0.01	0.41	0.29	0.12		88	6.0	2.8
8/3/2000	CPF089D3	9.2	27.1	7.9	124	1.3	0.02	0.60	<0.01	<0.01	0.61	0.60	0.01		78	6.0	5.4
8/3/2000	CPF089D4	9.1	26.4	7.9	126	1.3	0.02	0.40	<0.01	<0.01	0.41	0.40	0.01		86	2.0	3.1
8/3/2000	CPF089D5	9.2	26.5	7.8	125	1.7	0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		91	3.0	3.0
7/26/2000	CPF089D3	5.7	23.8	7.1	125	1.0	0.02	0.40	0.04	<0.01	0.41	0.36	0.05		86	5.0	6.4
7/26/2000	CPF089D4	6.4	24.0	7.6	125	0.9	0.03	0.50	0.03	<0.01	0.51	0.47	0.04		70	9.0	6.5
7/26/2000	CPF089D5	5.7	24.0	7.2	126	1.0	0.02	0.60	0.43	<0.01	0.61	0.17	0.44		90	6.0	3.8
7/13/2000	CPF089D3	6.5	26.7	7.3	123	1.1	<0.01	0.40	<0.01	<0.01	0.41	0.39	0.02		85	6.0	4.5
7/13/2000	CPF089D4	6.9	26.7	7.5	124	1.0	<0.01	0.40	0.02	<0.01	0.41	0.38	0.03		75	5.0	4.4
7/13/2000	CPF089D5	6.7	26.7	7.3	124	1.1	0.01	0.30	0.24	0.08	0.38	0.06	0.32		31	3.0	4.5
6/27/2000	CPF089D3	8.3	28.3	8.2	129	1.1	<0.01	0.30	<0.01	<0.01	0.31	0.30	0.01		79		5.5
6/27/2000	CPF089D4	8.0	27.4	8.0	129	1.1	<0.01	0.40	<0.01	<0.01	0.41	0.40	0.01		75	5.0	3.9
6/27/2000	CPF089D5	8.2	27.9	8.2	128	1.4	0.01	0.30	<0.01	<0.01	0.31	0.30	0.01		86	7.0	3.5
6/13/2000	CPF089D3	8.6	27.9	7.8	131	1.8	0.03	0.40	<0.01	<0.01	0.41	0.40	0.01		110	7.0	5.4
6/13/2000	CPF089D4	8.6	26.3	8.0	51	1.6	0.02	0.20	<0.01	<0.01	0.21	0.20	0.01		110	3.0	2.3
6/13/2000	CPF089D5	8.5	27.3	7.9	130	2.0	0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		110	4.0	2.5
8/20/1998	CPF089D3	7.5	27.2	7.2	78	0.9	0.03	0.30	<0.01	<0.01	0.31	0.29	0.02		60	4.0	3.3
8/20/1998	CPF089D4	8.2	27.8	8.0	78	0.8	0.03	0.20	<0.01	<0.01	0.21	0.19	0.02		64	3.0	3.2
8/20/1998	CPF089D5	7.5	27.2	7.4	77	0.9	0.03	0.20	<0.01	<0.01	0.21	0.19	0.02		68	2.0	3.3
030609																	
Sandy Creek Reservoir																	
8/26/2003	CPFSC1	12.3	31.1	8.3	92	0.9	0.08	0.63	<0.02	0.290	0.92	0.62	0.30	78	94	14.0	13.0
8/26/2003	CPFSC2	12.3	30.9	8.5	89	1.0	0.08	0.60	0.090	0.310	0.91	0.51	0.40	21	94	7.0	8.8
8/26/2003	CPFSC3	6.6	24.3	8.1	105	1.2	0.06	0.29	<0.02	0.510	0.80	0.28	0.52	<1	100	10.0	9.8
7/28/2003	CPFSC1	8.5	27.9	7.1	88	1.3	0.07	0.66	0.050	0.300	0.96	0.61	0.35	26	88	7.0	11.0
7/28/2003	CPFSC2	10.0	28.9	7.9	88	1.4	0.07	0.62	0.030	0.150	0.77	0.59	0.18	22	90	5.0	10.0
7/28/2003	CPFSC3	8.5	27.4	7.7	88	0.8	0.22	1.30	0.020	0.380	1.68	1,28	0.40	97	100	9.0	18.0
6/18/2003	CPFSC1	11.2	24.5	8.2	79	0.8	0.07	0.65	0.02	0.21	0.86	0.63	0.23	41	86	11.0	11.0
6/18/2003	CPFSC2	8.6	23.5	7.8	85	1.0	0.07	0.53	0.02	0.38	0.91	0.51	0.40	23	93	8.0	10.0
6/18/2003	CPFSC3	7.8	20.5	8.0	98	0.9	0.07	0.33	0.03	0.63	0.96	0.3	0.66	<1	100	9.0	12.0
8/4/1998	CPFSC1	9.7	28.4	8.7	98	0.8	0.05	0.40	<0.01	<0.01	0.41	0.39	0.02		82	6.0	6.3
8/4/1998	CPFSC2	9.3	27.5	8.5	98	0.7	0.05	0.30	<0.01	<0.01	0.31	0.30	0.01		92	6.0	7.2
8/4/1998	CPFSC3	8.8	25.4	7.5	103	0.8	0.06	0.30	<0.01	<0.01	0.31	0.30	0.02		80	5.0	6.3
7/16/1998	CPFSC1	10.4	29.9	8.9	100	1.0	0.04	0.30	<0.01	<0.01	0.31	0.29	0.02		82	5.0	6.1
7/16/1998	CPFSC2	10.4	30.2	8.7	101	0.9	0.06	0.30	<0.01	<0.01	0.31	0.30	0.01		81	5.0	7.0
7/16/1998	CPFSC3	11.8	28.0	9.0	100	0.6	0.10	0.20	<0.01	0.02	0.22	0.20	0.03		87	8.0	10.0
6/2/1998	CPFSC1	10.8	27.4	8.7	91	1.1	0.07	<0.10	<0.01	0.23	0.33	0.10	0.24		65	5.0	7.0
6/2/1998	CPFSC2	11.1	26.8	8.9	92	1.2	0.04	<0.10	<0.01	0.24	0.34	0.10	0.25		77	4.0	5.8
6/2/1998	CPFSC3	6.5	23.6	7.4	100	1.0	0.06	0.40	<0.01	0.73	1.13	0.39	0.74		86	3.0	9.1

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
030610																	
Carthage City Lake																	
8/12/2003	CPF113R	4.5	28.4	5.2	23	0.8	0.04	0.44	<0.02	<0.02	0.45	0.43	0.02	6	58	10.0	19.0
7/9/2003	CPF113R	6.6	31.3	5.5	25	2.3	0.02	0.31	<0.02	<0.02	0.32	0.30	0.02	6	<50	5.0	5.7
6/12/2003	CPF113R	7.0	27.7	5.8	25	3.2	<0.02	0.28	<0.02	<0.02	0.29	0.27	0.02	2	58	3.0	2.1
8/4/1998	CPF113R	6.9	27.4	6.0	45	2.2	0.01	<0.10	<0.01	<0.01	0.11	0.10	0.01		37	2.0	1.6
7/15/1998	CPF113R	7.0	29.0	6.9	44	2.5	0.03	0.20	0.03	<0.01	0.21	0.17	0.04		34	6.0	1.2
6/2/1998	CPF113R	7.4	28.4	6.0	42	3.3	<0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		32	<1.0	1.0
030612																	
Rocky River Reservoir																	
8/12/2003	CPF1201A	10.0	27.8	7.5	60	0.7	0.18	1.00	0.05	0.20	1.20	0.95	0.25	20	86	9.0	15.0
8/12/2003	CPF1201B	10.9	28.6	7.7	58	0.7	0.20	1.20	0.03	0.14	1.34	1.17	0.17	54	94	11.0	14.0
7/9/2003	CPF1201A	10.8	32.2	8.3	57	0.6	0.15	1.10	<0.02	<0.02	1.11	1.09	0.02	25	78	7.0	8.8
7/9/2003	CPF1201B	10.8	32.1	8.4	58	0.7	0.17	1.20	<0.02	0.02	1.22	1.19	0.03	30	84	10.0	9.8
6/12/2003	CPF1201A	8.3	27.1	6.5	70	0.5	0.17	1.20	0.02	0.04	1.24	1.18	0.06	32	120	10.0	11.0
6/12/2003	CPF1201B	10.5	28.8	7.8	70	0.5	0.17	1.20	<0.02	<0.02	1.21	1.19	0.02	28	120	8.0	11.0
8/6/1998	CPF1201A	7.5	27.0	7.5	79	0.5	0.08	0.70	0.02	<0.01	0.71	0.68	0.03		91	11.0	7.3
8/6/1998	CPF1201B	7.7	27.2	7.4	78	0.5	0.08	0.70	0.06	<0.01	0.71	0.64	0.07		90	14.0	8.4
7/8/1998	CPF1201A	4.9	28.0	7.2	85	0.4	0.07	0.60	0.23	0.03	0.63	0.37	0.26		75	8.0	6.1
7/8/1998	CPF1201B	9.2	28.7	8.4	89	0.4	0.07	0.70	0.06	<0.01	0.71	0.64	0.07		75	12.0	7.6
6/3/1998	CPF1201A	8.5	28.3	8.1	80	0.4	0.34	1.60	0.88	<0.01	1.61	0.72	0.89		89	12.0	9.3
6/3/1998	CPF1201B	8.6	28.7	8.3	82	0.5	0.05	0.20	<0.01	<0.01	0.21	0.19	0.02		82	14.0	9.8
030614																	
Old Town Reservoir																	
8/12/2003	CPF135B	7.6	27.8	5.9	19	1.4	0.02	0.43	<0.02	<0.02	0.44	0.42	0.02	19	<50	5.0	8.1
8/12/2003	CPF135D	7.9	28.2	5.8	19	1.3	0.02	0.34	<0.02	<0.02	0.35	0.33	0.02	15	<50	5.0	6.6
7/9/2003	CPF135B	7.6	30.1	5.8	20	2.1	0.02	0.39	<0.02	<0.02	0.40	0.38	0.02	7	<50	3.0	3.5
7/9/2003	CPF135D	7.7	30.1	6.0	20	1.9	0.02	0.28	<0.02	<0.02	0.29	0.27	0.02	5	<50	<2.5	1.8
6/12/2003	CPF135B	8.2	27.6	5.7	20	2.0	0.02	0.41	<0.02	<0.02	0.42	0.40	0.02	12	53	4.0	2.8
6/12/2003	CPF135D	8.0	27.7	6.5	20	2.1	<0.02	0.40	<0.02	<0.02	0.41	0.39	0.02	8	68	4.0	2.1
8/4/1998	CPF135B	7.0	27.5	6.2	30	2.8	0.01	<0.20	<0.01	<0.01	0.11	0.10	0.01		28	<1.0	1.4
8/4/1998	CPF135D	7.0	27.6	6.0	29	3.0	0.03	0.20	<0.01	<0.01	0.21	0.20	0.01		35	4.0	3.4
7/15/1998	CPF135B	7.2	28.9	6.2	33	2.8	0.03	0.20	0.07	0.02	0.22	0.13	0.09		26	2.0	1.6
7/15/1998	CPF135D	7.3	28.8	6.4	33	3.8	0.05	0.20	0.04	0.04	0.24	0.16	0.08		37	5.0	3.3
6/2/1998	CPF135B	8.1	27.8	6.2	30	1.5	<0.01	<0.10	<0.01	<0.01	0.11	0.10	0.02		28	2.0	3.2
6/2/1998	CPF135D	8.1	27.5	6.6	33	1.7	<0.01	0.50	<0.01	0.03	0.53	0.50	0.04		24	2.0	2.3
030615																	
Bonnie Doone Lake																	
8/14/2003	CPF138A4	6.9	30.3	5.3	17	0.8	0.03	0.35	0.04	0.07	0.42	0.31	0.11	6	72	10.0	22.0
7/15/2003	CPF138A4	7.0	28.1	4.6	18	1.2	0.03	0.32	0.04	0.06	0.38	0.28	0.10	12	<50	7.0	8.1
6/23/2003	CPF138A4	7.8	27.4	5.6	22	1.3	0.02	0.40	<0.02	0.05	0.45	0.39	0.06	8	<50	3.0	6.6
8/10/1998	CPF138A4	7.3	28.2	7.1	30	1.7	0.01	0.20	0.02	0.10	0.30	0.18	0.12		41	1.0	5.9
7/13/1998	CPF138A4	7.9	27.0	7.0	31	1.7	0.01	<0.10	<0.01	0.17	0.27	0.09	0.18		43	1.0	4.4
6/22/1998	CPF138A4	8.0	29.4	6.7	34	1.8	0.03	0.20	0.04	0.15	0.35	0.16	0.19		39	1.0	2.8
Kornbow Lake																	
8/14/2003	CPF138A6	6.5	30.6	5.4	21	1.2	0.02	0.40	<0.02	0.08	0.48	0.39	0.09	18	65	6.0	7.7
7/15/2003	CPF138A6	7.2	28.4	5.0	22	1.6	0.02	0.34	0.09	0.07	0.41	0.25	0.16	8	<50	4.0	3.0
6/23/2003	CPF138A6	7.7	27.7	5.9	26	1.4	0.02	0.43	0.02	0.14	0.57	0.41	0.16	7	<50	5.0	2.6
8/10/1998	CPF138A6	7.1	28.6	7.0	39	2.3	<0.01	0.20	0.02	0.15	0.35	0.18	0.17		42	5.0	2.9
7/13/1998	CPF138A6	6.3	28.4	6.8	41	2.2	0.01	0.20	<0.01	0.21	0.41	0.19	0.22		39	4.0	2.2
6/22/1998	CPF138A6	7.6	29.7	7.2	42	2.0	0.05	0.20	0.04	0.28	0.48	0.16	0.32		43	2.0	1.7

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
Mintz Pond																	
8/14/2003	CPF138A8	6.2	28.5	5.7	24	1.1	0.06	0.40	0.03	0.06	0.46	0.37	0.09	7	86	8.0	15.0
7/15/2003	CPF138A8	4.5	27.2	4.6	24	1.0	0.04	0.32	0.10	0.06	0.38	0.31	0.07	5	<50	8.0	8.5
6/23/2003	CPF138A8	4.7	26.5	5.4	29	1.1	0.04	0.43	<0.02	0.02	0.45	0.42	0.03	8	<50	6.0	4.2
8/10/1998	CPF138A8	4.2	27.2	6.7	44	1.1	0.04	0.20	<0.01	0.12	0.32	0.19	0.13		53	6.0	5.5
7/13/1998	CPF138A8	4.6	27.5	6.7	44	1.2	0.03	0.20	0.02	<0.01	0.21	0.18	0.03		47	5.0	3.4
6/22/1998	CPF138A8	6.4	28.7	7.1	48	1.2	0.06	0.20	0.03	0.12	0.32	0.17	0.15		53	5.0	3.1
Glenville Lake																	
8/14/2003	CPF138B	8.1	28.6	7.8	32	0.8	0.05	0.45	<0.02	0.03	0.48	0.44	0.04	24	85	8.0	13.0
7/15/2003	CPF138B	6.8	26.4	5.1	29	0.7	0.06	0.42	<0.02	0.05	0.47	0.41	0.06	20	52	13.0	20.0
8/10/1998	CPF138B	8.3	27.5	7.1	48	0.9	0.05	0.30	<0.01	<0.01	0.31	0.30	0.02		52	1.0	4.1
7/13/1998	CPF138B	6.4	27.6	6.9	51	0.8	0.04	0.30	0.07	0.03	0.33	0.23	0.10		53	5.0	4.8
6/22/1998	CPF138B	9.7	28.3	7.2	51	1.0	0.07	0.30	0.02	<0.01	0.31	0.28	0.03		53	8.0	4.4
Hope Mills Lake																	
8/10/1998	CPF151	6.5	27.1	6.9	50	1.1	0.03	0.30	<0.01	0.37	0.67	0.30	0.38		54	1.0	4.1
7/13/1998	CPF151	8.3	28.6	7.1	55	1.0	0.03	0.30	0.02	0.33	0.63	0.28	0.35		57	3.0	4.4
6/22/1998	CPF151	7.9	29.8	7.3	55	1.1	0.04	0.20	<0.01	0.36	0.56	0.19	0.37		64	1.0	3.9
030616																	
Salters Lake																	
8/7/2003	CPF153C	6.4	29.1	3.6	58	0.5	0.04	0.50	<0.02	<0.02	0.51	0.49	0.02	20	58	<2.5	5.6
8/7/2003	CPF153D	6.4	28.8	3.6	59	0.5	0.03	0.46	<0.02	<0.02	0.47	0.45	0.02	11	57	<2.5	5.7
7/8/2003	CPF153C	6.3	30.4	3.6	59	0.8	0.02	0.57	0.04	0.04	0.61	0.53	0.08	3	<50	3.0	3.6
7/8/2003	CPF153D	6.2	30.0	3.5	60	0.8	0.02	0.46	0.04	0.04	0.50	0.42	0.08	3	<50	<2.5	3.3
6/11/2003	CPF153C	7.4	29.0	3.4	66	0.9	0.02	0.41	0.04	0.02	0.45	0.37	0.06	4	46	<2.5	3.3
6/11/2003	CPF153D	6.7	28.3	3.5	67	0.9	<0.02	0.40	0.03	0.02	0.42	0.37	0.05	8	75	<2.5	3.8
8/4/1998	CPF153C	7.1	26.0	4.7	68	0.5	0.02	0.40	0.05	0.12	0.52	0.35	0.17		32	<1.0	4.0
8/4/1998	CPF153D	7.1	27.0	5.7	68	0.4	0.02	0.40	0.04	0.10	0.50	0.36	0.14		41	<1.0	4.2
7/14/1998	CPF153C	6.5	29.7	3.8	64	0.5	0.02	0.40	0.08	0.09	0.49	0.32	0.17		69	7.0	5.0
7/14/1998	CPF153D	6.4	29.1	3.8	66	0.5	0.02	0.50	0.12	0.09	0.59	0.38	0.21		64	3.0	4.0
6/16/1998	CPF153C	6.5	28.8	3.7	63	0.5	<0.01	0.30	0.05	0.09	0.39	0.25	0.14				2.3
6/16/1998	CPF153D	6.5	29.8	3.6	62	0.5	<0.01	0.40	0.05	0.09	0.49	0.35	0.14		34	<1.0	2.3
Jones Lake																	
8/7/2003	CPF1552A	5.6	29.6	3.7	53	0.4	0.02	0.73	0.14	0.07	0.80	0.59	0.21	5	74	<2.5	7.5
8/7/2003	CPF1553A	6.0	29.0	3.7	56	0.4	0.02	0.75	0.14	0.07	0.82	0.61	0.21	3	67	<2.5	7.3
7/8/2003	CPF1552A	6.1	31.6	3.6	53	0.5	0.03	0.64	0.15	0.05	0.69	0.49	0.20	1	<50	<2.5	5.2
7/8/2003	CPF1553A	6.2	31.2	3.5	54	0.5	0.03	0.64	0.15	0.05	0.69	0.49	0.20	1	<50	<2.5	5.3
6/11/2003	CPF1552A	6.9	29.9	3.5	62	0.6	0.02	0.51	0.06	0.05	0.56	0.45	0.11	4	70	<2.5	4.3
6/11/2003	CPF1553A	6.5	29.2	3.5	63	0.5	0.02	0.58	0.07	0.05	0.63	0.51	0.12	4	63	<2.5	4.1
8/4/1998	CPF1552A	6.8	27.2	3.6	72	0.5	0.02	0.40	0.03	0.12	0.52	0.37	0.15		53	<1.0	3.3
8/4/1998	CPF1553A	6.9	27.6	3.5	73	0.5	0.02	0.30	0.04	0.12	0.42	0.26	0.16		55	<1.0	3.5
7/14/1998	CPF1552A	5.9	29.7	3.8	69	0.5	0.02	0.40	0.09	0.12	0.52	0.31	0.21		72	2.0	3.8
7/14/1998	CPF1553A	5.9	29.4	3.8	69	0.4	0.02	0.40	0.10	0.12	0.52	0.30	0.22		76	2.0	3.5
6/16/1998	CPF1552A	6.3	29.5	3.7	67	0.4	<0.01	0.30	0.05	0.12	0.42	0.25	0.17		55	<1.0	2.5
6/16/1998	CPF1553A	6.2	30.1	3.6	68	0.4	<0.01	0.40	0.06	0.12	0.52	0.34	0.18		56	<1.0	2.2
White Lake																	
8/6/2003	CPF155A	7.4	29.2	4.2	51	2.9	0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	5	<50	3.0	<1.0
8/6/2003	CPF155B	7.4	28.9	4.2	50	2.9	0.01	<0.20	<0.02	<0.02	0.11	0.09	0.02	2	<50	<2.5	1.0
8/6/2003	CPF155C	7.3	29.0	4.2	50	2.8	0.01	<0.20	<0.02	<0.02	0.11	0.09	0.02	2	<50	<2.5	1.9
7/7/2003	CPF155A	7.6	29.1	4.1	52	2.9	0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	2	<50	5.0	2.4
7/7/2003	CPF155B	7.6	29.1	4.1	52	2.9	0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	8	<50	2.5	1.4
7/7/2003	CPF155C	7.6	29.1	4.1	52	2.7	<0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	2	<50	<2.5	1.4

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
6/10/2003	CPF155A	8.0	27.7	4.2	56	2.5	<0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	4	39	<5	2.6
6/10/2003	CPF155B	8.0	27.5	4.2	56	3.0	<0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	32	43	<2.5	1.1
6/10/2003	CPF155C	8.1	27.6	4.2	56	2.4	<0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	5	47	<2.5	1.7
8/5/1998	CPF155A	8.1	26.5	4.2	69	2.5	<0.01	0.05	<0.01	<0.01	0.06	0.05	0.01		51	1.0	<1.0
8/5/1998	CPF155B	8.0	26.4	4.3	69	2.5	<0.01	<0.20	0.08	<0.01	0.11	0.02	0.09		52	2.0	1.1
8/5/1998	CPF155C	8.1	26.9	4.5	68	2.5	<0.01	<0.20	0.03	<0.01	0.11	0.07	0.04		41	2.0	1.1
7/14/1998	CPF155A	7.3	29.3	4.3	74	2.4	0.01	0.20	0.04	<0.01	0.21	0.16	0.05		43	1.0	<1.0
7/14/1998	CPF155B	7.2	29.2	4.3	73	2.0	0.01	<0.20	0.06	<0.01	0.11	0.04	0.07		44	2.0	<1.0
7/14/1998	CPF155C	7.3	28.9	4.4	73	2.0	0.01	0.05	0.04	<0.01	0.06	0.01	0.05		39	1.0	<1.0
6/16/1998	CPF155A	7.2	28.3	4.2	64	2.2	<0.01	<0.20	<0.01	<0.01	0.11	0.09	0.02		30	<1.0	<1.0
6/16/1998	CPF155B	7.2	28.4	4.2	66	2.4	<0.01	<0.20	<0.01	<0.01	0.11	0.09	0.02		35	<1.0	<1
6/16/1998	CPF155C	7.4	28.3	4.3	64	2.6	<0.01	<0.20	<0.01	<0.01	0.11	0.09	0.02		32	<1.0	<1
030617																	
Greenfield Lake																	
8/21/2003	CPF211B	3.4	28.7	6.7	141	1.5	0.06	0.39	<0.02	<0.02	0.40	0.38	0.02	15	57	<2.5	
8/21/2003	CPF211C	3.9	29.1	6.7	141	1.5	0.07	0.44	<0.02	<0.02	0.45	0.43	0.02	31	58	4.0	
7/17/2003	CPF211B	6.2	29.2	7.0	219	1.4	0.19	0.53	<0.02	<0.02	0.54	0.52	0.02	3	170	17.0	9.9
7/17/2003	CPF211C	5.5	29.0	6.7	215	1.2	0.21	0.95	<0.02	<0.02	0.96	0.94	0.02	56	220	88.0	25.0
6/19/2003	CPF211B	6.0	29.6	7.0	192	1.2	0.02	0.46	<0.02	<0.02	0.47	0.45	0.02	6	130	3.0	1.6
6/19/2003	CPF211C	6.1	30.3	7.2	185	1.6	0.02	0.51	0.02	<0.02	0.52	0.49	0.03	6	120	<2.5	<1
8/3/1998	CPF211B	2.1	26.0	7.0	200	1.3	0.06	0.30	0.02	<0.01	0.31	0.28	0.03		130	6.0	1.8
8/3/1998	CPF211C	4.5	27.0	7.0	198	1.2	0.06	0.60	<0.01	<0.01	0.61	0.60	0.01		130	7.0	1.7
7/7/1998	CPF211B	7.1	27.7	7.6	176	1.5	0.04	0.20	0.09	<0.01	0.21	0.11	0.10		110	2.0	1.7
7/7/1998	CPF211C	4.3	27.9	7.3	203	1.4	0.08	0.50	0.13	<0.01	0.51	0.37	0.14		120	4.0	3.4
6/8/1998	CPF211B	5.1	25.9	7.3	193	1.5	0.03	0.30	<0.01	<0.01	0.31	0.30	0.01		130	10.0	2.6
6/8/1998	CPF211C	1.8	25.8	7.0	198	1.0	0.03	0.40	<0.01	<0.01	0.41	0.40	0.01		130	1.0	1.5
Boiling Springs Lake																	
8/19/2003	CPFBSL2	5.9	30.7	5.8	71	0.5	0.03	0.62	0.04	0.06	0.68	0.58	0.10	5	100	3.0	4.9
8/19/2003	CPFBSL4	5.6	30.2	6.0	72	0.5	0.03	0.61	0.03	0.07	0.68	0.58	0.10	8	100	<2.5	3.6
8/19/2003	CPFBSL6	8.3	28.6	6.9	73	0.5	0.02	0.65	0.03	0.07	0.72	0.62	0.10	5	100	<2.5	3.4
7/17/2003	CPFBSL2	5.0	30.0	5.1	63	0.3	0.02	0.78	0.03	0.05	0.83	0.75	0.08	4	130	3.0	3.0
7/17/2003	CPFBSL4	6.3	30.5	5.5	70	0.4	0.02	0.76	0.03	0.07	0.83	0.73	0.10	4	110	2.5	2.7
7/17/2003	CPFBSL6	6.5	30.4	5.3	70	0.4	0.03	0.65	0.03	0.07	0.72	0.62	0.10	6	110	2.0	2.7
6/19/2003	CPFBSL2	6.2	29.1	5.1	62	0.4	0.02	0.72	0.03	0.05	0.77	0.69	0.08	2	100	2.5	3.2
6/19/2003	CPFBSL4	6.6	31.1	5.5	66	0.4	0.02	0.68	0.03	0.06	0.74	0.65	0.09	2	110	<2.5	3.4
6/19/2003	CPFBSL6	6.9	30.3	5.6	64	0.4	0.02	0.72	0.04	0.06	0.78	0.68	0.10	2	100	<2.5	3.0
8/3/1998	CPFBSL2	7.1	26.0	6.3	84	0.6	0.01	0.40	0.08	0.08	0.48	0.32	0.16		75	5.0	2.8
8/3/1998	CPFBSL4	6.3	27.3	6.1	84	0.7	0.01	0.30	<0.01	0.09	0.39	0.29	0.10		88	2.0	2.3
8/3/1998	CPFBSL6	6.8	27.5	6.3	83	0.6	0.01	0.30	0.02	0.09	0.39	0.28	0.11		73	2.0	2.4
7/7/1998	CPFBSL2	7.9	29.7	6.9	79	0.5	0.02	0.30	<0.01	0.05	0.35	0.30	0.06		75	<1.0	3.1
7/7/1998	CPFBSL4	6.2	30.7	6.2	67	0.8									59	2.0	2.3
7/7/1998	CPFBSL6	6.1	29.8	6.4	78	0.6	0.01	0.40	0.09	0.10	0.50	0.31	0.19		77	<1.0	3.1
6/8/1998	CPFBSL2	6.6	28.6	6.3	69	0.5	<0.01	0.20	<0.01	0.08	0.28	0.20	0.09		120	3.0	3.2
6/8/1998	CPFBSL4	6.0	26.7	5.8	65	0.9	<0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		75	3.0	2.1
6/8/1998	CPFBSL6	6.5	27.1	6.5	70	0.5	<0.01	0.20	<0.01	0.10	0.30	0.20	0.11		95	2.0	2.6

Appendix 22 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water Temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL*a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
030618																	
Bay Tree Lake																	
8/6/2003	CPF155G	7.5	28.8	3.8	57	1.6	0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	6	<50	<2.5	2.0
8/6/2003	CPF155I	7.4	28.6	3.8	57	1.9	0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	3	<50	<2.5	1.8
7/7/2003	CPF155G	7.8	29.6	3.7	57	1.5	0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	5	<50	<2.5	2.5
7/7/2003	CPF155I	7.8	29.3	3.7	56	1.4	0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	5	<50	4.0	3.6
6/10/2003	CPF155G	7.9	29.2	3.8	62	2.0	0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	2	33	<2.5	2.0
6/10/2003	CPF155I	7.3	29.6	3.8	63	1.9	0.02	<0.20	<0.02	<0.02	0.11	0.09	0.02	1	36	<2.5	1.7
8/5/1998	CPF155G	8.3	26.0	4.0	70	1.0	<0.01	0.20	<0.01	<0.01	0.21	0.20	0.01		46	2.0	3.4
8/5/1998	CPF155I	8.1	25.6	4.2	69	0.7	<0.01	0.30	<0.01	<0.01	0.31	0.30	0.01		55	1.0	4.9
7/14/1998	CPF155G	7.7	28.0	4.2	75	0.9	0.02	0.40	0.05	0.04	0.44	0.35	0.09		45	3.0	2.7
7/14/1998	CPF155I	7.7	27.4	4.2	76	1.0	0.02	0.20	0.06	0.04	0.24	0.14	0.10		43	2.0	2.5
6/16/1998	CPF155G	7.2	27.9	4.1	68	0.7	<0.01	0.20	<0.01	0.11	0.31	0.19	0.12		37	4.0	4.7
6/16/1998	CPF155I	7.3	28.2	4.1	68	0.8	0.01	0.20	<0.01	0.11	0.31	0.19	0.12		26	3.0	5.4
030620																	
Singletary Lake																	
8/6/2003	CPF176D	6.8	30.1	3.6	48	0.8	0.03	0.35	<0.02	<0.02	0.36	0.34	0.02	16	<50	<5	2.9
8/6/2003	CPF176E	6.9	29.8	3.6	47	0.8	0.02	0.34	<0.02	<0.02	0.35	0.33	0.02	15	<50	3.0	2.9
8/6/2003	CPF176F	6.9	19.5	3.5	47	0.9	0.03	0.28	<0.02	<0.02	0.29	0.27	0.02	14	<50	<2.5	3.9
7/7/2003	CPF176D	7.1	29.9	3.6	48	0.8	0.02	0.36	<0.02	<0.02	0.37	0.35	0.02	9	<50	4.0	2.1
7/7/2003	CPF176E	7.1	29.6	3.6	48	0.9	0.02	0.40	<0.02	<0.02	0.41	0.39	0.02	2	<50	4.0	3.5
7/7/2003	CPF176F	7.4	29.8	3.5	48	0.8	0.02	0.39	<0.02	<0.02	0.40	0.38	0.02	6	<50	<2.5	2.1
6/10/2003	CPF176D	7.6	30.0	3.7	52	1.0	0.03	0.28	<0.02	<0.02	0.29	0.27	0.02	6	41	4.0	3.9
6/10/2003	CPF176E	7.5	30.8	3.6	51	1.0	0.02	0.38	<0.02	<0.02	0.39	0.37	0.02	25	40	<2.5	2.1
6/10/2003	CPF176F	7.7	30.2	3.6	51	1.0	0.02	0.33	<0.02	<0.02	0.34	0.32	0.02	6	36	<2.5	2.1
8/5/1998	CPF176D	7.6	26.4	3.8	65	0.6	0.01	0.30	0.05	0.04	0.34	0.25	0.09		50	2.0	4.2
8/5/1998	CPF176E	7.7	26.7	3.8	65	0.6	0.03	0.30	0.05	0.04	0.34	0.25	0.09		57	3.0	4.3
8/5/1998	CPF176F	7.5	26.7	3.9	63	0.7	0.02	0.40	0.08	0.04	0.44	0.32	0.12		44	2.0	4.1
7/14/1998	CPF176D	6.8	29.1	3.8	67	0.4	0.03	0.30	<0.01	<0.01	0.31	0.30	0.01		50	1.0	4.6
7/14/1998	CPF176E	6.5	29.1	3.8	67	0.4	0.03	0.30	0.10	<0.01	0.31	0.20	0.11		43	2.0	4.4
7/14/1998	CPF176F	6.3	28.6	3.8	68	0.5	0.03	0.30	0.12	<0.01	0.31	0.18	0.13		47	<1.0	4.5
6/16/1998	CPF176D	6.6	28.1	3.7	62	0.5	<0.01	0.30	0.03	0.03	0.33	0.27	0.06		36	4.0	4.3
6/16/1998	CPF176E	6.7	28.4	3.7	62	0.5	<0.01	0.30	0.02	0.02	0.32	0.28	0.04		36	2.0	4.2
6/16/1998	CPF176F	6.7	28.6	3.7	61	0.5	0.01	0.20	0.02	0.02	0.22	0.18	0.04		45	2.0	5.3
030622																	
Cabin Lake																	
8/13/2003	CPFCC	22.7	5.0	3.7	68	0.4	0.26	1.30	0.07	0.50	1.80	1.23	0.57	150	120	4.0	5.3
8/13/2003	CPFCL1	29.2	5.4	4.1	44	0.3	0.24	1.30	0.06	0.18	1.48	1.24	0.24	23	130	5.0	9.9
8/13/2003	CPFCL2	28.4	8.8	4.2	43	0.3	0.30	1.80	0.04	0.12	1.92	1.76	0.16	240	130	17.0	14.0
8/13/2003	CPFCL3	4.9	27.3	4.9	43	0.3	0.25	1.50	0.05	0.13	1.63	1.45	0.18	71	110	9.0	12.0
8/13/2003	CPFCL4	5.3	27.3	4.3	42	0.3	0.21	1.20	0.05	0.21	1.41	1.15	0.26	28	150	<5	11.0
7/10/2003	CPFCL1	4.4	31.8	4.6	38	0.3	0.18	1.30	0.03	0.12	1.42	1.27	0.15	30	100	11.0	11.0
7/10/2003	CPFCL2	4.9	31.3	4.5	40	0.4	0.16	1.20	0.02	0.12	1.32	1.18	0.14	24	100	10.0	12.0
7/10/2003	CPFCL3	4.6	30.6	4.4	39	0.3	0.16	1.20	0.03	0.12	1.32	1.17	0.15	19	100	8.0	10.0
7/10/2003	CPFCL4	4.9	30.6	4.4	40	0.3	0.50	2.40	1.00	<0.02	2.41	1.40	1.01	21	110	9.0	11.0
6/16/2003	CPFCL1	5.1	29.7	4.7	56	0.3	0.16	0.99	0.04	0.08	1.07	0.95	0.12	9	510	14.0	15.0
6/16/2003	CPFCL2	5.7	29.2	4.6	55	0.3	0.15	1.00	0.02	0.02	1.02	0.98	0.04	7	150	16.0	15.0
6/16/2003	CPFCL3	5.9	29.3	4.5	54	0.3	0.15	0.85	0.02	<0.02	0.86	0.83	0.33	7	140	8.0	14.0
6/16/2003	CPFCL4	5.8	29.1	4.5	53	0.3	0.14	1.10	0.02	<0.02	1.11	1.08	0.33	6	150	13.0	15.0
10/21/1994	LL1	9.1	18.0	6.1	114	0.3	0.60	1.40	0.06	1.80	3.20	1.34	1.86	2	110	13.0	12.0
10/21/1994	LL2	9.5	19.9	6.0	105	0.4	0.14	0.80	0.11	0.97	1.77	0.69	1.08	3	87	4.0	9.8

Appendix 21 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL *a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
030620																	
Singletary Lake																	
8/6/2003	CPF176D	6.8	30.1	3.6	48	0.8	0.03	0.35	<0.02	<0.02	0.36	0.34	0.02	16	<50	<5	2.9
8/6/2003	CPF176E	6.9	29.8	3.6	47	0.8	0.02	0.34	<0.02	<0.02	0.35	0.33	0.02	15	<50	3.0	2.9
8/6/2003	CPF176F	6.9	19.5	3.5	47	0.9	0.03	0.28	<0.02	<0.02	0.29	0.27	0.02	14	<50	<2.5	3.9
7/7/2003	CPF176D	7.1	29.9	3.6	48	0.8	0.02	0.36	<0.02	<0.02	0.37	0.35	0.02	9	<50	4.0	2.1
7/7/2003	CPF176E	7.1	29.6	3.6	48	0.9	0.02	0.40	<0.02	<0.02	0.41	0.39	0.02	2	<50	4.0	3.5
7/7/2003	CPF176F	7.4	29.8	3.5	48	0.8	0.02	0.39	<0.02	<0.02	0.40	0.38	0.02	6	<50	<2.5	2.1
6/10/2003	CPF176D	7.6	30.0	3.7	52	1.0	0.03	0.28	<0.02	<0.02	0.29	0.27	0.02	6	41	4.0	3.9
6/10/2003	CPF176E	7.5	30.8	3.6	51	1.0	0.02	0.38	<0.02	<0.02	0.39	0.37	0.02	25	40	<2.5	2.1
6/10/2003	CPF176F	7.7	30.2	3.6	51	1.0	0.02	0.33	<0.02	<0.02	0.34	0.32	0.02	6	36	<2.5	2.1
8/5/1998	CPF176D	7.6	26.4	3.8	65	0.6	0.01	0.30	0.05	0.04	0.34	0.25	0.09		50	2.0	4.2
8/5/1998	CPF176E	7.7	26.7	3.8	65	0.6	0.03	0.30	0.05	0.04	0.34	0.25	0.09		57	3.0	4.3
8/5/1998	CPF176F	7.5	26.7	3.9	63	0.7	0.02	0.40	0.08	0.04	0.44	0.32	0.12		44	2.0	4.1
7/14/1998	CPF176D	6.8	29.1	3.8	67	0.4	0.03	0.30	<0.02	<0.02	0.31	0.30	0.01		50	1.0	4.6
7/14/1998	CPF176E	6.5	29.1	3.8	67	0.4	0.03	0.30	0.10	<0.02	0.31	0.20	0.11		43	2.0	4.4
7/14/1998	CPF176F	6.3	28.6	3.8	68	0.5	0.03	0.30	0.12	<0.02	0.31	0.18	0.13		47	<1.0	4.5
6/16/1998	CPF176D	6.6	28.1	3.7	62	0.5	<0.01	0.30	0.03	0.03	0.33	0.27	0.06		36	4.0	4.3
6/16/1998	CPF176E	6.7	28.4	3.7	62	0.5	<0.01	0.30	0.02	0.02	0.32	0.28	0.04		36	2.0	4.2
6/16/1998	CPF176F	6.7	28.6	3.7	61	0.5	0.01	0.20	0.02	0.02	0.22	0.18	0.04		45	2.0	5.3
030622																	
Cabin Lake																	
8/13/2003	CPFCC	22.7	5.0	3.7	68	0.4	0.26	1.30	0.07	0.50	1.80	1.23	0.57	150	120	4.0	5.3
8/13/2003	CPFCL1	29.2	5.4	4.1	44	0.3	0.24	1.30	0.06	0.18	1.48	1.24	0.24	23	130	5.0	9.9
8/13/2003	CPFCL2	28.4	8.8	4.2	43	0.3	0.30	1.80	0.04	0.12	1.92	1.76	0.16	240	130	17.0	14.0
8/13/2003	CPFCL3	4.9	27.3	4.9	43	0.3	0.25	1.50	0.05	0.13	1.63	1.45	0.18	71	110	9.0	12.0
8/13/2003	CPFCL4	5.3	27.3	4.3	42	0.3	0.21	1.20	0.05	0.21	1.41	1.15	0.26	28	150	<5	11.0
7/10/2003	CPFCL1	4.4	31.8	4.6	38	0.3	0.18	1.30	0.03	0.12	1.42	1.27	0.15	30	100	11.0	11.0
7/10/2003	CPFCL2	4.9	31.3	4.5	40	0.4	0.16	1.20	0.02	0.12	1.32	1.18	0.14	24	100	10.0	12.0
7/10/2003	CPFCL3	4.6	30.6	4.4	39	0.3	0.16	1.20	0.03	0.12	1.32	1.17	0.15	19	100	8.0	10.0
7/10/2003	CPFCL4	4.9	30.6	4.4	40	0.3	0.50	2.40	1.00	<0.02	2.41	1.40	1.01	21	110	9.0	11.0
6/16/2003	CPFCL1	5.1	29.7	4.7	56	0.3	0.16	0.99	0.04	0.08	1.07	0.95	0.12	9	510	14.0	15.0
6/16/2003	CPFCL2	5.7	29.2	4.6	55	0.3	0.15	1.00	0.02	0.02	1.02	0.98	0.04	7	150	16.0	15.0
6/16/2003	CPFCL3	5.9	29.3	4.5	54	0.3	0.15	0.85	0.02	<0.02	0.86	0.83	0.33	7	140	8.0	14.0
6/16/2003	CPFCL4	5.8	29.1	4.5	53	0.3	0.14	1.10	0.02	<0.02	1.11	1.08	0.33	6	150	13.0	15.0
10/21/1994	LL1	9.1	18.0	6.1	114	0.3	0.60	1.40	0.06	1.80	3.20	1.34	1.86	2	110	13.0	12.0
10/21/1994	LL2	9.5	19.9	6.0	105	0.4	0.14	0.80	0.11	0.97	1.77	0.69	1.08	3	87	4.0	9.8
10/21/1994	LL3	11.4	20.4	6.3	95	0.4	0.10	0.80	0.06	0.03	0.83	0.74	0.09	3	80	5.0	11.0
10/21/1994	LL4	9.4	20.0	6.3	95	0.4	0.09	0.80	0.04	0.10	0.90	0.76	0.14	5	86	6.0	11.0
10/21/1994	LL5	9.1	19.5	6.2	95	0.5	0.05	0.80	0.07	0.10	0.90	0.73	0.17	2	78	4.0	10.0
10/21/1994	LL6	8.9	19.9	6.1	96	0.5	0.05	0.70	<0.02	0.11	0.81	0.69	0.12	<1	81	2.0	9.1
10/21/1994	LL7	10.2	19.9	6.4	96	0.5	0.07	0.60	<0.02	0.10	0.70	0.60	0.11	2	75	4.0	10.0
10/14/1994	LL1	7.0	17.6	4.3	180	0.4	0.88	1.80	0.85	5.60	7.40	0.95	6.45	<1	260	31.0	9.4
10/14/1994	LL2	8.6	17.7	5.6	90	0.4	0.13	0.60	<0.02	0.02	0.62	0.60	0.03	6	130	20.0	15.0
10/14/1994	LL3	8.3	18.1	4.6	80	0.5	0.07	0.50	0.03	0.10	0.60	0.47	0.13	2	120	16.0	11.0
10/14/1994	LL4	8.5	17.6	5.7	95	0.5	0.06	0.60	0.04	0.03	0.63	0.56	0.07	3	140	24.0	11.0
10/14/1994	LL5	8.7	17.6	6.1	95	0.5	0.06	0.60	0.06	0.02	0.62	0.54	0.08	6	100	3.0	10.0
10/14/1994	LL6	8.7	17.9	6.2	122	0.4	0.06	0.40	0.12	0.05	0.45	0.28	0.17	5	110	9.0	12.0
10/14/1994	LL7	8.3	17.5	6.1	96	0.5	0.06	0.60	0.07	0.02	0.62	0.53	0.09	5	110	2.0	8.9
8/16/1994	LL1	5.8	28.0	6.1	103	0.3	0.15	1.20	0.22	0.19	1.39	0.98	0.41	5	120	15.0	8.5
8/16/1994	LL2	5.5	28.2	6.0	98	0.4	0.09	0.90	0.02	0.03	0.93	0.88	0.05	4	96	6.0	7.0
8/16/1994	LL3	6.8	28.9	6.1	97	0.4	0.06	0.70	<0.02	<0.02	0.71	0.69	0.02	6	100	6.0	6.1

Appendix 21 (continued).

Subbasin/ Waterbody/ Date	Station	Dissolved Oxygen (mg/L)	Water temperature (°C)	pH (s.u.)	Conductivity (µmhos/cm)	Secchi depth (m)	TP (mg/L)	TKN (mg/L)	NH_3 (mg/L)	NO_x (mg/L)	TN (mg/L)	TON (mg/L)	TIN (mg/L)	CHL *a* (µg/L)	Total Solids (mg/L)	Susp. Solids (mg/L)	Turbidity (NTU)
8/16/1994	LL4	5.2	28.0	5.9	96	0.3	0.07	0.70	<0.02	<0.02	0.71	0.70	0.01	5	100	9.0	6.7
8/16/1994	LL5	5.4	28.5	6.0	95	0.3	0.05	0.60	<0.02	<0.02	0.61	0.59	0.02	4	100	8.0	7.4
8/16/1994	LL6	4.9	28.8	6.0	96	0.3	0.07	0.60	<0.02	<0.02	0.61	0.59	0.02	4		8.0	7.1
8/16/1994	LL7	5.9	28.7	6.0	96	0.3	0.07	0.60	0.02	<0.02	0.61	0.58	0.03	6	120	22.0	6.4
7/28/1994	LL1	6.4	27.9	6.4	109	0.4	0.22	1.70	0.94	0.15	1.85	0.76	1.09	9	130	12.0	9.1
7/28/1994	LL2	7.7	27.9	5.9	94	0.6	0.05	0.60	<0.02	<0.02	0.61	0.60	0.01	11	114	8.0	9.0
7/28/1994	LL3	7.5	28.5	5.4	87	0.7	0.05	0.50	<0.02	<0.02	0.51	0.50	0.01	2	123	15.0	7.5
7/28/1994	LL4	6.3	28.9	5.2	93	0.4	0.04	0.50	<0.02	<0.02	0.51	0.50	0.01	4	123	3.0	6.4
7/28/1994	LL5	4.8	28.2	5.0	94	0.8	0.05	0.60	<0.02	<0.02	0.61	0.59	0.02	3	118	2.0	6.2
7/28/1994	LL6	5.1	28.4	5.1	94	0.6	0.05	0.60	0.03	<0.02	0.61	0.57	0.04	4	111	3.0	6.6
7/28/1994	LL7	5.3	28.3	5.1	93	0.7	0.03	0.60	<0.02	<0.02	0.61	0.59	0.02	4	113	<1.0	5.9
5/24/1994	LL1	9.7	22.9	6.3	94	0.5	0.11	0.80	<0.02	0.22	1.02	0.79	0.23	27	120	8.0	12.0
5/24/1994	LL2	10.3	23.9	6.4	93	0.5	0.08	0.80	<0.02	0.14	0.94	0.80	0.15	17	110	13.0	14.0
5/24/1994	LL3	10.1	25.1	6.5	93	0.4	0.09	0.70	<0.02	0.10	0.80	0.70	0.11	27	120	10.0	13.0
5/24/1994	LL4	9.9	24.4	6.5	94	0.3	0.12	0.90	<0.02	0.08	0.98	0.90	0.09	51	120	14.0	14.0
5/24/1994	LL5	10.2	24.8	6.6	93	0.4	0.09	0.80	<0.02	0.06	0.86	0.80	0.07	32	93	10.0	12.0
5/24/1994	LL6	10.2	28.1	6.5	94	0.4	0.09	0.70	0.06	0.12	0.82	0.64	0.18	27	130	21.0	14.0
5/24/1994	LL7	10.2	26.3	6.6	94	0.4	0.10	0.70	0.06	0.06	0.76	0.64	0.12	28	110	11.0	12.0

Appendix 22. Common bloom forming algae in the Cape Fear River basin, 2003.

Gonyostomum (Diesing)

Classification: Raphidophyta, formally known as Chloromonads.
Gonyostomum is common in bogs, lakes and pond that are generally of low pH (< 6 s.u.). It is indicative of dystrophic and eutrophic conditions. *Gonyostomum* is a relatively large algae (Figure 1) and although usually in low numbers, may form nuisance blooms in the summer (Wehr and Sheath 2003). There are no known human or environmental health risks associated with *Gonyostomum.*

Figure 1. ***Gonyostomum.***

Chrysochromulina (Lackey)

Classification: Haptophyta, formally known as Prymnesiophyta.
There are two common freshwater species of *Chrysochromulina* in North Carolina (Figure 2). *C parva* is smaller (about 5 µm) and the larger (about 12 µm) was previously identified as *C breviturrita* but cannot be positively identified without electron microscopy. *Chrysochromulina* is often associated with elevated (> 40 µg/L) chlorophyll *a* concentrations in Piedmont reservoirs. It is an indicator of eutrophic conditions, known to form blooms, and even at moderate densities is reported to produce "rotten cabbage" or "garbage dump" odors in drinking waters (Wehr and Sheath 2003).

Figure 2. ***Chrysochromulina.***

Filamentous Bluegreens

Classification: Cyanophyta, also called Cyanobacteria or Cyanoprocaryotes.
Filamentous blue greens are often considered nuisance organisms because they can cause water discoloration, form surface films, create taste and odor problems and some strains can even produce toxins (Figure 3). There have been no documented human health problems caused by toxic blue-greens in North Carolina.

Figure 3. **A bloom of the bluegreen algae, *Microcystis.***

Filamentous blue greens are indicative of nutrient enrichment and are often dominate the phytoplankton assemblage in mid to late summer. They are particularly well adapted to warm, nutrient rich, slow moving or non-flowing waters. Many filamentous blue greens can regulate their buoyancy which allows them to move between the lower nutrient rich water to the light at the surface. Some filamentous bluegreens can even "fix" nitrogen gas (N_2) giving them a competitive edge in N limited systems.

Five of the most common bloom forming filamentous blue greens in basin in 2003 were *Lyngbya, Oscillatoria, Anabaena, Aphanizomenon flos-aquae,* and *Anabaenopsis raciborkii.*

Lyngbya (also known as *Planktolyngbya*) and *Oscillatoria* are amongst the smallest filamentous blue greens. They do not have heterocysts nor do they form surface films. Filaments of *Lyngbya* are short (< 100 µm) and have a characteristic sheath that extends beyond the filament. Filaments of *Oscillatoria* are longer (< 300 µm) and look like a chain of small sausages.

There are over 100 species of A*nabaena* and they are often found together. Cells are blue-green to yellow-green and form long, straight, curved, or regularly coiled filaments (Figures 4 and 5). Even at only moderate concentrations, *Anabaena* can cause a grassy or musty odor (AWWA 2002).

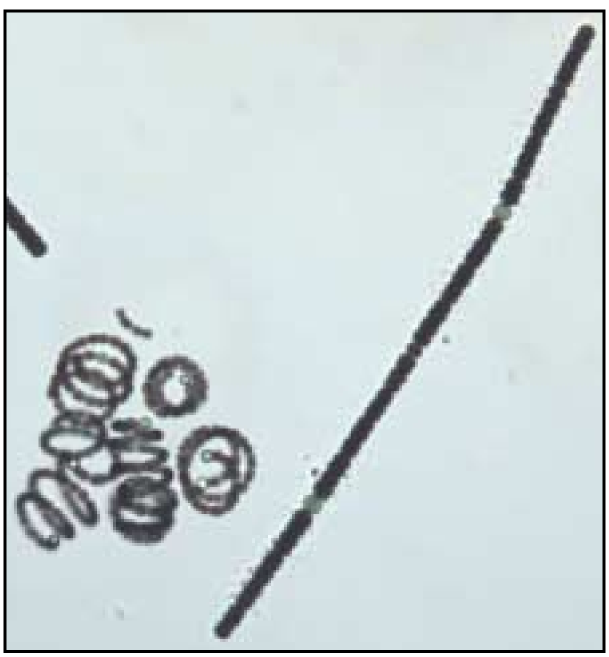


Figure 4. Two forms of *Anabaena.*

Figure 5. A coiled form of *Anabaena.*

Filaments of *Aphanizomenon flos-aquae* clump together and form characteristic rafts. During blooms these rafts are visible as small white flecks in the water column and look like sawdust when they collect at the surface.

Anabaenopsis raciborskii (also known as *Cylindrospermopsis raciborskii*) has a characteristic "arrowhead" shaped heterocyst at the end of the filament. Sometimes blooms of *A. raciborskii* can be found a few meters under the surface (Williams *et al*. 2001). These are referred to as stratified blooms. *A. raciborskii* is considered invasive and is currently causing toxicity problems in Florida.