# BASINWIDE ASSESSMENT REPORT

# CHOWAN RIVER AND PASQUOTANK RIVER BASINS

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

January 2002

TABLE OF CONTENTS

## LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

Table Page

## LIST OF FIGURES

LIST OF FIGURES (continued)

# EXECUTIVE SUMMARY

## Chowan River Basin

The Chowan River basin is located in the northeastern coastal plain of North Carolina and includes all or parts of Northampton, Hertford, Gates, Bertie and Chowan Counties (Figure 1). The Chowan River is formed at the border of Virginia and North Carolina by the confluence of the Nottoway and Blackwater Rivers, and its streams flow southeastward into Albemarle Sound.

The Chowan basin includes 1,315 square miles in North Carolina, but the largest part of the drainage basin (3,575 square miles-approximately 76 percent ) lies in Virginia. Major tributaries to the Chowan River include the Meherrin River and its largest tributary, Potecasi Creek, the Wiccacon River and its largest tributary, Ahoskie Creek. The Meherrin River flows into North Carolina from Greensville County, Virginia. Murfreesboro, Ahoskie, and Edenton are the largest urban areas in the basin. Land use within the basin is mainly forest and agriculture. Important natural resources include wetlands, anadromous fish spawning areas, and Merchant's Millpond State Park.

## Pasquotank River Basin

The Pasquotank River basin encompasses 3,697 square miles of flat lands and vast open waters (42 percent of the basin) in the far northeast outer coastal plain (Figure 1). It includes all or parts of Camden, Currituck, Dare, Gates, Hyde, Pasquotank, Perquimans, Tyrell and Washington counties. A small portion of the basin extends into Virginia. Watersheds in this basin drain into sections of Albemarle, Currituck, Croatan, Roanoke and Pamlico Sounds. Urban areas include Elizabeth City, Hertford, Columbia, Manteo and the Outer Banks north of Manteo.

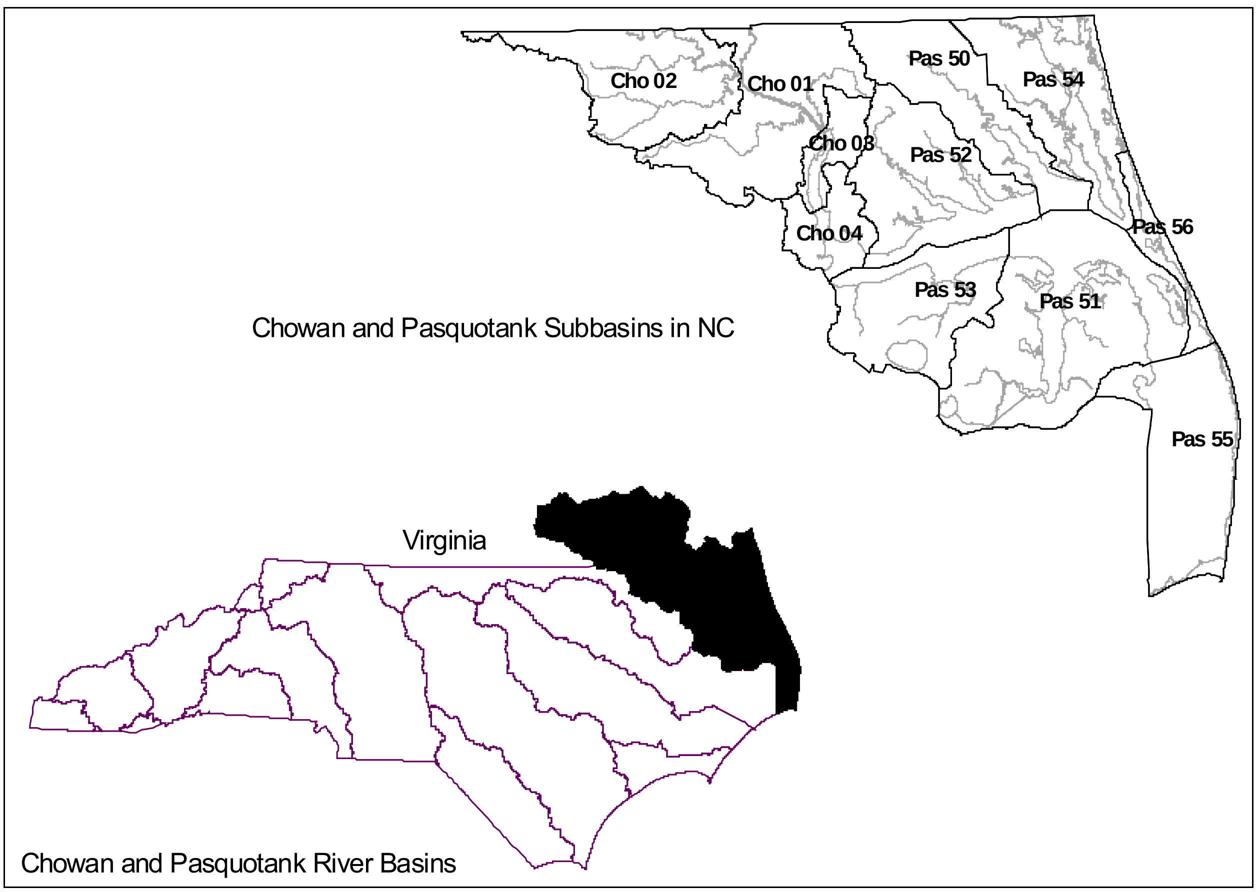



**Figure 1. Geographical relationships of the Chowan River and Pasquotank River basins in North Carolina and Virginia.**

On the northwest side of Albemarle Sound, the Pasquotank River is freshwater above and brackish and tidally influenced below Elizabeth City. The Little River is a slow-flowing freshwater stream that flows along the border of Perquimans and Pasquotank counties. The Perquimans River originates in the Great Dismal Swamp, and has the town of Hertford in its watershed. On the southeast side of Albemarle Sound, the Alligator River is a large blackwater river, with a surface area of 64,000 acres. The river has been designated as Outstanding Resource Waters. It is a remote area bordered by wooded swamps and pocosins. The Alligator River National Wildlife Refuge extends along the entire eastern shore of the river. The Scuppernong River watershed is mainly forested wetlands and agriculture with widespread use of canals which drain the wetlands.

## EXECUTIVE SUMMARIES BY PROGRAM AREA

### BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates have been collected at 43 freshwater and 19 estuarine sites in the Chowan River and Pasquotank River basins since 1983. However, in 2000, only five of these sites (all in the Chowan River basin) could be assigned a bioclassification with existing NCDWQ criteria (Figure 2). Eight additional swamp streams in the Chowan River basin and 13 in the Pasquotank River basin were "Not Rated. Many of these swamp streams were sampled for the first time.

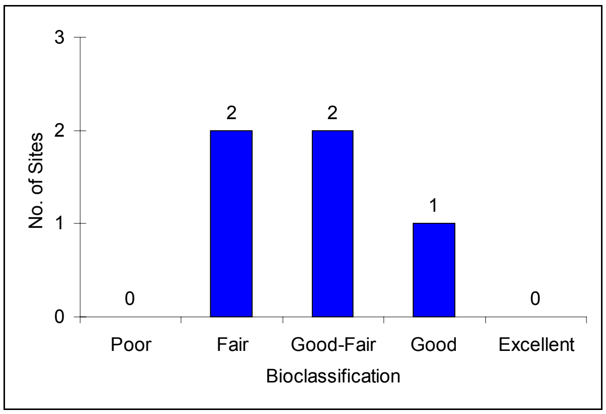



**Figure 2. Bioclassifications of benthos sites monitored in the Chowan River basin, 2000.**

No reference sites could be found in the Pasquotank River basin. Many of the swamp streams in the coastal plain were not assigned a bioclassification, but this information can be used to highlight areas of best and worst water quality. Such information also will be used to monitor future changes in water quality.

Aquatic habitats sampled included rivers, swamp streams (with a fairly natural channel), and channelized streams. All these systems receive large amounts of agricultural runoff, precluding the establishment of any "unimpacted" reference sites. The aquatic fauna of the Chowan River basin had the highest diversity in riverine habitats, provided dissolved oxygen was maintained at an adequate level through the summer months.

Samples from both basins have included collections that indicate substantial differences between channelized streams and streams with a more natural channel. Further information on summer flows may be required to determine how channelized streams in these basins should be evaluated.

### Chowan River Basin

The Chowan River and Meherrin Rivers received Good-Fair or Good ratings, but the Wiccacon River received only a Fair rating. The macroinvertebrate community for the latter site indicated problems with low dissolved oxygen and enrichment. The Wiccacon River catchment includes many channelized streams, and ambient water chemistry data has shown low dissolved oxygen concentrations during summer months.

Between-year changes in water quality could be evaluated at only four sites in this basin because most streams were sampled for the first time in 2000. None of the four sites showed any change in water quality since 1995. Only the upper Chowan River may have had a slight decline in the benthic community compared to data from 1990 and earlier. The changes observed for the upper Chowan River may have been influenced by high flows before recent collections.

The three sites on the Chowan River represented very different sections of the river. The upper site (near Riddicksville) had abundant *Corbicula* (Asiatic clam) at all depths, indicating that bottom water did not become anoxic. Higher flow rates at this site produced sandy substrate throughout the river's cross-section. At the site near Gatesville, however, the Chowan River was much wider and deeper than the site at Riddicksville. This produced lower current velocities, and the substrate was largely silt. The absence of *Corbicula* in the middle of the river indicated very low dissolved oxygen in bottom waters. The lower site (near Edenton) was characterized by occasional saline intrusions, shallow water, and severe wave action. At this site, *Corbicula* was again found in large numbers at all depths.

The lowest taxa richness was recorded in upper Potecasi Creek and Urahaw Swamp; EPT taxa were largely absent from these two streams. No significant problems were observed in other swamp streams, although data from Cole Creek indicated some enrichment and low dissolved oxygen.

The best streams in this basin reflected a combination of unchannelized catchments and well-drained, loamy soils. These streams included Kirbys Creek and the Meherrin River in the north, and Chinkapin Creek in the south. Even these streams, however, have catchments with large amounts of agricultural land use.

**Pasquotank River Basin**
Sampling of macroinvertebrates from swamp streams throughout the Pasquotank River basin indicated that intolerant EPT species are rare or absent at all wadeable sites. Larger rivers (sampled by boat) contain some EPT taxa, but are not expected to be similar to boat sites in other parts of the coastal plain.

The entire Pasquotank River basin lies to the east of the Suffolk Scarp, and this area is very different from other portions of the coastal plain. All waters in this part of the state have relatively low invertebrate taxa richness and few intolerant species. Reference sites established in other coastal basins could not be used to set criteria in the Pasquotank River basin.

In an effort to locate reference sites in this basin, samples were collected from headwater segments of the Alligator River and the Pasquotank River. These areas had very low taxa richness (< 30 taxa), and the fauna was limited by low dissolved oxygen (2 or 3 mg/L) and low pH (< 4.5). Low pH was found only in those sites draining forested pocosins/swamps. In spite of the low taxa richness, these low pH sites supported a unique fauna that was not found in other areas. Future winter sampling of the upper Pasquotank River may yield additional rare species. In catchments with more agricultural land use, the pH was close to neutral. These higher pH values allowed the development of a diverse mollusk assemblage.

Three river sites were sampled in the summer: the Perquimans River, the Pasquotank River, and the Scuppernong River. Samples were collected further upstream than in prior basinwide or ambient monitoring collections in an effort to avoid the effects of saline intrusions. All sites had a very limited fauna in deeper water and shallow water communities were usually dominated by very tolerant taxa. Indicators of enrichment were abundant in the Pasquotank River and Perquimans Rivers. The Scuppernong River had a dissolved oxygen close to zero and all taxa were tolerant of low dissolved oxygen conditions.

Six wadeable streams were sampled in the winter using swamp methods. Sawyers Creek, Areneuse Creek, and Newbegun Creek were sampled in February 2000; the first Biological Assessment Unit benthos collections from wadeable swamp streams in Subbasin 50. This part of the Pasquotank basin is characterized by very low gradient and deep organic soils. Deep Creek in Subbasin 53 also fits into this category of stream.

Although no rating system existed for this type of stream, a gradient in water quality, as evidenced by changes in taxa richness, biotic index, and community structure was demonstrated. Negative changes were associated with high amounts of agricultural and/or urban land use and by very high specific conductance. Within Subbasin 50, the stream with the best riparian buffer (Sawyers Creek) seemed to have the best water quality. Overall, Deep Creek had the best water quality, with a number of unusual invertebrate records.

**New Species and Distributional Records for the Benthic Macroinvertebrate Fauna**
Benthic monitoring in 2000 also recorded several rare taxa from these two river basins:

- Upper Chowan River --a mussel (*Elliptio lanceolata* group), two snails (*Lioplax subcarinata*, *Gyraulus deflectus*), a mayfly (*Brachycercus*, possibly an undescribed species), and a crayfish (*Orconectes virginiensis*);
- Chinkapin Creek -- *O. virginiensis*;
- Wiccacon River -- a leech (*Placobdella translucens*);
- Cole Creek -- a caddisfly (*Platycentropus*);
- Meherrin River -- a mayfly (*Brachycercus*), a caddisfly (*Ceraclea transversa* group), four midges (*Ablabesmyia simpsoni*, *Epoicocladius* (commensal on *Hexagenia* nymphs), *Hyporhygma quadripunctatum*, and *Microchironomus*), a crayfish (*Orconectes virginiensis*), a mussel (*Elliptio lanceolata* group), and a snail (*Gyraulus deflectus*);
- Kirbys Creek -- the caddisflies *Agarodes* sp., *Ceraclea tarsipunctata*, and *Rhyacophila ledra,* and one leech (*Piscicola*);
- Sawyers Creek and Deep Creek -- snails (*Promenetus exacuous* and *Gyraulus parvus*). These species are rare in other parts of North Carolina. Other unusual records at Deep Creek included the midge *Omisus pica* and the leech *Placobdella gracilis*; and
- Croatan Sound -- *Oecetis* sp. F (Floyd).

A 1979 survey of Panther Branch, a forested reference stream on Union Camp property (near Murfreesboro), by the NCDWQ (then known as the NC Division of Environmental Management) produced several unusual records for Subbasin 02 such as *Diplectrona modesta*, *Lepidostoma*, and *Heteroplectron americanum*.

## FISHERIES

### Fish Community Assessment

In 2000, four sites in subbasins 01and 02 were sampled between May and August and evaluated. Ahoskie Creek, Cutawhiskie Swamp, and Chinkapin Creek were wadeable sites while Sarem Creek was a nonwadeable, small boat site. Due to the ongoing revision in the NCIBI scoring and rating criteria for the coastal plain ecoregion and the development of evaluation protocols for small boat collecting, no fish community sites in this basin were rated.

Fish community data had been collected at Ahoskie Creek and Cutawhiskie Swamp as part of a special study before the 2000 basinwide monitoring. The new site on Chinkapin Creek was selected as a regional reference site and to fill a fish community data gap.

Many additional sites in the coastal plain basin were evaluated but could not be sampled. The primary reasons were a combination of water depth and accessibility. The typical pattern was to inspect a site only to find it too deep to wade for the entire 600 foot stretch required by the NCIBI protocols and yet too confined or with no access to sample it with the small electrofishing boat. Some small headwater sites were not sampled due to a lack of flow.

In 2000, although not rated, the fish communities at all the sites seemed to be fairly healthy. The most diverse fish community was found at Chinkapin Creek where 23 species were collected.

Based upon Menhinick (1991), NCDWQ, and NCDMF data, 62 species of fish are known from the two basins. Of these, the Atlantic sturgeon (*Acipenser oxyrhynchus*), shortnose sturgeon (*Acipenser brevirostrum*) and the Waccamaw killifish (*Fundulus waccamawensis*) have been given special protection by the U. S. Department of the Interior, the North Carolina Wildlife Resources Commission, and the North Carolina Natural Heritage Program under the North Carolina State Endangered Species Act (G.S. 113-311 to 1130337 (LeGrand and Hall 1999; Menhinick and Braswell 1997)) (Table 1). The shortnose sturgeon is federally and state endangered and the other two species are listed as state and federal "Special Concern" species. Additional information on the Atlantic sturgeon, shortnose sturgeon, and the Waccamaw killifish may be found in Menhinick and Braswell (1997).

**Table 1. Species of fish listed as endangered, rare, threatened, or of special concern in the Chowan River and Pasquotank River basins.**

| Species | Common Name | State Rank[1] |
|---|---|---|
| *Acipenser oxyrhynchus* | Atlantic sturgeon | S3 |
| *Acipenser brevirostrum* | Shortnose sturgeon | S1 |
| *Fundulus waccamawensis* | Waccamaw killifish | S1 |

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

### Fish Kills

The NCDWQ has systematically monitored and reported on fish kill events across the state since 1996. Field reports since 1996 have generally shown light fish kill activity (ten or less events) in the Chowan River and Pasquotank River basins each year (NCDENR 2000). These basins generally exhibited fewer conditions that have given rise to frequent kill activity in other coastal areas. Such conditions include eutrophication, stratification, and associated hypoxia, especially along the shallow, poorly flushed waterbodies. The Chowan River and Pasquotank River basins also have not experienced hurricane-related fish kills in recent years as compared with the more southern areas such as the Neuse River and Cape Fear River basins.

### Fish Tissue

Surveys conducted by the NCDWQ and other researchers have identified two tissue contaminant issues within the Chowan River and Pasquotank River basins -- dioxin and mercury.

The Chowan River from the Virginia border to Albemarle Sound was placed under a fish consumption advisory in 1990 for all species except herring and shad due to dioxin contamination from Union Camp's Franklin, Virginia paper mill. Yearly monitoring by Union Camp in North Carolina indicated that dioxin levels gradually decreased in fish from the Chowan River and Meherrin Rivers after new bleaching technologies were instituted in 1990 to improve effluent quality. In March 1998, the advisory was partially lifted, leaving carp and catfish as the only two species still considered unsafe to eat. The advisory was completely lifted in early 2000 after dioxin toxicity equivalents (TEQ – the sum of 2,3,7,8 TCDD and 2,3,7,8 TCDF congeners) from all stations and species remained below 3 pg/g (recommended level for North Carolina) for two consecutive years (1998 and 1999). The highest levels reported in 1998 and 1999 were 1.98 pg/g and 1.99 pg/g, respectively. The sampling of catfish species by Union Camp is scheduled to continue through the year 2001 to verify the reduction in dioxin concentrations.

Mercury has been identified as a widespread contaminant in fish from all North Carolina coastal river basins (NCDEHNR 1996c). In the Chowan River and Pasquotank River basins, elevated mercury levels have been measured in long-lived piscivores such as largemouth bass and bowfin. Significant mercury contamination was identified in areas such as Lake Phelps where over 50 percent of the fish sampled before 1996 contained levels above human health standards. Lake Phelps is unique because it possesses a minimal drainage area, receives most of its hydrologic input from the atmosphere, and represents a minimally impacted system. Research indicates that atmospheric mercury deposition is a significant source for the observed mercury levels (USEPA 1997).

Currently, there are no basin-specific fish consumption advisories for the Chowan River and Pasquotank River basins. However, a statewide advisory is in place for bowfin. This species is found throughout the basins.

From August 1998 through August 1999, the North Carolina Division of Marine Fisheries collected samples of king mackerel off the coast for mercury contaminant analysis. The samples were collected at the request of the North Carolina Division of Environmental Health after health agencies in Texas and Florida recently issued consumption advisories for king mackerel due to potentially harmful levels of mercury.

Fish larger than 95 cm or 6.5 kg were found to have concentrations of mercury in excess of the North Carolina criteria of 1 µg/g. Based on these results, North Carolina, joined together with South Carolina, Georgia, and Florida in March 2000 to issue a joint health advisory concerning high levels of mercury in large king mackerel. The advisory states:

- *"king mackerel less than 33 inches fork-length (from nose to where the tail forks) are safe to eat;*
- *king mackerel over 39 inches should not be eaten;*
- *people should limit their consumption of 33 to 39 inch fish;*
- *women of child bearing age and children age 12 and younger should eat no more than one, 8-ounce portion a month; and*
- *other adults should eat no more than four, 8-ounce portions a month."*

The advisory does not prevent commercial fisherman or recreational anglers from landing king mackerel. Recreational anglers are allowed to land three fish/person/day with a minimum-size limit of 24-inch fork length. Federally permitted commercial fishermen are limited to 3,500 pounds/trip with a 24-inch fork length minimum size.

Since 1995, the NCDWQ has conducted one fish tissue survey in the Chowan River basin. Fish samples were collected on the Chowan River near Gatesville during August 2000. The survey was conducted to obtain baseline metals data before operation of the Nucor steel mill near Tunis (Hertford County). Metals concentrations were non-detectable or at levels below current USEPA, USFDA, and North Carolina criteria.

**LAKE ASSESSMENT**

Lake Phelps was the only lake monitored in the Chowan River and Pasquotank River basins as part of the Lake Assessment program. Lake Phelps is a unique Carolina Bay lake and is used recreationally for boating, sailing, skiing, and fishing. In August 2000, in recognition of its resource values (registered North Carolina Natural Area, integral component of Pettigrew State Park, and presence of rare or globally imperiled plant and fish species), the Environmental Management Commission reclassified Lake Phelps from C Swamp to B Swamp Outstanding Resource Waters.

The only water quality concern at this time in Lake Phelps is the fish consumption advisory for bowfin (blackfish) and large mouth bass due to elevated mercury concentrations in their tissue. Due to the nature of the lake (natural precipitation and groundwater recharge), atmospheric deposition is thought t o be a significant source of the observed mercury levels (USEPA 1997).

**PHYTOPLANKTON MONITORING**

Phytoplankton samples were analyzed from two sites in each basin.

At the Chowan River at Colerain, throughout the five-year sampling period, phytoplankton biovolumes were relatively low and the phytoplankton community exhibited little change over time. Cryptomonads predominated throughout much of the sampling period. The only exceptions to these trends occurred during a July 1998 bloom of the blue green algal (cyanobacterial) species *Anabaena portoricensis* and *Anabaena subcylindrica* and a July 2000 bloom of *Melosira*, a chain-forming diatom common to local estuaries. Variations in nutrient concentrations of total phosphorus and inorganic and organic nitrogen did not seem to coincide with algal blooms. Surface blue green algal blooms of *Anabaena planctonica* were reported during mid-summer 2000 on the lower Chowan River.

At the Chowan River at Edenhouse, throughout the five-year sampling period, phytoplankton biovolumes were relatively low and the phytoplankton community exhibited little change over time with cryptomonads predominating throughout much of the sampling period. The only exception to these trends occurred during an August 1999 dinoflagellate bloom. Nutrient concentrations did not seem to coincide with this bloom or vary much within the overall sampling period.

At a site in the Albemarle Sound near Frog Island, samples collected during 1996 and 1997 were dominated by blue green algae, particularly *Cylindrospermopsis raciborskii* and *Lyngbya*. An algal bloom of *C. raciborskii* was investigated at a site near Frog Island during late July 1996. Phytoplankton biovolume measurements were low from September 1998 to July 1999 and during 2000. However, phytoplankton biovolume concentrations peaked during late summer 1999. Nutrient concentrations recorded during the overall sampling period did not exhibit much overall change.

At a site in the Albemarle Sound near Harvey Neck, throughout the five-year sampling period, phytoplankton biovolumes were generally low. The phytoplankton community exhibited little change over time. Nutrient concentrations fluctuated somewhat during this time. A blue green algal (cyanobacterial) bloom of *Anabaena portoricensis* was investigated in the Edenton Bay area during August 1996, and the filamentous diatom *Skeletonema* and cryptomonads bloomed in the Perquimans River during July 2000. One fish kill associated with mild blooms of non-toxic dinoflagellates was investigated during August 1999.

**AMBIENT MONITORING SYSTEM**

Physical and chemical characteristics of the water were sampled monthly from twenty-six monitoring stations in the Chowan and Pasquotank River basins. Important findings during the recent monitoring cycle included:

- ➢ Water quality in these basins is influenced by swamp and wetland conditions, which can lower dissolved oxygen concentrations and decrease pH. There are no waterbodies with the swamp water (Sw) supplemental classification in the Chowan basin. The Little River (C Sw) and Scuppernong River (SC Sw ORW) had median dissolved oxygen concentrations below 5.0 mg/L due to apparent natural conditions.
- ➢ Overall turbidity and total suspended solids concentrations were low.
- ➢ The most nutrient rich areas include the Little River, Scuppernong River, Pasquotank River, Perquimans River and Kendricks Creek, all located in the Pasquotank River basin. Wetland conditions and nutrient loading through nonpoint sources may have contributed to this pattern.
- ➢ Geometric means for fecal coliform bacteria were less than 200 colonies/100 ml for all stations.
- ➢ More than 10 percent of the samples for copper exceeded 7.0 µg/L at the stations in Potecasi Creek and the Chowan River at Edenhouse. However, median copper concentrations were low at both sites (2 or 3 µg/L respectively).
- ➢ Chlorophyll-a did not exceed the water quality standard of 40 µg/L for more than 10 percent of the samples at any station suggesting management strategies implemented during the 1980s were very successful.

**AQUATIC TOXICITY MONITORING**

Eight facility permits in the Chowan River and Pasquotank River basins currently require whole effluent toxicity (WET) monitoring. Five facility permits have a WET limit; the other three facility permits specify monitoring with no limit. The compliance rate of those facilities with limits has been consistently high at 95 percent or greater, with minor fluctuations in 1997 and 1998.

Facilities that have had difficulty meeting their toxicity limits are:

- Piece Dye Acquisition Corporation (Subbasin Chowan 03). This facility, which discharges into the Chowan River, experienced failing chronic toxicity tests in August and September of 1998. Though no absolute cause-effect relationship was established, removal of algal growth in the wastewater treatment plant seemed to solve the toxicity problem. The facility has not failed a test since September 1998.

- The Elizabeth City WWTP (Subbasin Pasquotank 50). This facility, which discharges into the Pasquotank River, experienced problems with whole effluent toxicity during 1997. The causes of these events were not clear. The facility has not failed a test since September 1997.

# INTRODUCTION TO PROGRAM METHODS

The NCDWQ uses a basinwide approach to water quality management. Activities within the NCDWQ, including permitting, monitoring, modeling, nonpoint source assessments, and planning are coordinated and integrated for each of the 17 major river basins within the state. All basins are reassessed every five years, and the Chowan and Pasquotank River basins were sampled by the Environmental Sciences Branch in 1995 and 2000.

The Environmental Sciences Branch collects a variety of biological, chemical, and physical data that can be used in a myriad of ways within the basinwide planning program. In some areas there may be adequate data from several program areas to allow a fairly comprehensive analysis of ecological integrity or water quality. In other areas, data may be limited to one program area, such as only benthic macroinvertebrate data or only fisheries data, with no other information available. Such data may or may not be adequate to provide a definitive assessment of water quality, but can provide general indications of water quality. The primary program areas from which data were drawn for this assessment of the Chowan and Pasquotank River basins include benthic macroinvertebrates, fish community, fish tissue, 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 NCDWQ'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. NCDWQ 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 B1) 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 present in the intolerant groups Ephemeroptera, Plecoptera and Trichoptera (EPT S) (Appendix B1) and the value of the North Carolina Biotic Index (NCBI (BI)). This index summarizes tolerance data for all taxa in each collection. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis. Different criteria have been developed for different ecoregions (mountains, piedmont, and coastal) within North Carolina for freshwater flowing waterbodies.

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

## 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). 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, 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. However, 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 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. When 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, the Environmental Sciences Branch (ESB) has performed fish tissue surveys as part of the Basinwide Assessment Program. As part of the 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 North Carolina 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 the DWQ's Standard Operating Procedures (NCDEHNR 1997). 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 (Appendix FT1).

### 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. Information on fish kills in other basins may be found on NCDWQ's website (refer to the Glossary).

## LAKE ASSESSMENT

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

private) where water quality problems have been observed.
Data are normally used to determine the trophic state of each lake, a relative measure of nutrient enrichment and productivity. These determinations will not be possible for this report based on chlorophyll *a* laboratory issues from the most recent summertime sampling (Appendices L1 - L3).

**PHYTOPLANKTON MONITORING**
Phytoplankton samples were collected and analyzed in accordance with standard operating procedures (NCDEHNR 1992; NCDENR 1998) (Appendix P1). Due to analytical problems discovered with chlorophyll *a*, no chlorophyll *a* results are reported for the period 1996 - 2000.

***Pfiesteria* and *Pfiesteria*-like dinoflagellates**
The term "*Pfiesteria*-like dinoflagellate" refers to all cells that bear a cursory resemblance to the dinoflagellates *Pfiesteria piscicida* and *Pfiesteria shumwayae* (collectively referred to as "*Pfiesteria*"). Multiple dinoflagellate species tend to look like *Pfiesteria*. It is difficult to discern *Pfiesteria* from other look-alike dinoflagellates under light microscopy. Therefore, cell counts reported by the Environmental Sciences Branch (ESB) are only presumptive and include all cells that resemble *Pfiesteria*.

During late June 1999, ESB obtained equipment to view phytoplankton samples under epifluorescence microscopy (FM). This method excites chlorophyll *a* under 397 to 563 µm light frequencies. FM allows for the documentation of photosynthetic dinoflagellates from heterotrophic dinoflagellates. Photosynthetic dinoflagellates always contain chloroplasts and glow throughout their cell when viewed under FM. *Pfiesteria*, a heterotroph, does not contain its own chloroplasts. It instead relies on ingested algae, small aquatic invertebrates, and fish substances for nutrition. Therefore, *Pfiesteria* does not characteristically fluoresce unless it temporarily retains chloroplasts from algae it has ingested (Burkholder and Glasgow 1997, Burkholder, *et al*. 1998). However, definitive identification of *Pfiesteria* requires the examination of its sub-membrane plate structure under electron microscopy. The NCDWQ does not have this capability, which is generally available only to research institutions.

Unpreserved samples collected from a potential fish health event are examined under FM upon the day of their arrival. To calculate total cell densities of all *Pfiesteria*-like dinoflagellates, preserved aliquots are examined under a light microscope without fluorescence. Any cell that visually resembles *Pfiesteria* is counted as a *Pfiesteria*-like dinoflagellate. Samples collected from fish kills are often given to researchers at the North Carolina State University's Center for Applied Aquatic Ecology (for fish bioassays and scanning electron microscopy) and the University of North Carolina at Greensboro (for RNA probes) to confirm the presence or absence of *Pfiesteria piscicida* or *Pfiesteria shumwayae* (Glasgow, *et al*., 2001) during a fish health event.

**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. This section summarizes the field and laboratory chemical measures of water quality, typically referred to as ambient water quality measures.

The Ambient Monitoring System is a network of stream, lake, and estuarine stations strategically located for the collection of physical and chemical water quality data. Parametric coverage is 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 2).

Water quality data collected at all sites 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. These chemistry data summaries are found at the end of the Ambient Monitoring Section.

Data collected from January 1996 to September 2000 were displayed in box plots. Box plots provide measures of central tendency and variation (Figure 3). The parameters presented in this report were also presented in the previous basin assessment report (NCDEHNR 1996a).

**Table 2. Freshwater parametric coverage for the ambient monitoring system.**[1]

| Parameter | All freshwater | Water Supply |
|---|---|---|
| Dissolved oxygen (s) | ✔ | ✔ |
| pH (s) | ✔ | ✔ |
| Conductivity | ✔ | ✔ |
| Temperature (s) | ✔ | ✔ |
| | | |
| Total phosphorus | ✔ | ✔ |
| Ammonia as N | ✔ | ✔ |
| Total Kjeldahl as N | ✔ | ✔ |
| Nitrate+nitrite as N (s) | ✔ | ✔ |
| | | |
| Total suspended solids | ✔ | --- |
| Total dissolved solids (s) | --- | ✔ |
| Turbidity (s) | ✔ | ✔ |
| Hardness, total (s) | ✔ | ✔ |
| Chloride (s) | ✔ | ✔ |
| | | |
| Fecal coliform bacteria (s) | ✔ | ✔ |
| Total coliform bacteria (s) | --- | ✔ |
| | | |
| Aluminum (s) | ✔ | ✔ |
| Arsenic (s) | ✔ | ✔ |
| Cadmium (s) | ✔ | ✔ |
| Chromium, total (s) | ✔ | ✔ |
| Copper, total (s) | ✔ | ✔ |
| Iron (s) | ✔ | ✔ |
| Lead (s) | ✔ | ✔ |
| Mercury | ✔ | ✔ |
| Nickel (s) | ✔ | ✔ |
| Silver (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).

The water quality reference value may be an ecological evaluation level, a narrative or numeric standard, or an action level as specified in the North Carolina Administrative Code 15A NCAC 2B .0200 (Table 3). 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.

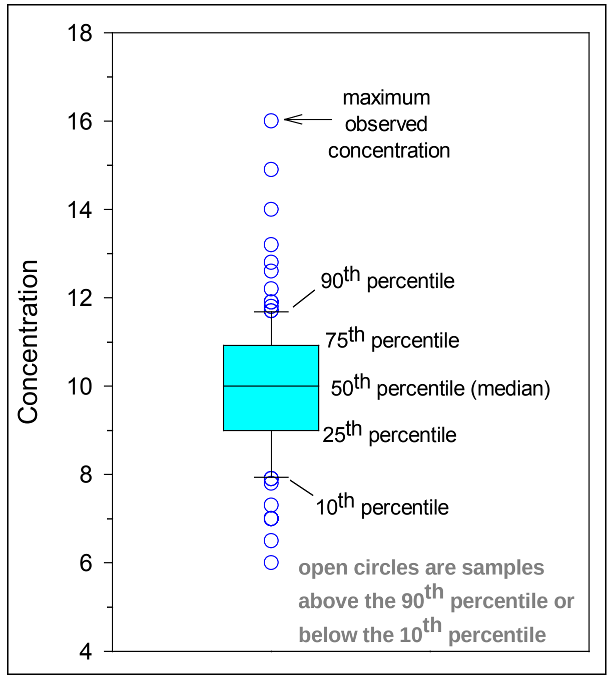



**Figure 3. Explanation of box and whisker charts.**

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

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

**Table 3. Water quality standards for parameters sampled as part of the ambient monitoring system (freshwater (top) and saltwater (bottom)).[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] | | | |
| Coliform, fecal (MFFCC/100 ml)[5] | | 200[3] | | | | |
| Copper, total | 7[2] | | | | | |
| Dissolved oxygen (mg/L) | 5.0[6] | | | 6.0 | [7] | [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, 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.

# CHOWAN RIVER SUBBASIN 01

## Description

Subbasin 01 is located in the northeastern coastal plain (Figure 4). The Chowan River is formed near the border of Virginia and North Carolina by the confluence of the Nottoway and Blackwater Rivers and it flows southeast towards Albemarle Sound. The basin includes 1,315 $mi^2$ in North Carolina, but the largest part of the drainage basin (3,575 $mi^2$) lies in Virginia.

The major tributary to the Chowan River in this subbasin is the Wiccacon River. The major tributaries to the Wiccacon River include Ahoskie Creek and Chinkapin Creek. The largest urban area is Ahoskie. Land use within this subbasin is mainly forested wetlands and agriculture. There are only four small permitted dischargers.

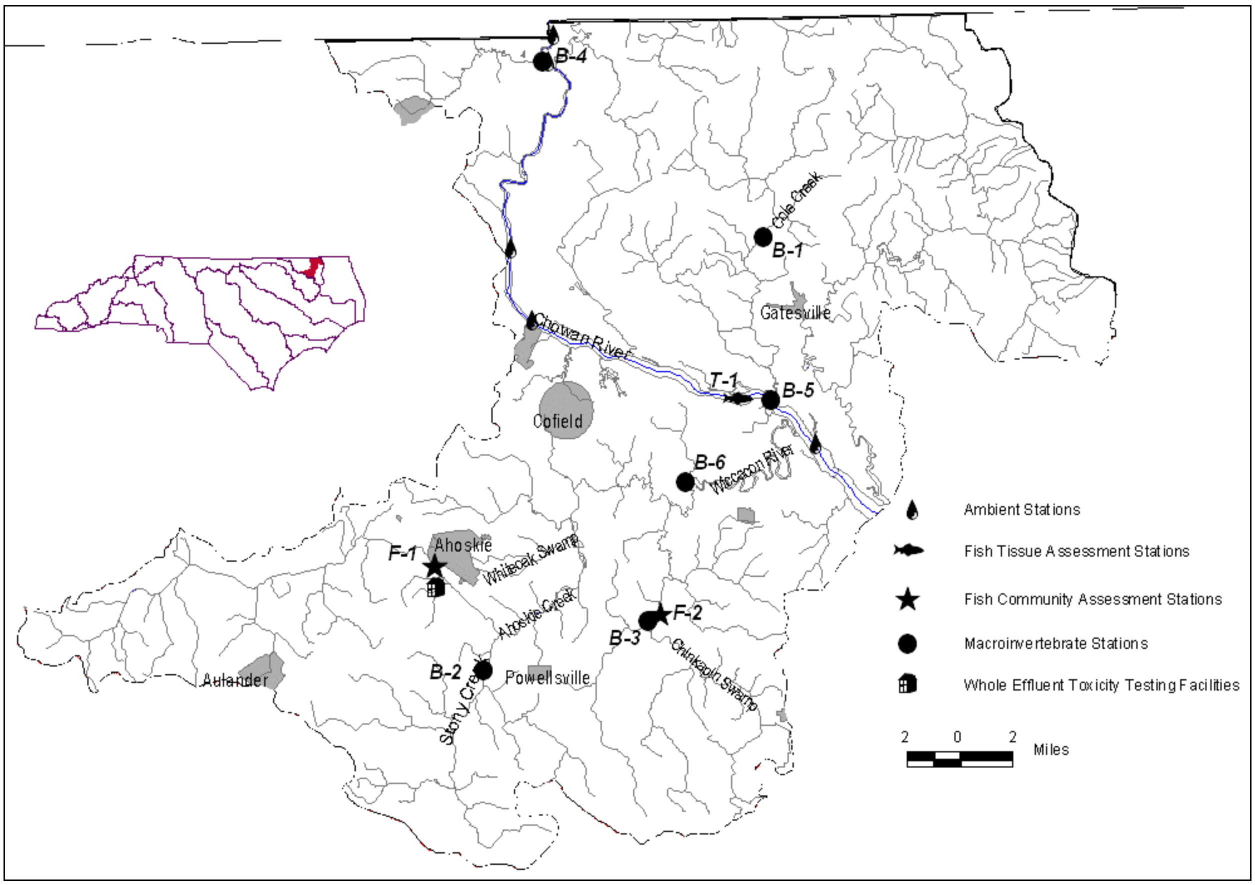



**Figure 4. Sampling sites in Subbasin 01 in the Chowan River basin.**

## Overview of water quality

Aquatic habitats sampled in this subbasin include the Chowan River, swamp streams (with a fairly natural channel), and channelized streams (Table 4). All these systems receive large amounts of agricultural runoff, precluding the establishment of any “unimpacted” reference sites. The aquatic macroinvertebrate fauna had the highest diversity in riverine habitats, provided dissolved oxygen was maintained at an adequate level through the summer.

Water quality problems encountered in this subbasin seemed related to the low dissolved oxygen concentrations during the summer. From 1990 – 1995, 50 percent of the samples taken from the Wiccacon River had DO concentrations less than 4.0 mg/L. During the same period, however, only 14 percent of the samples collected from the Chowan River at Riddicksville were less than this concentration. Water chemistry samples are no longer collected from the Wiccacon River, but low dissolved oxygen concentrations continued to be observed at the Riddicksville site. Concentrations near 2 mg/L were recorded in February 1998 (at extreme high flow) and in August 1999 during summer low flow.

Eight sites have been sampled for benthic macroinvertebrates in this subbasin. Sampling of river sites indicated better water quality in the upper Chowan River (Good or Good-Fair) than in the Wiccacon River (Fair). The macroinvertebrate community in the Wiccacon River indicated problems caused by nutrient enrichment and low dissolved oxygen. There has been no significant change over time in the benthic community of the Wiccacon River. A slight decline may have occurred at the uppermost site on the Chowan River, though the Good-Fair rating found in 1995 was retained in 2000.

Swamp streams normally cease flowing during dry periods, and are expected to have very low dissolved oxygen concentrations during summer low-flow. This portion of the basin is outside of the area used to develop swamp stream criteria for benthic macroinvertebrate samples and this type of stream in subbasin 01 will be given a "Not Rated" classification. Comparisons between sites in this area, however, can be used to discuss general trends in water quality.

Three swamp streams were sampled for the first time through the addition of a winter sampling period in 2000: Cole Creek, Stoney Creek and Chinkapin Creek. These samples did not indicate any serious water quality problems.

Ahoskie Creek and its tributaries west of NC 13, as well as other streams, have been channelized. Some tributaries of Merchant's Mill Pond also have been channelized. Channelization has a significant effect on both stream habitat and flow characteristics. One effect is to increase flow velocity during the normal summer low-flow periods (Mason *et al*. 1990, Winner and Simmons 1977). The higher flow velocity results from confining the stream to a channel and from an increase in groundwater contributions. The channelization of Ahoskie Creek (1962-1964) changed this system from a stream with seasonal flow interruptions (about 8 percent of the time) to a stream with permanent flow (Daniels 1980). This combination of higher velocities and greater permanence in the channelized sections allowed the development of a different type of macroinvertebrate fauna than found in more natural streams.

**Table 4. Waterbodies monitored in Subbasin 01 in the Chowan River basin for basinwide assessment, 1995 - 2000.**

| Map #[1] | Waterbody | County | Location | 1995 | 2000 |
|---|---|---|---|---|---|
| Winter Swamp Samples | | | | | |
| B-1 | Cole Cr | Gates | NC 58 | --- | Not Rated |
| B-2 | Stony Cr | Bertie | SR 1235 | --- | Not Rated |
| B-3 | Chinkapin Cr | Hertford | SR 1432 | --- | Not Rated |
| Summer Boat Samples | | | | | |
| B-4 | Chowan R[2] | Hertford | near Riddicksville | Good-Fair | Good-Fair |
| B-5 | Chowan R | Hertford | near Gatesville | --- | Good |
| B-6 | Wiccacon R[2] | Hertford | SR 1433 | Fair | Fair |
| F-1 | Ahoskie Cr | Hertford | NC 42 | --- | Not Rated |
| F-2 | Chinkapin Cr | Hertford | SR 1432 | --- | Not Rated |
| T-1 | Chowan R | Hertford | Near Gatesville | --- | --- |

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites, T = fish tissue monitoring sites.
[2]Data are available before 1995, refer to Appendix B2.

Fish community structure was evaluated at three sites in this subbasin in 2000. More species of fish were found in Chinkapin Creek than in Ahoskie Creek, but both sites had fairly healthy communities. Small-boat electroshocking at Sarem Creek also did not indicate any water quality problems.

Prior NCDWQ samples had documented a dioxin problem in the Chowan River below the Union Camp discharge, located near the North Carolina/Virginia border. A fish consumption advisory was put in place in 1990. Dioxin levels have steadily declined in fish-tissue samples since this time and the advisory was lifted in 2000 after dioxin fish tissue concentrations were shown to be at safe levels for two consecutive years (1998-1999). Metals in fish tissue were also analyzed in 2000 from a site on the Chowan River near Gatesville. No significant metal contamination was found in 26 tissue samples from this site.

## River and Stream Assessment

Flows were variable during 2000 with low-normal flows during winter benthos collections, but high flows during summer boat benthos sampling.

### RIVER SITES (SUMMER BOAT SAMPLING)

### Chowan River near Riddicksville

The Chowan River site near Riddicksville is located near the state line. The access point was moved in 2000 to the Three Rivers Marina (Virginia), as the prior access was through private property. The actual sampling location was about one mile downstream of the Blackwater River, and about one mile above the prior sampling location.

The substrate here is composed of sand and silt. The upper Chowan River is a typical large, slow moving, coastal river. The river was clear and humic-colored during the 2000 benthos collections, in contrast to turbid water observed at many other basin sites. Both snags and water lilies are important habitats for this portion of the river, although water lilies are typically observed along only one bank of the river. During higher flow periods, there is enough current at this site to scour out a midstream area of gravel and hardpan clay at a depth of nine meters. A heavy layer of algae and silt was observed on all snags, indicating some nutrient enrichment. This site often has low surface dissolved oxygen concentrations during summer months (< 4 mg/L). Both the Asiatic clam ( *Corbicula fluminea*) and amphipods were abundant in dredge samples, indicating that bottom water does not become anoxic.

This site was rated based on EPT taxa richness, and had been assigned bioclassifications ranging from Excellent (1990) to Good-Fair (1995 and 2000) using criteria for non-flowing (Coastal B) rivers (Table 5 ). The overall trend suggested a slight decline in water quality after 1990. The 1995 and 2000 samples had lower EPT taxa richness and total richness than the 1990 sample (Figure 5). This pattern was in agreement with the slightly lower dissolved oxygen concentrations (near 2 mg/L) that have been occasionally recorded at this site over the last five years.

**Table 5. Flow and bioclassifications for the Chowan River near Riddicksville, Hertford County.**

| Year | Flow | Rating |
|---|---|---|
| 2000 | Normal-High | Good-Fair |
| 1995 | Normal | Good-Fair |
| 1990 | Normal | Excellent |
| 1988 | Normal | Good |
| 1986 | Low | Good |
| 1984 | High | Good |

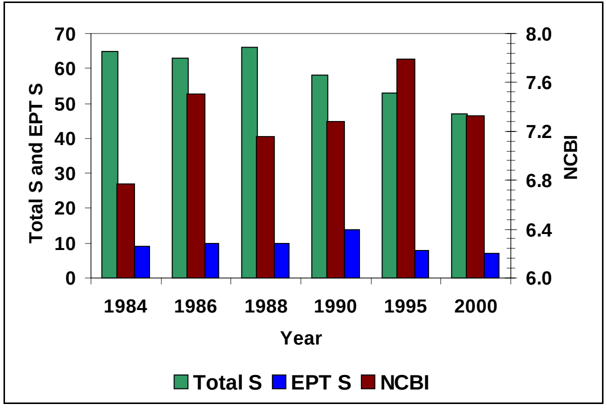



**Figure 5. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Chowan River near Riddicksville, Hertford County, 1984 - 2000.**

Several unusual taxa have been collected at this site, although none since 1990. These taxa include a mayfly (*Brachycercus*), two caddisflies (*Molanna tryphena*, *Mystacides* ?), a midge (*Ablabesmyia annulata*), a worm (*Bothrioneurum vejdovskyanum*), a crayfish (*Orconectes virginiensis*), two snails (*Gyraulus deflectus*, *Lioplax subcarinata*), and a mussel (*Elliptio lanceolata* group). The dominant taxa were the Asiatic clam (*Corbicula fluminea*) in the mid-channel sediments and the amphipod *Gammarus fasciatus* along the banks.

**Chowan River near Gatesville**
The summer 2000 collections were the first benthic macroinvertebrate samples from this segment of the Chowan River. This part of the river is very different from the Riddicksville site, with a width of about one half mile and a maximum depth of nine meters. The change in the channel profile meant slower velocities, a greater tendency for particulate organics to settle out, and an increase in sediment oxygen demand. The black sediments and the absence of *Corbicula* in the mid-channel area indicated very low dissolved oxygen concentrations in bottom waters. Water lilies were very abundant along the banks.

**Chowan River near Gatesville, Hertford County.**

This site received a Good bioclassification, based on an EPT taxa richness of nine. In comparison to the Riddicksville site, higher total taxa richness (62 vs. 46) and higher EPT abundance (43 vs. 31) was found.

The chironomid assemblage of enrichment indicators (*Polypedilum illinoense* and *Dicrotendipes simpsoni*) were still abundant but typical macrophyte grazers were also abundant (*Cricotopus sylvestris* group). Five kinds of leptocerid caddisflies occurred at this site, including two species each of *Ceraclea* and *Oecetis*.

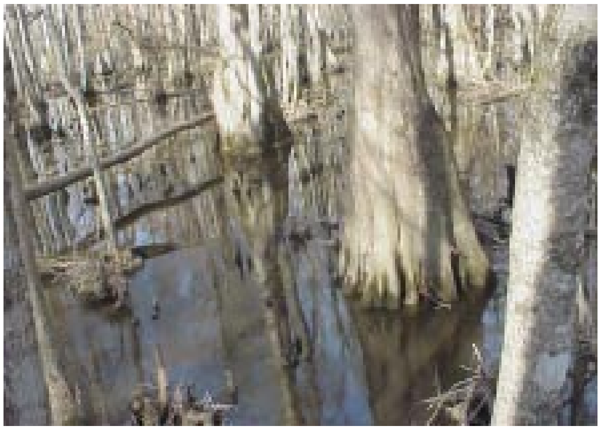
**Wiccacon River at NC 45 and SR 1433**
Before August 1995, this site was located on private property off NC 45, but in 1995, the sampling site was moved to a wildlife boat ramp off SR 1433 (slightly downstream). This site was very turbid during the 2000 benthos collection, after a period of high rainfall. This site may have anoxic bottom water, as evidenced by the absence of *Corbicula* in dredge samples plus the high numbers of *Chaoborus* and *Chironomus* in deeper water. The abundance of freshwater sponge on most snags indicated that low dissolved oxygen concentrations also occurred in surface waters.

**Wiccacon River at SR 1433, Hertford County.**

This site has consistently received a Fair bioclassification, with one Poor rating in 1989, reflecting upstream agricultural land use and its many channelized tributaries. The data did not indicate any change in water quality from 1983 - 2000.

Midges were abundant in shore samples in August 2000, especially the chironomid *Dicrotendipes simpsoni*. The observed assemblage of chironomids was characteristic of nutrient enrichment. At least nine types of leeches have been found at this site, including one uncommon species (*Placobdella translucens).*

**SWAMP STREAMS**
**Cole Creek, NC 58**
Cole Creek is an eastern tributary of Sarem Creek, and this winter collection represents the first macroinvertebrate sample from this portion of the basin. This is a braided swamp stream, but an old embankment constricts the flow to a channel less than eight meters wide.



**Cole Creek at NC 58, Gates County.**

Cole Creek resembled some streams in the lower Roanoke River basin, especially in the abundance of an unidentified moss-like macrophyte. This is the only collection locality in the Chowan River basin for an unusual caddisfly (*Platycentropus*). Low EPT abundance (13) and a high biotic index (7.6) suggested some moderate stress at this site. Some of the dominant taxa indicated enrichment (*Dicrotendipes simpsoni*) and low dissolved oxygen (*Physella* and *Sphaerium*).

**Ahoskie Creek, NC 42**

Ahoskie Creek at NC 42 is a channelized, sand bottom stream approximately seven meters wide. Due largely to an impacted riparian zone on one side and poor instream habitat, the overall habitat score was 44.

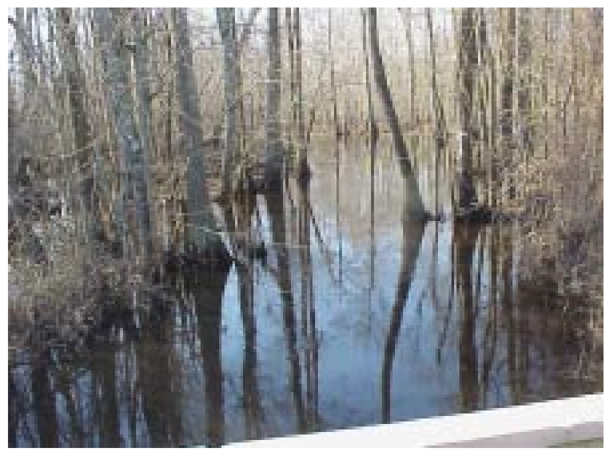
**Ahoskie Creek looking upstream from NC 42, Hertford County.**

In addition to the 2000 basin survey, a fish community sample was collected in February 1995 as part of a special study to assess the fish communities in lower coastal plain streams. Although some of the difference may be due to seasonality, the number of species collected increased from 15 in 1995 to 19 in 2000, and the number of individuals increased from 298 in 1995 to 384 in 2000. The most abundant species for both collections was the tolerant redbreast sunfish. No intolerant fish were collected during either sampling event.

A benthos sample was not collected due to high flows in the summer.

**Stony Creek, SR 1235**

Stony Creek is a southern tributary of Ahoskie Creek. It has a channel width of about 20 meters, but there are extensive cypress wetlands adjacent to the stream. Macrophytes were abundant in these adjacent wetlands.



**Stony Creek at SR 1235, Bertie County.**

The relatively low flow observed at this site in February 2000 may have limited the diversity of EPT taxa (only two species), but the biotic index values (7.2) and taxa richness (43) did not indicate any significant problems relative to other swamp streams in this area. Unusual taxa collected at this site included the beetle *Bidessonotus* and the isopod *Asellus* (= *Caecidotea*) *laticaudatus*. The community structure did not indicate a problem with either enrichment or low dissolved oxygen.

**Chinkapin Creek, SR 1432**

Chinkapin Creek is a southern tributary of the Wiccacon River, with a distinct channel (8-10 meters wide) and good winter flow. The substrate is composed of silt and woody debris, with some small areas of sand. The area around this site is completely wooded although there are areas in agricultural use in the upper portions of the catchment. The habitat score for the fish community sampling reach was high (83). This portion of Chinkapin Creek is connected to lateral wetlands only during high flow periods.

**Chinkapin Creek at SR 1432, Hertford County, February 2000.**

**Chinkapin Creek, looking upstream from SR 1432, Hertford County, May 2000.**

Chinkapin Creek had high invertebrate taxa richness for this region (60), including 10 crustacean taxa. The latter included the first record in the Wiccacon River catchment of the crayfish *Orconectes virginiensis*. The benthos community structure did not indicate a problem with either enrichment or low dissolved oxygen. A very diverse fish community was documented with 23 species collected. This was the highest species count to date recorded by the NCDWQ for the basin. The community was balanced with no more than 18 percent of the fish collected being any particular species. The most common species were the American eel, pirate perch, bluegill, and redfin pickerel.

**SPECIAL STUDY**
**Small Boat IBI**

A site on Sarem Creek above the confluence with Cole Creek was sampled as part of an ongoing project to develop methods and criteria to assess fish communities using an electrofishing boat. The lower portions of the stream, including the collection area, were completely wooded. The habitat score was 71. Stream width was approximately 30 meters with an average depth of four meters.

**Sarem Creek above Cole Creek, Hertford County.**

A diverse assemblage of coastal plain species was found including bowfin, creek chubsucker, bluespotted sunfish, flier, and redfin pickerel. The presence of the typical species and the collection of 15 species suggested an unimpacted fish community.

## Fish Tissue

### Chowan River, near Gatesville

Twenty-six tissue samples were collected from the Chowan River near Gatesville during August 2000 and analyzed for metals contaminants. The survey was conducted to obtain baseline metals data before operation of the Nucor steel mill near Tunis (Hertford County). Metal concentrations were at non-detectable levels or less than current USEPA, USFDA, and North Carolina criteria. (Appendices FT1 and FT2).

## OTHER DATA

### Chowan River Dioxin Monitoring

The Chowan River from the state line to Albemarle Sound was placed under a fish consumption advisory in 1990 for all species except herring and shad due to dioxin contamination from Union Camp's Franklin, Virginia paper mill. Yearly monitoring by Union Camp in North Carolina indicated that dioxin levels gradually decreased in fish from the Chowan River and Meherrin River after new bleaching technologies were instituted in 1990 to improve effluent quality (Figure 6).

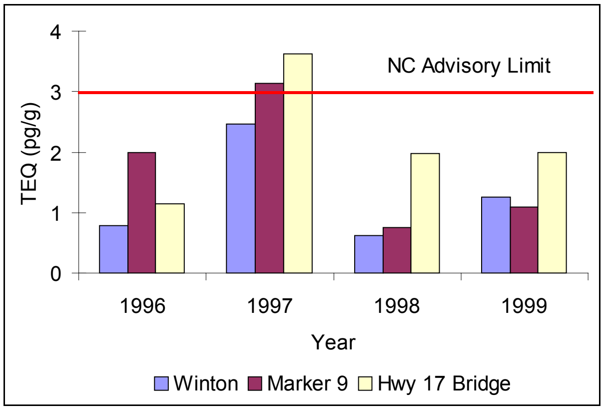



**Figure 6. Average toxicity equivalents (TEQ pg/g) from the Chowan River, 1996 - 1999.**

In March 1998, the advisory was partially modified, leaving carp and catfish as the only species still considered unsafe to eat. The advisory was completely lifted in early 2000 after dioxin toxicity equivalents (TEQ – the sum of 2,3,7,8 TCDD and 2,3,7,8 TCDF congeners) from all stations and species remained below 3 pg/g (recommended level for North Carolina) for two consecutive years (1998 and 1999). The highest concentrations reported in 1998 and 1999 were 1.98 pg/g and 1.99 pg/g, respectively.

# CHOWAN RIVER SUBBASIN 02

## Description

Subbasin 02 includes the Meherrin River and its tributary streams in North Carolina (Figure 7), although much of the river's catchment is in Virginia. The largest of the North Carolina tributaries are Kirbys Creek and Potecasi Creek. Murfreesboro is the largest urban area in this subbasin. Land use is mainly forest and agriculture and there are no permitted dischargers.

Aquatic habitats in this subbasin include the Meherrin River, swamp streams (with a fairly natural channel) and channelized streams. Swamp streams normally cease flowing during dry periods, and are expected to have very low dissolved oxygen concentrations during these low-flow periods. Streams in the northern part of this subbasin are located in areas with permeable (well-drained) loamy soils, while streams to the south are in areas with poorly-drained clay soils. These regional differences may have substantial effects on both the amount of direct runoff into streams and stream permanence.

Reconnaissance sampling for benthos throughout this subbasin in 2000 indicated that most streams had pH values close to neutral, reflecting agricultural drainage. NCDWQ biologists in 1979, however, recorded pH values of 5.2 in one small forested catchment.

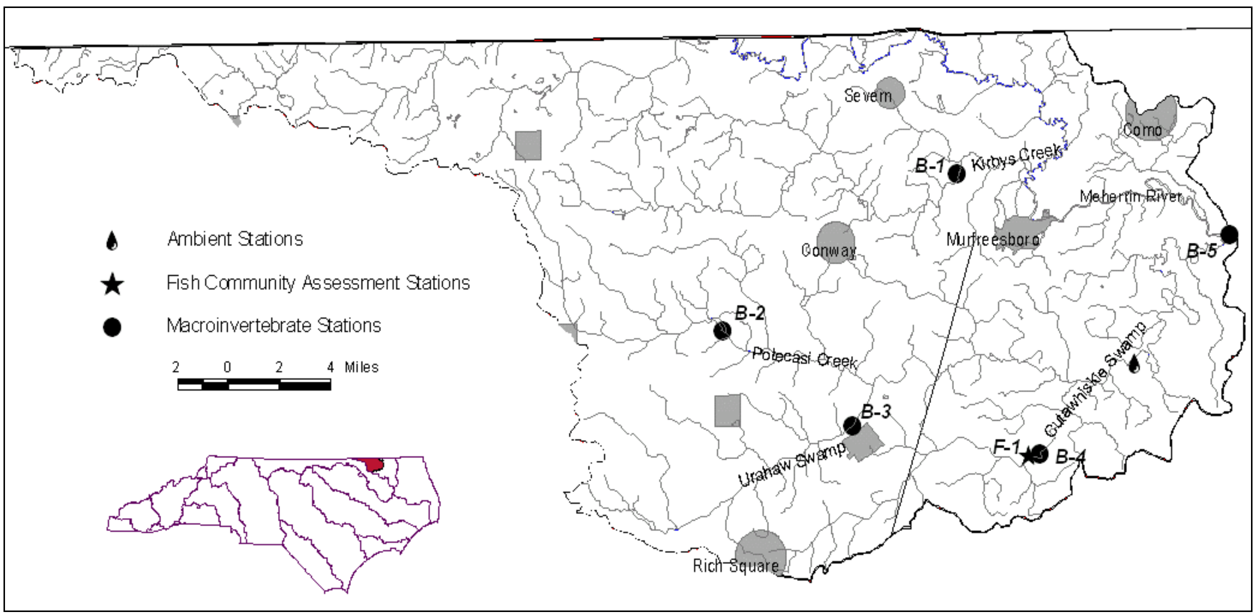



**Figure 7. Sampling sites in Subbasin 02 in the Chowan River basin.**

## Overview of Water Quality

Based on benthic macroinvertebrate data, water quality is Good in the Meherrin River (Table 6). Kirbys Creek, Potecasi Creek, and Cutawhiskie Swamp were sampled but not rated. Swamp sampling in February indicated very low taxa richness of benthic macroinvertebrates in the upper part of Potecasi Creek, Cutawhiskie Swamp, and Urahaw Swamp. Both the Meherrin River and Kirbys Creek support a large number of rare invertebrate species.

Potecasi Creek is listed on the 303(d) List as an impaired stream, with low dissolved oxygen as the problem parameter (NCDENR 2000a). From 1990 - 1995, 42 percent of the dissolved oxygen samples had a concentration less than 4 mg/L.

Fish sampling in Cutawhiskie Swamp did not indicate the same problems recorded from the invertebrate collections. This pattern is similar to that observed for other channelized streams in the Chowan River basin.

**Table 6. Waterbodies monitored in Subbasin 02 in the Chowan River basin for basinwide assessment, 1995 - 2000.**

| Map #[1] | Waterbody | County | Location | 1995 | 2000 |
|---|---|---|---|---|---|
| Winter Swamp Samples | | | | | |
| B-1 | Kirbys Cr | Northampton | SR 1362 | Not Rated | Not Rated |
| B-2 | Potecasi Cr | Northampton | SR 1502 | --- | Not Rated |
| B-3 | Urahaw Cr | Northampton | NC 35 | --- | Not Rated |
| B-4 | Cutawhiskie Swp | Hertford | SR 1141 | Not Rated | Not Rated |
| Summer Boat Samples | | | | | |
| B-5 | Meherrin R[2] | Hertford | SR 1175 | Good | Good |
| F-1 | Cutawhiskie Swp | Hertford | SR 1141 | Not Rated | Not Rated |

[1]B = benthic macroinvertebrate monitoring sites; F = fish community monitoring sites.
[2]Data are available before 1995, refer to Appendix B2.

## River and Stream Assessment

Several sites in this subbasin were evaluated as possible fish community assessment sites, but were not sampled due to unsuitable physical characteristics (too deep, too wide, or lack of a defined channel). These sites were Potecasi Creek at NC 35, Northampton County; Potecasi Creek at SR 1160, Hertford County; Corduroy Swamp at SR 1344 and SR 1341, Northampton County; and Kirbys Creek at NC 35, Northampton County.

### RIVER SITES

**Meherrin River, SR 1175 (Parker's Ferry)**

The Meherrin River was sampled for benthos at Parker's Ferry, with the greatest part of the collection taken from the south shore within a prominent band of water lilies. Many snags also were found in this area. The 2000 collection was during a period of drenching rainfall, and the river was very turbid.

**Meherrin River at SR 1175, Hertford County.**

The river has been consistently given a bioclassification of Good or Excellent, and seemed to have the best water quality of any Coastal B site in this part of the state. However, the overall species lists for this site and for the Chowan River at Riddicksville were very similar.

The Excellent rating was observed at low flow in 1985, and many rare species were collected only during that year. This site may have had an increase over time in the dissolved oxygen concentration of the bottom waters. Two low dissolved oxygen indicators were abundant in dredge samples only prior to 1989: *Chaoborus* (1983 - 1987) and *Limnodrilus* (1985). Large *Corbicula* were very abundant in the most recent dredge samples, with densities up to $400/m^2$.

Many rare or unusual taxa have been collected from the Meherrin River. These taxa included a mayfly (*Brachycercus*), a caddisfly (*Ceraclea transversa* group), a dragonfly (*Celithemis eponina)*, five midges (*Ablabesmyia simpsoni*, *Epoicocladius* (commensal on *Hexagenia* nymphs), *Hyporhygma quadripunctatum*, *Labrundinia johanseni*, and *Microchironomus)*, a crayfish (*Orconectes virginiensis*), a mussel (*Elliptio lanceolata* group), and a snail (*Gyraulus deflectus)*.

### SWAMP STREAMS

**Kirbys Creek, SR 1362**

Kirbys Creek was selected as a swamp stream reference site. This stream is close to the Coastal A category, but USGS records indicate that seasonal flow interruptions may occur during summer droughts. This area may have a higher gradient than adjacent swamp streams.

Kirbys Creek had the greatest EPT taxa richness of any stream in either the Chowan River or Pasquotank River basins and supported a very large number of rare and/or intolerant species. Five stonefly species have been collected at this site--a geographical area where stoneflies are largely absent. Other unusual taxa included *Agarodes* sp., *Ceraclea tarsipunctata*, *Rhyacophila ledra* and *Piscicola* sp. Of the 28 EPT taxa recorded in Chowan River basin streams, 12 were found only at Kirbys Creek.

**Potecasi Creek, SR 1502 and Urahaw Swamp, NC 35**

Potecasi Creek had been sampled for benthos at NC 11, near Union until 1989. This site, however, was characterized by low summer flows, or was too deep, and was difficult to assign a rating using Coastal A criteria. For the 2000 basinwide collections, winter swamp sampling was conducted further upstream on Urahaw Swamp and on Potecasi Creek (above its confluence with Urahaw Swamp).

The poorly drained soils in these catchments may lead to extended periods with little or no flow. Both sites had very braided channels, flowing through swamp forest. Potecasi Creek and Urahaw Swamp were very turbid during the February collections.

**Potecasi Creek at SR 1502, Northampton County.**

**Urahaw Swamp at NC 35, Northampton County.**

EPT taxa were largely absent in these two streams and total taxa richness was very low (20 and 24). Comparisons with reference swamp streams suggested severe stress at both these sites. Neither of these sites, however, had been channelized, and few pollution indicator species were abundant. Aquatic insects had very low taxa richness in these streams, but there was a surprising diversity of Crustacea. Five isopod species were found in these two streams, including two undescribed species.

In 1979, NCDWQ biologists surveyed Panther Branch, another tributary to Potecasi Creek. This stream, however, was located in a catchment with well-drained soils. Multiple collections throughout the year recorded at least 11 EPT taxa, with at least six of these expected to be abundant during winter sampling.

**Cutawhiskie Swamp, SR 1141**

Cutawhiskie Swamp is about eight meters wide, with a coarse sand substrate. Habitat scores for this site have been low (51 and 65), with a straight channel, homogeneous sand substrate, few pools, moderate to severe bank erosion, little canopy, and a narrow riparian zone on one bank.

**Cutawhiskie Swamp, at SR 1141, Hertford County, February 2000.**

There have been two winter and one summer invertebrate collections at this site, with fairly consistent total taxa richness (46-49) and EPT taxa richness (3 or 4). Although flows may be continuous in some summers, this swamp stream has not been rated. Filter-feeders are abundant, including *Cheumatopysche, Simulium*, and *Rheotanytarsus*.

Fish community samples were collected in 2000 and February 1995. The latter collection was part of a special study to assess the fish communities in lower coastal plain streams. The area around the site had been clear-cut between the 1995 and 2000 collections, although instream habitats did not appear to have changed much.

A large difference in the community was seen between the special study sampling and the basinwide monitoring dates. The number of species collected increased from eight in 1995 to 19 in 2000, while the number of fish collected increased from 209 in 1995 to 368 in 2000. The difference in sampling seasons may account for some of the differences. Although different collection protocols were used, the USGS collected 16 species of fish and 446 individuals at this site in July 1995. These results were similar to those from the May 2000 NCDWQ collection.

While no single species was dominant in either sample, the highfin shiner was the most abundant fish collected in 1995 and 2000. The most abundant fish collected by the USGS in 1995 was the pirate perch. Two individuals of the intolerant sawcheek darter were collected in 2000.

## CHOWAN RIVER SUBBASIN 03

### Description

This subbasin contains the middle section of the Chowan River, above Rockyhock Creek and below Bennett Creek, and includes the Indian Creek and Catharine Creek tributaries (Figure 8). Land use is mainly forested wetlands and agriculture.

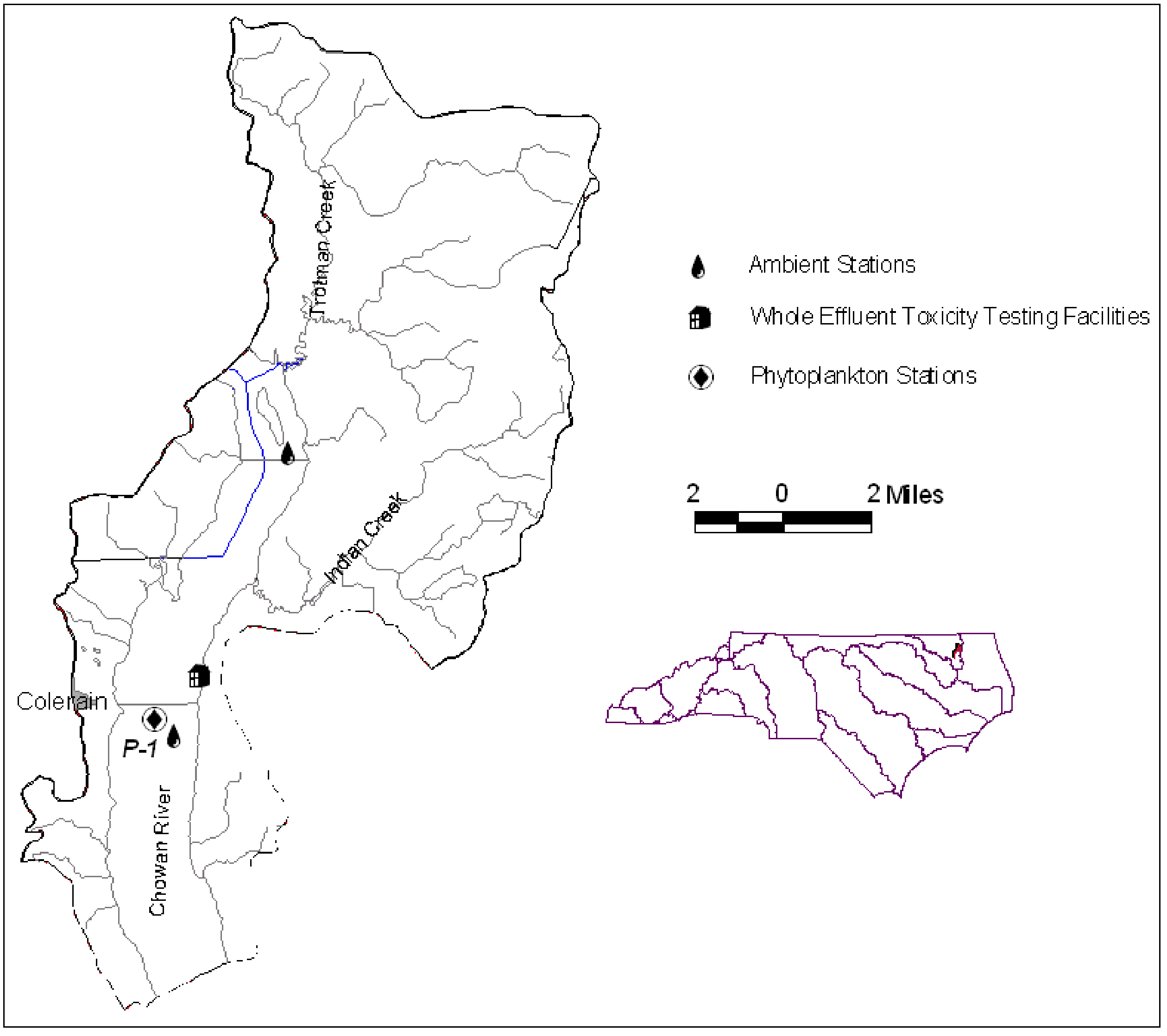



**Figure 8. Sampling sites in Subbasin 03 in the Chowan River basin.**

### Overview of Water Quality

Most of the information about water quality in this subbasin has come from water chemistry and phytoplankton sampling (Table 7). Phytoplankton blooms were a frequent problem in this portion of the Chowan River, especially from 1970-1978. Reduction in nutrient inputs has led to a steady decline in both the frequency and intensity of algal blooms. This trend is evident in comparing recent data from the Chowan River near Colerain (1995-2000) to data from 1980-1994 (NCDENR 1997). Only two blooms of nuisance blue-green algae (*Anabaena spp*.) were reported from 1990-1994, while only a single blue-green bloom (July 1998) occurred during the last five years.

No benthos or fish community structure collections have been made in this subbasin. Fish tissue monitoring by Union Camp had shown significant dioxin contamination, especially in catfish, but levels along the lower Chowan River seemed to be decreasing as a result of mill improvements (refer to Subbasin 01). A fish consumption advisory was lifted in 2000 after dioxin fish tissue concentrations were shown to be a safe levels for two consecutive years (1998-1999).

One facility (Piece Dye Acquisition Corporation, discharging to the Chowan River) failed two chronic toxicity tests in 1998. No toxicity problems have been recorded since that time

**Table 7. Waterbodies monitored in Subbasin 03 in the Chowan River basin for basinwide assessment, 1995 - 2000.**

| Map #[1] | Waterbody | County | Location | 1995 | 2000 |
|---|---|---|---|---|---|
| P-1 | Chowan River | Hertford | at Colerain | --- | --- |

[1]P = phytoplankton monitoring site.

## Phytoplankton Monitoring

### Chowan River at Colerain

Phytoplankton and nutrient samples were analyzed from the Chowan River at Colerain (Station D8950000).

Throughout the five-year sampling period, biovolumes were relatively low and generally ranged from 10 $mm^3/m^3$ to 2,409 $mm^3/m^3$. The community exhibited little change over time with cryptomonads predominating throughout much of the period. The only exceptions to these trends occurred during a July 1998 bloom of the blue green algal (cyanobacterial) species *Anabaena portoricensis* and *A. subcylindrica* (8,287 $mm^3/m^3$ total sample biovolume) and a July 2000 bloom of *Melosira*, a chain-forming diatom common to local estuaries (total sample biovolume 57,799 $mm^3/m^3$) (Figure 9). Variations in nutrient concentrations of total phosphorus and inorganic and organic nitrogen did not seem to coincide with the blooms (Figures 10 and 11).

During early summer 1996, the cryptomonads *Cryptomonas erosa* and *C. ovata* were common along with the chrysophyte species *Mallomonas majorensis*. Later in the summer, *Mallomonas caudata*, *M. acaroides* and the colonial green algae *Gonium pectorale* and *Gloecystis* were prevalent. Cryptomonads including *C. erosa* and *Chroomonas minimum* dominated the algal community biovolume during September and November.

Cryptomonads, particularly *Cryptomonas erosa*, were common throughout 1997. The dinoflagellates *Glenodinium* and *Peridinium* also dominated community biovolume during July and August 1997, and green algal taxa *Gonium pectorale* and *Kirchneriella obesa* were prevalent along with cryptomonads during September and November. The filamentous blue green *A. portoricensis* was common during September.

During late winter 1998, the cryptomonad *Chroomonas amphioxeia* and the colonial green alga *Pandorina morum* dominated the algal community biovolume, and the chloromonadophyte *Vacuolaria virescens* was prevalent in addition to *Cryptomonas erosa*. The site experienced a filamentous blue green bloom of *A. portoricensis* and *A. subcylindrica* during July, but *C. erosa* was again prevalent the following month.

Cryptomonads including *C. erosa*, *C. ovata*, and *C. minimum* and small chrysophyte flagellates were common during February and June 1999. *C. erosa* continued to be prevalent throughout the summer of 2000. During June and July, *Melosira* species were also prevalent and were recorded at bloom concentrations during July. The following month, another chain forming diatom, *Skelotonema potamos* was also common.

Surface blue green algal blooms were reported in 1998 and 2000 during mid-summer elsewhere on the lower Chowan, but these blooms did not always extend into the photic zone of the river where ambient phytoplankton samples are collected. These blooms were dominated by the filamentous blue green *A. planctonica* (Appendix P1).

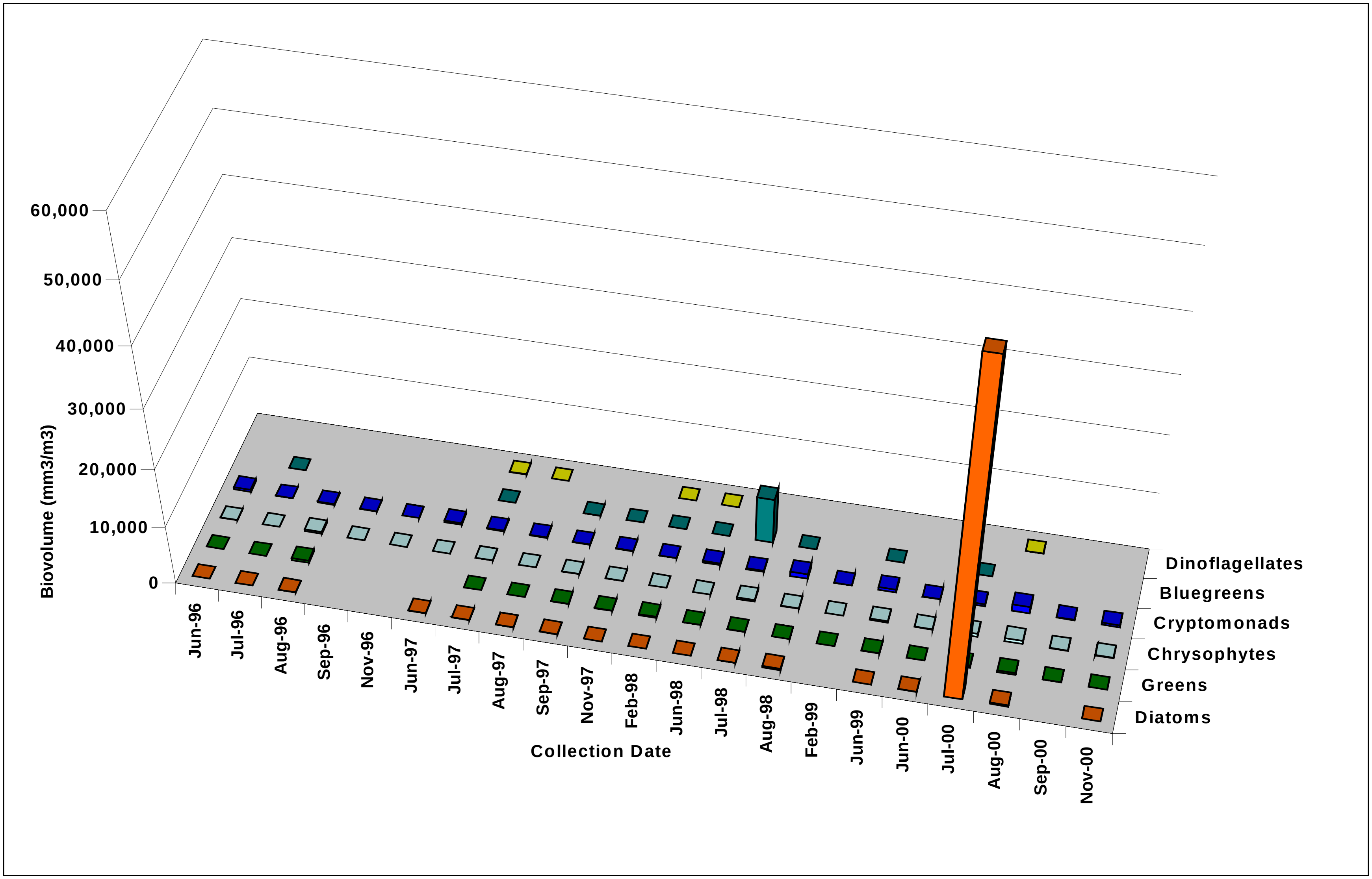



**Figure 9.** **Phytoplankton divisions from the Chowan River at Colerain, 1996 - 2000.**

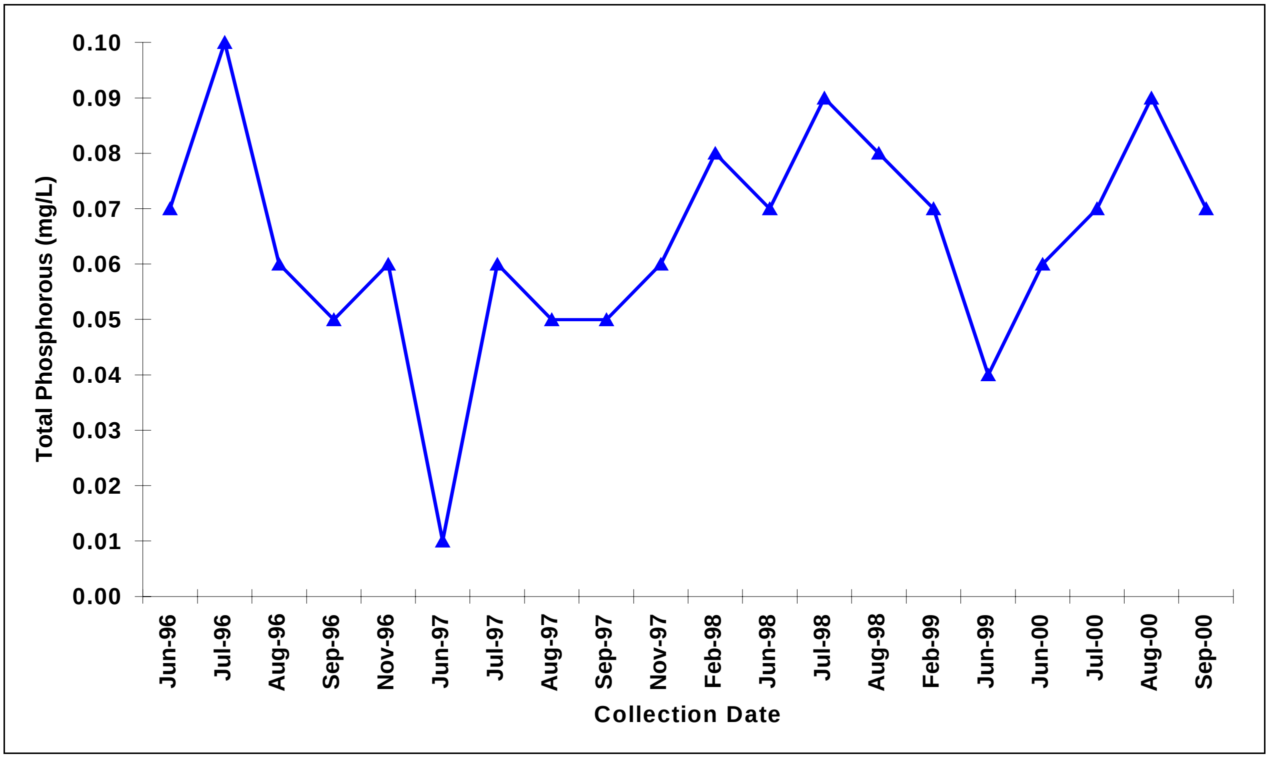



**Figure 10.** **Total phosphorus from the Chowan River at Colerain, 1996 - 2000.**

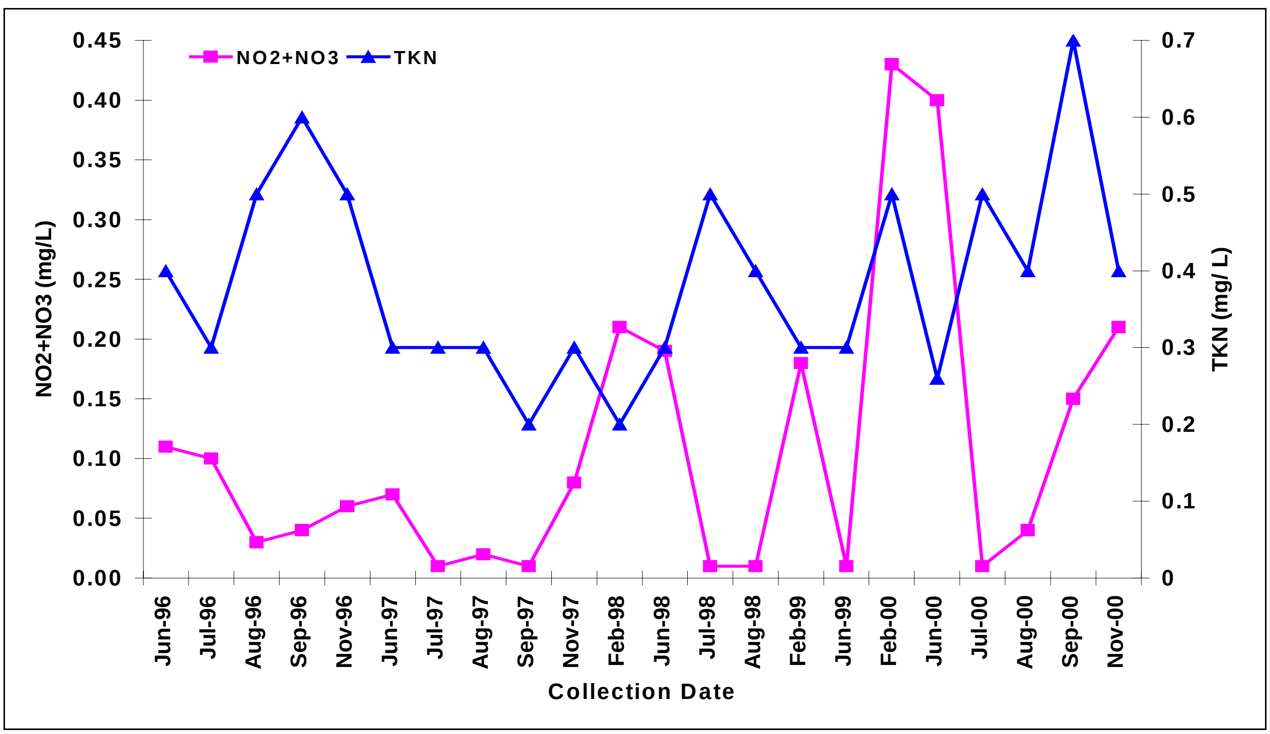



**Figure 11.** **Nitrite+nitrate and total Kjeldahl nitrogen from the Chowan River at Colerain, 1996 - 2000.**

## CHOWAN RIVER SUBBASIN 04

### Description

This subbasin contains the lower Chowan River (near Edenton) and a few small tributaries (Figure 12). The largest of these tributaries is Salmon Creek. Edenton is the only urban area and land use is mainly forested wetlands and agriculture. There are no major dischargers in the subbasin.

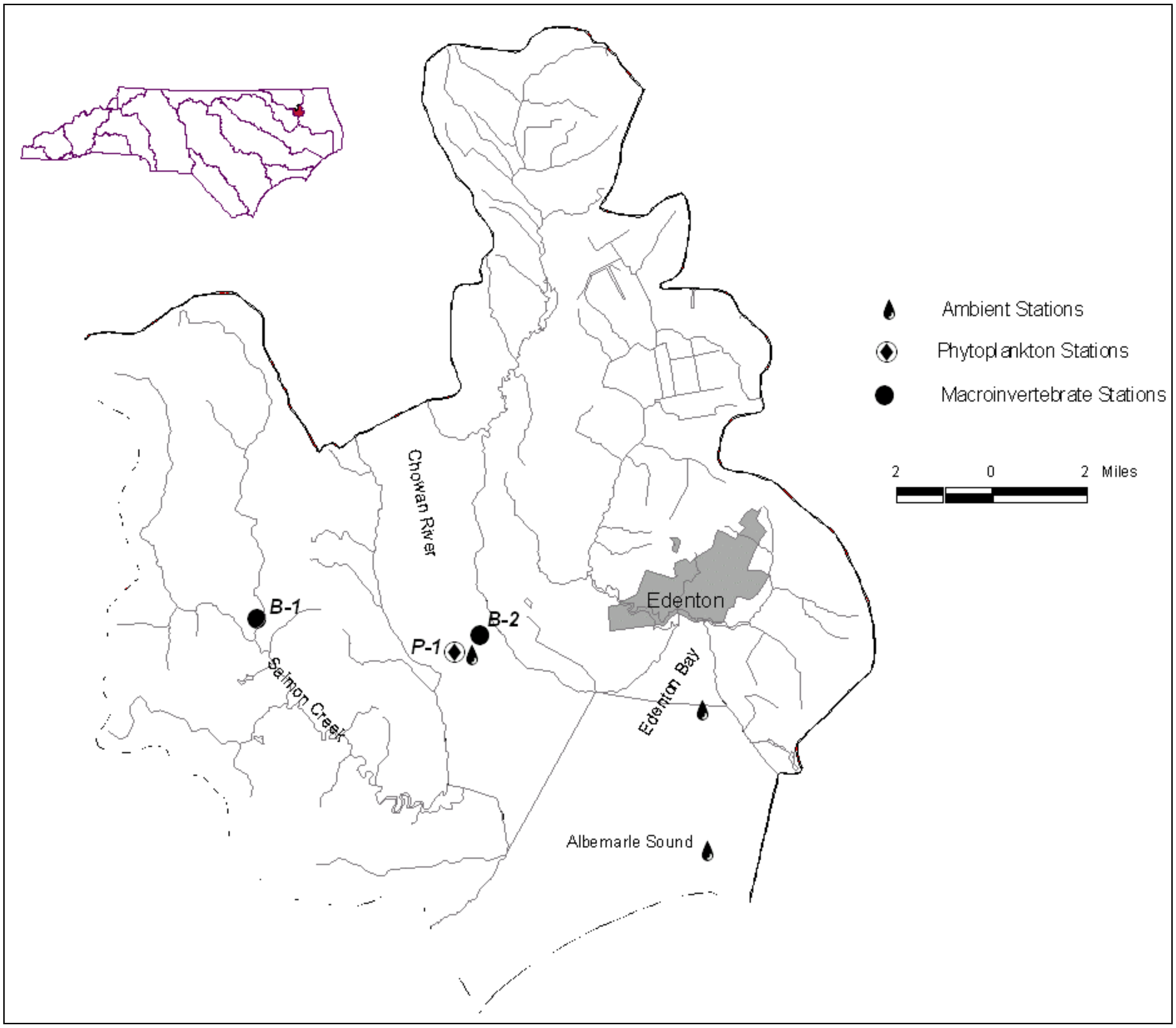



**Figure 12. Sampling sites in Subbasin 04 in the Chowan River basin.**

### Overview of Water Quality

The only long-term benthos site in this subbasin is the Chowan River near Edenton, where the bioclassification has generally remained Good-Fair since 1983 (Table 8). This portion of the Chowan River is influenced by the intrusion of brackish water during low-flow periods (NCDEM 1982). A swamp sample at Eastmost Swamp, a tributary to Salmon Creek, did not indicate any major water quality problems.

Phytoplankton blooms were a frequent problem in this portion of the Chowan River, especially from 1970-1978. Reduction in nutrient inputs has led to a steady decline in both the frequency and intensity of algal blooms. This trend is evident in comparing recent data from the Chowan River near Edenton (1995 - 2000) to data from 1980 - 1994 (NCDENR 1997).

Only two blooms of nuisance blue-green algae (*Anabaena* spp.) were reported from 1990-1994, while only one blue-green bloom occurred during the last five years (summer 1996, Edenton Bay). At the time of maximum phytoplankton biovolume (August 1999), the phytoplankton community was dominated by dinoflagellates.

Riggs *et al*. (1993) reported high concentrations of metals (especially copper) for some sites in Edenton Bay near marinas.

**Table 8. Waterbodies monitored in Subbasin 04 in the Chowan River basin for basinwide assessment, 1995 - 2000.**

| Map #[1] | Waterbody | County | Location | 1995 | 2000 |
|---|---|---|---|---|---|
| B-1 | Eastmost Swp | Bertie | SR 1361 | --- | Not rated |
| B-2 | Chowan R[2] | Bertie | US 17 | Good-Fair | Good-Fair |
| P-1 | Chowan R | Bertie | US 17 | --- | --- |

[1]B = benthic macroinvertebrate monitoring sites; P = phytoplankton monitoring site.
[2]Data are available before 1995, refer to Appendix B2.

## River and Stream Assessment

**Chowan River, US 17**
This site near Edenton is located at the mouth of the Chowan River before it empties into Albemarle Sound. The river is quite wide at this point (~ 1 mile), shallow, and subjected to occasional salt-water intrusions. Wave action limits the amount of silt that is deposited in this part of the river and hindered sampling in 2000.

This site has been classified as a freshwater site and as an oligohaline site (salinity < 5ppt). Historically, it was considered as estuarine because an oligohaline clam (*Rangia cuneata*) and several oligohaline crustaceans (*Cyathura polita* and several other isopods) frequently occurred here. Conductivity values, however, have not consistently been representative of an estuarine system. With the exception of 1985 and 1986, all invertebrate samples have been collected at a specific conductance < 350 µmhos/cm. Due to this low salinity before the invertebrate collections, all samples were assigned a bioclassification based on Coastal B Criteria (Appendix B1).

Water quality remained fairly stable from 1983 to 2000 at Good-Fair, with little change in the benthic community structure. *Corbicula* occurs in large numbers at this site. Comparisons of recent data with Lauritsen and Mozley (1983) suggested that *Corbicula* has increased in abundance since 1980.

**Eastmost Swamp, SR 1361**
Eastmost Swamp had a distinct channel near the bridge (eight meters wide) but it had a more braided channel upstream when sampled in February 2000. A beaver dam altered the nature of the channel in this area. There were few pools, although water was impounded behind the beaver dam. At least three types of macrophytes were found in the pools, and filamentous algae were abundant in a few scattered patches. Poorly-drained clay soils may promote rapid runoff from adjacent agricultural land.

**Eastmost Swamp at SR 1361, Bertie County.**

Invertebrate taxa richness was fairly high (56) for a swamp stream in this part of the coastal plain, although the biotic index was elevated (7.4). The fauna was dominated by amphipods (especially *Hyalella azteca*), isopods, and midges. *Orthocladius* and *Hydrobaenus* were abundant, indicating that enrichment is not a problem.

## Phytoplankton Monitoring

### Chowan River at Edenhouse

Phytoplankton and nutrient samples were analyzed from the Chowan River at Edenhouse (Station D9490000).

Throughout the five-year sampling period, phytoplankton biovolumes were relatively low and ranged from 87 $mm^3/m^3$ to 3,222 $mm^3/m^3$. The phytoplankton community exhibited little change over time with cryptomonads predominating throughout much of the sampling period. The only exception to these trends occurred during an August 1999 dinoflagellate bloom of *Gymnodinium nelsonii* and *Gyrodinium galatheanum* (total sample biovolume 6,611 $mm^3/m^3$) (Figure 13). Nutrient concentrations did not seem to coincide with this bloom or vary much within the overall sampling period (Figures 14 and 15).

Cryptomonads, primarily *Cryptomonas erosa* and *Chroomonas minimum* dominated the biovolume of the community throughout the 1996 sampling seasons. The dinoflagellate *Peridinium* was also prevalent during July, and a silico-flagellate chrysophyte, *Dictyocha fibula*, was common during November.

The following year, cryptomonads *C. erosa*, *C. minimum*, and *Chroomonas caudata* were prevalent, but chain-forming diatoms also comprised a large part of the community during early summer and early fall. *Skeletonema potamos* was prevalent during June and *Melosira* chains were common the following month. During November 1997, *S. potamos* and the flagellated green alga *Chlamydomonas* also predominated.

Cryptomonads again dominated in community biovolume throughout winter and summer 1998. In February, the colonial green alga *Pandorina morum* was also common. During July, the dinoflagellate *Gymnodinium* and diatoms *Melosira* and *Skeletonema potamos* were prevalent, and the following month, the flagellated chrysophyte *Mallomonas majorensis* was common.

During 1999, cryptomonads were common during late winter and early summer. The pennate diatom *Rhizosolenia* and small flagellated chrysophytes were also present during June. Later that summer, the biovolume was dominated by a dinoflagellate bloom of *G. nelsonii* and *G. galetheanum* with the colonial green alga *Dictyosphaerium pulchellum*. During the fall, cryptomonads were again common in addition to small chrysophyte flagellates.

During early summer of 2000, the chain-forming diatoms *S. potamos* and *Melosira* were prevalent in the phytoplankton community. During June, the cryptomonad *Rhodomonas minuta* was also common, and the large dinoflagellate *Gyrodinium uncatenum* contributed to the community biovolume the following month. During August, the green alga *Pandorina morum* and small flagellated chrysophytes were common. The dinoflagellate *Gyrodinium aureolum* and the cryptomonad *C. erosa* were prevalent during September.

Surface blue green algal blooms were reported during July 2000 elsewhere on the lower Chowan River. These blooms did not always extend into the photic zone of the river where ambient phytoplankton samples are collected. The samples were dominated by the filamentous blue green *Anabaena planctonica* (Appendix P1).

### Algal Blooms

One blue green algal bloom of *Anabaena portoricensis* was documented in this subbasin in the Edenton Bay area during August 1996 (Appendix P1).

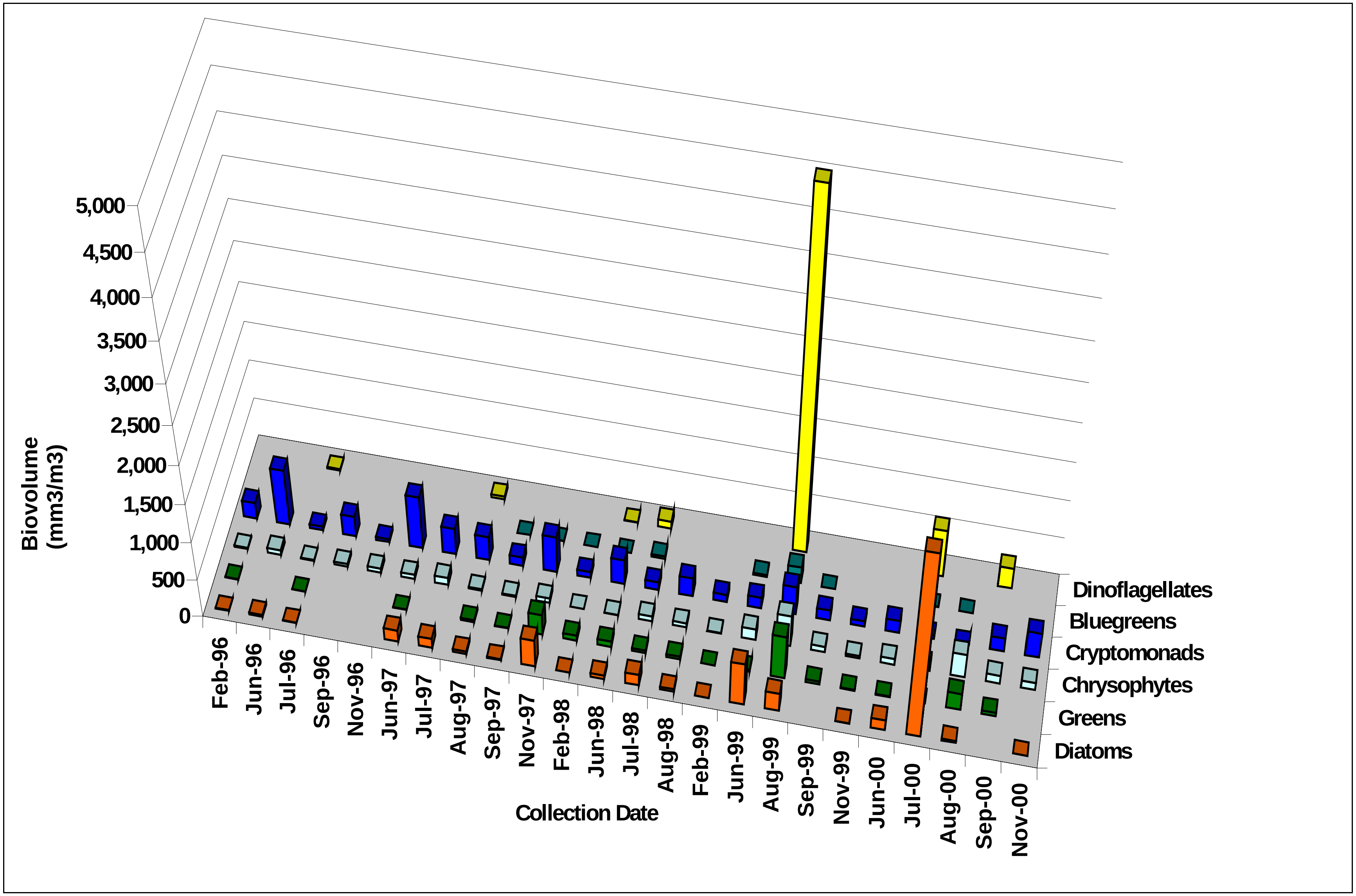



**Figure 13.** **Phytoplankton divisions from the Chowan River at Edenhouse, 1996 - 2000.**

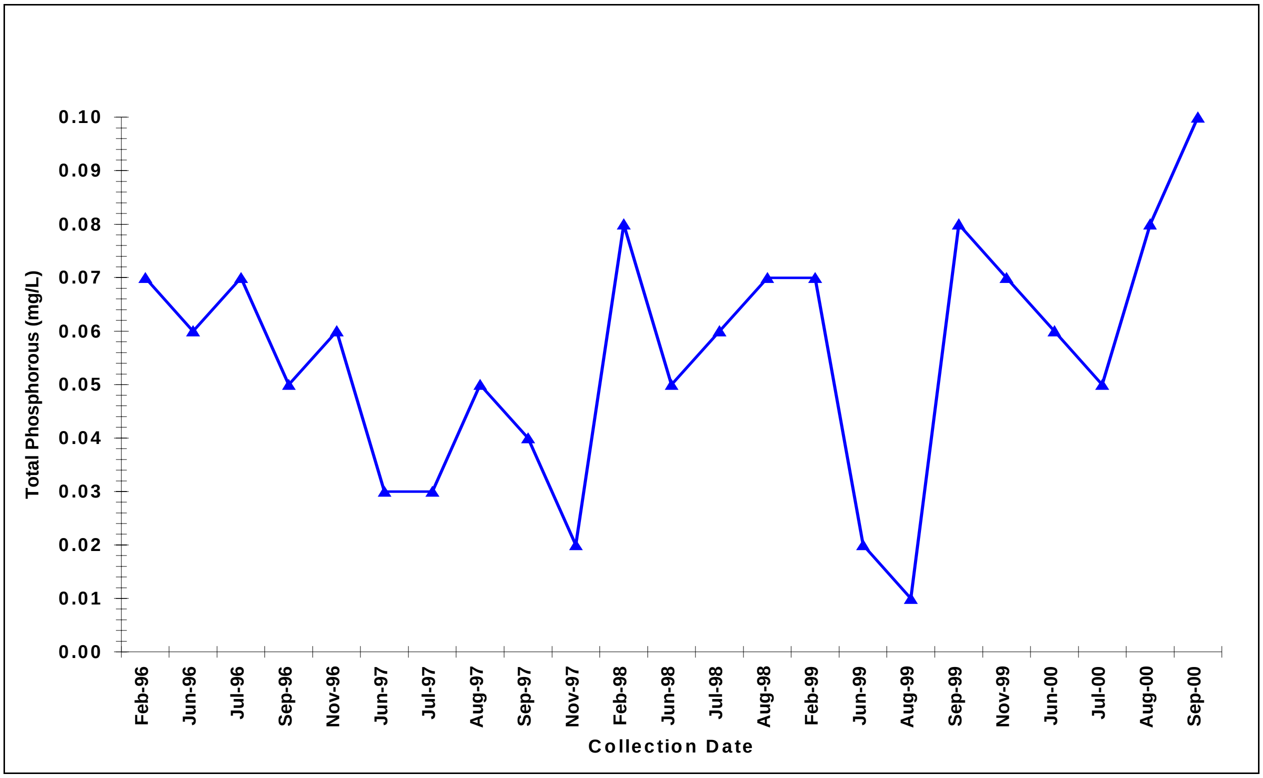



**Figure 14.** **Total phosphorus from the Chowan River at Edenhouse, 1996 - 2000.**

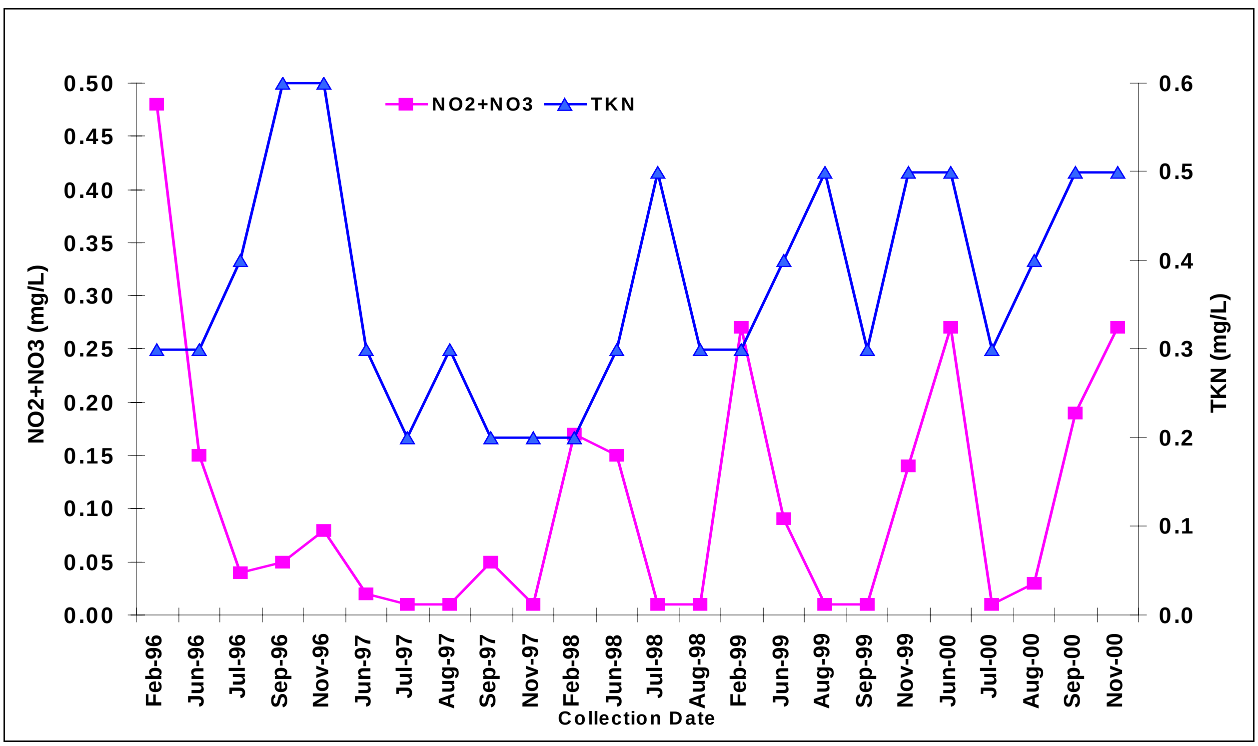



**Figure 15.** **Nitrite+nitrate and total Kjeldahl nitrogen from the Chowan River at Edenhouse, 1996 - 2000.**

# PASQUOTANK RIVER SUBBASIN 50

## Description

This subbasin consists primarily of the Pasquotank River and its tributaries in Camden, Pasquotank and Gates counties (Figure 16). Most of the waters in this subbasin are estuarine, including Albemarle Sound and the Pasquotank River below Elizabeth City. Land use is mostly cropland or forest, with the greatest amount of agricultural land use in the lower half of the subbasin. This land is utilized for row crops, such as cabbage, corn, and soybeans (NCDEH 1998b). Most of the development is in the Elizabeth City area; other small towns include Camden and South Mills.

Many tributaries have little or no flow in summer time, and there are few wadeable streams. This entire subbasin lies to the east of the Suffolk Scarp, in an area of extremely flat topography and quaternary sediments (Copeland *et al*. 1983).

The headwaters of the Pasquotank River drain the Great Dismal Swamp, a wetland area with many rare plant and animal species (Frost 1982). This vast area includes the Dismal Swamp National Wildlife Refuge (13,500 acres), the Shield Fern Natural Area (16 acres), Dismal Swamp Mesic Islands (600 acres), and Corapeake Marsh (300 acres). This area is threatened by rapid conversion of wetlands, with over half of the Dismal Swamp already converted to agriculture or silviculture (Frost 1982).

The Elizabeth City WWTP (4.5 MGD) is the only major discharger in this subbasin. This facility was upgraded in 1997 and now discharges through three diffused outfalls into the Pasquotank River near Knobbs Creek.

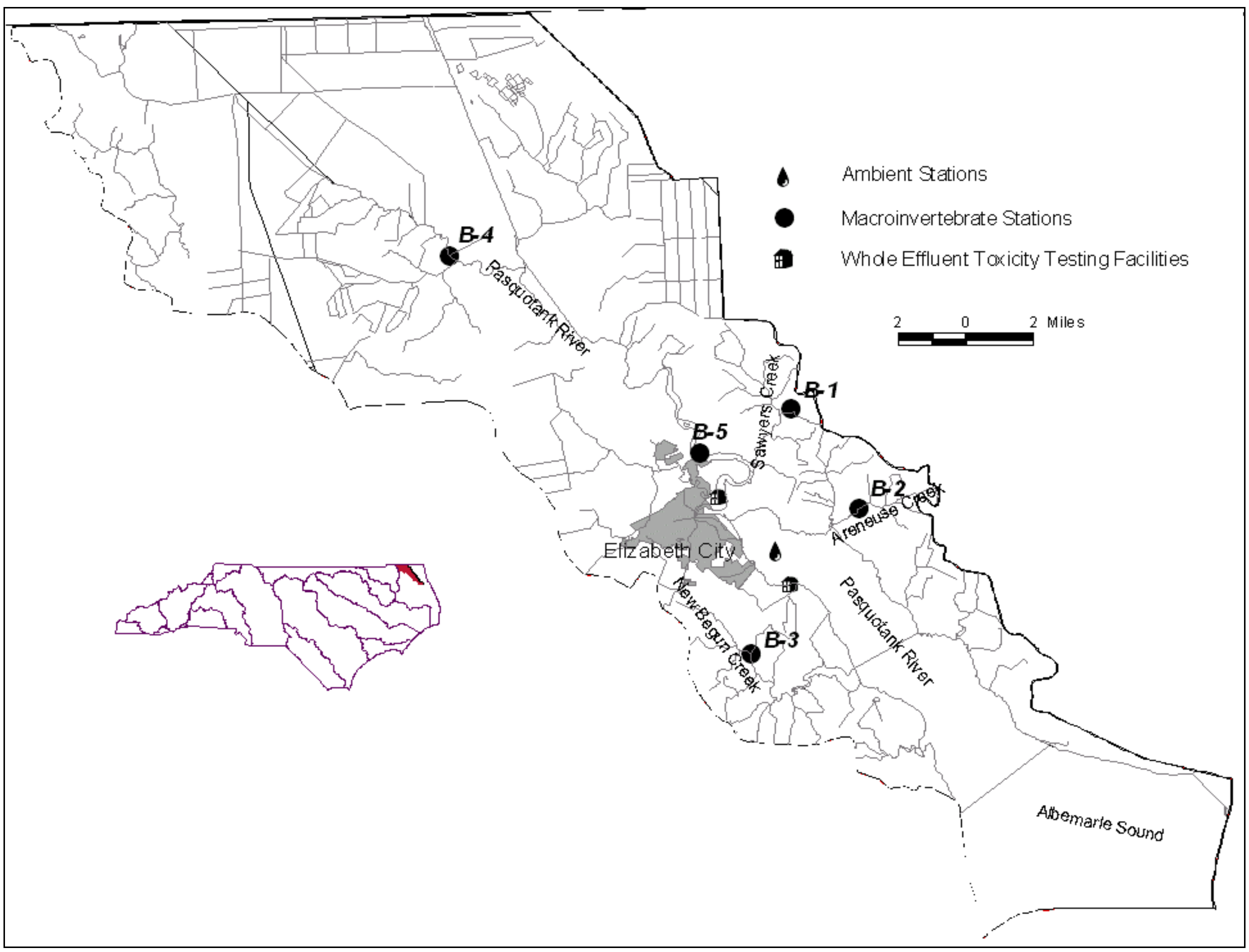



**Figure 16. Sampling sites in Subbasin 50 in the Pasquotank River basin.**

## Overview of Water Quality

Streams in this subbasin run through a highly agricultural landscape, but they include both channelized streams and streams with a more natural channel. No samples were collected from the deeper channelized streams due to problems with access. Based on data from similar habitats in Dare County (Subbasin 51), these channelized streams and ditches are expected to have a very limited macroinvertebrate fauna.

No macroinvertebrate reference sites could be located in the Pasquotank River basin. Therefore, a system to rate streams in this area has not been developed. Between-stream comparisons, however, can be used to help evaluate water quality and identify the problem. Benthic macroinvertebrates have been collected at eight sites in this subbasin, including five sites sampled in 2000 (Table 9). Long-term benthos data were available only for the Pasquotank River at Elizabeth City.

Benthic samples collected in 2000 from the headwaters of the Pasquotank River (below the Great Dismal Swamp) indicated a system stressed in summer months by both low dissolved oxygen (< 2 mg/L) and very low pH (4.0). There were some indications, however, that this part of the river may support some rare and/or intolerant taxa during the winter.

Samples from the middle segment of the river also indicated a system stressed by low dissolved oxygen, but with higher numbers of EPT taxa than had been observed downstream in the Elizabeth City area. These between-site differences in EPT taxa richness were probably related more to differences in salinity than to any change in water quality.

Sawyers Creek, Areneuse Creek, and Newbegun Creek were sampled in February 2000; the first macroinvertebrate collections from wadeable swamp streams in this subbasin. This area is characterized by very low gradient and deep organic soils. These streams demonstrated a gradient in water quality, as evidenced by changes in taxa richness, biotic index, and community structure. Negative changes were associated with large amounts of agricultural and/or urban land use. The most disturbed streams also had very high specific conductance values. The stream with the best riparian buffer, Sawyers Creek, seemed to have the best water quality.

Few water quality problems were found for the portion of Albemarle Sound within this subbasin, nutrients were generally low, and there were few signs of algal blooms. In the Pasquotank River, however, nutrients were elevated and some blooms had been documented.

During the last five years, only one bloom was recorded in this area (July 2000), with a dense blue-green bloom observed in the lower portions of Areneuse Creek and Newbegun Creek. Because nutrient concentrations were the greatest upstream of Elizabeth City and its WWTP, it seemed that nonpoint sources were the major sources of nutrients.

**Table 9. Waterbodies monitored in Subbasin 50 in the Pasquotank River basin for basinwide assessment, 1995 - 2000.**

| Map #[1] | Waterbody | County | Location | 1995 | 2000 |
|---|---|---|---|---|---|
| Swamp Streams (sampled in winter) | | | | | |
| B-1 | Sawyers Cr | Camden | SR 1200 | --- | Not Rated |
| B-2 | Areneuse Cr | Camden | NC 343 | --- | Not Rated |
| B-3 | Newbegun Cr | Camden | SR 1132 | --- | Not Rated |
| Boat Sites (sampled in summer) | | | | | |
| B-4 | Pasquotank R | Pasquotank | End of SR 1361 | --- | Not Rated |
| B-5 | Pasquotank R | Pasquotank | Goat Island | --- | Not Rated |

[1]B = benthic macroinvertebrate monitoring sites.

Two facilities conduct effluent toxicity monitoring in subbasin 50: the Elizabeth City WWTP and the US Coast Guard Station. Neither facility showed any failures in 2000, although the Elizabeth City discharge had shown occasional failures before 2000 (9/45 tests).

Analysis of sediment contamination in North Carolina estuaries (Hackney *et al*. 1998) included a site on the Pasquotank near Elizabeth City. Data collected in 1996 indicated elevated concentrations of metals and pesticides.

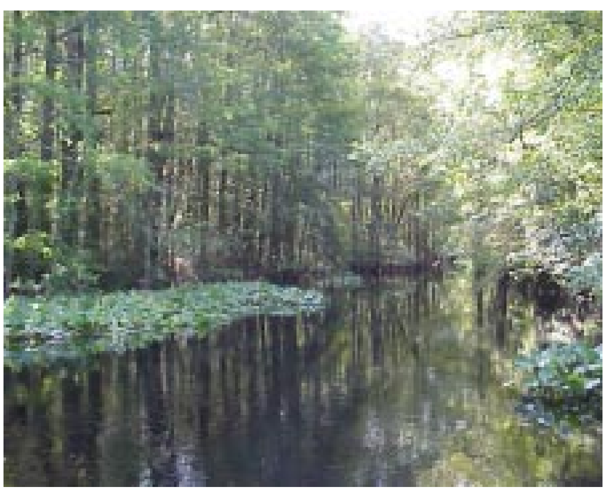
## River and Stream Assessment

Flows were generally low to normal for both the winter and summer collections. No samples were taken from the deeper channelized streams.

### RIVER SITES

#### Pasquotank River, end of SR 1361

This headwater site was selected because it drained an undisturbed area, suggesting an area of better water quality than those sites draining more agricultural areas within the subbasin. This part of the river, however, was characterized by very low dissolved oxygen (< 2 mg/L) and very low pH (4.0). The low pH values are the result of natural drainage from the Great Dismal Swamp. This site was about 17 meters wide, shallow enough to wade, and one segment had visible current. Macrophytes (water lilies and *Sagittaria*) were abundant along the banks and in backwater areas.



**Pasquotank River, end of SR 1361, Pasquotank County.**

The combination of low pH and low dissolved oxygen resulted in low taxa richness (27) and a very high biotic index (8.3). Taxonomic indicators of enrichment and low dissolved oxygen concentrations were abundant, including *Chironomus*, *Polypedilum illinoense*, and *Glyptotendipes*.

Unusual taxa included *Labrundinia beckae* (a chironomid) and *Procotyla fluviatilis* (a flatworm). *Platycentropus* cases were found at this site, indicating that a more intolerant community might be found in the winter. This caddisfly has not been found at other Pasquotank River basin sites.

#### Pasquotank River at Goat Island

The Pasquotank River had formerly been sampled for benthic macroinvertebrates in Elizabeth City at the US 158 bridge. This site was moved upstream in 2000 to avoid the portion of the river influenced by brackish water. The Goat Island site is about two miles upstream from the mouth of Sawyer Creek.

**Pasquotank River at Goat Island, Pasquotank County.**

This reach of the river is very wide and serves as a portion of the Intracoastal Waterway. Patches of alligator weed were found along the banks, and heavy growths of duckweed had accumulated along the shore.

**Duckweed accumulations along the shore, Pasquotank River at Goat Island, Pasquotank County.**

Low pH (5.5) and low dissolved oxygen (4.1 mg/L) may have influenced the invertebrate community. Dredge samples indicated a very depauperate fauna, especially in areas with high amounts of peat. Amphipods were dominant in shore samples, but the abundant midges indicated nutrient enrichment: *Dicrotendipes simpsoni* and *Glyptotendipes*.

This site had greater EPT taxa richness (4) than the Elizabeth City site (0 or 1), but the fauna still suggested water quality problems. The EPT taxa richness at this site is probably more related to low salinity than to any between-site differences in water quality.

### SWAMP STREAMS (WINTER SAMPLES)

There were no prior swamp stream data from this subbasin. Winter 2000 collections were a first attempt to use macroinvertebrate data to evaluate water quality in these small, low gradient swamp streams. More natural streams in this basin (like the upper Pasquotank River) have low pH values, but all three streams sampled in February had almost neutral pH (6.8 or 6.9). These values probably reflected large amounts of agricultural and/or urban land use. Field reconnaissance and inspection of land use information (topographic maps and GIS layers) both indicated a very high percentage of agricultural land in this part of the subbasin.

All these sites were surrounded by a good buffer of swamp forest and had good habitat ratings. The water was very clear, reflecting the low amount of clay in the local soils. These forested buffer areas also may act as an important wildlife corridor in this very fragmented landscape.

### Sawyers Creek, SR 1200

Sawyer Creek was about seven meters wide, with a silt-detritus substrate. The high specific conductance (232 µmhos/cm) reflected agricultural land use in this area. The water was remarkably clear, even after heavy rain. Filamentous algae were present, but these growths were not as abundant as those observed at the other two swamp streams in this subbasin.

**Sawyers Creek at SR 1200, Camden County.**

The macroinvertebrate community was dominated by typical swamp taxa, especially a chironomid (*Orthocladius obumbratus* group) and an isopod (*Asellus obtusus*). There were no indicators of enrichment or organic loading. Seven mollusks were present, including *Promenetus exacuous* and *Gyraulus parvus*. The latter snails were rare or absent in the other two streams.

Within this group of swamp streams, Sawyer Creek seemed to have the best water quality, as evidenced by having the highest taxa richness (27) and the lowest biotic index (7.6). Inspection of GIS layers (data approximately 1997) also indicated that this stream has the best riparian buffer.

### Areneuse Creek, NC 343

Areneuse Creek was similar to Sawyer Creek in width (seven meters), substrate (silt-detritus), and high dissolved oxygen (7.7 mg/L). The channel was very braided away from the bridge crossing.

**Areneuse Creek at NC 343, Camden County.**

The catchment had a high percentage of agricultural land use (1998 GIS land use information) and this may have influenced the very high specific conductance (372 µmhos/cm). There was also an abundance of filamentous algae and duckweed.

Relative to Sawyer Creek, Areneuse Creek had slightly lower taxa richness (22), and a higher biotic index (7.9). The fauna was strongly dominated by crustaceans, especially an isopod (*Asellus obtusus)*. There were no indicators of enrichment or organic loading, but the number of mollusk taxa was much lower than at Sawyers Creek.

**Newbegun Creek, SR 1132**

Newbegun Creek drains portions of Elizabeth City, as well as extensive agricultural land. The stream runs through a wide swamp forest, with a distinct channel (six meters wide) only at the bridge crossing.

**Newbegun Creek at SR 1132, Camden County.**

This site had a high specific conductance (336 µmhos/cm) and massive growths of filamentous algae. These algal growths may cause large diurnal changes in dissolved oxygen concentrations, and concentrations ranging from 7.1 to 12.0 mg/L were recorded over a 24-hour period.

This site was characterized by low taxa richness (20) and a very high biotic index (8.6), indicating more severe water quality problems than the other two sites. The most abundant chironomid (*Kiefferulus dux*), indicated low dissolved oxygen and organic loading. The abundance of the snail *Physella* also indicated low dissolved oxygen.

**OTHER DATA**

Sediment samples were collected by the US EPA Environmental Monitoring and Assessment Program from the Pasquotank River near Elizabeth City (Hackney *et al*. 1998). A single sample from 1996 showed elevated concentrations of several contaminants, including PCBs, DDT and metals.

## Phytoplankton Monitoring

### Algal Blooms

On July 19, 2000, NCDWQ personnel investigated reports of dense surface blue green algal (cyanobacteria) blooms in Areneuse and Newbegun Creeks off the Pasquotank River. A slight surface bloom could be seen in a canal at the Treasure Point residential community. But, winds from an incoming cold front may have been responsible for breaking up blooms in the river and adjacent canals the previous day. Samples collected from Treasure Point documented the filamentous blue green alga *Anabaena planctonica* (>25,000 units/ml). This species has been referred to in research literature as containing potentially toxic strains, but no adverse health effects were reported in conjunction with this bloom.

## PASQUOTANK RIVER SUBBASIN 51

### Description

This subbasin consists of the Alligator River and its tributaries; Alligator (New) Lake, part of Albemarle Sound, Croatan Sound, Roanoke Island and part of Roanoke Sound in Dare, Tyrell and Hyde counties (Figure 17). Many waters in this subbasin are estuarine, including the Sounds and the Alligator River to the Intracoastal Waterway. There are no wadeable streams in this subbasin, and few streams have flowing water.

The Alligator River area contains the state's best remaining example of a palustrine swamp forest. The ecosystem was once the predominant vegetation type over much of the eastern North Carolina peatlands (MacDonald and Ash, 1981, Peacock and Lynch 1982, Lynch and Peacock 1982). Wetlands have abundant wildlife, including black bear and many breeding warblers. The Upper Alligator River pocosins contains some huge bald cypress trees, perhaps some of state record size (MacDonald and Ash, 1981). Several other significant natural areas (all wetlands) also are found in the Alligator River basin.

Land use in the area is mostly forest and agriculture, including the Alligator River National Wildlife Refuge. The Alligator River area contains little industry and few residences (NCDEH 1998b). Roanoke Island, with the cities of Manteo and Wanchese, is the most developed area in this subbasin. The Manteo WWTP (0.25 MGD) is the only large discharger and is located on the east side of Roanoke Island.

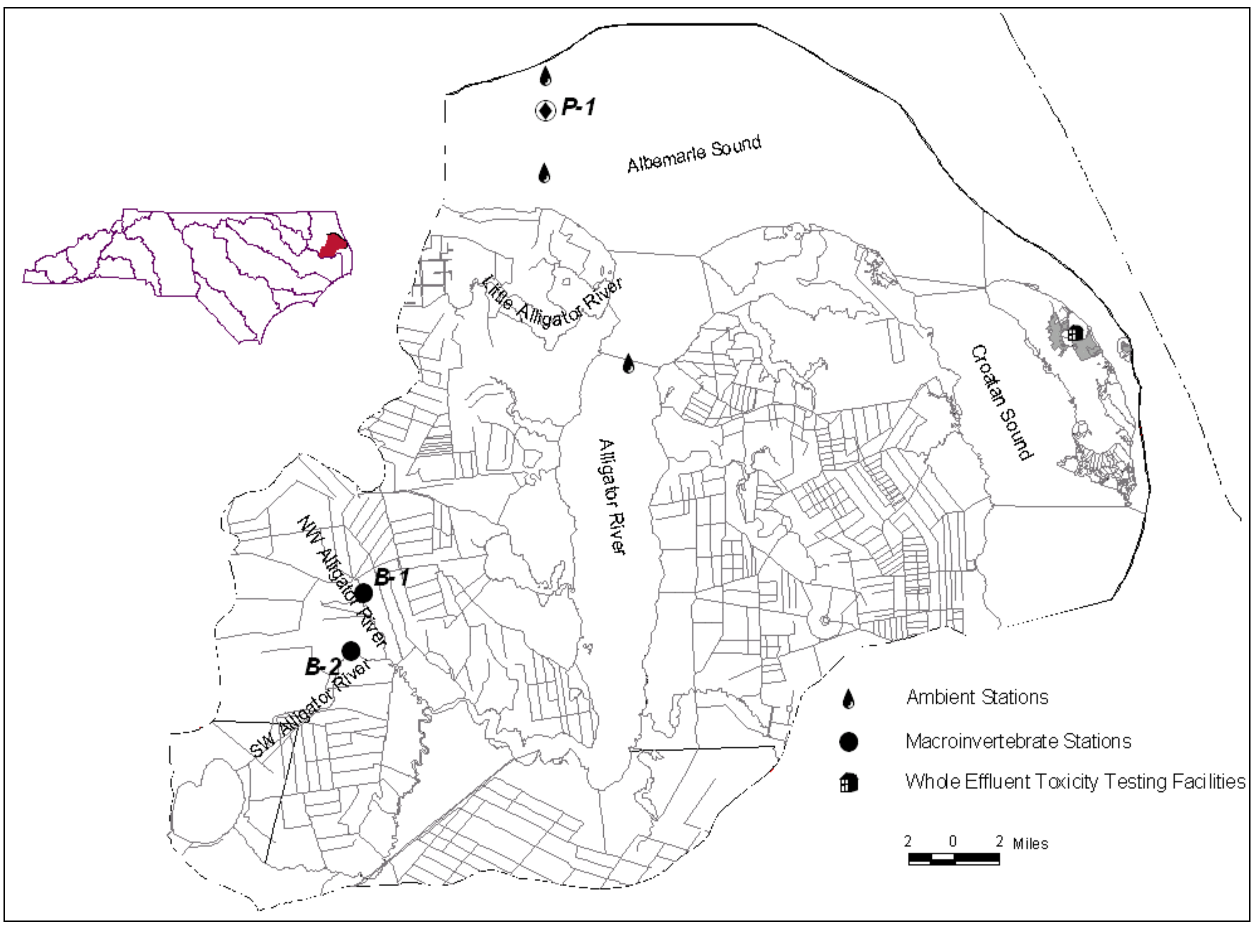



**Figure 17. Sampling sites in Subbasin 51 in the Pasquotank River basin.**

## Overview of Water Quality

The Alligator River upstream of US 64 and all its natural tributaries (excluding canals, Alligator Lake, and the Intracoastal Waterway) have been classified as Outstanding Resource Waters. Two tributaries to Shallowbag Bay (upper Scarboro Creek and Doughs Creek) have been classified as High Quality Waters, based on their designations as Primary Nursery Areas.

Limited benthic invertebrate monitoring has been recently conducted in this subbasin (Table 10). There have been four ambient monitoring sites along the Alligator River, although current sampling is limited to a single site at US 64.

The upper reaches of the Alligator River were found to have elevated nitrogen concentrations, low pH and low dissolved oxygen concentrations based on data through 1994. The low pH values suggested that much of the oxygen problem was related to drainage from Hollow Ground Swamp, but possible effects from agricultural runoff around New Lake could not be ruled out. The USDA (1995) also singled out the area around Gum Neck as having a high pollution potential from cropland runoff.

Reconnaissance sampling in March 2000 found very low pH values ( as low as 3.6) and low dissolved oxygen values (< 3 mg/L) in the Northwest and Southwest Prongs of the Alligator River. Both areas had a very limited macroinvertebrate fauna. Alligator River National Wildlife Refuge personnel also reported low pH values (3.8 -4.5) in Upper Milltail Creek, Whipping Creek and Swan Creeks (Dennis Stewart, personal communication, January 2000).

The salinity regime of the Albemarle Sound is an important factor in the establishment of phytoplankton communities. Median salinity values (since collecting began in 1982) averaged 2 ppt. Shifts in algal species were evident moving from the freshwater tributaries which feed Albemarle Sound to the more saline open sound. The nuisance blue-green algae found in some freshwater portions of the Chowan River and Pasquotank River basins cannot tolerate the slightly higher salinities in the Albemarle Sound.

Chlorophyll *a* concentrations were relatively low throughout the Albemarle Sound and there was little seasonal variation in chlorophyll despite the high densities of blue-green algae during the summer. In the winter, diatoms were most likely to dominate algal biovolume and density estimates. In the summer, however, small filamentous blue greens constituted the majority of algal biovolume and density.

During the last five years, phytoplankton monitoring has been confined to a single station in Albemarle Sound near Frog Island. Phytoplankton populations generally followed the patterns seen in prior years, except when a series of tropical storms disrupted the system in 1999. These storm events lead to increased biovolumes in August and September, but these peaks were caused by dinoflagellates, greens, and cryptomonads. Algal blooms were documented in July 1996 and August 1999.

The sediments in the Alligator River were relatively free of contamination (Riggs *et al*. 1993). The North Carolina Division of Environmental Health's Shellfish Sanitation Branch (1998a, 1998b, 1999) monitors shellfish waters in Croatan Sound and Roanoke Sound. Closed areas in Croatan Sound include Spencer Creek, Callaghan Creek and areas on Roanoke Island near Manteo and Wanchese. Closed areas in Roanoke Sound include Shallowbag Bay, upper Broad Creek and the Wanchese Harbor area. *Rangia* clams are the only shellfish resource in the Alligator River, but oysters are the primary resource in the sounds.

**Table 10. Waterbodies monitored in Subbasin 51 in the Pasquotank River basin for basinwide assessment, 1995 - 2000.**

| Map #[1] | Waterbody | County | Location | 1995 | 2000 |
|---|---|---|---|---|---|
| Swamp Streams (sampled in winter) | | | | | |
| B-1 | NW Fk Alligator R | Tyrell | Canoe trail mile 4 | --- | Not Rated |
| B-2 | SW Fk Alligator R | Tyrell | Canoe trail mile 2 | --- | Not Rated |
| P-1 | Albemarle Sound | Pasquotank | Near Frog Island | --- | --- |

[1]B = benthic macroinvertebrate monitoring sites; P = phytoplankton monitoring sites.

Tributaries streams that run through agricultural land are usually channelized ditches. Some of these streams were sampled in both January 1999 and October 2000. The collections showed that these waterbodies have a limited macroinvertebrate fauna, dominated by highly tolerant species. Low dissolved oxygen concentrations are often found in these systems, even outside of the summer months.

The Manteo WWTP is the only discharger in subbasin 51 that conducts effluent toxicity monitoring. This facility passed all self-monitoring tests in 2000, although it had failed 3/25 tests before 2000.

## River and Stream Assessment

**NW Fk Alligator River, at canoe trail mile 4**
This site was selected in an attempt to locate in this subbasin a wadeable, visibly flowing, unimpacted stream. A boat was launched at the NC 94 crossing, traveling upstream to canoe trail mile 4 marker. While this site had a few locations with visible current, most of the habitat was lentic, and not wadeable.

**Northwest Fork Alligator River, at canoe trail mile 4, Tyrell County.**

At this site, the river was about nine meters wide, with a very soft, silty bottom. This site had a low pH (4.3) and low dissolved oxygen concentration (2.8 mg/L). An unidentified macrophyte was abundant along the shoreline. The water was very darkly tannin stained, with a specific conductance of 110 µmhos/cm. Low dissolved oxygen and low pH were recorded in the river from this site to the confluence with the Southwest Fork Alligator River. These conditions of natural stress (especially the low pH) limited the macroinvertebrate fauna diversity and precluded any use of this site as a reference station.

Only 5 of the 13 taxa collected were abundant. The dominant taxa was *Zalutschia*, a midge adapted to low pH. Other abundant taxa were naidid worms (*Nais*/*Dero*), *Hydroporus* (a beetle), *Ischnura* (a damselfly), and *Hydrobaenus* (a midge).

**SW Fk Alligator River, at canoe trail mile 2**
This site was slightly wider (15-20 meters) than the Northwest Fork Alligator River site, but the sites shared several characteristics: no visible flow, silty bottom, darkly stained, low pH (~4.0), and low dissolved oxygen (3.8-4.8 mg/L). The Southwest Fork Alligator River, however, had a higher specific conductance (180 µmhos/cm), less macrophytes, and more filamentous algae than the Northwest Fork Alligator River. These observations suggested greater enrichment at this site than in the Northwest Fork Alligator River.

Only 4 of the 14 taxa were abundant: *Zalutschia* (a midge), *Hydroporus* (a beetle), and two isopods (*Asellus obtusus* and *Lirceus*).

**SPECIAL STUDY**
**Dare County Landfill**
A fire occurred at the Dare County landfill in December 1998. In the process of extinguishing the fire, contaminated water was washed into adjacent wetlands and canals such as the unnamed tributary to Callaghan Creek.

**Unnamed tributary to Callaghan Creek, Dare County.**

Surveys indicated toxic conditions adjacent to the landfill, but few changes to the invertebrate fauna at other nearby sites (Biological Assessment Unit Memoranda B990122 and B001211). Samples collected in both January 1999 and October 2000 demonstrated that these ditches and canals have a limited macroinvertebrate fauna, dominated by highly tolerant species. Low dissolved oxygen concentrations are often found in these systems, even outside of the summer months.

**OTHER DATA**
The sediments in the Alligator River were relatively free of contamination (Riggs *et al*. 1993).

## Phytoplankton Monitoring

**Albemarle Sound, near Frog Island**
Phytoplankton and nutrient samples were analyzed from the Albemarle Sound near Frog Island (Station M3900000).

Samples collected during 1996 and 1997 were dominated by blue green algae (cyanobacteria) -- particularly *Cylindrospermopsis raciborskii* and *Lyngbya*. The cryptomonad *Cryptomonas erosa* was also common during these months. During August 1996, blue greens were so abundant that biovolume increased to 6,474 $mm^3/m^3$ (Figure 18). A bloom of *Cylindrospermopsis raciborskii* was also documented at a site near Frog Island during late July 1996 (Appendix P1).

By contrast, individual phytoplankton groups were less dominant in communities sampled during February and June 1998 and biovolume measurements dropped sharply from September 1998 to July 1999. During February 1998, cryptomonads including *Chroomonas amphioxeia* and green algae including the colonial *Dictyosphaerium pulchellum* were common, and during the following June, blue greens, greens, and cryptomonads were relatively abundant. Community biovolume measurements were low from September 1998 through July 1999 and ranged from only 317 $mm^3/m^3$ in September to 1,039 $mm^3/m^3$ during July.

During August 1999, total biovolume peaked at 11,874 $mm^3/m^3$. The September 1999 sample contained a large gymnodinoid dinoflagellate, green algae including a few species of flagellated *Chlamydomonas*, and the cryptomonads *Cryptomonas erosa* and *C. ovata*. During the following November, biovolume continued to be elevated at 5,533 $mm^3/m^3$ and was dominated by *Euglena*.

During 2000, relatively low biovolume concentrations returned and ranged from 678 $mm^3/m^3$ to 2,936 $mm^3/m^3$. The latter measurement was recorded during September as the chain-forming diatom *Melosira* dominated the community. During November, biovolume decreased.

The dominant blue green assemblage found from June 1996 through November 1997 shifted to a more diverse assemblage as community biovolume declined in February 1998. The decline continued through July 1999 but this trend reversed during late summer and fall.

Total phosphorus and nitrogen measurements recorded during the overall five year sampling period did not exhibit much overall change (Figures 19 and 20).

The Albemarle Sound receives water from several different rivers including the Chowan, Perquimans, and Pasquotank. Flushing, which would decrease phytoplankton retention times within the Sound, may impact phytoplankton communities. However, the higher biovolume measurements recorded during the summer and fall of 1999 were recorded after three tropical storm systems impacted the coast. After these storm events, phytoplankton biovolume at stations within the Neuse, Tar, and White Oak River basins were unusually low, but biovolume actually increased at Station M3900000. Biomass at Station M6100000 (Albemarle Sound, near Harvey Neck), a site upstream from Station M3900000, was relatively unchanged (see Subbasin 52).

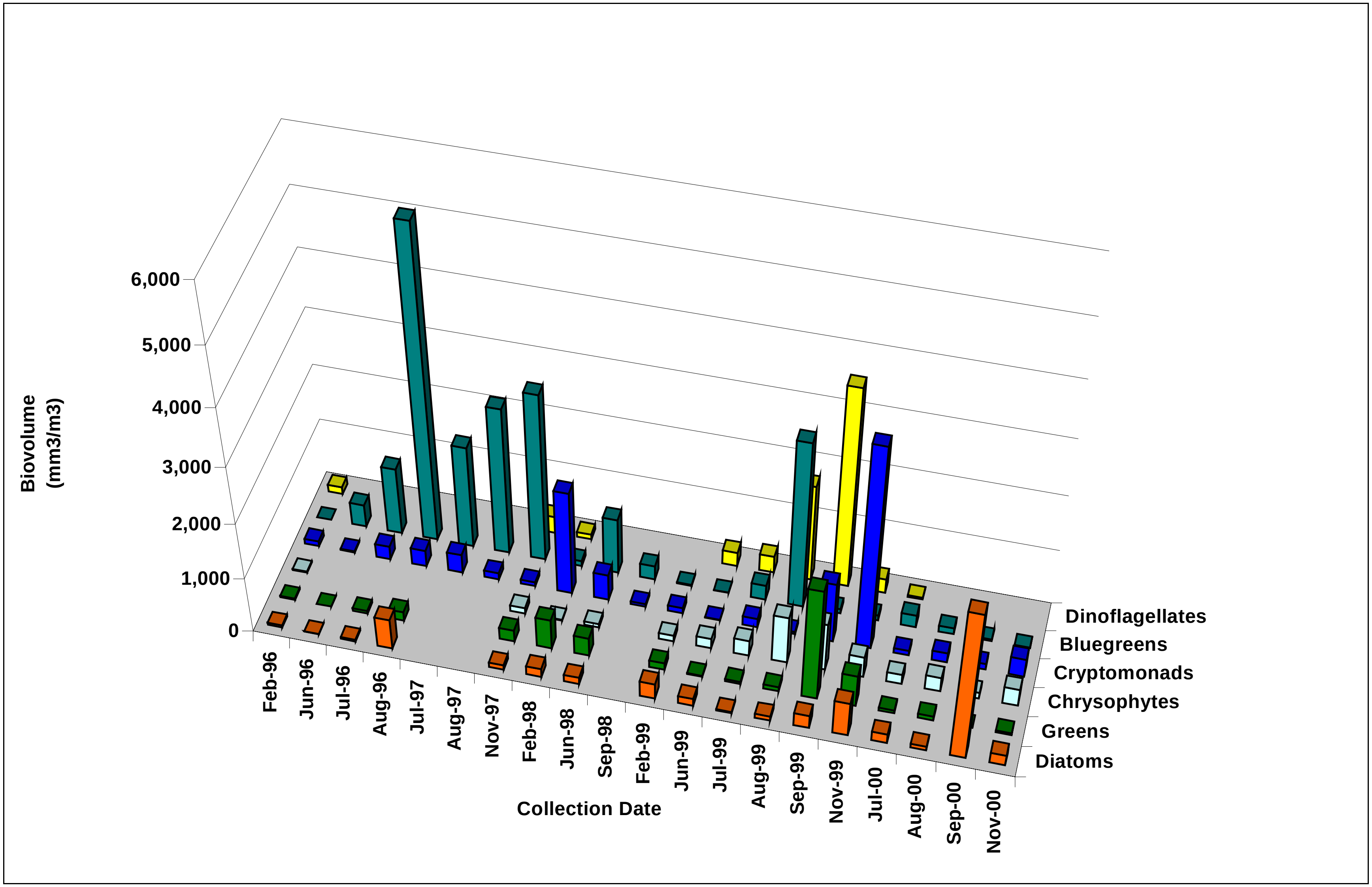



**Figure 18.** Phytoplankton divisions from the Albemarle Sound near Frog Island, 1996 - 2000.

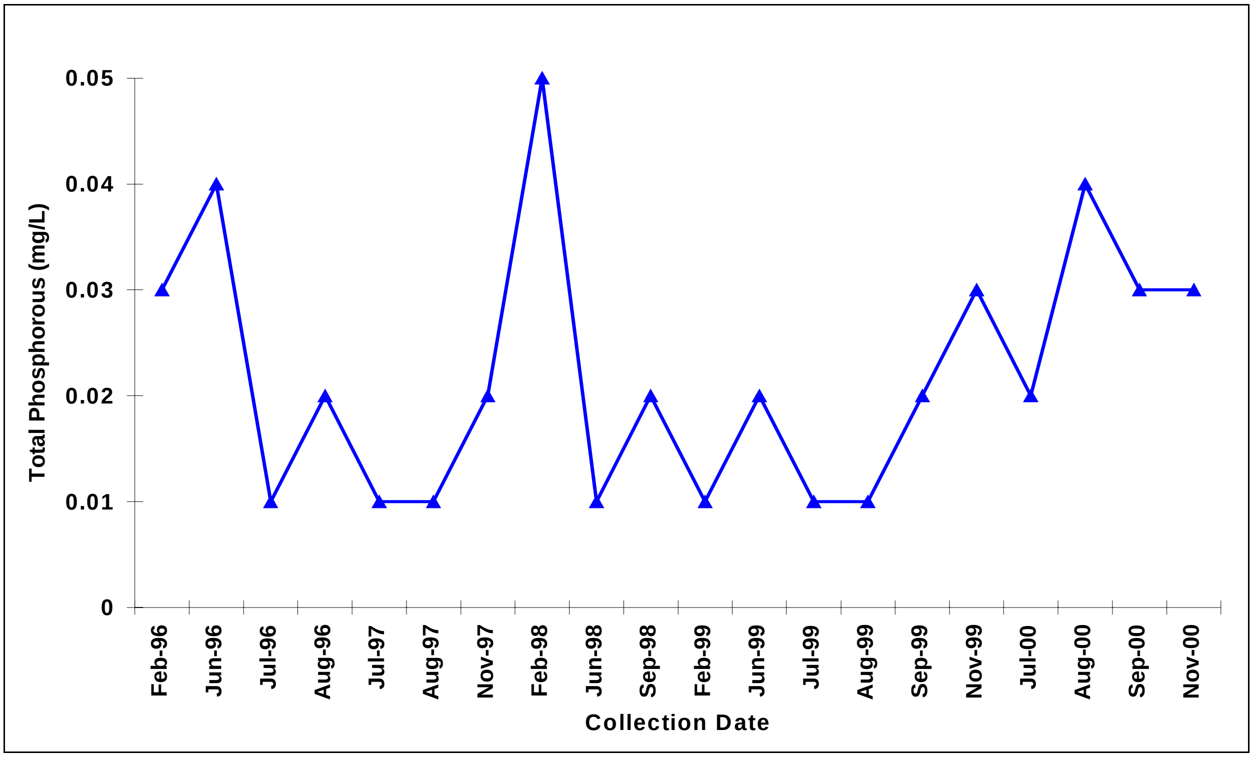



**Figure 19.** **Total phosphorus from the Albemarle Sound near Frog Island, 1996 - 2000.**

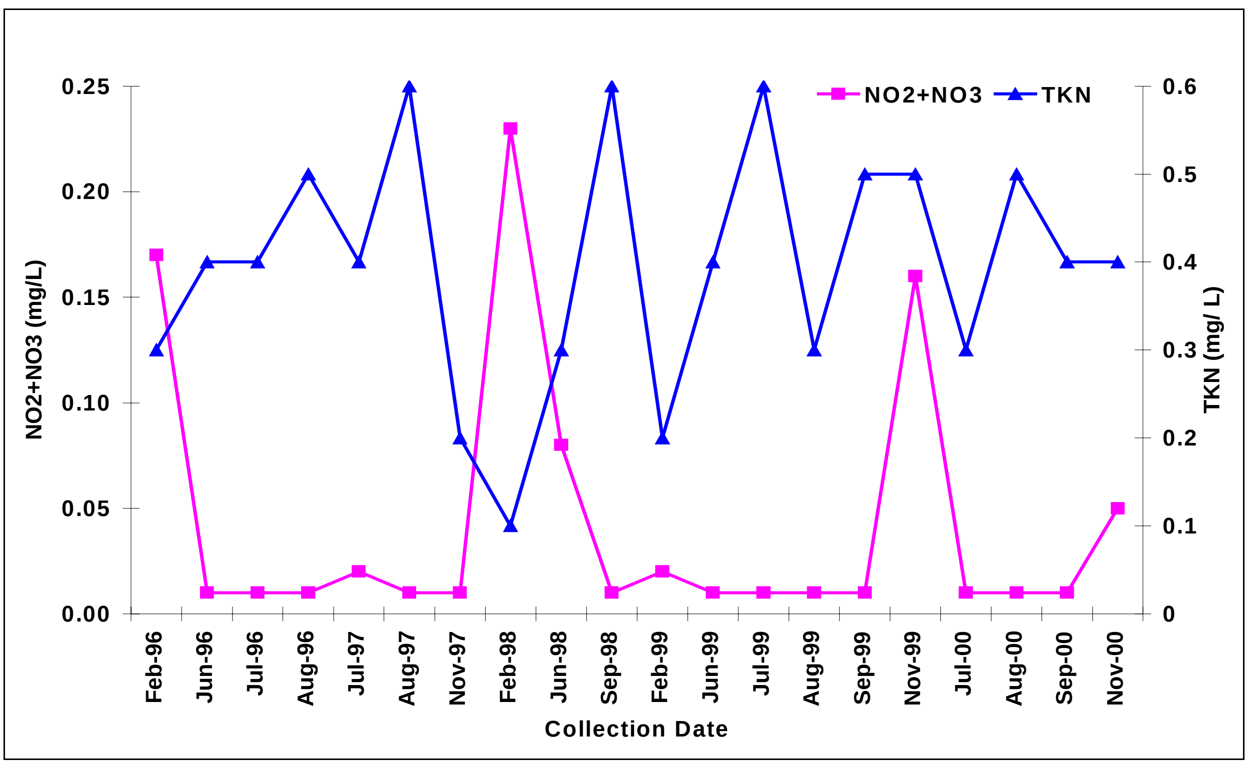



**Figure 20.** **Nitrite+nitrate and total Kjeldahl nitrogen from the Albemarle Sound near Frog Island, 1996 - 2000.**

# PASQUOTANK RIVER SUBBASIN 52

## Description

This subbasin consists of the northwestern edge of Albemarle Sound and its tributaries (Figure 21). The largest of these rivers are the Little River and the Perquimans River. The Perquimans River originates in the Great Dismal Swamp and flows southward. This entire subbasin lies to the east of the Suffolk Scarp, in an area of extremely flat topography and quaternary sediments.

The only large town in this subbasin is Hertford. Land use is mainly agriculture with widespread use of canals to drain wetlands.

There are four permitted dischargers in this subbasin, the largest is the Hertford WWTP (design flow = 0.4 MGD).

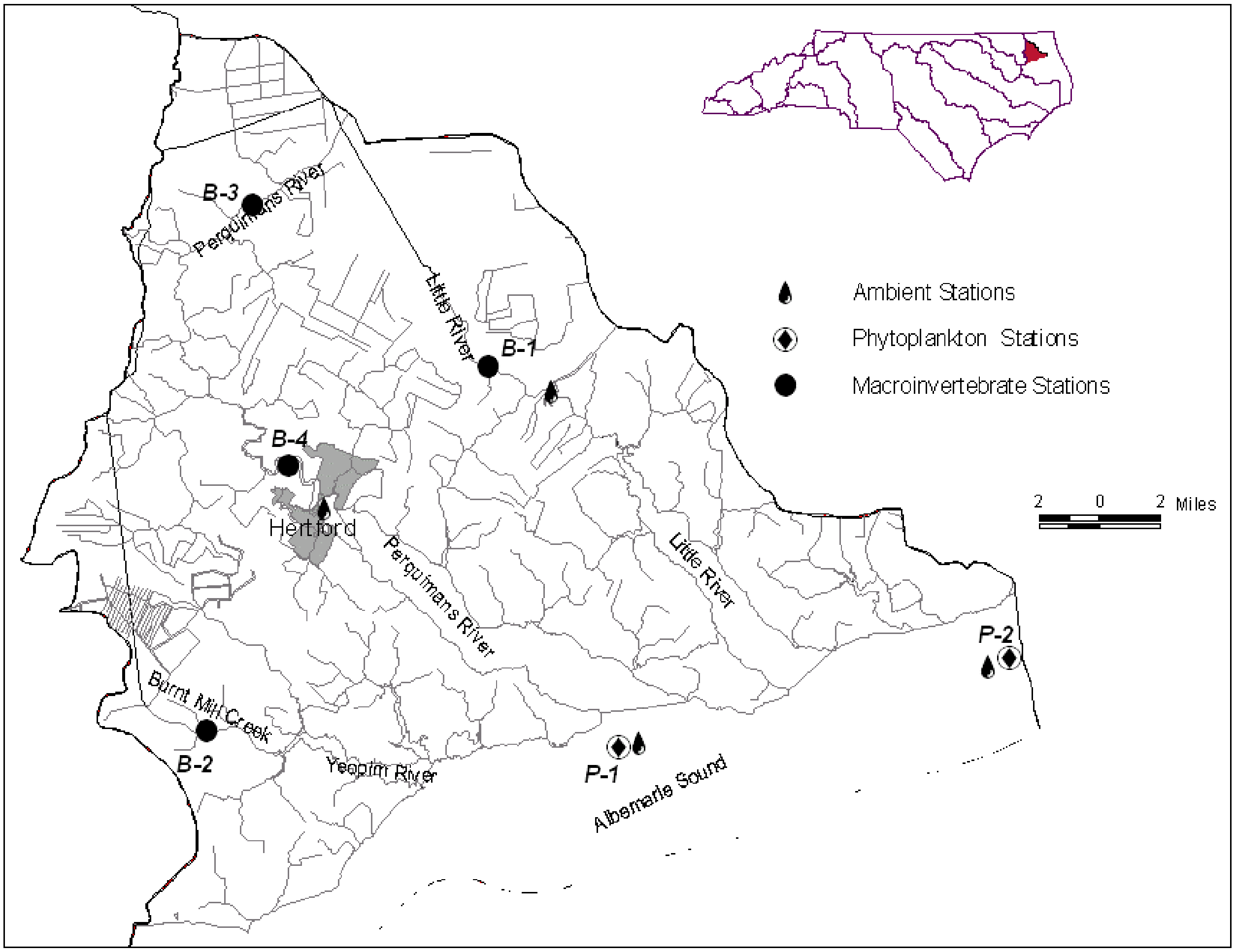



**Figure 21. Sampling sites in Subbasin 52 in the Pasquotank River basin.**

## Overview of water quality

Nonpoint source runoff seems to be the greatest problem in this subbasin. The nonpoint source pollution potential from cropland is moderate to high, based on Natural Resource Conservation Service land use estimates (USDA 1995).

No macroinvertebrate reference sites could be located in the Pasquotank River basin. Therefore, a system to rate streams in this area has not been developed. Between-stream comparisons, however, can be used to help evaluate water quality and identify the problem.

Benthic macroinvertebrates were collected in 2000 at four sites (Table 11). Three swamp streams were sampled in February (Little River, Burnt Mill Creek and the upper Perquimans River); the lower Perquimans River was sampled in August. Invertebrate data indicated that low dissolved oxygen concentrations and nutrient enrichment were widespread. A few rare taxa were observed in the upper portion of the Perquimans River, but the fauna at this site was limited by low pH and low dissolved oxygen.

Regular phytoplankton monitoring is confined to a single station in the Albemarle Sound at Harvey neck. As in prior collections, this site occasionally has high summer phytoplankton densities, but high growths of nuisance algae were absent. Maximum biovolume for 1995-2000 was observed in July 1997, although blooms were recorded in the Perquimans River during July 2000 and in Albemarle sound during August 1999. The August 1999 bloom was associated with a fish kill, but did not seem to be due to a *Pfiesteria*-like organism.

Sediments in the Perquimans River near Hertford and in the this part of the Albemarle Sound had slightly elevated concentrations of metals and pesticides (Hackney *et al*. 1998). These sites also had low invertebrate taxa richness.

**Table 11. Waterbodies monitored in Subbasin 52 in the Pasquotank River basin for basinwide assessment, 1995 - 2000.**

| Map #[1] | Waterbody | County | Location | 1995 | 2000 |
|---|---|---|---|---|---|
| Swamp Streams (sampled in winter) | | | | | |
| B-1 | Little R | Perquimans | SR 1221 | --- | Not Rated |
| B-2 | Burnt Mill Cr | Chowan | NC 37 | --- | Not Rated |
| B-3 | Perquimans R | Perquimans | SR 1111 | --- | Not Rated |
| Boat Site (sampled in summer) | | | | | |
| B-4 | Perquimans R | Perquimans | 2 miles above Hertford | --- | Not Rated |
| P-1 | Albemarle Sound | Perquimans | Harvey Neck | --- | --- |

[1]B = benthic macroinvertebrate monitoring sites; P = phytoplankton monitoring sites.

## River and Stream Assessment

All tributary streams in this subbasin have little or no flow in summer time. Flow was observed in wadeable streams during winter collections, although high flow rates were found only in one channelized stream (Burnt Mill Creek).

### STREAM SITES, WINTER SAMPLING

There were no prior swamp stream data from this subbasin. Winter 2000 collections were a first attempt to use macroinvertebrate data to evaluate water quality in these small, low gradient swamp streams.

### Little River, SR 1221

This portion of the Little River has a channel width of seven meters, although the total stream width was over 50 meters. The substrate was silt and detritus (65% and 35%, respectively). Although a good riparian buffer (swamp forest) was found at SR 1221, the adjacent forest had been clear-cut at the next upstream bridge at SR 1223. The Little River also had been channelized in this upper segment.

A high pH was recorded at this site (6.9), which may reflect upstream agricultural land use. Tributary ditches drained adjacent agricultural land (mostly cotton) and were very turbid.

**Little River at SR 1221, Perquimans County.**

**Land use at the next upstream bridge at SR 1223, Perquimans County.**

Abundant algal growths were observed in lateral areas (outside of the channel) and the macroinvertebrate fauna also indicated low dissolved oxygen concentrations. Abundant taxa included *Chironomus*, *Dero*, and *Physella*. The overall abundance of mollusks (five abundant taxa) may have reflected the high pH for this site. Normal swamp species also were abundant here, including two isopods and one midge (*Orthocladius obumbratus* group).

**Burnt Mill Creek, NC 37**
Burnt Mill Creek is a channelized stream in a heavily agricultural area. The adjacent land was planted in cotton. The stream was six meters wide and had a silt (60-70 percent) and sand (30 percent) substrate. This site had higher flow velocities than streams with a more natural channel because the stream was confined to a much narrower channel. The neutral pH (7.0) and high specific conductance (216 µmhos/cm) reflected agricultural land use in this catchment.

**Burnt Mill Creek at NC 37, Chowan County.**

The overall habitat rating was low, due to the homogeneous nature of the stream, poor riparian buffer, and eroding banks. The higher flow velocity at this site allowed a greater taxa richness (41 and 37 taxa in 1995 and 2000, respectively) than at the natural channel sites, and between-stream comparisons should be made with caution.

This stream did not have the amphipods and isopods normally abundant in swamp streams, but it supported a high number of midges, worms and mollusks. All dominant taxa were very tolerant, but the fauna were not indicative of low dissolved oxygen concentrations during the winter months.

**Perquimans River, SR 1111**
The headwaters of the Perquimans River drain the Great Dismal Swamp, which accounts for the low pH recorded at this site (5.0). Channel width was about 10 meters, but an extensive swamp forest was found on both sides of the river.

Although much of the catchment is swamp forest, the area upstream of the site was mostly ditched agricultural land, planted in cotton. The stream channel was homogeneous with few bends. The substrate is largely silt and filamentous algae were very abundant.

**Perquimans River at SR 1111, Perquimans County.**

The dominant taxa included some normal swamp species, especially isopods (*Asellus forbesi* and *Asellus* sp. 1), and midges (*Hydrobaenus* and *Zalutschia*). Some of these taxa reflect the low pH of the upper Perquimans River, but other abundant species (all midges) indicated low dissolved oxygen (*Chironomus* and *Kiefferulus*), and enrichment (*Dicrotendipes simpsoni*).

A few unusual species were found, in spite of the stressed conditions. These rare taxa included one dragonfly (*Epiaeschna heros*) and three midges (*Omisus pica*, *Orthocladius* (*Euorthocladius*) *rivulorum*, and Genus nr. *Nanocladius* B).

**RIVER SITES**

**Perquimans River, above Hertford**

This site was reached by putting in a boat at Hertford and proceeding upstream about two miles to the powerlines. The river was very wide here, with clear tannic water. Macrophytes were found along the east bank (*Sagittaria*), and abundant duckweed growths accumulated along the shore.

**Perquimans River, above Hertford at power lines, Perquimans County.**

The macroinvertebrate fauna in this portion of the river was probably controlled by low dissolved oxygen. In August, the dissolved oxygen concentration in the surface waters was 3.6 mg/L. There were abundant growths of freshwater sponge. Such growths have been associated with low dissolved oxygen in other areas of the Chowan River and Pasquotank River basins. Likewise, the large number of *Chaoborus* in the Ponar samples indicated low dissolved oxygen concentrations in the bottom waters.

*Dicrotendipes simpsoni* was dominant in the shore samples and indicated nutrient enrichment. Four EPT taxa were found here, although none of them were abundant.

**OTHER DATA**

Sediments in the Perquimans River near Hertford and in the this part of the Albemarle Sound had slightly elevated concentrations of metals and pesticides (Hackney *et al*. (1998). These sites also had low invertebrate taxa richness.

## Phytoplankton Monitoring

**Albemarle Sound, near Harvey Neck**

Phytoplankton and nutrient samples were analyzed from the Albemarle Sound, near Harvey Neck (Station M6100000).

Throughout the five-year sampling period, biovolumes were relatively low with the exception of July 1997. The community exhibited little change over time (Figure 22). Nutrient concentrations of total phosphorus and inorganic and organic nitrogen fluctuated somewhat during this time (Figures 23 and 24).

During 1996, biovolumes were relatively low and ranged from 139 to 1,354 $mm^3/m^3$. No particular group dominated during this year with the possible exception of blue green algae (cyanobacteria), particularly the species *Cylindrospermopsis raciborskii*, during August. The following year, biovolumes increased somewhat and peaked during the entire five-year study at 7,235 $mm^3/m^3$

during July 1997. This concentration was possibly due to the blue greens *Phormidium angustissimum* and *Lyngbya* and the cryptomonad *Cryptomonas erosa*. The following month, the chrysophyte *Dictyocha fibula* and blue greens *Lyngbya* and *Cylindrospermopsis raciborskii* were common, and in November 1997, the colonial green alga *Dictyosphaerium pulchellum* dominated.

Biovolumes were again relatively low during the 1998 growing season and ranged from 378 to 544 $mm^3/m^3$. Cryptomonad species including *Chroomonas amphioxeia*, *C. minuta*, and *Cryptomonas erosa* dominated in February and June, and blue greens *Lyngbya* and *Cylindrospermopsis raciborskii* were common during September.

During 1999, biovolumes were somewhat higher and ranged from 1,133 $mm^3/m^3$ during November to 3,980 $mm^3/m^3$ in August. The common winter dinoflagellate *Katodinium rotundatum*, the cryptomonad *Chroomonas caudata*, and the pennate diatom *Rhizosolenia* predominated during February. *Rhizosolenia* along with *Dictyosphaerium pulchellum* and the chrysophyte *Ebria* were common during June. Small flagellated chrysophytes, the dinoflagellate *Gyrodinium galetheanum*, and the blue green *Oscillatoria geminata* were common during July and August. Flagellated green algal species of *Chlamydomonas*, the chain forming diatom *Melosira*, and *Cryptomonas erosa* dominated September algal biovolume, and small centric diatoms were predominant during November.

Biovolumes were lower during 2000 and ranged from 451 to 1,742 $mm^3/m^3$. This peak occurred during November and was dominated by the cryptomonads *Chroomonas amphioxeia* and *Cryptomonas erosa.*

**Algal Blooms**

Two algal blooms were documented in this subbasin:

- The filamentous diatom *Skeletonema potamos* and cryptomonads *Cryptomonas erosa* and *Rhodomonas minuta* bloomed in the Perquimans River during July 2000.
- During August 1999, the NCDWQ's Pamlico River Rapid Response Team investigated a fish kill associated with mild blooms of the dinoflagellates *Prorocentrum minimum* and *Gyrodinium estuariale* and the filamentous blue green *Oscillatoria geminata* (Appendix P1). The samples were collected off Wade Point (Pasquotank County) and off Harvey Point (Perquimans County). Samples collected from these events contained *Pfiesteria*-like cells (cells which bear a cursory resemblance to actual *Pfiesteria* species under light microscopy), but when these cells were viewed under fluorescence microscopy, the cells glowed as if they were obligate autotrophs and not heterotrophic *Pfiesteria* species.

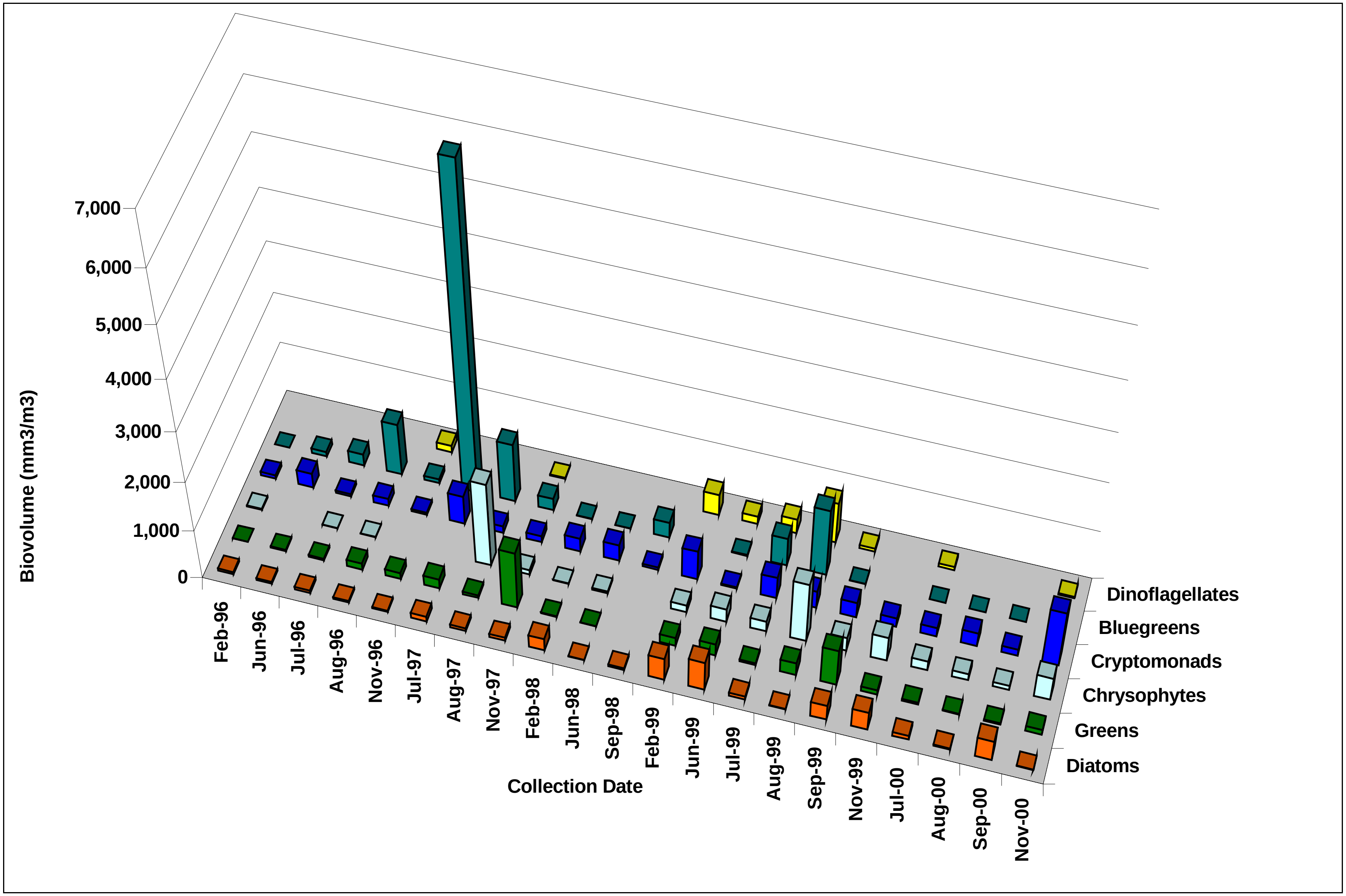



**Figure 22.** **Phytoplankton divisions from the Albemarle Sound near Harvey Neck, 1996 - 2000.**

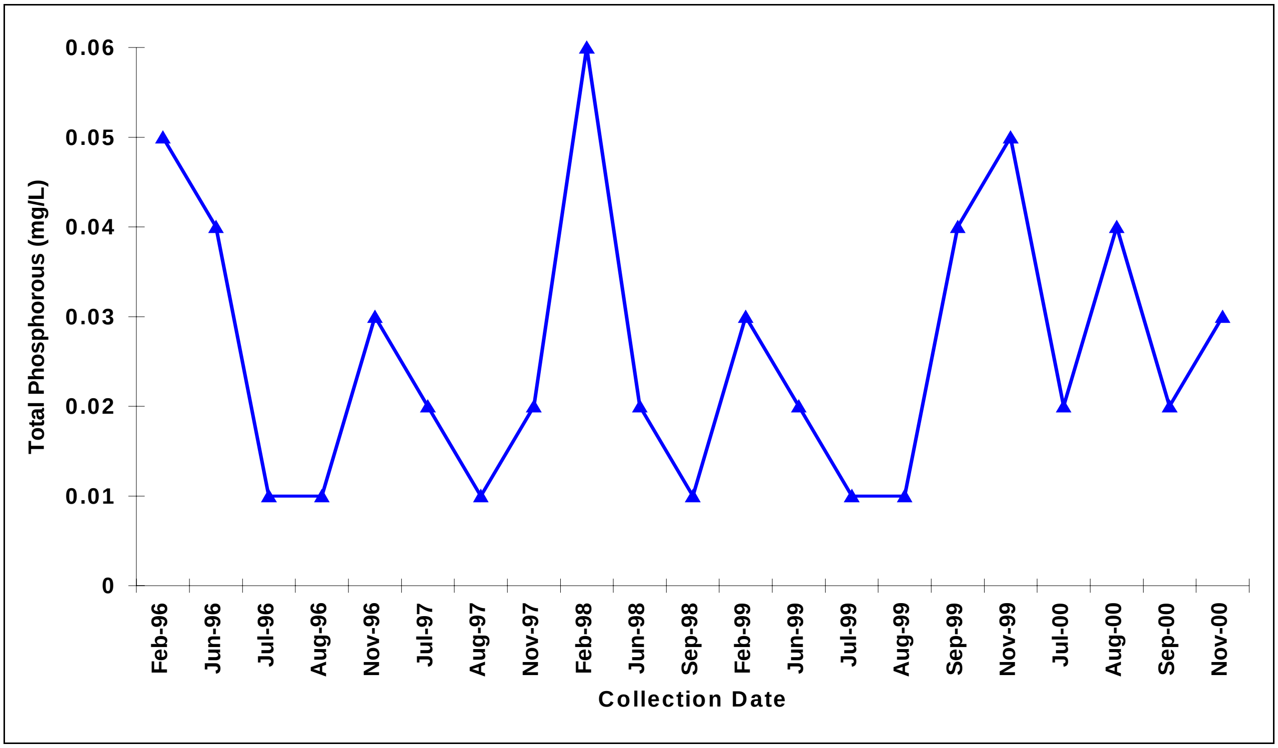



**Figure 23.** Total phosphorus from the Albemarle Sound near Harvey Neck, 1996 - 2000.

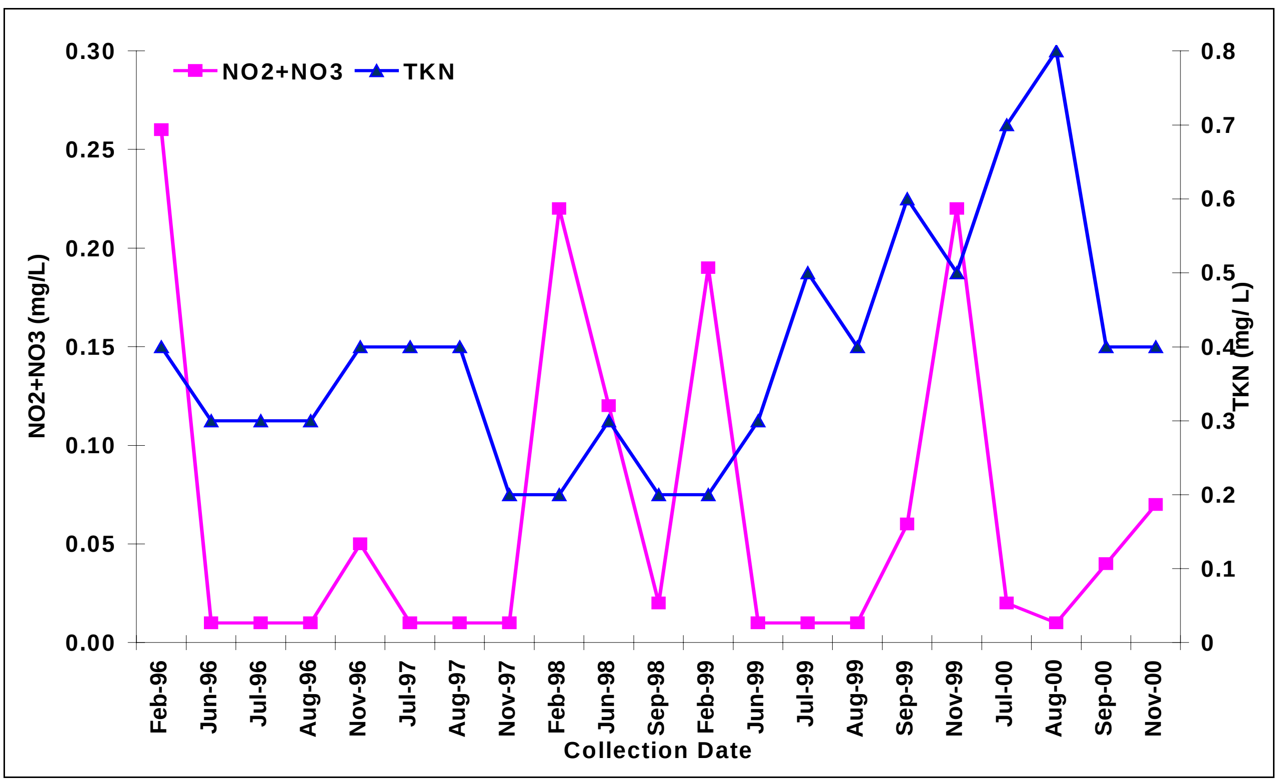



**Figure 24.** Nitrite+nitrate and total Kjeldahl nitrogen from the Albemarle Sound near Harvey Neck, 1996 - 2000.

## PASQUOTANK RIVER SUBBASIN 53

### Description

The Scuppernong River and Kendricks Creek are the largest streams in this subbasin (Figure 25). The headwaters of both streams have been extensively ditched and channelized to promote drainage of agricultural lands. Land use within this subbasin is mainly forested wetlands and agriculture. Columbia is the only large town in this subbasin, although scattered development occurs along the US 64 corridor.

There are no major permitted dischargers in subbasin 53; the largest discharger is the Columbia WWTP with a design flow of 0.3 MGD into the Scuppernong River. This facility was upgraded in 1997.

This entire subbasin lies to the east of the Suffolk Scarp, in an area of extremely flat topography and quaternary sediments. These streams are expected to have low invertebrate taxa richness relative to other coastal plain streams.

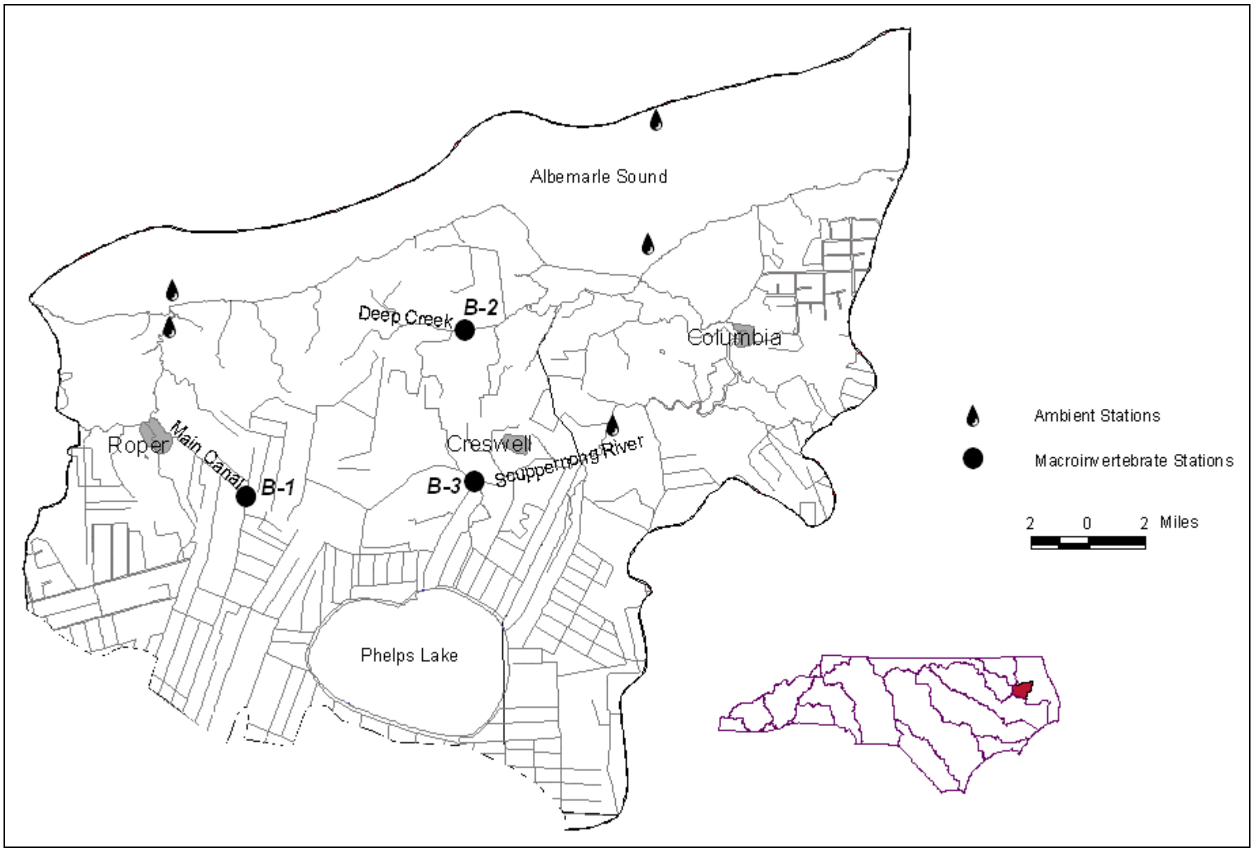



**Figure 25. Sampling sites in Subbasin 53 in the Pasquotank River basin.**

### Overview Of Water Quality

Benthic macroinvertebrates have been collected from three sites in this subbasin (Table 12). Severe water quality problems were found in Main Canal and the Scuppernong River, but Deep Creek seemed to be one of the better small swamp streams in the entire basin. It is not possible to make direct comparisons between most of the macroinvertebrate sites in this subbasin, due to differences in size, flow, and habitat.

From 1990-1994, 76 percent of the water quality samples taken from the Scuppernong River had dissolved oxygen concentrations less than 4 mg/L, and similar values were observed from 1996 - 2000. Very low dissolved oxygen concentrations were also recorded in 2000 during macroinvertebrate surveys.

Lake Phelps is the second largest natural lake in North Carolina. This shallow and acidic lake (pH < 5) is located at a higher elevation than the surrounding land, so most of the recharge comes from precipitation. There were no algal blooms in Lake Phelps during the assessment period.

Lake Phelps has recently been reclassified to B SW ORW, and serves as habitat for two unusual species: the Lake Waccamaw killifish and leafless watermilfoil. There are excellent game fish populations in Lake Phelps, although there is a fish consumption advisory (due to mercury contamination) for bowfin and largemouth bass.

Based on Natural Resources Conservation Service land use estimates of this area, nonpoint source pollution potential is high from both cropland and farm animals (USDA 1995).

Contaminated sediments, including DDT, were found at one site on the Scuppernong River in 1996 (Hackney *et al*. (1998). No high concentrations of contaminants were found in the Albemarle sound (Bull Bay).

**Table 12. Water bodies monitored in Subbasin 53 in the Pasquotank River basin for basinwide assessment, 1995 - 2000.**

| Map #[1] | Waterbody | County | Location | 1995 | 2000 |
|---|---|---|---|---|---|
| Swamp Streams (sampled in winter) | | | | | |
| B-1 | Main Canal | Washington | SR 1180 | --- | Not Rated |
| B-2 | Deep Cr | Washington | SR 1302 | --- | Not Rated |
| Boat Site (sampled in summer) | | | | | |
| B-3 | Scuppernong R | Washington | SR 1155 | --- | Not Rated |
| | Lake Phelps | Washington | | Oligotrophic | --- |

[1]B = benthic macroinvertebrate monitoring sites.

## River and Stream Assessment

Flows were generally low to normal for both the winter and summer collections.

**RIVER SITES, SUMMER SAMPLING**
**Scuppernong River, SR 1155**
Samples were taken from the middle segment of the river near Creswell. Here, the river is about 16 meters wide, with a maximum depth of four meters. The bottom is soft silt, even along the shore, and the water was turbid after a period of heavy rain. Patches of *Sagittaria* and alligator weed were found in backwater areas, but macrophytes were rarely seen in the main channel. Duckweed growths were abundant and filamentous algal growths were very abundant on any snags near the surface.

**Scuppernong River at SR 1155, Washington County.**

Macroinvertebrates at this site were limited by low dissolved oxygen. In August 2000, the concentration in the surface waters was only 0.5 mg/L. The specific conductance was high (208 µmhos/cm).

Invertebrates were absent from the dredge samples. The shoreline samples were dominated by organisms indicative of enrichment and low dissolved oxygen: *Dicrotendipes nervosus*, *Peltodytes*, *Enallagma*, *Sphaerium*, and *Physella*. The highest taxa richness was for the "Other" category, including leeches, flatworms and Hemiptera. The very high biotic index (8.1) indicated severe water quality problems.

**STREAM SITES, WINTER SAMPLING**
**Main Canal, SR 1180**
Main Canal is a channelized site, with a habitat score of only 32 out of 100 possible points. This site has good flow, making it difficult to make comparisons with more natural streams in this basin (with lower current speeds). The substrate was very silty, although there were abundant growths of macrophytes and filamentous algae. The riparian zone was narrow (with many breaks) and there was little canopy cover. Most of the stream was a uniform run habitat, with few riffles or pools. Conductivity was high (212 µmhos/cm). Main Canal was very turbid during the February 2000 collection.

**Main Canal at SR 1180, Washington County.**

This site has been sampled twice, in February of 1995 and 2000. Both times, the community was dominated by chironomids, although not by low dissolved oxygen indicators. *Procambarus clarkii* was also collected. It is an introduced crayfish that may compete with our native species.

Taxa richness was low for a flowing water site (31 in both collections), with low diversity even for odonates and mollusks. The low taxa richness and very high biotic index (8.6 for the 2000 collection) indicated severe water quality problems.

**Deep Creek, SR 1302**
Deep Creek appeared to be one of the highest quality low-gradient swamp streams in the Pasquotank River basin and a likely comparison site for other small swamp streams in Subbasin 50. This stream has a channel width of only five meters at the bridge, but it quickly forms a wide braided channel away from the bridge. Filamentous algae were abundant in some parts of the stream, although not to the extent seen in Newbegun Creek (Subbasin 50). Specific conductance was only 90 µmhos/cm, compared to > 200 µmhos/cm at less forested sites.

**Deep Creek at SR 1302, Washington County.**

Taxa richness (28) was higher and the biotic index lower (7.1) at Deep Creek in comparison with other small swamp streams in this basin. This site was also characterized by a large number of unusual species: *Bidessonotus* (a beetle), *Omisus pica* (a midge), *Procotyla fluvialis* (a flatworm), and *Philobdella gracilis* (a leech; this is a northern range extension). Unusual specimens of one midge (*Corynoneura)* and two snails (*Physella* and *Promenetus*) were collected; some of which may represent new species. These records emphasize the importance of minimally disturbed streams as a refuge for many species.

**SPECIAL STUDY**
**Kendricks Creek**
An abbreviated sample was taken from Kendricks Creek at US 64 in October 2000. The data demonstrated a lack of estuarine taxa and indicated that a freshwater classification was appropriate for this segment of the creek.

(Biological Assessment Unit Memorandum B001031).

**OTHER DATA**
Sediment samples were collected by the US EPA's Environmental Monitoring and Assessment Program (Hackney *et al*. 1998) from the Scuppernong River and Albemarle Sound (Bull Bay). Elevated concentrations of several contaminants were detected from the Scuppernong River, but high levels were not detected from the Albemarle Sound site.

## Lake Assessment

### Lake Phelps
Lake Phelps, North Carolina's second largest natural lake, is located in Washington and Tyrrell counties (Figure 26 and Table 13). It lies within a vast peninsula between the Albemarle Sound to the north and the Pamlico River to the south. This peninsula contains numerous low-lying swampy areas underlain by thick organic muck and relatively well-drained areas with fertile mineral and organic soils. Much of this area has been cleared of vegetation, drained, and put into large scale agricultural use.

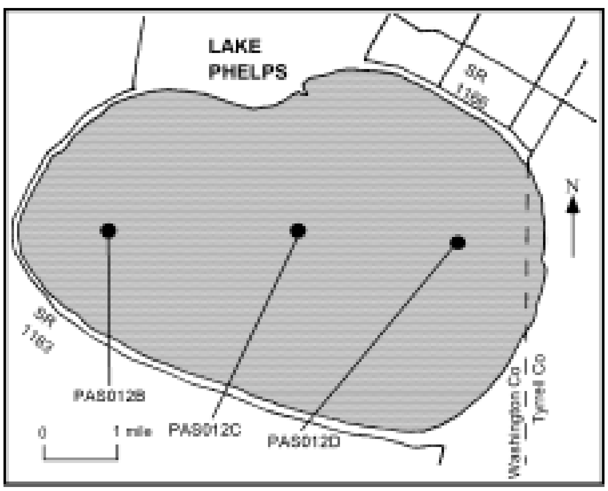



**Figure 26. Monitoring sites at Lake Phelps, Washington and Tyrell counties.**

**Table 13. Physical characteristics of Lake Phelps.**

| | |
|---|---|
| **Classification** | B SW ORW |
| **Surface area (Ac)** | 16,600 |
| **Mean depth (ft.)** | 4.9 |
| **Volume (X $10^6$ $m^3$)** | 98.7 |
| **Retention time (days)** | 1,161 |
| **Watershed** | n/a |

The lake is owned by the State of North Carolina as part of Pettigrew State Park. This lake is principally recharged by natural precipitation with a small fraction of the water coming from underground aquifers. Because of its shallow depth, the lake is wind mixed and rarely stratifies. The water is acidic, typical of coastal plain lakes, but unlike other coastal plain lakes, the water is not colored.

Lake Phelps is used primarily for boating and fishing. It has also been used as a source of water for fighting peat fires. The lake provides habitat for the endemic Waccamaw killifish (*Fundulus waccamensis*) and for the leafless watermilfoil (*Myriophyllum tenellum*), an aquatic macrophyte not previously found south of New Jersey.

A fish consumption advisory exists for the consumption of bowfin (blackfish) and largemouth bass due to mercury contamination. Children and childbearing women are advised not to eat these fish while the general public is advised to consume no more than two meals per month (NCDHHS 2000).

In August 2000, Lake Phelps was reclassified from C Swamp Water (SW) to B SW ORW (Outstanding Resource Water) (NCDENR 2000).

The lake was most recently monitored during the summer of 2000 (Table 14 and Appendices L2 and L3). In June, Secchi depths were less than one meter at all sites (mean = 0.8 m). Nutrient concentrations were low to moderate.

In July, Secchi depths were greater (mean = 1.1 m). Nutrient concentrations were again moderate. The greatest nutrient concentrations were present at Station PAS012D.

In August, Secchi depths again increased (mean = 1.5 m). Total phosphorus concentrations were low; however, nitrogen concentrations were moderate to elevated.

Concentrations of total Kjeldahl nitrogen (1.8 mg/L), total nitrogen (1.88 mg/L) and total organic nitrogen (1.77 mg/L), were the greatest values for these parameters recorded by the NCDWQ since the lake was first monitored in 1981.

The lake was previously monitored by the NCDWQ in 1995 and 1996. In June, 1996, the mean surface pH was 4.4 s.u. This pH value is not exceptionally low due to the swamp-like nature of this lake and its immediate shoreline. Exposed peat at the bottom of the lake may also contribute to the acidic nature of the lake water. Mean nutrient concentrations ranged from moderate to elevated in June as compared with values observed in July. Mean Secchi depths were similar in June and July.

On August 10, 1995, physical measurements indicated thorough mixing of the water column at all sites. Nutrient, chlorophyll *a*, and solids concentrations were low and uniformly distributed in the lake.

**Table 14. Biological monitoring and water chemistry data for Lake Phelps, 1995 – 2000.**

| Date | NCTSI | Rating | TP (mg/L) | TON (mg/L) | CHL a (µg/L) | Secchi (m) |
|---|---|---|---|---|---|---|
| 08/21/2000 | --- | --- | 0.01 | 0.83 | --- | 1.5 |
| 07/05/2000 | --- | --- | 0.02 | 0.22 | --- | 1.1 |
| 06/26/2000 | --- | --- | 0.01 | 0.30 | --- | 0.8 |
| 07/23/1996 | --- | --- | 0.02 | 0.18 | --- | 1.3 |
| 06/24/1996 | --- | --- | 0.02 | 0.35 | --- | 1.2 |
| 08/10/1995 | -4.5 | Oligotrophic | < 0.01 | 0.16 | 3 | 1.8 |

# PASQUOTANK RIVER SUBBASIN 54

### Description

This subbasin consists of Currituck Sound, plus the North River and its tributaries in Currituck and Camden counties (Figure 27). Land use is mostly cropland and forest. However, development is increasing rapidly along US 158 and throughout the Outer Banks. Most waters are estuarine, including Currituck Sound and the North River. Many canals drain the Great Dismal Swamp primarily into the North River and the Northwest River.

Currituck Sound is a shallow, fresh to brackish waterbody, whose circulation is influenced largely by wind movement. A large portion of the sound serves as a critical part of the Atlantic Flyway for migratory waterfowl. Thousands of wintering ducks, geese, and swans contribute to the sound's reputation for waterfowl hunting.

Currituck is the largest town in this subbasin; other small towns include Waterlily, Poplar Branch and Point Harbor on the mainland and Corolla on the Outer Banks. While land use around Currituck Sound is mostly rural, Virginia Beach, on the northern edge of the basin, is highly urbanized. There are no major dischargers in this subbasin.

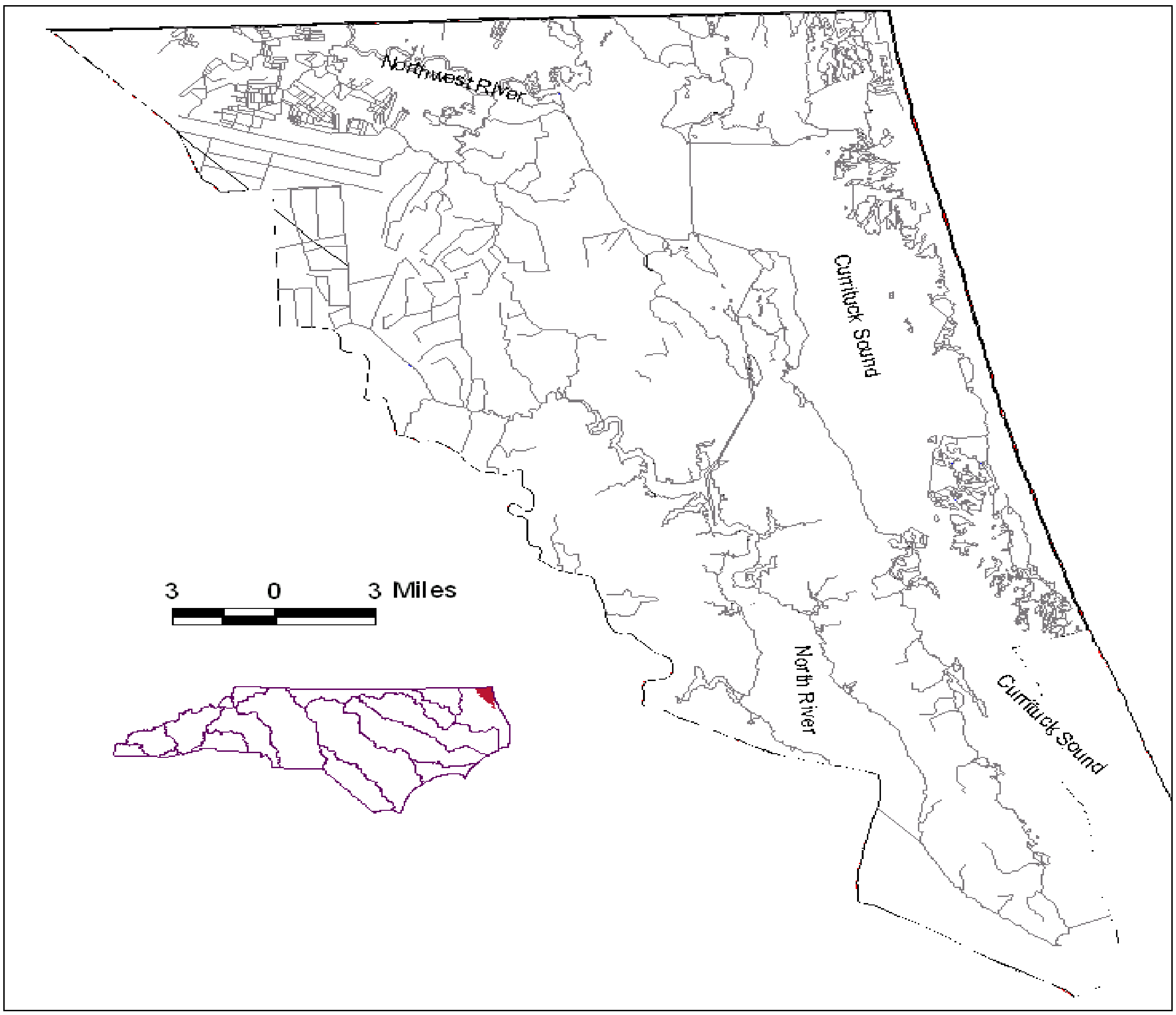



**Figure 27. Sampling sites in Subbasin 54 in the Pasquotank River basin.**

## Overview Of Water Quality

There has been no recent biological monitoring in this subbasin. All waters in this subbasin are classified as SC or C-Swamp with the exception of Tulls Creek (B-Swamp). No blooms have been documented since 1995, although “green water” was occasionally reported.

The ecology of Currituck Sound is controlled by salinity levels, and salinity varies between seasons and years. Salinity is influenced by the amount of direct or indirect saltwater input from the ocean and by the amount of freshwater input from tributaries. Sources of salt water into the sound include the Albemarle Sound, Back Bay, North Landing River and the Intracoastal Waterway. Inputs of freshwater are provided by Tulls Creek and Jean Guite Creek. Increasing salinity can reduce populations of brackish water fish (especially largemouth bass), as well as freshwater macrophytes.

The previous basinwide assessment report, (NCDEHNR 1996b) provided detailed information from special studies conducted before 1995.

The North Carolina Shellfish Sanitation Section conducted a sanitary survey for this area, with detailed shoreline survey and evaluation of shellfish resources (NCDEH 1998`). *Rangia* clams are the only shellfish resource in this subbasin. Water closed to shellfishing included Hog Quarter Landing and Currituck Sound upstream of Dews Island, plus North River and its tributaries upstream of Marker 159.

# PASQUOTANK RIVER SUBBASIN 55

## Description

This subbasin consists of Pamlico Sound from Oregon Inlet to Hatteras Inlet and the Outer Banks (Figure 28). It also includes Black Lake and Stumpy Point Bay (formerly in Subbasin 57). [Note: there is no longer a Subbasin 57.] All waters in this subbasin are estuarine or oceanic and are classified as SA. Land use in the area is largely undeveloped, because most of the subbasin lies within the Cape Hatteras National Seashore and Pea Island National Wildlife Refuge. Hatteras is the largest town in this subbasin, but smaller towns such as Avon and Buxton are also located along NC 12. There are six minor permitted dischargers in this subbasin.

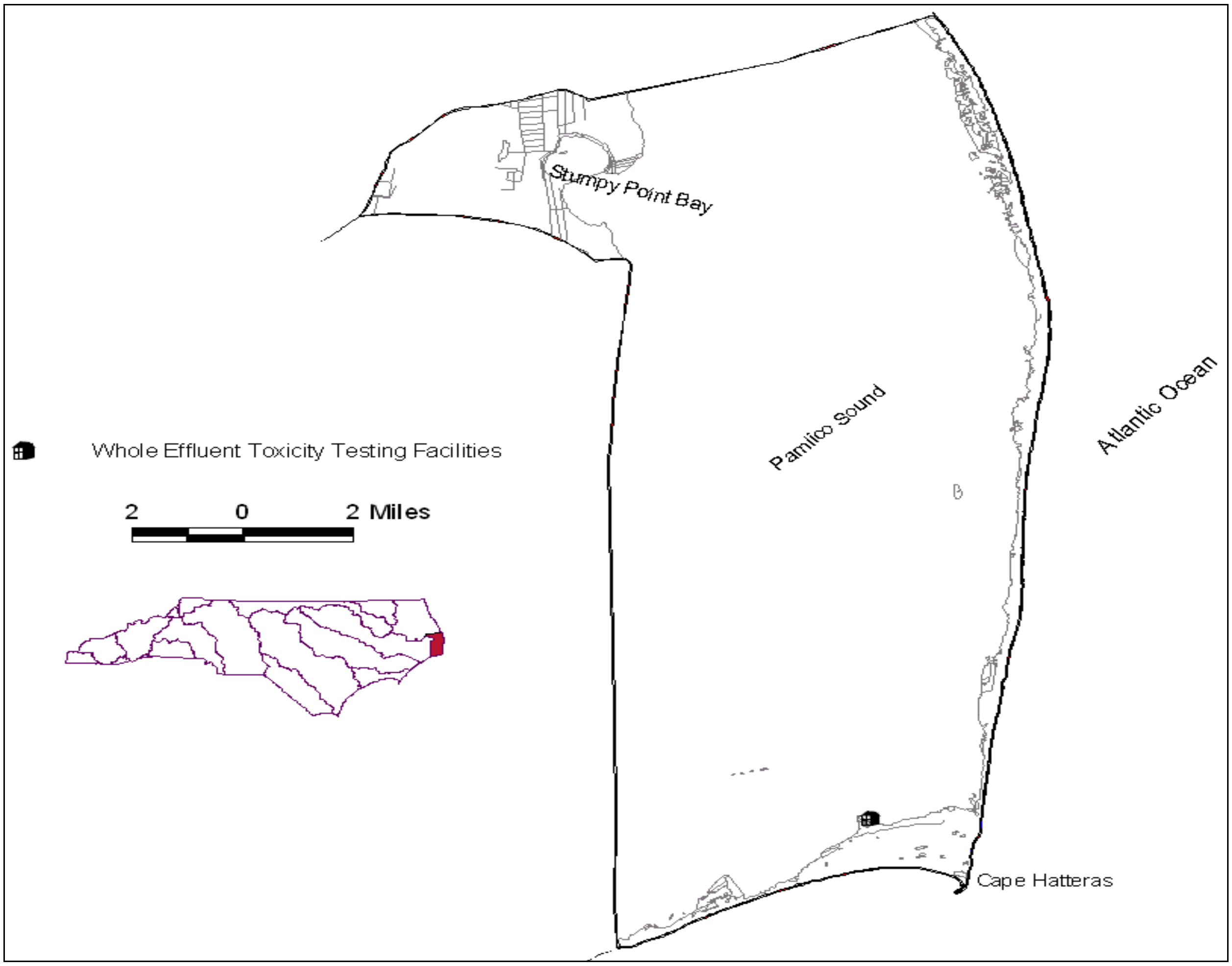



**Figure 28. Sampling sites in Subbasin 55 in the Pasquotank River basin.**

## Overview Of Water Quality

Water quality seemed to be generally high, although there has been little data collected by the NCDWQ.

This subbasin includes several areas monitored by the NC Shellfish Sanitation Branch: the Stumpy Point area (H3), the Hatteras area (H-4), and the Outer Banks Area (H-5) (NCDEH 1998, 1999). About 1 percent of the total area is closed to shellfishing, usually near more developed area. Oyster and clam production in this subbasin is generally Fair, with little commercial harvest.

## PASQUOTANK RIVER SUBBASIN 56

### Description

This subbasin consists of the lower portion of Currituck Sound, the outer Albemarle Sound, Kitty Hawk Bay, and eastern Roanoke Sound (Figure 29). There are large residential and commercial land use areas along the Outer Banks including the towns of Duck, Kill Devil Hills and Nags Head. All waters in this subbasin are estuarine or oceanic, with the exception of a few small lakes in the maritime forest on the Outer Banks. Roanoke Sound is classified SA, Albemarle Sound is classified SB, and Currituck Sound and Kitty Hawk Bay are classified SC. There are two permitted dischargers in this subbasin.


**Figure 29. Sampling sites in Subbasin 56 in the Pasquotank River basin.**

### Overview of Water Quality

No studies by the NCDWQ have been conducted in this subbasin since 1995. This subbasin includes only one area, the Roanoke Sound (Area H1), monitored by the NC Shellfish Sanitation Branch(NCDEH 1999). About 10 percent of the area is closed to shellfishing, usually near the more developed areas.

# AMBIENT MONITORING SYSTEM

## INTRODUCTION

An 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 monitoring stations. Routine sampling from fixed stations is referred to as ambient monitoring. During this assessment period (1995 - 2000), 26 stations were monitored monthly in the Chowan River and Pasquotank River basins (Table 15; Figures 30 and 31).

Three areas or waterbodies were considered wide enough to sample in three different locations – and these are referred to as transects. Each transect site can be considered an independent monitoring station because spatial differences, due to hydrology or other factors, can affect water quality at a specific point in the transect. These three transects occur within the Albemarle Sound: 1) near Edenton, 2) near Frog Island, and 3) between Harvey and Mill Points.

Water quality and algal blooms in the Chowan River received considerable attention from water quality researchers during the 1970s and 1980s. During this period, the river experienced severe algal blooms (*Anabaena* and *Aphanizomenon*) and fish kills. These problems were addressed through research and a variety of water quality management strategies. The lack of algal blooms and fish kills during this assessment cycle strongly suggested that the management plans implemented in the 1980s have been very successful.

Much of the research in the two basins has been funded as part of the Albemarle Pamlico Estuarine Study and the Albemarle-Pamlico National Estuarine Program (APNEP). Synopses of this broad spectrum of work can be found at the APNEP web site (http://h2o.enr.state.nc.us/nep/).

**Table 15. Ambient monitoring system stations within the Chowan River and Pasquotank River basins. Transect stations are denoted with an asterisk (*).**

| Subbasin/Station | Location | County | Class[1] |
|---|---|---|---|
| **01** | | | |
| D0000050 | Nottaway River at US 258 near Riverdale, VA | Southampton, VA | II Estuarine |
| D0001200 | Blackwater River at Horseshoe Bend at Cherry Grove, VA | Southampton, VA | II Estuarine |
| D0001800 | Blackwater River 150 yards upstream of mouth near Wyanoke | Gates | B NSW |
| D0010000 | Chowan River near Riddicksville | Hertford | B NSW |
| D6250000 | Chowan River at US 13 at Winton | Hertford | B NSW |
| D8356200 | Chowan River at CM 16 near Gatesville | Hertford | B NSW |
| **02** | | | |
| D4150000 | Potecasi Creek near Union | Hertford | C NSW |
| D5000000 | Meherrin River at SR 1175 near Com | Hertford | B NSW |
| 03 | | | |
| D8430000 | Chowan River 200 yards downstream Holiday Island | Chowan | B NSW |
| D8950000 | Chowan River at Colerain | Bertie | B NSW |
| **04** | | | |
| D9490000 | Chowan River at Edenhouse | Bertie | B NSW |
| D999500C* | Albemarle Sound near Edenton mid channel | Chowan | B NSW |
| D999500N* | Albemarle Sound near Edenton north shore | Chowan | B NSW |
| D999500S* | Albemarle Sound near Edenton south shore | Chowan | SB |
| **50** | | | |
| M2750000 | Pasquotank River at Elizabeth City | Pasquotank | SB |
| **51** | | | |
| M698000C | Scuppernong River at SR 1105 near Columbia | Tyrrell | C SW |
| M7175000 | Alligator River at US 64 near Alligator | Tyrrell | SC SW ORW |
| **52** | | | |
| M3500000 | Little River at US 17 at Woodville | Perquimans | C SW |
| M390000C* | Albemarle Sound near Frog Island mid channel | Tyrrell | SB |
| M390000N* | Albemarle Sound near Frog Island north shore | Pasquotank | SB |
| M390000S* | Albemarle Sound near Frog Island south shore | Tyrrell | SB |
| M5000000 | Perquimans River at SR 1336 at Hertford | Perquimans | SC |
| M610000C* | Albemarle Sound between Harvey Point and Mill Point mid channel | Tyrrell | SB |
| M610000N* | Albemarle Sound between Harvey Point and Mill Point north shore | Perquimans | SB |
| M610000S* | Albemarle Sound between Harvey Point and Mill Point south shore | Tyrrell | SB |
| **53** | | | |
| M6920000 | Kendricks Creek at SR1300 at Mackeys | Washington | SC |

[1]Swamp waters are present in the Chowan River basin, but there are no waterbodies with Sw supplemental classifications.

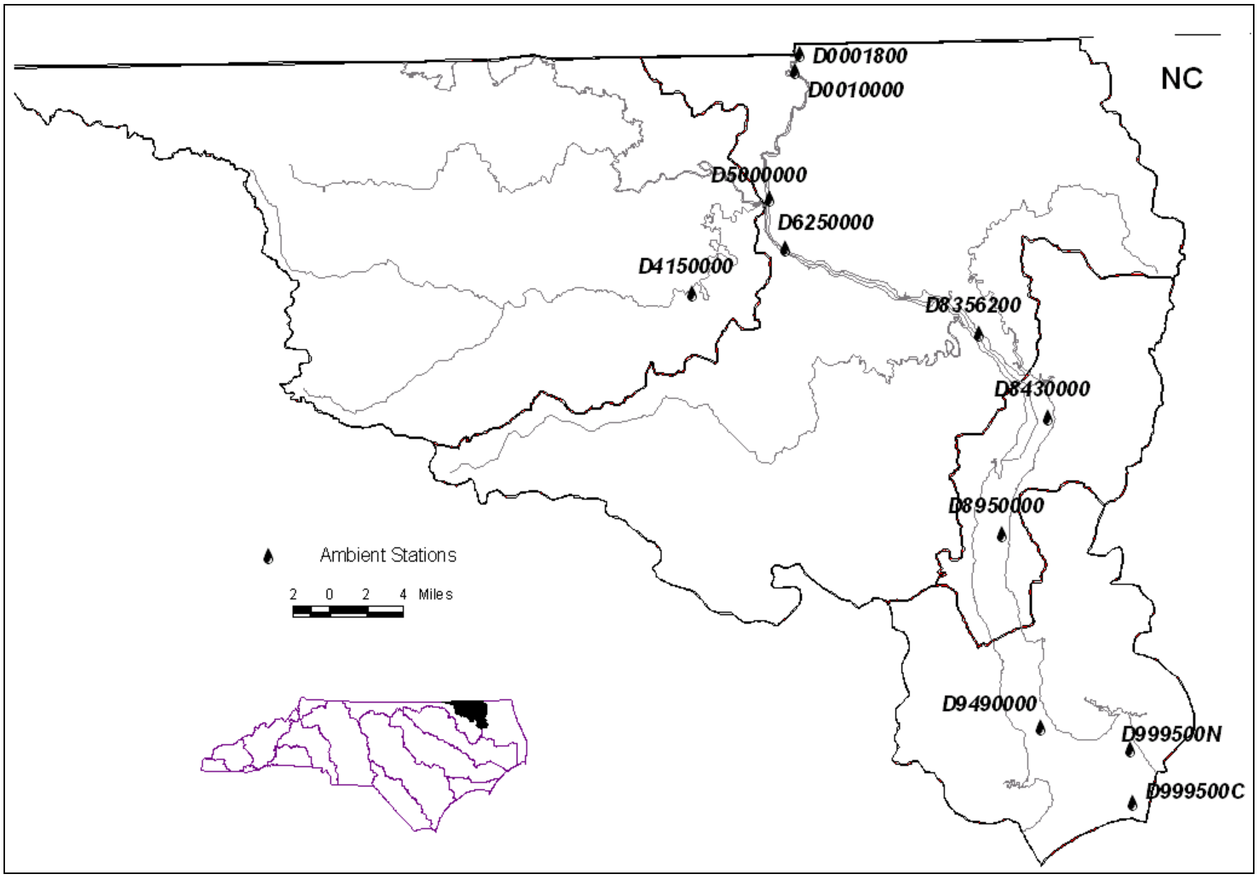



**Figure 30. Ambient monitoring system sites within the Chowan River basin.**

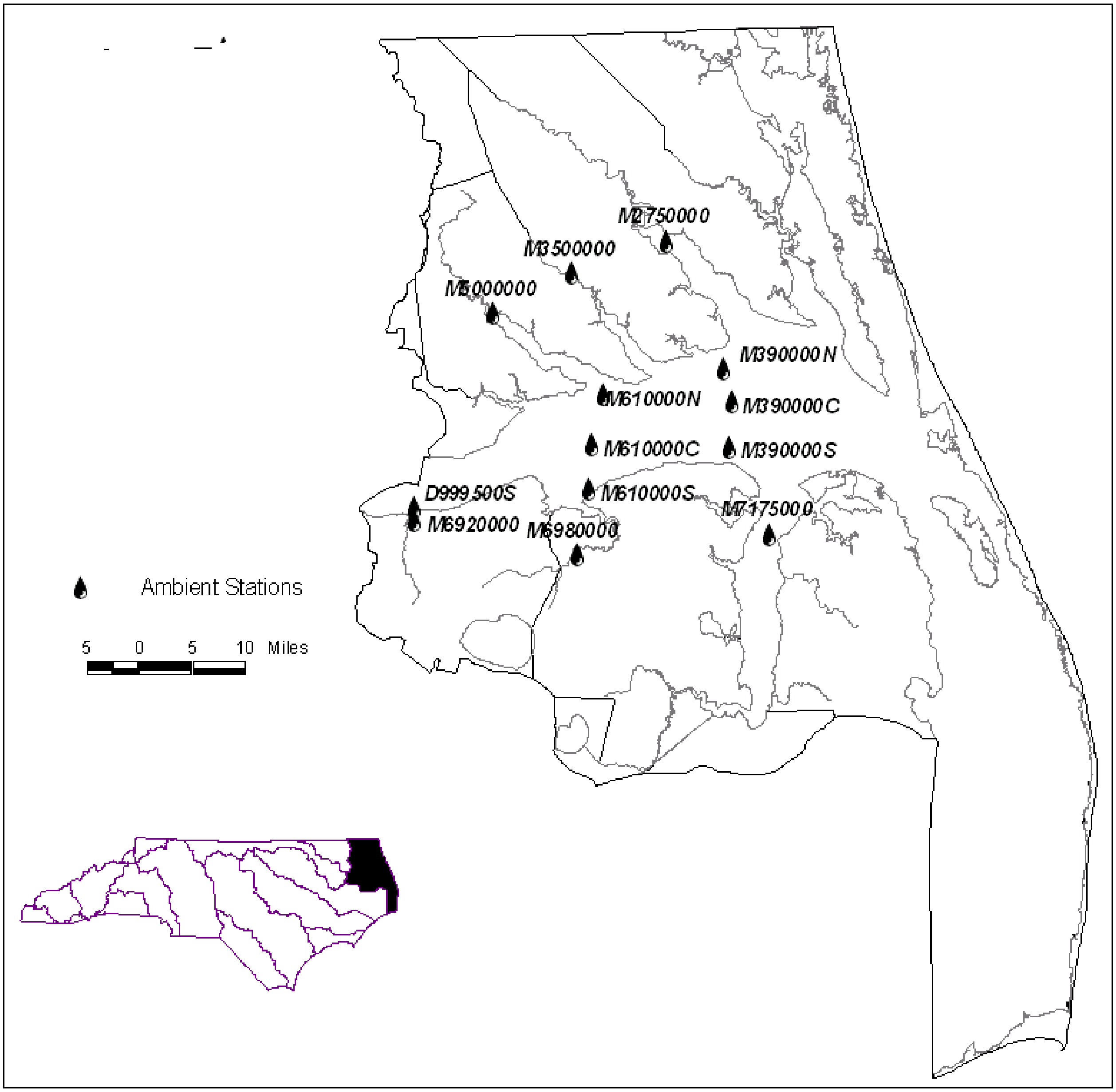



**Figure 31. Ambient monitoring system sites within the Pasquotank River basin.**

**DATA ASSESSMENT AND INTERPRETATION**

Data are summarized from those stations routinely monitored by NCDWQ as part of its ambient monitoring network. Generally, samples or measurements represent monthly sampling trips. Monitoring and sampling results considered in this report represent samples collected or measurements taken at less than one meter in depth to establish a consistent comparison across the basin. Median and percentile statistics (Tables 16 - 41) are calculated from all data; values less than the reporting level were evaluated as equal to the reporting level. Calculations were performed using Microsoft® Excel 2000. Graphs were made using SigmaPlot version 6.

**Analytical Considerations**

During this assessment period, three issues were noted as part of the analytical laboratory process:

- Laboratory or sampling related contamination may have produced higher than expected values of zinc between April 1995 and March 1999.
- Nitrogen and phosphorus results less than 0.05 mg/L and total Kjeldahl nitrogen results less than 1.0 mg/L did not meet desired

quality assurance measures. Neither the accuracy nor precision of those results is known.
- The analysis for chlorophyll *a* did not meet quality assurance measures and the data presented here have been corrected from estimated bias.

**Use Support Assessment Considerations**

- The daily average dissolved freshwater oxygen standard of 5.0 mg/L is presented as an evaluation level. Instantaneous values of 4.0 mg/L or less can occur and may be acceptable if caused by natural (e.g. swampy) conditions.
- Action level standards (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.
- The geometric mean was calculated for fecal coliform results for each station. This value was compared to 200 colonies/100 mL as an evaluation level. For an understanding of the fecal coliform standard and appropriate interpretation of results one should refer to the NC Administrative Code Section 15A NCAC 2B.0211(3)(e).

## DISCUSSION

### Flow -- Water Volume and Velocity

The volume and movement of water can influence many water quality parameters. Terrestrial runoff can carry significant amounts of sediment and various other pollutants in areas where land disturbing practices occur. The US Geological Survey (USGS) routinely measures flow using both automated gage sites and manual measurements funded by the NCDWQ and others.

The contribution of pollutants from non-point source is generally assumed to be greatest after rainfall events. Point source discharges tend to have their greatest relative influence during low stream flows where the instream waste concentration of the discharge is relatively greater. Periods of low flow, which frequently occur during summer months and hot weather, also reduce physical re-aeration of the water column. This factor, coupled with the reduced capacity for water to hold oxygen at higher temperatures, can result in conditions increasingly stressful to aquatic life.

Using the flow patterns since 1995 for Ahoskie Creek and the Pasquotank River as examples (Figure 32), low flows were most severe during the summers of 1995, 1998, and 1999. High flows resulted from the hurricanes of 1999 and continued for most of 2000.

### Dissolved Oxygen and pH

Swamp waters are expected to have low dissolved oxygen concentrations and low pH due to natural conditions. However, several stream segments not classified as "swamp waters" had more than 10 percent of their observations with less than 5.0 mg/L of dissolved oxygen. These sites are located on the Blackwater River, the Chowan River at Riddicksville, Potecasi Creek, and Kendricks Creek (Tables 17, 22, and 41; Figure 33). There are no stream segments classified as swamp waters (Sw) in the Chowan River basin. In the Pasquotank River basin, three monitoring stations are located in stream segments classified as swamp waters, but only the two freshwater stations (Scuppernong River and Little River) showed dissolved oxygen concentrations less than 4.0 mg/L for more than 10 percent of the observations (Tables 31 and 33).

All but two of the saltwater classified sites in the two basins had greater than 10 percent of pH values less than the standard of 6.8 s.u. This is likely due to the prevalence of wetlands in these basins. The pH at Perquimans River and Kendricks Creek showed more than 74 percent of the measurements were less than the lower standard of 6.8 s.u. (Tables 37 and 41). However, Kendricks Creek drains Pocosin Lakes and the Perquimans River drains a portion of the Great Dismal Swamp. Both Pocosin Lakes and the Dismal Swamp are extensive wetland areas and wetlands are common throughout these basins.

The majority of surface waters in the Chowan River and Pasquotank River basins, particularly lower order streams, could be regarded as having "blackwater" and swamp characteristics. These characteristics include highly colored organic humic materials resulting from drainage of decaying vegetation in wetlands. Both dissolved oxygen and pH can be influenced by these conditions. Slow moving (low reaeration) waterbodies draining swamps and wetlands with decaying vegetation produce high concentrations of dissolved organic carbon (humic acids), depress pH, and consume some of the already low dissolved oxygen concentrations. Methods to better characterize conditions that reflect these swamp conditions and to appropriately classify swamp waters need continued investigation.

**Turbidity and Total Suspended Solids**

Turbidity is a laboratory measurement for the ability of light to pass through a sample of water. It is an indicator for dissolved, colored materials, colloids, and suspended materials that inhibit light penetration. Depending on the cause(s) of increased turbidity, assumptions can be made about potential effects on benthic or planktonic algal communities by reduction of available light, and the potential for sediment deposition in a water body.

Both turbidity and total suspended solids (TSS) across the two basins remained fairly low (Figures 34 and 35). Potecasi Creek had the highest turbidities across both basins and among the highest for TSS (Table 22). A possible contributor to these characteristics is a housing development immediately upstream of the monitoring station.

**Metals**

In these two river basins, copper, iron and nickel often exceeded action levels. The seemingly high observations for nickel reflected that the minimum laboratory reporting level was greater than the action level. Iron can often be observed to exceed its action level, but iron is an element commonly found in soils and its natural occurrence may be responsible for this pattern. Concentrations of copper exceeded the freshwater action level (7.0 μg/L) and saltwater action level (3.0 μg/L) for more than 10 percent of the samples collected from two freshwater stations and all but one (n=11) saltwater station. Accurately measuring copper in salt water is difficult because other elements may interfere with the procedure.

Monitoring stations located in Potecasi Creek and the Chowan River at Edenhouse had more than 10 percent of the observations exceeding the action level for copper (Tables 22 and 26). However, median concentrations were very low (2 or 3 μg/L) at both stations.

**Fecal Coliform Bacteria**

Fecal coliform bacteria are the most commonly used indicator in North Carolina of the possible presence of pathogenic (disease causing) microorganisms in the water column. The water quality standards for fecal coliform bacteria can vary depending on the classification (e.g. water supply and Class C) of the waterbody. However, the language addressing fecal coliform concentrations in Class C waters [15A NCAC 02B .0211 (3)(e)] is applicable for all monitoring stations in the Chowan and Pasquotank basins. This language states: "*Organisms of coliform group: fecal coliforms [are] not to exceed geometric mean of 200/100 ml (MF count) based upon at least five consecutive samples examined during any 30 day period; not to exceed 400/100 ml 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*."

The strict application of this standard is often hindered because the monthly (circa 30 days) sampling frequency employed for ambient water quality monitoring usually does not provide more than one sample per 30-day period. However, problems can be discerned using monthly sampling (Tables 16 - 42; Figure 36). The geometric means for all stations were well below the 200 colonies/100ml reference level. Individual samples can exceed the reference level, but are often attributable to precipitation events.

**Nutrients**

Compounds of nitrogen and phosphorus are required for biological growth and are often found in concentrations that may limit or control the productivity algae in aquatic systems. Thus, as the availability of nutrients increase, there is often a concomitant increase in the amount of algae and other biota present in a body of water. This enrichment of an aquatic ecosystem is commonly referred to as eutrophication and can be a major water quality problem. Eutrophic conditions can be observed in natural systems, but human influences (cultural eutrophication) can produce or exacerbate water quality problems. Associated with an increase in the amount of organic matter (including nutrients), there can be an increase in the decomposition of dead organisms. The decomposition process requires oxygen from the water column which may decrease oxygen concentrations below limits necessary to support aquatic life such as fish. Thus, nutrient concentrations are watched closely.

The availability of nutrients to aquatic life is controlled by a variety of factors. Generally low concentrations of phosphorus limit biological productivity in freshwater systems. On the other hand, nitrogen is often the limiting nutrient in estuaries. The biological availability of nitrogen is largely dependent on the form of nitrogen.

The most eutrophic stations include the Pasquotank River, Scuppernong River, Little River, and Kendricks Creek - all located in the Pasquotank River basin (Tables 30, 31, 33, and 41; Figures 37 and 38). Elevated concentrations of all nutrients (ammonia nitrogen, total Kjeldahl nitrogen, nitrate+nitrite-nitrogen, and total phosphorus) occurred at these sites. Both the Little and the Scuppernong Rivers are classified as swamp waters and have high proportions of dissolved oxygen concentrations below 4.0 mg/L. A seasonal pattern was present for nitrate+nitrite-nitrogen which showed concentrations decreasing during the warmer months which coincided with increased biological activity.

**Chlorophyll *a***

Chlorophyll *a* is the primary photosynthetic pigment found in plants, including algae. Its concentration can be indicative of the amount of algae present in the water column. High concentrations may denote algal blooms and provide evidence of culturally eutrophic waters. The North Carolina water quality standard for chlorophyll a is 40 µg/L.

Concentrations of chlorophyll-*a* did not exceed this standard for more than 10 percent of the samples at any station (Table 43 and Figures 39 and 40). Overall, concentrations of chlorophyll a were low with 90 percent of the samples from the two basins less than 10 and 25 µg/L respectively (Figure 40). The largest concentration (190 µg/L) occurred in the Scuppernong River.

**Table 16. Summary of the water quality parameters from the Nottaway River at US 258 near Riverdale, VA (D0000050; Class II Estuarine – summarized as NC – Class B NSW) collected between September 19, 1995 and August 10, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 56 | na | <4 | 3 | 5.4 | 3.6 | 4.1 | 5.2 | 6.4 | 8.3 | 9.6 | 12.5 |
| (DO; mg/L) | | | <5 | 14 | 25.0 | . | . | . | . | . | . | . |
| Conductivity | 56 | na | . | . | . | 42 | 62 | 71 | 88 | 148 | 214 | 405 |
| Temperature (C) | 56 | na | . | . | . | 0 | 7 | 11 | 17 | 25 | 28 | 30 |
| pH (s.u.) | 56 | na | <6 | 1 | 1.8 | 5.7 | 6.4 | 6.5 | 6.6 | 6.8 | 7.0 | 7.3 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 54 | 3 | >10 | 2 | 3.7 | 1 | 1 | 1 | 2 | 3 | 5 | 17 |
| | | | >20 | 0 | 0.0 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Turbidity (NTU) | 58 | na | >50 | 0 | 0.0 | 2 | 3 | 4 | 5 | 7 | 12 | 22 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 7 | 12.1 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 58 | 10 | . | . | . | 0.01 | 0.01 | 0.02 | 0.04 | 0.07 | 0.09 | 0.37 |
| TKN as N | 58 | 0 | . | . | . | 0.20 | 0.20 | 0.30 | 0.40 | 0.40 | 0.60 | 0.80 |
| $NO_2$+$NO_3$ as N | 58 | 2 | >10 | 0 | 0.0 | 0.01 | 0.03 | 0.07 | 0.11 | 0.18 | 0.22 | 0.34 |
| Total Phosphorus | 58 | 0 | 0.05 | 43 | 74.1 | 0.01 | 0.04 | 0.05 | 0.06 | 0.07 | 0.09 | 0.13 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 59 | 0 | . | . | . | 71 | 120 | 170 | 260 | 425 | 942 | 1600 |
| Arsenic (As) | 59 | 59 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 59 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 59 | 59 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 59 | 27 | >7 | 4 | 6.8 | 2 | 2 | 2 | 2 | 3 | 6 | 20 |
| Iron (Fe) | 59 | 0 | >1000 | 36 | 61.0 | 320 | 528 | 730 | 1200 | 1500 | 1900 | 2300 |
| Lead (Pb) | 59 | 59 | >25 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Manganese (Mn) | 1 | 0 | >200 | 0 | 0.0 | 37 | 37 | 37 | 37 | 37 | 37 | 37 |
| Mercury (Hg) | 59 | 59 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 59 | 59 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 59 | 21 | >50 | 5 | 8.5 | 10 | 10 | 10 | 13 | 24 | 43 | 150 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 17.** **Summary of the water quality parameters from the Blackwater River at Horseshoe Bend at Cherry Grove, VA (D0001200; Class II Estuarine – summarized as NC – Class B NSW) collected between September 19, 1995 and August 10, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | Percentiles 25 | Percentiles 50 | Percentiles 75 | Percentiles 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 56 | na | <4 | 12 | 21.4 | 2.0 | 3.3 | 4.2 | 5.8 | 7.6 | 9.2 | 12.2 |
| (DO; mg/L) | | | <5 | 24 | 42.9 | . | . | . | . | . | . | . |
| Conductivity | 56 | na | . | . | . | 69 | 79 | 86 | 102 | 126 | 163 | 199 |
| Temperature (C) | 56 | na | . | . | . | 0 | 6 | 11 | 17 | 25 | 27 | 30 |
| pH (s.u.) | 55 | na | <6 | 1 | 1.8 | 5.8 | 6.2 | 6.4 | 6.5 | 6.6 | 6.8 | 6.9 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 53 | 1 | >10 | 2 | 3.8 | 1 | 1 | 1 | 2 | 3 | 5 | 24 |
| | | | >20 | 1 | 1.9 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Turbidity (NTU) | 57 | na | >50 | 0 | 0.0 | 2 | 3 | 3 | 5 | 7 | 10 | 28 |
| | | | >25 | 1 | 1.8 | . | . | . | . | . | . | . |
| | | | >10 | 6 | 10.5 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 57 | 10 | . | . | . | 0.01 | 0.01 | 0.02 | 0.05 | 0.08 | 0.12 | 0.53 |
| TKN as N | 56 | 0 | . | . | . | 0.30 | 0.30 | 0.40 | 0.40 | 0.50 | 0.70 | 2.50 |
| $NO_2$+$NO_3$ as N | 56 | 0 | >10 | 0 | 0.0 | 0.04 | 0.10 | 0.16 | 0.24 | 0.31 | 0.40 | 0.63 |
| Total Phosphorus | 56 | 0 | 0.05 | 36 | 64.3 | 0.01 | 0.03 | 0.05 | 0.06 | 0.08 | 0.09 | 0.13 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 58 | 0 | . | . | . | 84 | 117 | 173 | 255 | 425 | 620 | 1300 |
| Arsenic (As) | 58 | 58 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 58 | 0 | >2 | 1 | 1.7 | 2 | 2 | 2 | 2 | 2 | 2 | 5 |
| Chromium (Cr) | 58 | 58 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 58 | 27 | >7 | 4 | 6.9 | 2 | 2 | 2 | 2 | 3 | 6 | 150 |
| Iron (Fe) | 58 | 0 | >1000 | 40 | 69.0 | 430 | 707 | 933 | 1400 | 1875 | 2200 | 3200 |
| Lead (Pb) | 58 | 58 | >25 | 1 | 1.7 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 58 | 58 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 57 | 57 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 57 | 12 | >50 | 4 | 7.0 | 10 | 10 | 10 | 15 | 24 | 41 | 95 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 18.** **Summary of the water quality parameters from the Blackwater River 150 yards upstream from the mouth near Wyanoke (D0001800; Class B NSW) collected between September 19, 1995 and August 10, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 55 | na | <4 | 12 | 21.8 | 2.9 | 3.3 | 4.2 | 6.0 | 7.6 | 8.5 | 11.1 |
| (DO; mg/L) | | | <5 | 20 | 36.4 | . | . | . | . | . | . | . |
| Conductivity | 55 | na | . | . | . | 69 | 82 | 88 | 114 | 170 | 248 | 634 |
| Temperature (C) | 55 | na | . | . | . | 0 | 7 | 11 | 17 | 25 | 27 | 30 |
| pH (s.u.) | 55 | na | <6 | 1 | 1.8 | 5.8 | 6.3 | 6.4 | 6.6 | 6.8 | 7.0 | 7.3 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | |
| TSS | 51 | 2 | >10 | 0 | 0.0 | 1 | 1 | 1 | 2 | 3 | 5 | 8 |
| | | | >20 | 0 | 0.0 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | |
| Turbidity (NTU) | 56 | na | >50 | 0 | 0.0 | 2 | 3 | 3 | 5 | 7 | 8 | 19 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 4 | 7.1 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 58 | 0 | . | . | . | 0.01 | 0.01 | 0.02 | 0.05 | 0.08 | 0.15 | 0.54 |
| TKN as N | 57 | 0 | . | . | . | 0.20 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 1.10 |
| $NO_2$+$NO_3$ as N | 57 | 0 | >10 | 0 | 0.0 | 0.01 | 0.07 | 0.15 | 0.22 | 0.32 | 0.45 | 0.62 |
| Total Phosphorus | 57 | 0 | >0.05 | 45 | 78.9 | 0.01 | 0.05 | 0.06 | 0.07 | 0.09 | 0.15 | 0.48 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 59 | 0 | . | . | . | 100 | 136 | 170 | 250 | 400 | 538 | 1400 |
| Arsenic (As) | 59 | 59 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 59 | 0 | >2 | 1 | 1.7 | 2 | 2 | 2 | 2 | 2 | 2 | 4 |
| Chromium (Cr) | 59 | 58 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 59 | 32 | >7 | 2 | 3.4 | 2 | 2 | 2 | 2 | 3 | 6 | 26 |
| Iron (Fe) | 59 | 0 | >1000 | 37 | 62.7 | 450 | 662 | 780 | 1400 | 1700 | 2000 | 2300 |
| Lead (Pb) | 59 | 59 | >25 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | |
| Mercury (Hg) | 59 | 59 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 59 | 59 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 59 | 12 | >50 | 2 | 3.4 | 10 | 10 | 11 | 15 | 19 | 30 | 67 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 19. Summary of the water quality parameters from the Chowan River near Riddicksville (D0010000; Class B NSW) collected between September 19, 1995 and August 10, 2000.**

| | | Num. | Eval. | < or > Eval. Level | | | Percentiles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **N** | **< R.L.** | **Level** | **n** | **%** | **Min.** | **10** | **25** | **50** | **75** | **90** | **Max.** |
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 56 | na | <4 | 8 | 14.3 | 2.7 | 3.6 | 4.6 | 6.2 | 7.9 | 9.1 | 11.6 |
| (DO; mg/L) | | | <5 | 19 | 33.9 | . | . | . | . | . | . | . |
| Conductivity | 56 | na | . | . | . | 57 | 74 | 82 | 113 | 175 | 237 | 428 |
| Temperature (C) | 56 | na | . | . | . | 0 | 7 | 10 | 17 | 25 | 27 | 30 |
| pH (s.u.) | 55 | na | <6 | 1 | 1.8 | 5.8 | 6.3 | 6.4 | 6.6 | 6.8 | 7.0 | 7.3 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 56 | 3 | >10 | 1 | 1.8 | 1 | 1 | 1 | 2 | 4 | 6 | 18 |
| | | | >20 | 0 | 0.0 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Turbidity (NTU) | 57 | na | >50 | 0 | 0.0 | 2 | 3 | 4 | 5 | 7 | 11 | 23 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 6 | 10.5 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 58 | 0 | . | . | . | 0.01 | 0.01 | 0.02 | 0.04 | 0.07 | 0.13 | 0.46 |
| TKN as N | 58 | 0 | . | . | . | 0.20 | 0.20 | 0.30 | 0.40 | 0.50 | 0.70 | 1.00 |
| $NO_2$+$NO_3$ as N | 58 | 0 | >10 | 0 | 0.0 | 0.01 | 0.05 | 0.09 | 0.16 | 0.22 | 0.28 | 0.44 |
| Total Phosphorus | 58 | 0 | >0.05 | 47 | 81.0 | 0.03 | 0.05 | 0.06 | 0.07 | 0.09 | 0.12 | 0.35 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 58 | 0 | . | . | . | 68 | 120 | 170 | 290 | 435 | 778 | 1900 |
| Arsenic (As) | 58 | 58 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 58 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 58 | 58 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 58 | 20 | >7 | 4 | 6.9 | 2 | 2 | 2 | 2 | 4 | 6 | 25 |
| Iron (Fe) | 58 | 0 | >1000 | 37 | 63.8 | 180 | 620 | 783 | 1200 | 1600 | 1930 | 2300 |
| Lead (Pb) | 58 | 58 | >25 | 1 | 1.7 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 58 | 58 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 58 | 58 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 58 | 21 | >50 | 3 | 5.2 | 10 | 10 | 10 | 15 | 22 | 37 | 78 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 20.** **Summary of the water quality parameters from the Chowan River at US 13 at Winton (D6250000; Class B NSW) collected between September 19, 1995 and August 10, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 52 | na | <4 | 4 | 7.7 | 2.9 | 4.2 | 5.9 | 7.2 | 8.2 | 9.3 | 12.6 |
| (DO; mg/L) | | | <5 | 9 | 17.3 | . | . | . | . | . | . | . |
| Conductivity | 52 | na | . | . | . | 49 | 69 | 78 | 89 | 111 | 153 | 305 |
| Temperature (C) | 52 | na | . | . | . | 0 | 7 | 10 | 17 | 24 | 27 | 30 |
| pH (s.u.) | 51 | na | <6 | 2 | 3.9 | 5.5 | 6.3 | 6.4 | 6.6 | 6.9 | 7.2 | 110.0 |
| | | | >9 | 1 | 2.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 52 | 3 | >10 | 0 | 0.0 | 1 | 1 | 1 | 2 | 3 | 5 | 7 |
| | | | >20 | 0 | 0.0 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Turbidity (NTU) | 57 | na | >50 | 0 | 0.0 | 2 | 4 | 5 | 6 | 10 | 14 | 43 |
| | | | >25 | 2 | 3.5 | . | . | . | . | . | . | . |
| | | | >10 | 14 | 24.6 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 58 | 0 | . | . | . | 0.01 | 0.01 | 0.03 | 0.05 | 0.08 | 0.12 | 0.26 |
| TKN as N | 58 | 0 | . | . | . | 0.10 | 0.30 | 0.30 | 0.40 | 0.50 | 0.63 | 0.80 |
| $NO_2$+$NO_3$ as N | 58 | 0 | >10 | 0 | 0.0 | 0.01 | 0.08 | 0.10 | 0.16 | 0.20 | 0.25 | 0.38 |
| Total Phosphorus | 58 | 0 | >0.05 | 44 | 75.9 | 0.03 | 0.05 | 0.06 | 0.07 | 0.08 | 0.11 | 0.13 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 58 | 0 | . | . | . | 120 | 157 | 250 | 365 | 530 | 976 | 2600 |
| Arsenic (As) | 58 | 58 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 58 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 58 | 58 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 58 | 26 | >7 | 5 | 8.6 | 2 | 2 | 2 | 2 | 3 | 7 | 27 |
| Iron (Fe) | 58 | 0 | >1000 | 41 | 70.7 | 660 | 824 | 993 | 1350 | 1700 | 1900 | 2700 |
| Lead (Pb) | 58 | 58 | >25 | 1 | 1.7 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 58 | 58 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 58 | 57 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 23 |
| Zinc (Zn) | 58 | 20 | >50 | 5 | 8.6 | 10 | 10 | 10 | 15 | 24 | 43 | 100 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 21. Summary of the water quality parameters from the Chowan River at Channel Marker 16 near Gatesville (D8356200; Class B NSW) collected between September 19, 1995 and August 09, 2000.**

| | | Num. | Eval. | < or > Eval. Level | | | Percentiles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **N** | **< R.L.** | **Level** | **n** | **%** | **Min.** | **10** | **25** | **50** | **75** | **90** | **Max.** |
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 56 | na | <4 | 2 | 3.6 | 3.1 | 5.4 | 6.0 | 7.4 | 8.6 | 9.3 | 12.6 |
| (DO; mg/L) | | | <5 | 3 | 5.4 | . | . | . | . | . | . | . |
| Conductivity | 56 | na | . | . | . | 49 | 67 | 71 | 88 | 123 | 177 | 2251 |
| Temperature (C) | 56 | na | . | . | . | 2 | 7 | 11 | 18 | 26 | 29 | 31 |
| pH (s.u.) | 56 | na | <6 | 0 | 0.0 | 6.0 | 6.3 | 6.5 | 6.7 | 7.0 | 7.2 | 7.5 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 52 | 1 | >10 | 1 | 1.9 | 1 | 1 | 1 | 3 | 4 | 5 | 12 |
| | | | >20 | 0 | 0.0 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Turbidity (NTU) | 57 | na | >50 | 0 | 0.0 | 2 | 4 | 5 | 6 | 9 | 12 | 32 |
| | | | >25 | 1 | 1.8 | . | . | . | . | . | . | . |
| | | | >10 | 8 | 14.0 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 56 | 0 | . | . | . | 0.01 | 0.01 | 0.03 | 0.06 | 0.09 | 0.11 | 0.29 |
| TKN as N | 56 | 0 | . | . | . | 0.20 | 0.30 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 |
| $NO_2$+$NO_3$ as N | 57 | 0 | >10 | 0 | 0.0 | 0.01 | 0.01 | 0.04 | 0.12 | 0.20 | 0.24 | 0.39 |
| Total Phosphorus | 56 | 1 | >0.05 | 38 | 67.9 | 0.01 | 0.04 | 0.05 | 0.07 | 0.09 | 0.10 | 0.15 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 57 | 0 | . | . | . | 77 | 160 | 250 | 370 | 580 | 994 | 1500 |
| Arsenic (As) | 57 | 57 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Cadmium (Cd) | 57 | 0 | >2 | 1 | 1.8 | 2 | 2 | 2 | 2 | 2 | 2 | 10 |
| Chromium (Cr) | 57 | 57 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 57 | 22 | >7 | 4 | 7.0 | 2 | 2 | 2 | 3 | 4 | 6 | 34 |
| Iron (Fe) | 57 | 0 | >1000 | 42 | 73.7 | 460 | 830 | 1000 | 1300 | 1600 | 1900 | 2600 |
| Lead (Pb) | 57 | 57 | >25 | 1 | 1.8 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 57 | 57 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 57 | 56 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 47 |
| Zinc (Zn) | 57 | 19 | >50 | 2 | 3.5 | 10 | 10 | 10 | 15 | 24 | 35 | 250 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 22. Summary of the water quality parameters from Potecasi Creek at NC 11 near Union (D4150000; Class C NSW) collected between September 25, 1995 and August 24, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 41 | na | <4 | 12 | 29.3 | 2.3 | 3.1 | 3.9 | 5.5 | 8.2 | 10.3 | 12.5 |
| (DO; mg/L) | | | <5 | 16 | 39.0 | . | . | . | . | . | . | . |
| Conductivity | 41 | na | . | . | . | 42 | 58 | 66 | 80 | 109 | 112 | 133 |
| Temperature (C) | 42 | na | . | . | . | 2 | 5 | 10 | 16 | 20 | 23 | 56 |
| pH (s.u.) | 41 | na | <6 | 2 | 4.9 | 5.6 | 6.1 | 6.2 | 6.4 | 6.6 | 6.7 | 8.7 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 56 | 1 | >10 | 11 | 19.6 | 1 | 1 | 2 | 5 | 8 | 25 | 220 |
| | | | >20 | 7 | 12.5 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Turbidity (NTU) | 56 | na | >50 | 6 | 10.7 | 6 | 7 | 10 | 16 | 20 | 51 | 634 |
| | | | >25 | 10 | 17.9 | . | . | . | . | . | . | . |
| | | | >10 | 40 | 71.4 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 56 | 0 | . | . | . | 0.01 | 0.01 | 0.02 | 0.06 | 0.11 | 0.15 | 0.38 |
| TKN as N | 56 | 0 | . | . | . | 0.20 | 0.30 | 0.40 | 0.50 | 0.60 | 0.70 | 1.00 |
| $NO_2$+$NO_3$ as N | 56 | 0 | >10 | 0 | 0.0 | 0.01 | 0.02 | 0.05 | 0.12 | 0.18 | 0.36 | 0.50 |
| Total Phosphorus | 56 | 0 | >0.05 | 55 | 98.2 | 0.03 | 0.07 | 0.08 | 0.11 | 0.14 | 0.16 | 0.54 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 56 | 0 | . | . | . | 51 | 160 | 388 | 745 | 1800 | 4200 | 50000 |
| Arsenic (As) | 56 | 56 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 56 | 0 | >2 | 1 | 1.8 | 2 | 2 | 2 | 2 | 2 | 2 | 8 |
| Chromium (Cr) | 56 | 56 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 56 | 18 | >7 | 6 | 10.7 | 2 | 2 | 2 | 3 | 5 | 8 | 14 |
| Iron (Fe) | 56 | 0 | >1000 | 54 | 96.4 | 220 | 1600 | 1900 | 2650 | 3525 | 4150 | 24000 |
| Lead (Pb) | 56 | 54 | >25 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 15 |
| Manganese (Mn) | 1 | 0 | >200 | 0 | 0.0 | 56 | 56 | 56 | 56 | 56 | 56 | 56 |
| Mercury (Hg) | 56 | 56 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 56 | 56 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 56 | 12 | >50 | 5 | 8.9 | 10 | 10 | 11 | 16 | 27 | 43 | 120 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 23. Summary of the water quality parameters from the Meherrin River at SR 1175 near Com (D5000000; Class B NSW) collected between September 19, 1995 and August 10, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 57 | na | <4 | 5 | 8.8 | 2.9 | 4.1 | 5.1 | 6.9 | 8.1 | 9.7 | 12.6 |
| (DO; mg/L) | | | <5 | 14 | 24.6 | . | . | . | . | . | . | . |
| Conductivity | 57 | na | . | . | . | 48 | 62 | 69 | 77 | 91 | 111 | 258 |
| Temperature (C) | 57 | na | . | . | . | 0 | 7 | 11 | 17 | 25 | 27 | 30 |
| pH (s.u.) | 55 | na | <6 | 3 | 5.5 | 3.3 | 6.2 | 6.5 | 6.6 | 6.8 | 7.0 | 7.2 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 54 | 0 | >10 | 3 | 5.6 | 1 | 1 | 2 | 3 | 5 | 9 | 345 |
| | | | >20 | 1 | 1.9 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Turbidity (NTU) | 58 | na | >50 | 0 | 0.0 | 2 | 4 | 6 | 7 | 13 | 19 | 45 |
| | | | >25 | 4 | 6.9 | . | . | . | . | . | . | . |
| | | | >10 | 19 | 32.8 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 59 | 0 | . | . | . | 0.01 | 0.01 | 0.01 | 0.04 | 0.08 | 0.12 | 0.37 |
| TKN as N | 59 | 0 | . | . | . | 0.20 | 0.20 | 0.30 | 0.40 | 0.40 | 0.60 | 1.00 |
| $NO_2$+$NO_3$ as N | 59 | 0 | >10 | 0 | 0.0 | 0.01 | 0.06 | 0.11 | 0.17 | 0.22 | 0.28 | 0.39 |
| Total Phosphorus | 59 | 0 | >0.05 | 36 | 61.0 | 0.02 | 0.04 | 0.05 | 0.06 | 0.07 | 0.09 | 0.23 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 59 | 0 | . | . | . | 100 | 130 | 210 | 420 | 585 | 1220 | 3400 |
| Arsenic (As) | 59 | 59 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 59 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 59 | 59 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 59 | 23 | >7 | 2 | 3.4 | 2 | 2 | 2 | 2 | 3 | 6 | 14 |
| Iron (Fe) | 59 | 0 | >1000 | 46 | 78.0 | 570 | 826 | 1150 | 1400 | 1900 | 2200 | 3200 |
| Lead (Pb) | 59 | 59 | >25 | 1 | 1.7 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 59 | 59 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 59 | 59 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 59 | 22 | >50 | 3 | 5.1 | 10 | 10 | 10 | 12 | 23 | 36 | 77 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 24.** **Summary of the water quality parameters from the Chowan River 200 yards downstream from Holiday Island (D8430000; Class B NSW) collected between September 19, 1995 and August 09, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | Percentiles 25 | Percentiles 50 | Percentiles 75 | Percentiles 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 55 | na | <4 | 0 | 0.0 | 4.2 | 5.7 | 6.7 | 7.9 | 9.2 | 10.1 | 12.6 |
| (DO; mg/L) | | | <5 | 2 | 3.6 | . | . | . | . | . | . | . |
| Conductivity | 55 | na | . | . | . | 50 | 66 | 75 | 90 | 121 | 351 | 2710 |
| Temperature (C) | 55 | na | . | . | . | 2 | 8 | 11 | 18 | 26 | 29 | 31 |
| pH (s.u.) | 55 | na | <6 | 0 | 0.0 | 6.2 | 6.4 | 6.5 | 6.8 | 7.0 | 7.3 | 8.2 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 52 | 3 | >10 | 2 | 3.8 | 1 | 1 | 1 | 2 | 3 | 5 | 15 |
| | | | >20 | 0 | 0.0 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Turbidity (NTU) | 57 | na | >50 | 0 | 0.0 | 1 | 3 | 4 | 6 | 9 | 15 | 42 |
| | | | >25 | 2 | 3.5 | . | . | . | . | . | . | . |
| | | | >10 | 10 | 17.5 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 57 | 0 | . | . | . | 0.01 | 0.01 | 0.03 | 0.05 | 0.08 | 0.13 | 0.37 |
| TKN as N | 57 | 0 | . | . | . | 0.20 | 0.30 | 0.30 | 0.40 | 0.50 | 0.60 | 0.90 |
| $NO_2$+$NO_3$ as N | 57 | 0 | >10 | 0 | 0.0 | 0.01 | 0.02 | 0.06 | 0.14 | 0.20 | 0.25 | 0.41 |
| Total Phosphorus | 57 | 1 | >0.05 | 40 | 70.2 | 0.01 | 0.03 | 0.04 | 0.06 | 0.08 | 0.09 | 0.15 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 58 | 0 | . | . | . | 54 | 177 | 233 | 415 | 623 | 873 | 1600 |
| Arsenic (As) | 58 | 58 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 58 | 0 | >2 | 1 | 1.7 | 2 | 2 | 2 | 2 | 2 | 2 | 10 |
| Chromium (Cr) | 58 | 57 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 58 | 22 | >7 | 5 | 8.6 | 2 | 2 | 2 | 2 | 4 | 7 | 24 |
| Iron (Fe) | 58 | 0 | >1000 | 39 | 67.2 | 160 | 855 | 975 | 1200 | 1575 | 1830 | 2700 |
| Lead (Pb) | 58 | 58 | >25 | 1 | 1.7 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 1 | 0 | >200 | 0 | 0.0 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |
| Mercury (Hg) | 58 | 58 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 58 | 57 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 35 |
| Zinc (Zn) | 58 | 21 | >50 | 2 | 3.4 | 10 | 10 | 10 | 14 | 24 | 39 | 210 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 25.** **Summary of the water quality parameters from the Chowan River at Colerain (D8950000; Class B NSW) collected between September 20, 1995 and August 09, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 53 | na | <4 | 0 | 0.0 | 5.3 | 6.9 | 7.6 | 8.4 | 9.8 | 10.5 | 12.8 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 52 | na | . | . | . | 52 | 72 | 81 | 101 | 152 | 344 | 3478 |
| Temperature (C) | 53 | na | . | . | . | 2 | 7 | 11 | 19 | 25 | 29 | 32 |
| pH (s.u.) | 53 | na | <6 | 0 | 0.0 | 6.2 | 6.5 | 6.7 | 6.9 | 7.2 | 7.5 | 8.6 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 51 | 0 | >10 | 0 | 0.0 | 1 | 1 | 1 | 2 | 2 | 4 | 6 |
| | | | >20 | 0 | 0.0 | | | | | | | |
| Chloride | 22 | 0 | . | . | . | 6 | 8 | 10 | 14 | 20 | 28 | 100 |
| Turbidity (NTU) | 56 | na | >50 | 0 | 0.0 | 1 | 3 | 4 | 5 | 8 | 11 | 19 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 8 | 14.3 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 56 | 0 | . | . | . | 0.01 | 0.01 | 0.03 | 0.04 | 0.08 | 0.14 | 0.60 |
| TKN as N | 56 | 0 | . | . | . | 0.10 | 0.30 | 0.30 | 0.40 | 0.50 | 0.55 | 0.90 |
| $NO_2$+$NO_3$ as N | 56 | 0 | >10 | 0 | 0.0 | 0.01 | 0.01 | 0.04 | 0.13 | 0.19 | 0.25 | 0.43 |
| Total Phosphorus | 57 | 1 | >0.05 | 34 | 59.6 | 0.01 | 0.04 | 0.05 | 0.06 | 0.08 | 0.10 | 0.13 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 57 | 1 | . | . | . | 50 | 136 | 200 | 350 | 510 | 746 | 1400 |
| Arsenic (As) | 57 | 57 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 57 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 57 | 57 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 57 | 27 | >7 | 5 | 8.8 | 2 | 2 | 2 | 2 | 3 | 6 | 25 |
| Iron (Fe) | 57 | 0 | >1000 | 30 | 52.6 | 100 | 668 | 860 | 1100 | 1300 | 1700 | 3300 |
| Lead (Pb) | 57 | 57 | >25 | 1 | 1.8 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 56 | 56 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 57 | 57 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 57 | 17 | >50 | 5 | 8.8 | 10 | 10 | 10 | 14 | 26 | 47 | 190 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 26. Summary of the water quality parameters from the Chowan River at Edenhouse (D9490000; Class B NSW) collected between September 20, 1995 and August 09, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 56 | na | <4 | 0 | 0.0 | 6.7 | 7.5 | 7.8 | 8.8 | 10.1 | 10.8 | 13.3 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 56 | na | . | . | . | 59 | 76 | 84 | 117 | 560 | 1938 | 5633 |
| Temperature (C) | 56 | na | . | . | . | 3 | 8 | 11 | 18 | 25 | 29 | 32 |
| pH (s.u.) | 56 | na | <6 | 0 | 0.0 | 6.2 | 6.7 | 7.0 | 7.2 | 7.5 | 7.9 | 8.4 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 52 | 1 | >10 | 0 | 0.0 | 1 | 1 | 1 | 2 | 3 | 4 | 7 |
| | | | >20 | 0 | 0.0 | | | | | | | |
| Chloride | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Turbidity (NTU) | 57 | na | >50 | 0 | 0.0 | 1 | 3 | 3 | 5 | 6 | 11 | 15 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 7 | 12.3 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 58 | 0 | . | . | . | 0.01 | 0.01 | 0.01 | 0.04 | 0.07 | 0.10 | 0.37 |
| TKN as N | 58 | 0 | . | . | . | 0.10 | 0.20 | 0.30 | 0.40 | 0.40 | 0.60 | 0.70 |
| $NO_2$+$NO_3$ as N | 58 | 0 | >10 | 0 | 0.0 | 0.01 | 0.01 | 0.03 | 0.12 | 0.21 | 0.27 | 0.48 |
| Total Phosphorus | 58 | 0 | >0.05 | 30 | 51.7 | 0.01 | 0.02 | 0.04 | 0.06 | 0.07 | 0.08 | 0.10 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 58 | 1 | . | . | . | 50 | 144 | 190 | 315 | 525 | 737 | 1300 |
| Arsenic (As) | 58 | 58 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 58 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 58 | 58 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 58 | 22 | >7 | 9 | 15.5 | 2 | 2 | 2 | 2 | 4 | 9 | 37 |
| Iron (Fe) | 58 | 0 | >1000 | 24 | 41.4 | 50 | 384 | 640 | 885 | 1200 | 1400 | 1700 |
| Lead (Pb) | 58 | 58 | >25 | 1 | 1.7 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 1 | 0 | >200 | 0 | 0.0 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| Mercury (Hg) | 58 | 58 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 58 | 57 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 14 |
| Zinc (Zn) | 58 | 20 | >50 | 5 | 8.6 | 10 | 10 | 10 | 13 | 25 | 39 | 190 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 27.** **Summary of the water quality parameters from the Albemarle Sound near Edenton, mid channel (D999500C; Class B NSW) collected between September 20, 1995 and August 08, 2000.**

| | | Num. | Eval. | < or > Eval. Level | | | Percentiles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **N** | **< R.L.** | **Level** | **n** | **%** | **Min.** | **10** | **25** | **50** | **75** | **90** | **Max.** |
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 55 | na | <4 | 0 | 0.0 | 6.7 | 7.5 | 8.0 | 9.1 | 10.5 | 11.3 | 12.2 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 55 | na | . | . | . | 89 | 94 | 106 | 156 | 1248 | 3277 | 6539 |
| Temperature (C) | 55 | na | . | . | . | 4 | 8 | 11 | 18 | 25 | 28 | 29 |
| pH (s.u.) | 55 | na | <6 | 0 | 0.0 | 6.1 | 6.8 | 7.1 | 7.3 | 7.5 | 7.7 | 8.6 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 51 | 0 | >10 | 4 | 7.8 | 1 | 1 | 2 | 4 | 5 | 8 | 24 |
| | | | >20 | 1 | 2.0 | | | | | | | |
| Chloride | 41 | 0 | . | . | . | 6 | 8 | 11 | 44 | 400 | 1100 | 1800 |
| Turbidity (NTU) | 51 | na | >50 | 0 | 0.0 | 1 | 2 | 3 | 4 | 6 | 12 | 22 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 6 | 11.8 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 36 | 0 | . | . | . | 0.01 | 0.01 | 0.02 | 0.04 | 0.06 | 0.13 | 0.24 |
| TKN as N | 36 | 0 | . | . | . | 0.20 | 0.20 | 0.28 | 0.35 | 0.40 | 0.40 | 0.70 |
| $NO_2$+$NO_3$ as N | 36 | 0 | >10 | 0 | 0.0 | 0.01 | 0.02 | 0.06 | 0.15 | 0.21 | 0.27 | 0.38 |
| Total Phosphorus | 36 | 0 | >0.05 | 11 | 30.6 | 0.01 | 0.02 | 0.03 | 0.05 | 0.06 | 0.07 | 0.08 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 35 | 0 | . | . | . | 51 | 93 | 170 | 240 | 400 | 516 | 1100 |
| Arsenic (As) | 35 | 34 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Cadmium (Cd) | 35 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 35 | 35 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 35 | 22 | >7 | 2 | 5.7 | 2 | 2 | 2 | 2 | 3 | 4 | 37 |
| Iron (Fe) | 35 | 0 | >1000 | 6 | 17.1 | 63 | 230 | 470 | 630 | 940 | 1260 | 1400 |
| Lead (Pb) | 35 | 35 | >25 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 35 | 35 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 35 | 35 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 35 | 19 | >50 | 2 | 5.7 | 10 | 10 | 10 | 10 | 19 | 38 | 200 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 28. Summary of the water quality parameters from the Albemarle Sound near Edenton, north shore (D999500N; Class B NSW) collected between September 20, 1995 and August 08, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 47 | na | <4 | 1 | 2.1 | 1.0 | 7.2 | 7.9 | 8.7 | 10.3 | 11.0 | 12.2 |
| (DO; mg/L) | | | <5 | 1 | 2.1 | . | . | . | . | . | . | . |
| Conductivity | 47 | na | . | . | . | 85 | 99 | 111 | 261 | 1629 | 2687 | 8480 |
| Temperature (C) | 47 | na | . | . | . | 5 | 9 | 11 | 18 | 25 | 29 | 30 |
| pH (s.u.) | 47 | na | <6 | 1 | 2.1 | 1.0 | 6.6 | 7.0 | 7.2 | 7.5 | 7.8 | 8.5 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 49 | 1 | >10 | 3 | 6.1 | 1 | 1 | 2 | 2 | 5 | 7 | 63 |
| | | | >20 | 1 | 2.0 | | | | | | | |
| Chloride | 42 | 0 | . | . | . | 6 | 8 | 10 | 53 | 223 | 831 | 1900 |
| Turbidity (NTU) | 52 | na | >50 | 0 | 0.0 | 1 | 2 | 3 | 4 | 7 | 14 | 27 |
| | | | >25 | 1 | 1.9 | . | . | . | . | . | . | . |
| | | | >10 | 8 | 15.4 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 36 | 0 | . | . | . | 0.01 | 0.01 | 0.03 | 0.05 | 0.10 | 0.16 | 0.35 |
| TKN as N | 36 | 0 | . | . | . | 0.10 | 0.20 | 0.28 | 0.40 | 0.40 | 0.40 | 0.90 |
| $NO_2$+$NO_3$ as N | 36 | 0 | >10 | 0 | 0.0 | 0.01 | 0.01 | 0.05 | 0.13 | 0.20 | 0.28 | 0.36 |
| Total Phosphorus | 36 | 1 | >0.05 | 12 | 33.3 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 0.08 | 0.09 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 36 | 0 | . | . | . | 50 | 66 | 150 | 225 | 433 | 560 | 1100 |
| Arsenic (As) | 36 | 36 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Cadmium (Cd) | 36 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 36 | 36 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 36 | 16 | >7 | 2 | 5.6 | 2 | 2 | 2 | 2 | 4 | 6 | 36 |
| Iron (Fe) | 36 | 0 | >1000 | 7 | 19.4 | 61 | 210 | 440 | 670 | 1000 | 1250 | 1400 |
| Lead (Pb) | 36 | 36 | >25 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 36 | 36 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 36 | 35 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 20 |
| Zinc (Zn) | 36 | 19 | >50 | 1 | 2.8 | 10 | 10 | 10 | 10 | 19 | 40 | 53 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 29. Summary of the water quality parameters from the Albemarle Sound near Edenton, south shore (D999500S; Class SB) collected between September 20, 1995 and August 08, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 55 | na | <4 | 0 | 0.0 | 6.9 | 7.4 | 8.1 | 8.9 | 10.2 | 10.8 | 11.8 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 55 | na | . | . | . | 70 | 95 | 117 | 189 | 1094 | 2235 | 6271 |
| Temperature (C) | 55 | na | . | . | . | 5 | 8 | 11 | 19 | 25 | 29 | 30 |
| pH (s.u.) | 54 | na | <6.8 | 4 | 7.4 | 6.6 | 6.8 | 7.1 | 7.3 | 7.6 | 7.8 | 8.3 |
| | | | >8.5 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 52 | 1 | . | . | . | 1 | 1 | 1 | 3 | 5 | 11 | 110 |
| Chloride | 42 | 0 | . | . | . | 7 | 10 | 14 | 37 | 368 | 764 | 2500 |
| Turbidity (NTU) | 52 | na | >50 | 0 | 0.0 | 1 | 2 | 3 | 4 | 7 | 12 | 24 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 9 | 17.3 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 33 | 7 | . | . | . | 0.01 | 0.01 | 0.01 | 0.05 | 0.09 | 0.16 | 0.52 |
| TKN as N | 33 | 0 | . | . | . | 0.20 | 0.30 | 0.30 | 0.40 | 0.40 | 0.50 | 0.60 |
| $NO_2$+$NO_3$ as N | 33 | 4 | . | . | . | 0.01 | 0.01 | 0.06 | 0.15 | 0.21 | 0.30 | 0.36 |
| Total Phosphorus | 33 | 0 | . | . | . | 0.01 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.11 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 33 | 0 | . | . | . | 62 | 130 | 180 | 250 | 380 | 822 | 1100 |
| Arsenic (As) | 33 | 33 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Cadmium (Cd) | 33 | 0 | >5 | 1 | 3.0 | 2 | 2 | 2 | 2 | 2 | 2 | 10 |
| Chromium (Cr) | 33 | 33 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 33 | 16 | >3 | 7 | 21.2 | 2 | 2 | 2 | 2 | 3 | 6 | 35 |
| Iron (Fe) | 33 | 0 | . | . | . | 72 | 410 | 520 | 680 | 800 | 1080 | 1900 |
| Lead (Pb) | 33 | 33 | >25 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Manganese (Mn) | 1 | 0 | . | . | . | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| Mercury (Hg) | 33 | 32 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 33 | 33 | >8.3 | 33 | 100.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 33 | 15 | >86 | 0 | 0.0 | 10 | 10 | 10 | 11 | 17 | 38 | 69 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 30. Summary of the water quality parameters from the Pasquotank River at Elizabeth City (M2750000; Class SB) collected between September 26, 1995 and August 29, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 44 | na | <4 | 0 | 0.0 | 5.7 | 7.0 | 7.6 | 8.6 | 9.6 | 11.0 | 12.0 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 45 | na | . | . | . | 413 | 678 | 884 | 1807 | 4839 | 6901 | 9463 |
| Temperature (C) | 45 | na | . | . | . | 6 | 9 | 12 | 18 | 27 | 29 | 31 |
| pH (s.u.) | 45 | na | <6.8 | 21 | 46.7 | 5.3 | 6.3 | 6.5 | 6.9 | 7.2 | 7.8 | 8.9 |
| | | | >8.5 | 3 | 6.7 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 42 | 2 | . | . | . | 1 | 1 | 1 | 3 | 6 | 9 | 14 |
| Chloride | 36 | 0 | . | . | . | 24 | 170 | 303 | 790 | 1700 | 2200 | 2600 |
| Turbidity (NTU) | 44 | na | >50 | 0 | 0.0 | 1 | 2 | 2 | 3 | 4 | 6 | 11 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 1 | 2.3 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 45 | 6 | . | . | . | 0.01 | 0.01 | 0.03 | 0.07 | 0.17 | 0.23 | 0.44 |
| TKN as N | 45 | 0 | . | . | . | 0.30 | 0.40 | 0.40 | 0.50 | 0.80 | 1.06 | 2.90 |
| $NO_2$+$NO_3$ as N | 45 | 14 | . | . | . | 0.01 | 0.01 | 0.01 | 0.14 | 0.31 | 0.44 | 0.73 |
| Total Phosphorus | 45 | 2 | . | . | . | 0.01 | 0.02 | 0.03 | 0.04 | 0.09 | 0.11 | 0.14 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 45 | 0 | . | . | . | 54 | 118 | 250 | 430 | 750 | 904 | 1400 |
| Arsenic (As) | 45 | 44 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Cadmium (Cd) | 45 | 0 | >5 | 3 | 6.7 | 2 | 2 | 2 | 2 | 2 | 2 | 10 |
| Chromium (Cr) | 45 | 45 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 45 | 13 | >3 | 21 | 46.7 | 2 | 2 | 2 | 3 | 5 | 6 | 17 |
| Iron (Fe) | 45 | 0 | . | . | . | 99 | 158 | 240 | 600 | 1100 | 1780 | 2400 |
| Lead (Pb) | 45 | 44 | >25 | 2 | 4.4 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Manganese (Mn) | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 45 | 45 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 45 | 45 | >8.3 | 45 | 100.0 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Zinc (Zn) | 45 | 8 | >86 | 0 | 0.0 | 10 | 10 | 10 | 16 | 29 | 40 | 70 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 31.** **Summary of the water quality parameters from the Scuppernong River at SR 1105 near Columbia (M6980000; Class C Sw) collected between September 25, 1995 and June 14, 2000.**

| | | Num. | Eval. | < or > Eval. Level | | | Percentiles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **N** | **< R.L.** | **Level** | **n** | **%** | **Min.** | **10** | **25** | **50** | **75** | **90** | **Max.** |
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 44 | na | <4 | 24 | 54.5 | 0.0 | 1.5 | 2.3 | 3.6 | 5.3 | 6.5 | 10.2 |
| (DO; mg/L) | | | <5 | 32 | 72.7 | . | . | . | . | . | . | . |
| Conductivity | 44 | na | . | . | . | 94 | 150 | 167 | 205 | 316 | 2122 | 4904 |
| Temperature (C) | 44 | na | . | . | . | 6 | 7 | 10 | 17 | 22 | 26 | 28 |
| pH (s.u.) | 44 | na | <6 | 6 | 13.6 | 5.2 | 5.9 | 6.2 | 6.4 | 6.5 | 6.7 | 7.0 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 50 | 3 | >10 | 2 | 4.0 | 1 | 1 | 2 | 4 | 6 | 9 | 45 |
| | | | >20 | 2 | 4.0 | | | | | | | |
| Chloride | 46 | 0 | . | . | . | 13 | 18 | 21 | 30 | 93 | 580 | 2000 |
| Turbidity (NTU) | 54 | na | >50 | 0 | 0.0 | 2 | 3 | 4 | 6 | 8 | 12 | 26 |
| | | | >25 | 1 | 1.9 | . | . | . | . | . | . | . |
| | | | >10 | 7 | 13.0 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 52 | 0 | . | . | . | 0.01 | 0.02 | 0.08 | 0.15 | 0.23 | 0.38 | 0.60 |
| TKN as N | 52 | 0 | . | . | . | 0.20 | 0.50 | 0.70 | 0.80 | 0.90 | 1.19 | 1.90 |
| $NO_2$+$NO_3$ as N | 52 | 0 | >10 | 0 | 0.0 | 0.01 | 0.01 | 0.04 | 0.30 | 1.05 | 2.79 | 6.00 |
| Total Phosphorus | 52 | 0 | >0.05 | 48 | 92.3 | 0.04 | 0.06 | 0.07 | 0.09 | 0.14 | 0.19 | 1.70 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 52 | 0 | . | . | . | 55 | 171 | 298 | 480 | 890 | 1290 | 4200 |
| Arsenic (As) | 52 | 52 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Cadmium (Cd) | 52 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 52 | 52 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 52 | 23 | >7 | 5 | 9.6 | 2 | 2 | 2 | 2 | 4 | 6 | 13 |
| Iron (Fe) | 52 | 0 | >1000 | 45 | 86.5 | 560 | 991 | 1200 | 1550 | 2025 | 2490 | 4600 |
| Lead (Pb) | 52 | 52 | >25 | 1 | 1.9 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 0 | 0 | >200 | 0 | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 52 | 52 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 52 | 52 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 52 | 8 | >50 | 4 | 7.7 | 10 | 10 | 14 | 19 | 29 | 45 | 99 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 32. Summary of the water quality parameters from the Alligator River at US 64 near Alligator (M7175000; Class SC Sw ORW) collected between September 25, 1995 and June 14, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 43 | na | <4 | 0 | 0.0 | 6.4 | 7.7 | 8.3 | 8.9 | 10.2 | 11.4 | 13.0 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 42 | na | . | . | . | 95 | 1693 | 2493 | 4484 | 6723 | 7688 | 10032 |
| Temperature (C) | 43 | na | . | . | . | 5 | 6 | 9 | 16 | 23 | 28 | 30 |
| pH (s.u.) | 42 | na | <6.8 | 8 | 19.0 | 6.0 | 6.2 | 7.0 | 7.3 | 7.6 | 7.8 | 8.1 |
| | | | >8.5 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 48 | 0 | . | . | . | 1 | 3 | 7 | 10 | 17 | 24 | 85 |
| Chloride | 44 | 0 | . | . | . | 430 | 642 | 903 | 1600 | 2225 | 2870 | 3600 |
| Turbidity (NTU) | 52 | na | >50 | 0 | 0.0 | 2 | 3 | 3 | 6 | 7 | 11 | 21 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 6 | 11.5 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 53 | 20 | . | . | . | 0.01 | 0.01 | 0.01 | 0.02 | 0.06 | 0.09 | 0.62 |
| TKN as N | 52 | 0 | . | . | . | 0.20 | 0.30 | 0.40 | 0.45 | 0.60 | 0.70 | 0.90 |
| $NO_2$+$NO_3$ as N | 52 | 20 | . | . | . | 0.01 | 0.01 | 0.01 | 0.05 | 0.11 | 0.17 | 0.27 |
| Total Phosphorus | 52 | 5 | . | . | . | 0.01 | 0.01 | 0.01 | 0.02 | 0.03 | 0.05 | 0.11 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 54 | 0 | . | . | . | 58 | 143 | 225 | 410 | 650 | 991 | 2300 |
| Arsenic (As) | 54 | 52 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 15 | 50 |
| Cadmium (Cd) | 54 | 0 | >5 | 2 | 3.7 | 2 | 2 | 2 | 2 | 2 | 2 | 10 |
| Chromium (Cr) | 54 | 54 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 54 | 24 | >3 | 14 | 25.9 | 2 | 2 | 2 | 2 | 3 | 5 | 20 |
| Iron (Fe) | 54 | 0 | . | . | . | 110 | 159 | 275 | 435 | 758 | 1064 | 2100 |
| Lead (Pb) | 54 | 53 | >25 | 3 | 5.6 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 54 | 54 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 54 | 54 | >8.3 | 54 | 100.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 54 | 9 | >86 | 3 | 5.6 | 10 | 10 | 12 | 16 | 25 | 38 | 99 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 33. Summary of the water quality parameters from the Little River at US 17 at Woodville (M3500000; Class C Sw) collected between September 25, 1995 and June 14, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 44 | na | <4 | 28 | 63.6 | 0.0 | 0.2 | 0.5 | 2.8 | 5.6 | 8.9 | 10.5 |
| (DO; mg/L) | | | <5 | 32 | 72.7 | . | . | . | . | . | . | . |
| Conductivity | 44 | na | . | . | . | 154 | 192 | 222 | 268 | 401 | 1043 | 1709 |
| Temperature (C) | 44 | na | . | . | . | 0 | 5 | 9 | 14 | 21 | 24 | 25 |
| pH (s.u.) | 43 | na | <6 | 1 | 2.3 | 5.2 | 6.3 | 6.5 | 6.7 | 6.8 | 6.9 | 7.1 |
| | | | >9 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other (mg/L)** | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 51 | 1 | >10 | 6 | 11.8 | 1 | 1 | 2 | 5 | 8 | 12 | 63 |
| | | | >20 | 3 | 5.9 | | | | | | | |
| Chloride | 45 | 0 | . | . | . | 16 | 23 | 32 | 46 | 78 | 286 | 1000 |
| Turbidity (NTU) | 53 | na | >50 | 0 | 0.0 | 1 | 2 | 3 | 4 | 9 | 13 | 20 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 7 | 13.2 | . | . | . | . | . | . | . |
| **Nutrients (mg/L)** | | | | | | | | | | | | |
| $NH_3$ as N | 54 | 0 | . | . | . | 0.01 | 0.01 | 0.04 | 0.11 | 0.31 | 0.65 | 1.60 |
| TKN as N | 54 | 0 | . | . | . | 0.50 | 0.60 | 0.80 | 0.95 | 1.18 | 1.54 | 5.10 |
| $NO_2$+$NO_3$ as N | 54 | 0 | >10 | 0 | 0.0 | 0.01 | 0.01 | 0.01 | 0.03 | 0.16 | 0.85 | 1.90 |
| Total Phosphorus | 54 | 0 | >0.05 | 50 | 92.6 | 0.04 | 0.07 | 0.11 | 0.25 | 0.36 | 0.58 | 1.10 |
| **Metals (µg/L)** | | | | | | | | | | | | |
| Aluminum (Al) | 55 | 0 | . | . | . | 65 | 114 | 175 | 260 | 625 | 1056 | 5100 |
| Arsenic (As) | 55 | 55 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Cadmium (Cd) | 55 | 0 | >2 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 55 | 55 | >50 | 0 | 0.0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 55 | 23 | >7 | 3 | 5.5 | 2 | 2 | 2 | 2 | 3 | 6 | 29 |
| Iron (Fe) | 55 | 0 | >1000 | 38 | 69.1 | 430 | 732 | 940 | 1300 | 2300 | 3020 | 5600 |
| Lead (Pb) | 55 | 55 | >25 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Manganese (Mn) | 2 | 0 | >200 | 0 | 0.0 | 83 | 85 | 87 | 91 | 94 | 97 | 98 |
| Mercury (Hg) | 55 | 55 | >0.012 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 55 | 55 | >88 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Zinc (Zn) | 55 | 14 | >50 | 2 | 3.6 | 10 | 10 | 11 | 16 | 25 | 42 | 89 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 34. Summary of the water quality parameters from the Albemarle Sound near Frog Island, mid channel (M390000C; Class SB) collected between September 26, 1995 and August 29, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 43 | na | <4 | 0 | 0.0 | 7.3 | 7.7 | 8.1 | 9.1 | 10.5 | 11.5 | 12.1 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 44 | na | . | . | . | 203 | 2185 | 2969 | 4059 | 8348 | 11422 | 15250 |
| Temperature (C) | 44 | na | . | . | . | 6 | 9 | 12 | 19 | 27 | 28 | 31 |
| pH (s.u.) | 44 | na | <6.8 | 6 | 13.6 | 6.2 | 6.6 | 7.2 | 7.6 | 7.9 | 8.2 | 8.5 |
| | | | >8.5 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 40 | 0 | . | . | . | 1 | 2 | 4 | 8 | 11 | 17 | 140 |
| Chloride | 32 | 0 | . | . | . | 40 | 564 | 950 | 1750 | 2850 | 3860 | 4400 |
| Turbidity (NTU) | 39 | na | >50 | 0 | 0.0 | 1 | 2 | 2 | 4 | 7 | 16 | 50 |
| | | | >25 | 1 | 2.6 | . | . | . | . | . | . | . |
| | | | >10 | 8 | 20.5 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 26 | 7 | . | . | . | 0.01 | 0.01 | 0.01 | 0.03 | 0.06 | 0.13 | 0.31 |
| TKN as N | 26 | 0 | . | . | . | 0.20 | 0.30 | 0.30 | 0.40 | 0.50 | 0.65 | 0.70 |
| $NO_2$+$NO_3$ as N | 26 | 20 | . | . | . | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.11 | 0.21 |
| Total Phosphorus | 26 | 2 | . | . | . | 0.01 | 0.01 | 0.01 | 0.03 | 0.04 | 0.06 | 0.18 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 26 | 1 | . | . | . | 50 | 81 | 103 | 195 | 415 | 910 | 7100 |
| Arsenic (As) | 26 | 24 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 16 | 50 |
| Cadmium (Cd) | 26 | 0 | >5 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 26 | 26 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 26 | 12 | >3 | 9 | 34.6 | 2 | 2 | 2 | 2 | 4 | 6 | 17 |
| Iron (Fe) | 26 | 0 | . | . | . | 50 | 95 | 163 | 225 | 400 | 1130 | 7100 |
| Lead (Pb) | 26 | 26 | >25 | 1 | 3.8 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Manganese (Mn) | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 26 | 26 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 26 | 25 | >8.3 | 26 | 100.0 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Zinc (Zn) | 26 | 7 | >86 | 0 | 0.0 | 10 | 10 | 10 | 15 | 22 | 25 | 74 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 35. Summary of the water quality parameters from Albemarle Sound near Frog Island, north shore (M390000N; Class SB) collected between September 26, 1995 and August 29, 2000.**

| | | Num. | Eval. | < or > Eval. Level | | | Percentiles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **N** | **< R.L.** | **Level** | **n** | **%** | **Min.** | **10** | **25** | **50** | **75** | **90** | **Max.** |
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 44 | na | <4 | 0 | 0.0 | 7.4 | 7.7 | 8.0 | 9.0 | 10.4 | 11.4 | 13.0 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 45 | na | . | . | . | 144 | 1242 | 2508 | 3921 | 7940 | 10870 | 13702 |
| Temperature (C) | 45 | na | . | . | . | 6 | 9 | 12 | 19 | 26 | 28 | 30 |
| pH (s.u.) | 45 | na | <6.8 | 5 | 11.1 | 6.2 | 6.8 | 7.2 | 7.5 | 7.9 | 8.1 | 8.5 |
| | | | >8.5 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 41 | 0 | . | . | . | 1 | 3 | 4 | 6 | 12 | 19 | 32 |
| Chloride | 33 | 0 | . | . | . | 28 | 338 | 840 | 1100 | 2700 | 3380 | 3900 |
| Turbidity (NTU) | 40 | na | >50 | 0 | 0.0 | 2 | 2 | 3 | 4 | 7 | 13 | 21 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 6 | 15.0 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 25 | 5 | . | . | . | 0.01 | 0.01 | 0.01 | 0.04 | 0.07 | 0.14 | 0.71 |
| TKN as N | 25 | 0 | . | . | . | 0.20 | 0.30 | 0.30 | 0.40 | 0.50 | 0.60 | 1.20 |
| $NO_2$+$NO_3$ as N | 25 | 14 | . | . | . | 0.01 | 0.01 | 0.01 | 0.01 | 0.04 | 0.17 | 0.20 |
| Total Phosphorus | 25 | 3 | . | . | . | 0.01 | 0.01 | 0.01 | 0.02 | 0.04 | 0.06 | 0.08 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 27 | 0 | . | . | . | 55 | 116 | 145 | 240 | 350 | 1262 | 2200 |
| Arsenic (As) | 27 | 26 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 11 | 50 |
| Cadmium (Cd) | 27 | 0 | >5 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 27 | 27 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 27 | 14 | >3 | 5 | 18.5 | 2 | 2 | 2 | 2 | 3 | 5 | 6 |
| Iron (Fe) | 27 | 0 | . | . | . | 57 | 87 | 155 | 340 | 590 | 1228 | 2100 |
| Lead (Pb) | 27 | 27 | >25 | 1 | 3.7 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Manganese (Mn) | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 27 | 27 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 27 | 27 | >8.3 | 27 | 100.0 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Zinc (Zn) | 27 | 11 | >86 | 0 | 0.0 | 10 | 10 | 10 | 11 | 21 | 29 | 63 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 36.** **Summary of the water quality parameters from Albemarle Sound near Frog Island, south shore (M390000S; Class SB) collected between September 26, 1995 and August 29, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 42 | na | <4 | 0 | 0.0 | 7.4 | 7.7 | 8.0 | 9.4 | 10.6 | 11.6 | 12.0 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 43 | na | . | . | . | 999 | 1664 | 2442 | 4564 | 7863 | 11204 | 14639 |
| Temperature (C) | 43 | na | . | . | . | 6 | 9 | 12 | 19 | 27 | 28 | 30 |
| pH (s.u.) | 43 | na | <6.8 | 7 | 16.3 | 6.2 | 6.5 | 7.1 | 7.6 | 7.9 | 8.3 | 8.9 |
| | | | >8.5 | 3 | 7.0 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 41 | 0 | . | . | . | 1 | 3 | 5 | 8 | 12 | 25 | 100 |
| Chloride | 33 | 0 | . | . | . | 34 | 394 | 700 | 1400 | 2400 | 3680 | 4600 |
| Turbidity (NTU) | 40 | na | >50 | 0 | 0.0 | 1 | 2 | 3 | 5 | 7 | 13 | 50 |
| | | | >25 | 1 | 2.5 | . | . | . | . | . | . | . |
| | | | >10 | 7 | 17.5 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 23 | 7 | . | . | . | 0.01 | 0.01 | 0.01 | 0.03 | 0.07 | 0.09 | 0.16 |
| TKN as N | 23 | 0 | . | . | . | 0.20 | 0.30 | 0.30 | 0.40 | 0.50 | 0.60 | 0.80 |
| $NO_2$+$NO_3$ as N | 23 | 14 | . | . | . | 0.01 | 0.01 | 0.01 | 0.01 | 0.03 | 0.06 | 0.22 |
| Total Phosphorus | 23 | 1 | . | . | . | 0.01 | 0.01 | 0.02 | 0.03 | 0.05 | 0.06 | 0.14 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 24 | 0 | . | . | . | 55 | 67 | 128 | 255 | 485 | 1041 | 5500 |
| Arsenic (As) | 24 | 23 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 11 | 50 |
| Cadmium (Cd) | 24 | 0 | >5 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 24 | 24 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 24 | 9 | >3 | 9 | 37.5 | 2 | 2 | 2 | 2 | 4 | 9 | 10 |
| Iron (Fe) | 24 | 0 | . | . | . | 50 | 76 | 145 | 240 | 613 | 1262 | 4700 |
| Lead (Pb) | 24 | 24 | >25 | 1 | 4.2 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Manganese (Mn) | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 24 | 24 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 24 | 24 | >8.3 | 24 | 100.0 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Zinc (Zn) | 24 | 10 | >86 | 2 | 8.3 | 10 | 10 | 10 | 14 | 24 | 78 | 170 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 37. Summary of the water quality parameters from the Perquimans River at SR 1336 at Hertford (M5000000; Class SC) collected between September 25, 1995 and June 14, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 43 | na | <4 | 3 | 7.0 | 2.7 | 5.3 | 6.3 | 7.4 | 8.6 | 9.8 | 11.5 |
| (DO; mg/L) | | | <5 | 4 | 9.3 | . | . | . | . | . | . | . |
| Conductivity | 43 | na | . | . | . | 133 | 186 | 330 | 516 | 1788 | 2822 | 4707 |
| Temperature (C) | 43 | na | . | . | . | 5 | 8 | 11 | 18 | 23 | 28 | 31 |
| pH (s.u.) | 43 | na | <6.8 | 32 | 74.4 | 5.2 | 6.2 | 6.4 | 6.6 | 6.8 | 7.0 | 7.3 |
| | | | >8.5 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 50 | 1 | . | . | . | 1 | 1 | 2 | 3 | 6 | 9 | 15 |
| Chloride | 44 | 0 | . | . | . | 22 | 31 | 67 | 180 | 753 | 944 | 1400 |
| Turbidity (NTU) | 52 | na | >50 | 0 | 0.0 | 1 | 2 | 2 | 3 | 5 | 7 | 20 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 2 | 3.8 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 55 | 10 | . | . | . | 0.01 | 0.01 | 0.04 | 0.08 | 0.18 | 0.31 | 1.00 |
| TKN as N | 55 | 0 | . | . | . | 0.20 | 0.40 | 0.50 | 0.70 | 1.00 | 1.16 | 4.10 |
| $NO_2$+$NO_3$ as N | 55 | 10 | . | . | . | 0.01 | 0.01 | 0.03 | 0.10 | 0.48 | 0.85 | 2.40 |
| Total Phosphorus | 55 | 0 | . | . | . | 0.03 | 0.05 | 0.06 | 0.10 | 0.15 | 0.24 | 0.27 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 55 | 0 | . | . | . | 92 | 154 | 220 | 380 | 655 | 832 | 1700 |
| Arsenic (As) | 55 | 55 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Cadmium (Cd) | 55 | 0 | >5 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 55 | 55 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 55 | 21 | >3 | 19 | 34.5 | 2 | 2 | 2 | 3 | 4 | 6 | 16 |
| Iron (Fe) | 55 | 0 | . | . | . | 250 | 360 | 425 | 690 | 1200 | 1760 | 4200 |
| Lead (Pb) | 55 | 55 | >25 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Manganese (Mn) | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 55 | 55 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 55 | 55 | >8.3 | 55 | 100.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Zinc (Zn) | 55 | 9 | >86 | 4 | 7.3 | 10 | 10 | 13 | 19 | 34 | 79 | 260 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 38. Summary of the water quality parameters from the Albemarle Sound between Harvey Point and Mill Point, mid channel (M610000C; Class SB) collected between September 26, 1995 and August 29, 2000.**

| | | Num. | Eval. | < or > Eval. Level | | | Percentiles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **N** | **< R.L.** | **Level** | **n** | **%** | **Min.** | **10** | **25** | **50** | **75** | **90** | **Max.** |
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 45 | na | <4 | 0 | 0.0 | 7.4 | 7.7 | 8.0 | 9.2 | 10.6 | 11.3 | 12.4 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 46 | na | . | . | . | 94 | 248 | 1051 | 1919 | 5275 | 7985 | 10804 |
| Temperature (C) | 46 | na | . | . | . | 5 | 8 | 11 | 18 | 26 | 28 | 30 |
| pH (s.u.) | 45 | na | <6.8 | 7 | 15.6 | 6.1 | 6.5 | 7.0 | 7.5 | 7.7 | 8.0 | 8.7 |
| | | | >8.5 | 2 | 4.4 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 41 | 1 | . | . | . | 1 | 1 | 2 | 4 | 7 | 13 | 75 |
| Chloride | 33 | 0 | . | . | . | 8 | 17 | 240 | 740 | 1500 | 2400 | 3100 |
| Turbidity (NTU) | 40 | na | >50 | 0 | 0.0 | 1 | 1 | 2 | 3 | 7 | 11 | 37 |
| | | | >25 | 1 | 2.5 | . | . | . | . | . | . | . |
| | | | >10 | 6 | 15.0 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 43 | 12 | . | . | . | 0.01 | 0.01 | 0.01 | 0.04 | 0.07 | 0.18 | 0.31 |
| TKN as N | 43 | 0 | . | . | . | 0.10 | 0.20 | 0.20 | 0.30 | 0.50 | 0.58 | 0.80 |
| $NO_2$+$NO_3$ as N | 43 | 14 | . | . | . | 0.01 | 0.01 | 0.01 | 0.03 | 0.13 | 0.20 | 0.26 |
| Total Phosphorus | 43 | 1 | . | . | . | 0.01 | 0.01 | 0.02 | 0.03 | 0.05 | 0.06 | 0.12 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 45 | 3 | . | . | . | 50 | 62 | 120 | 200 | 400 | 788 | 3300 |
| Arsenic (As) | 45 | 44 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Cadmium (Cd) | 45 | 0 | >5 | 2 | 4.4 | 2 | 2 | 2 | 2 | 2 | 2 | 10 |
| Chromium (Cr) | 45 | 45 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 45 | 25 | >3 | 8 | 17.8 | 2 | 2 | 2 | 2 | 3 | 4 | 16 |
| Iron (Fe) | 45 | 0 | . | . | . | 50 | 66 | 140 | 300 | 800 | 1060 | 3100 |
| Lead (Pb) | 45 | 44 | >25 | 4 | 8.9 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Manganese (Mn) | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 45 | 45 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 45 | 45 | >8.3 | 45 | 100.0 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Zinc (Zn) | 45 | 13 | >86 | 0 | 0.0 | 10 | 10 | 10 | 16 | 22 | 31 | 62 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 39. Summary of the water quality parameters from the Albemarle Sound between Harvey Point and Mill Point, north shore (M610000N; Class SB) collected between September 26, 1995 and August 29, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 47 | na | <4 | 0 | 0.0 | 5.5 | 7.4 | 7.9 | 8.9 | 10.4 | 11.2 | 12.1 |
| (DO; mg/L) | | | <5 | 0 | 0.0 | . | . | . | . | . | . | . |
| Conductivity | 47 | na | . | . | . | 121 | 282 | 625 | 1501 | 5252 | 7346 | 10316 |
| Temperature (C) | 47 | na | . | . | . | 5 | 8 | 11 | 19 | 26 | 28 | 29 |
| pH (s.u.) | 47 | na | <6.8 | 7 | 14.9 | 6.1 | 6.5 | 7.2 | 7.3 | 7.6 | 8.0 | 8.4 |
| | | | >8.5 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 41 | 0 | . | . | . | 1 | 1 | 2 | 5 | 6 | 9 | 16 |
| Chloride | 34 | 0 | . | . | . | 18 | 35 | 120 | 585 | 1625 | 2400 | 3100 |
| Turbidity (NTU) | 40 | na | >50 | 0 | 0.0 | 1 | 2 | 2 | 4 | 7 | 10 | 17 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 4 | 10.0 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 41 | 12 | . | . | . | 0.01 | 0.01 | 0.01 | 0.04 | 0.07 | 0.13 | 0.19 |
| TKN as N | 41 | 0 | . | . | . | 0.20 | 0.20 | 0.20 | 0.30 | 0.40 | 0.50 | 0.70 |
| $NO_2$+$NO_3$ as N | 41 | 17 | . | . | . | 0.01 | 0.01 | 0.01 | 0.04 | 0.14 | 0.21 | 0.28 |
| Total Phosphorus | 41 | 1 | . | . | . | 0.01 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.10 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 43 | 0 | . | . | . | 55 | 81 | 115 | 230 | 460 | 820 | 1200 |
| Arsenic (As) | 43 | 42 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 19 |
| Cadmium (Cd) | 43 | 0 | >5 | 2 | 4.7 | 2 | 2 | 2 | 2 | 2 | 2 | 10 |
| Chromium (Cr) | 43 | 43 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 43 | 22 | >3 | 14 | 32.6 | 2 | 2 | 2 | 2 | 4 | 5 | 10 |
| Iron (Fe) | 43 | 0 | . | . | . | 50 | 112 | 195 | 410 | 765 | 1100 | 1700 |
| Lead (Pb) | 43 | 42 | >25 | 2 | 4.7 | 10 | 10 | 10 | 10 | 10 | 10 | 100 |
| Manganese (Mn) | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 43 | 43 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 43 | 40 | >8.3 | 43 | 100.0 | 10 | 10 | 10 | 10 | 10 | 11 | 100 |
| Zinc (Zn) | 43 | 16 | >86 | 2 | 4.7 | 10 | 10 | 10 | 12 | 20 | 33 | 230 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.

**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 40.** **Summary of the water quality parameters from the Albemarle Sound between Harvey Point and Mill Point, south shore (M610000S; Class SB) collected between September 26, 1995 and August 29, 2000.**

| Parameter | N | Num. < R.L. | Eval. Level | < or > Eval. Level n | < or > Eval. Level % | Min. | Percentiles 10 | 25 | 50 | 75 | 90 | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 47 | na | <4 | 1 | 2.1 | 3.9 | 7.6 | 8.0 | 9.2 | 10.4 | 11.1 | 12.3 |
| (DO; mg/L) | | | <5 | 1 | 2.1 | . | . | . | . | . | . | . |
| Conductivity | 48 | na | . | . | . | 118 | 289 | 977 | 2259 | 5073 | 7421 | 10111 |
| Temperature (C) | 48 | na | . | . | . | 6 | 9 | 11 | 19 | 25 | 28 | 31 |
| pH (s.u.) | 48 | na | <6.8 | 7 | 14.6 | 6.0 | 6.6 | 7.2 | 7.6 | 7.9 | 8.0 | 8.4 |
| | | | >8.5 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 42 | 0 | . | . | . | 1 | 1 | 2 | 4 | 8 | 14 | 27 |
| Chloride | 34 | 0 | . | . | . | 14 | 33 | 220 | 820 | 1575 | 2300 | 2800 |
| Turbidity (NTU) | 41 | na | >50 | 0 | 0.0 | 1 | 2 | 3 | 4 | 7 | 12 | 21 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 6 | 14.6 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 41 | 11 | . | . | . | 0.01 | 0.01 | 0.01 | 0.03 | 0.06 | 0.12 | 0.24 |
| TKN as N | 41 | 0 | . | . | . | 0.20 | 0.20 | 0.30 | 0.30 | 0.40 | 0.50 | 1.30 |
| $NO_2$+$NO_3$ as N | 41 | 13 | . | . | . | 0.01 | 0.01 | 0.01 | 0.02 | 0.16 | 0.26 | 0.42 |
| Total Phosphorus | 41 | 1 | . | . | . | 0.01 | 0.01 | 0.02 | 0.03 | 0.05 | 0.08 | 0.10 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 41 | 1 | . | . | . | 50 | 88 | 140 | 240 | 440 | 840 | 3400 |
| Arsenic (As) | 42 | 41 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 11 |
| Cadmium (Cd) | 42 | 0 | >5 | 3 | 7.1 | 2 | 2 | 2 | 2 | 2 | 2 | 10 |
| Chromium (Cr) | 42 | 42 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 42 | 17 | >3 | 11 | 26.2 | 2 | 2 | 2 | 2 | 4 | 5 | 30 |
| Iron (Fe) | 42 | 0 | . | . | . | 50 | 79 | 148 | 390 | 733 | 1449 | 2900 |
| Lead (Pb) | 42 | 42 | >25 | 4 | 9.5 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 0 | 0 | . | . | . | . | . | . | . | . | . | . |
| Mercury (Hg) | 42 | 42 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 42 | 42 | >8.3 | 42 | 100.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Zinc (Zn) | 42 | 14 | >86 | 1 | 2.4 | 10 | 10 | 10 | 14 | 25 | 36 | 88 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

**Table 41. Summary of the water quality parameters from Kendricks Creek at SR 1300 at Mackeys (M6920000; Class SC) collected between September 25, 1995 and August 31, 2000.**

| | | Num. | Eval. | < or > Eval. Level | | | Percentiles | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parameter** | **N** | **< R.L.** | **Level** | **n** | **%** | **Min.** | **10** | **25** | **50** | **75** | **90** | **Max.** |
| **Field** | | | | | | | | | | | | |
| Dissolved Oxygen | 43 | na | <4 | 10 | 23.3 | 1.9 | 2.9 | 4.1 | 5.9 | 6.9 | 7.7 | 8.9 |
| (DO; mg/L) | | | <5 | 14 | 32.6 | . | . | . | . | . | . | . |
| Conductivity | 43 | na | . | . | . | 78 | 154 | 189 | 215 | 391 | 829 | 1913 |
| Temperature (C) | 43 | na | . | . | . | 5 | 7 | 11 | 17 | 22 | 27 | 29 |
| pH (s.u.) | 43 | na | <6.8 | 34 | 79.1 | 5.1 | 5.9 | 6.2 | 6.5 | 6.7 | 6.9 | 7.7 |
| | | | >8.5 | 0 | 0.0 | . | . | . | . | . | . | . |
| **Other** (mg/L) | | | | | | | | | | | | |
| Total Residue | 0 | . | . | . | . | . | . | . | . | . | . | . |
| TSS | 51 | 0 | . | . | . | 1 | 1 | 2 | 4 | 5 | 7 | 17 |
| Chloride | 45 | 0 | . | . | . | 9 | 13 | 16 | 22 | 86 | 280 | 1000 |
| Turbidity (NTU) | 54 | na | >50 | 0 | 0.0 | 3 | 4 | 5 | 9 | 12 | 18 | 25 |
| | | | >25 | 0 | 0.0 | . | . | . | . | . | . | . |
| | | | >10 | 19 | 35.2 | . | . | . | . | . | . | . |
| **Nutrients** (mg/L) | | | | | | | | | | | | |
| $NH_3$ as N | 56 | 5 | . | . | . | 0.01 | 0.01 | 0.05 | 0.11 | 0.19 | 0.36 | 0.63 |
| TKN as N | 56 | 0 | . | . | . | 0.20 | 0.30 | 0.50 | 0.80 | 0.93 | 1.10 | 1.80 |
| $NO_2$+$NO_3$ as N | 56 | 2 | . | . | . | 0.01 | 0.02 | 0.19 | 0.69 | 2.13 | 3.90 | 8.00 |
| Total Phosphorus | 56 | 0 | . | . | . | 0.01 | 0.05 | 0.06 | 0.08 | 0.11 | 0.14 | 0.33 |
| **Metals** (µg/L) | | | | | | | | | | | | |
| Aluminum (Al) | 57 | 1 | . | . | . | 50 | 152 | 270 | 710 | 1500 | 2000 | 4000 |
| Arsenic (As) | 57 | 57 | >50 | 0 | 0.0 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Cadmium (Cd) | 57 | 0 | >5 | 0 | 0.0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Chromium (Cr) | 57 | 57 | . | . | . | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Copper (Cu) | 57 | 16 | >3 | 23 | 40.4 | 2 | 2 | 2 | 3 | 5 | 7 | 24 |
| Iron (Fe) | 57 | 0 | . | . | . | 110 | 740 | 1000 | 1600 | 2000 | 2540 | 5500 |
| Lead (Pb) | 57 | 57 | >25 | 1 | 1.8 | 10 | 10 | 10 | 10 | 10 | 10 | 50 |
| Manganese (Mn) | 2 | 0 | . | . | . | 68 | 75 | 86 | 104 | 122 | 133 | 140 |
| Mercury (Hg) | 57 | 57 | >0.025 | 0 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Nickel (Ni) | 57 | 47 | >8.3 | 57 | 100.0 | 10 | 10 | 10 | 10 | 10 | 17 | 50 |
| Zinc (Zn) | 57 | 5 | >86 | 3 | 5.3 | 10 | 11 | 17 | 23 | 45 | 61 | 240 |

**Abbreviations**: N or n = number; Num.<R.L. = number < Reporting Level; < or > refers to "less than or greater than"; TSS = Total Suspended Solids; Conductivity measured as µmhos/cm; na = not applicable.
**Evaluation Levels** (Eval. Level) are presented to facilitate review. Some levels refer to water quality standards; others may be used for ecological or Action Level review. Measurements should not exceed the range (< or >) indicated by the evaluation level.

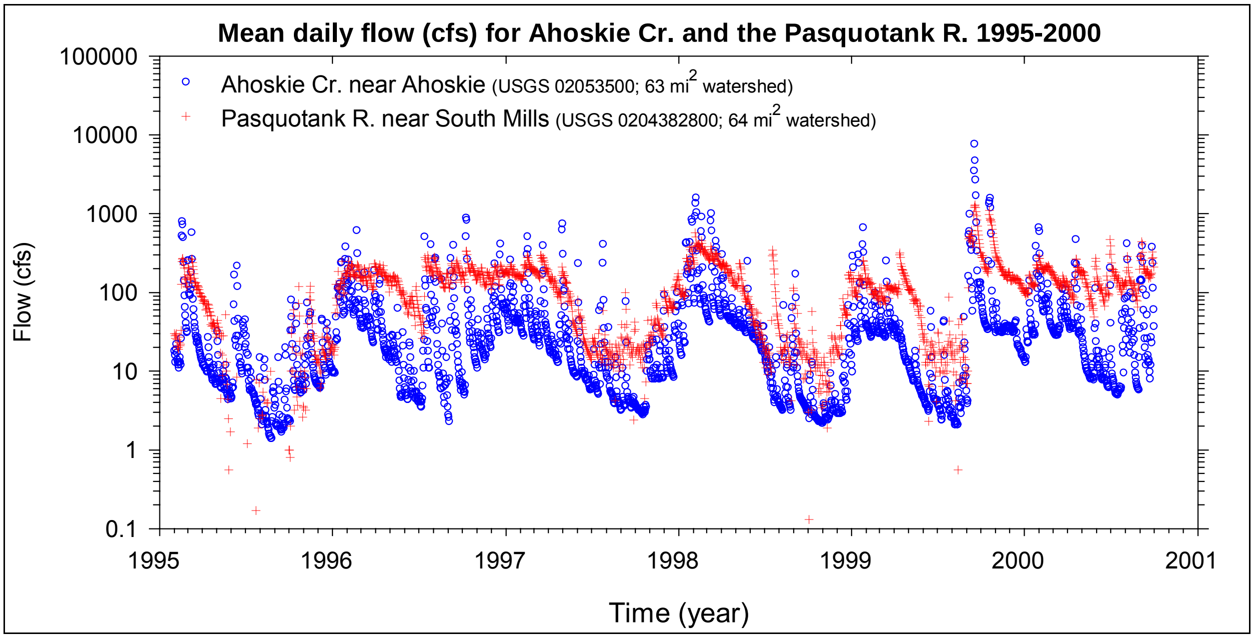
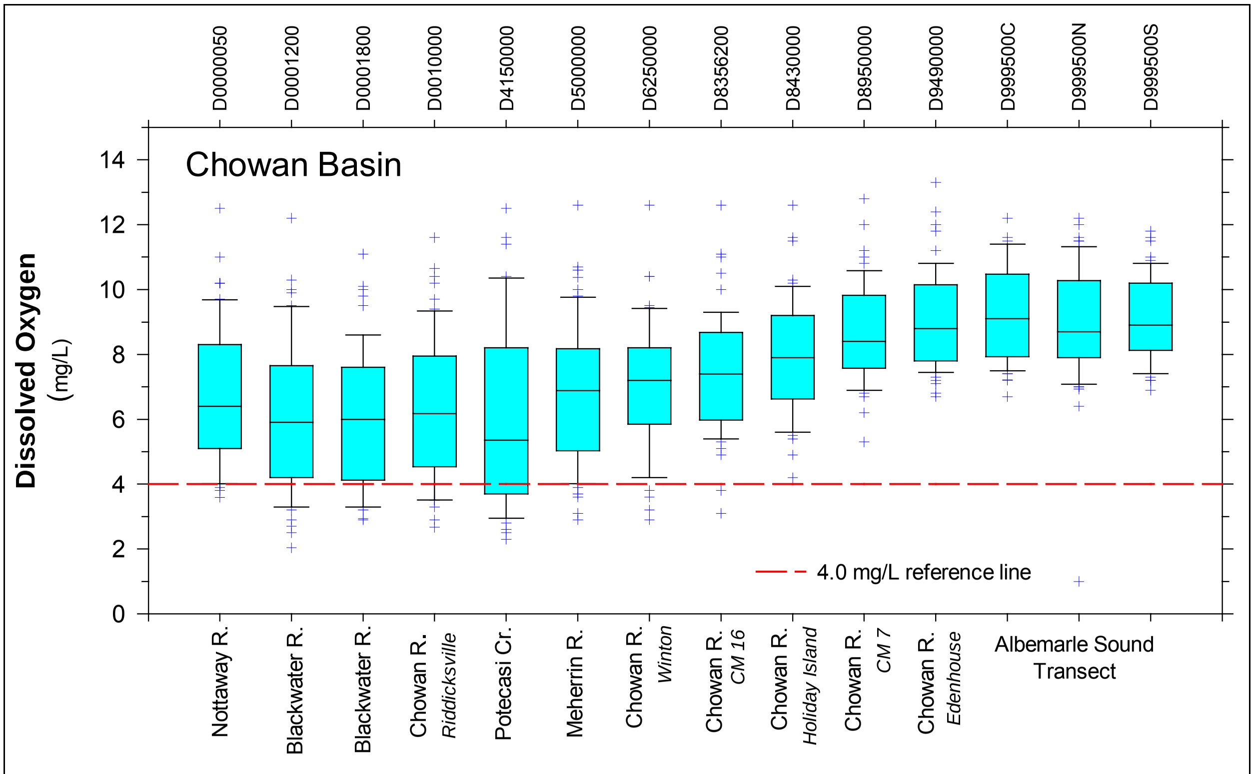



**Figure 32.** Mean daily flow (cfs) of Ahoskie Creek and the Pasquotank Rivers from USGS gages, 1995 - 2000. Data were obtained from http://nc.water.usgs.gov/.



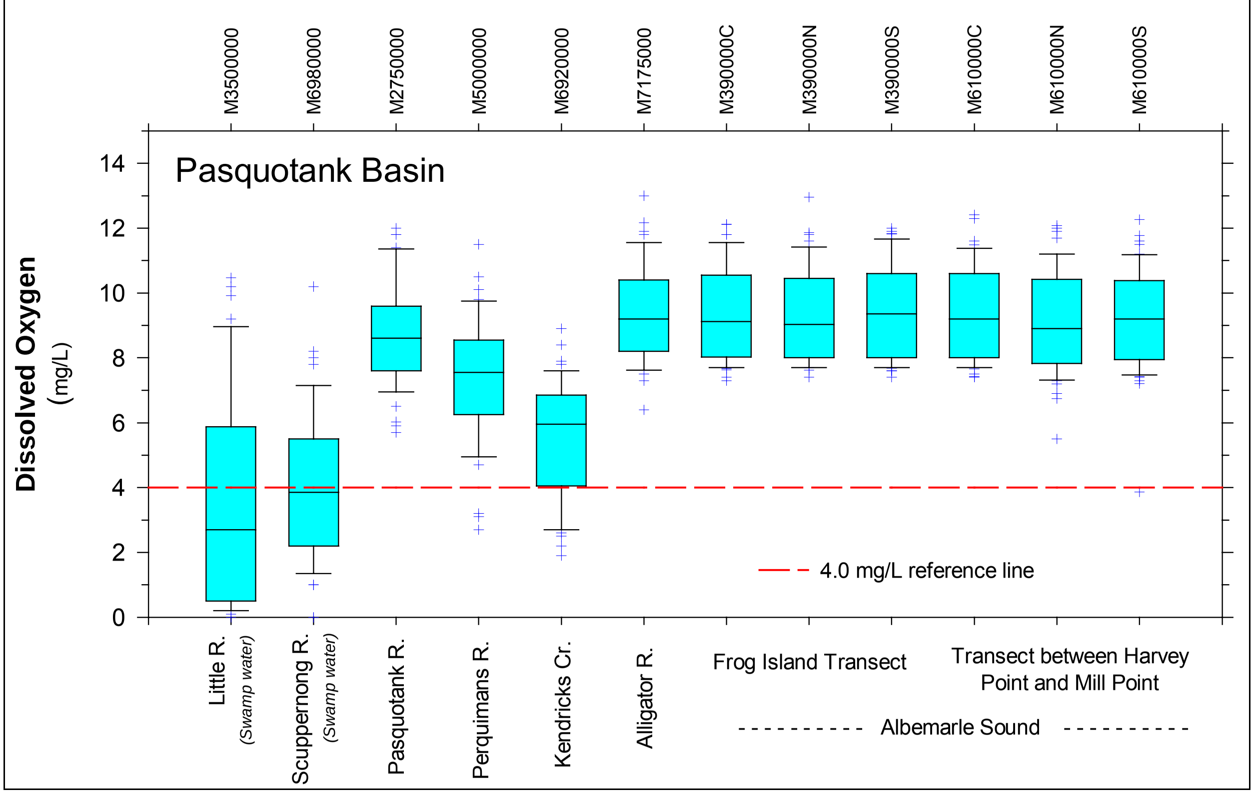




**Figure 33.** **Dissolved oxygen in the Chowan River and Pasquotank River basins, 1995 - 2000.**

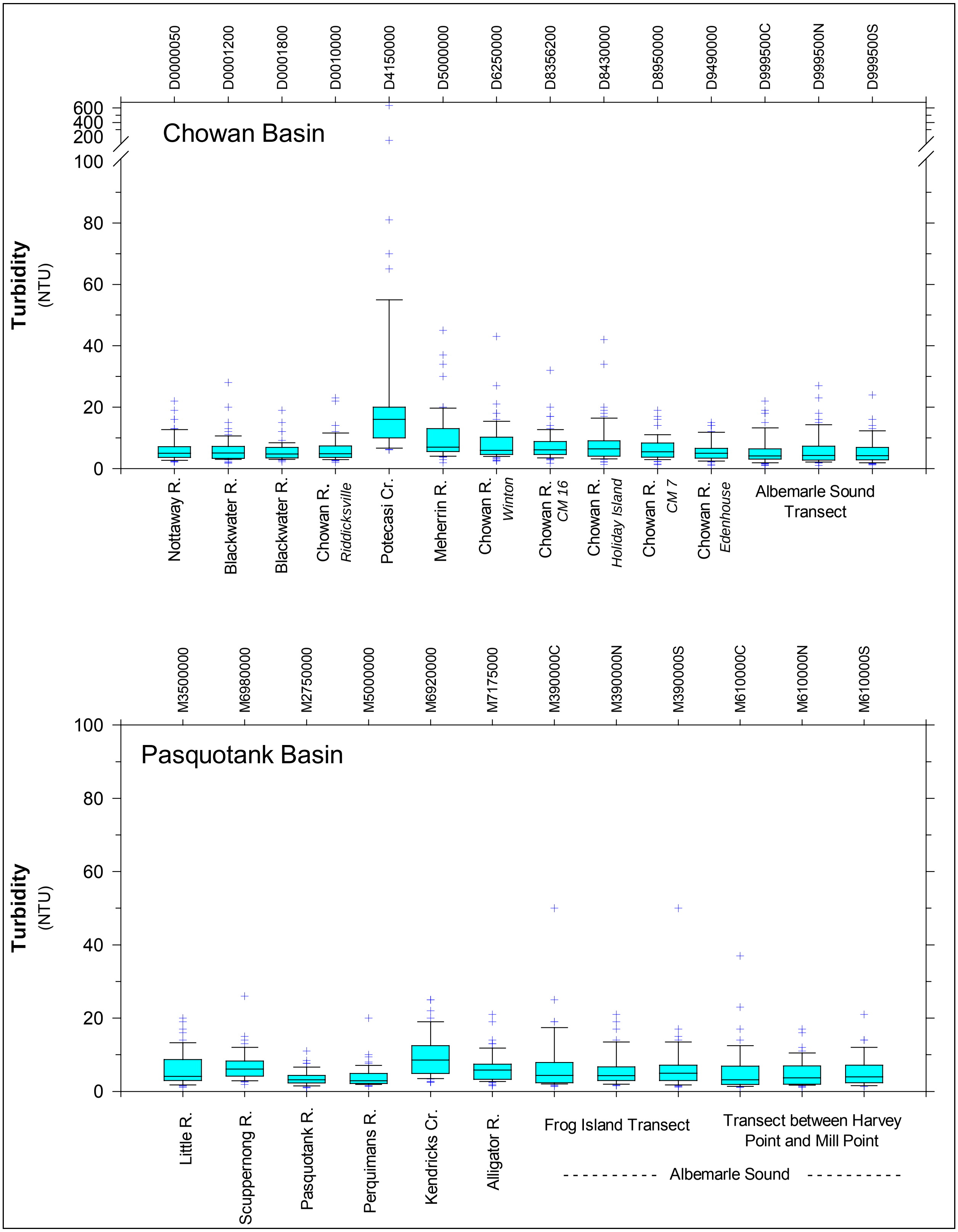



**Figure 34.** **Turbidity in the Chowan River and Pasquotank River basins, 1995 - 2000.**

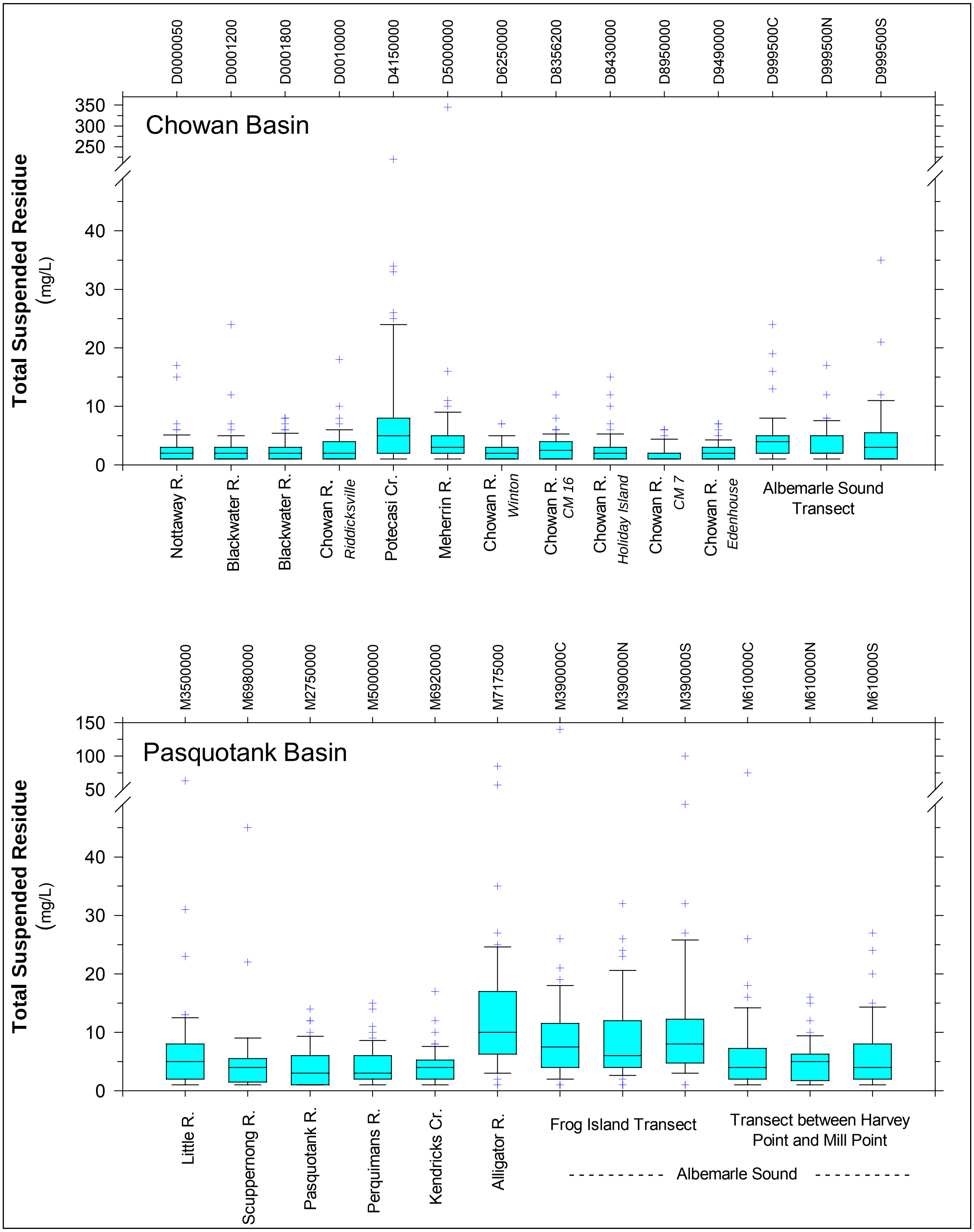
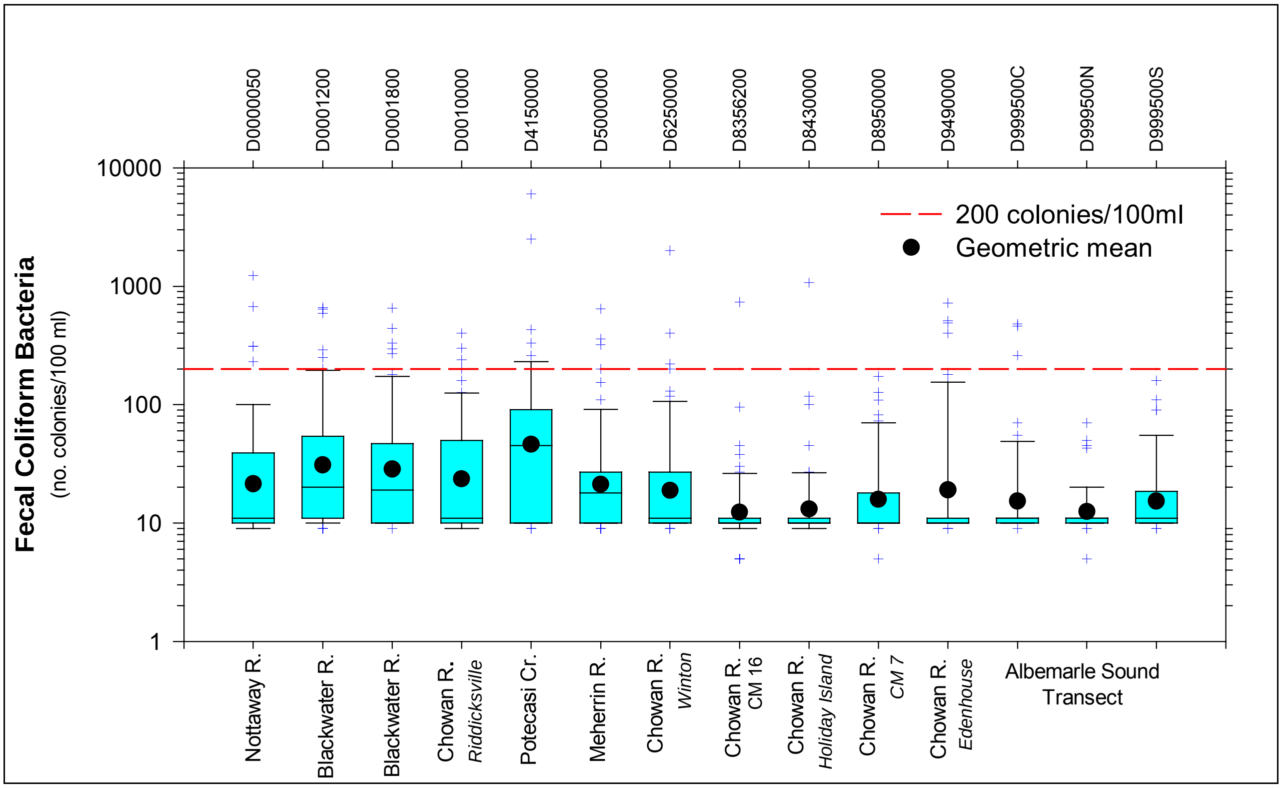



**Figure 35.** **Total suspended solids in the Chowan River and Pasquotank River basins, 1995 - 2000.**

**Table 42.** **Summary for fecal coliform bacteria in the Chowan River and Pasquotank River basins, 1995 - 2000 (no. colonies/100 ml)[1].**

| Subbasin Station | Location | N | N<RL | GeoMean | Percentiles Min | 10 | 25 | 50 | 75 | 90 | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **01** | | | | | | | | | | | |
| D0000050 | Nottaway R | 59 | 14 | 21 | 9 | 9 | 10 | 11 | 40 | 100 | 1225 |
| D0001200 | Blackwater R - Cherry Grove | 58 | 8 | 31 | 9 | 10 | 11 | 20 | 54 | 205 | 660 |
| D0001800 | Blackwater R - Wyanoke | 57 | 11 | 28 | 9 | 10 | 10 | 19 | 49 | 198 | 653 |
| D0010000 | Chowan R - Riddicksville | 58 | 11 | 24 | 9 | 9 | 10 | 11 | 50 | 130 | 400 |
| D6250000 | Chowan R - Winton | 58 | 16 | 19 | 9 | 10 | 10 | 11 | 27 | 119 | 2000 |
| D8356200 | Chowan R - Gatesville | 56 | 25 | 12 | 5 | 9 | 10 | 10 | 11 | 28 | 736 |
| **02** | | | | | | | | | | | |
| D4150000 | Potecasi Cr | 56 | 10 | 46 | 9 | 10 | 10 | 48 | 91 | 281 | 5999 |
| D5000000 | Meherrin R | 59 | 13 | 21 | 9 | 10 | 10 | 18 | 27 | 110 | 645 |
| **03** | | | | | | | | | | | |
| D8430000 | Chowan R - Holiday Island | 57 | 28 | 13 | 9 | 9 | 10 | 10 | 11 | 27 | 1071 |
| D8950000 | Chowan R at Colerain | 56 | 25 | 16 | 5 | 10 | 10 | 10 | 18 | 71 | 173 |
| **04** | | | | | | | | | | | |
| D9490000 | Chowan R at Edenhouse | 56 | 23 | 19 | 9 | 10 | 10 | 10 | 11 | 163 | 720 |
| D999500C | Albemarle Sound - Mid | 51 | 17 | 15 | 9 | 10 | 10 | 11 | 11 | 53 | 480 |
| D999500N | Albemarle Sound - N shore | 52 | 19 | 12 | 5 | 10 | 10 | 11 | 11 | 20 | 70 |
| D999500S | Albemarle Sound - S shore | 52 | 15 | 15 | 9 | 10 | 10 | 11 | 19 | 55 | 160 |
| **50** | | | | | | | | | | | |
| M2750000 | Pasquotank R | 43 | 10 | 16 | 5 | 7 | 10 | 11 | 24 | 115 | 210 |
| **51** | | | | | | | | | | | |
| M6980000 | Scuppernong R | 53 | 12 | 29 | 9 | 9 | 10 | 27 | 73 | 120 | 720 |
| M7175000 | Alligator R | 51 | 27 | 11 | 9 | 10 | 10 | 10 | 11 | 11 | 130 |
| 52 | | | | | | | | | | | |
| M3500000 | Little R | 52 | 3 | 60 | 5 | 10 | 20 | 61 | 125 | 475 | 1320 |
| M390000C | Albemarle S - Frog Island Mid | 39 | 17 | 11 | 9 | 10 | 10 | 11 | 11 | 11 | 18 |
| M390000N | Albemarle S - Frog I N shore | 40 | 18 | 11 | 5 | 9 | 10 | 10 | 11 | 11 | 73 |
| M390000S | Albemarle S - Frog I S shore | 40 | 16 | 11 | 9 | 9 | 10 | 11 | 11 | 11 | 30 |
| M5000000 | Perquimans R | 51 | 11 | 24 | 9 | 10 | 10 | 18 | 50 | 98 | 460 |
| M610000C | Albemarle S - Harvey Mid | 39 | 15 | 11 | 9 | 9 | 10 | 10 | 11 | 11 | 30 |
| M610000N | Albemarle S - Harvey N shore | 40 | 13 | 11 | 9 | 10 | 10 | 11 | 11 | 11 | 33 |
| M610000S | Albemarle S - Harvey S shore | 41 | 16 | 10 | 5 | 9 | 10 | 10 | 11 | 11 | 22 |
| **53** | | | | | | | | | | | |
| M6920000 | Kendricks Cr | 53 | 4 | 36 | 9 | 10 | 13 | 30 | 78 | 284 | 520 |

[1] N= Number of samples; R.L. = Reporting Level; GeoMean = Geometric Mean; 50$^{th}$ percentile is also known as the median.



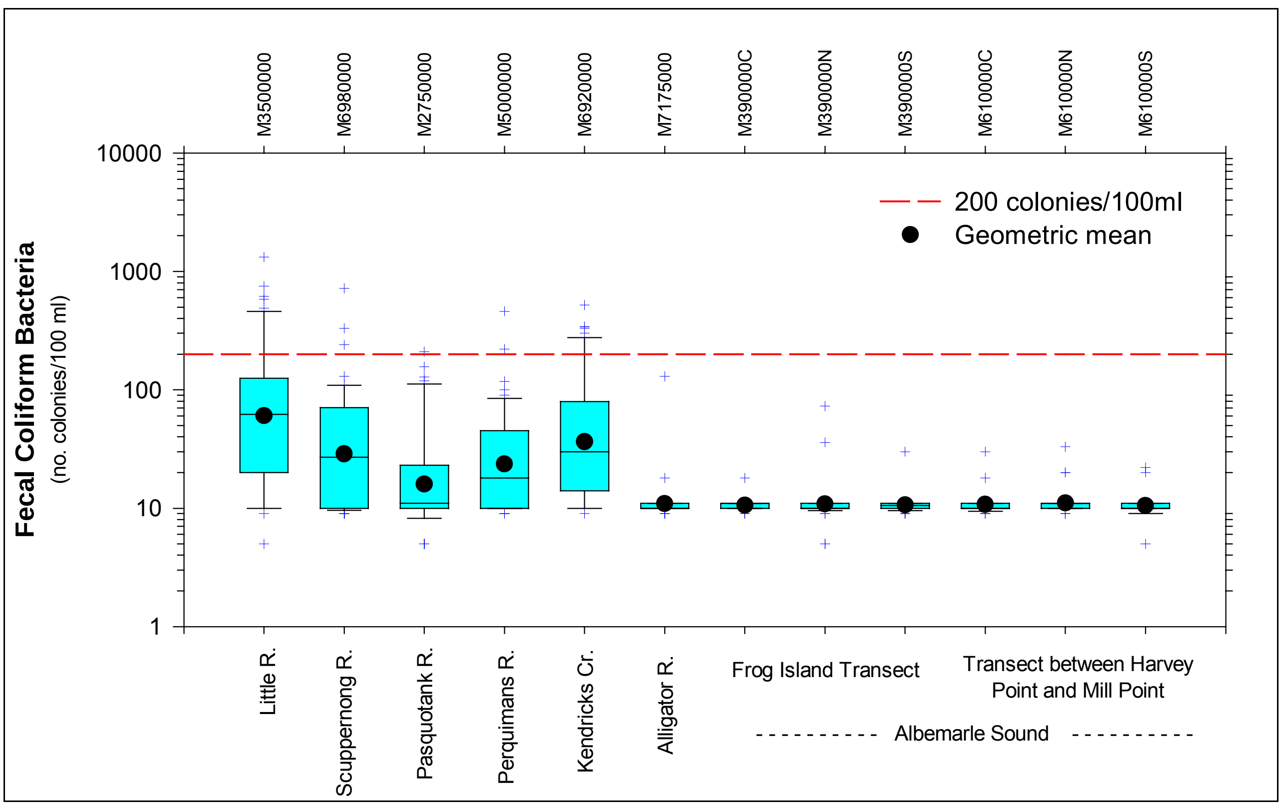




**Figure 36.** **Fecal coliform bacteria concentrations from monitoring sites in the Chowan River (top) and Pasquotank River (bottom) basins, 1995 - 2000. Horizontal line represents a reference level of 200 colonies/100 ml.**

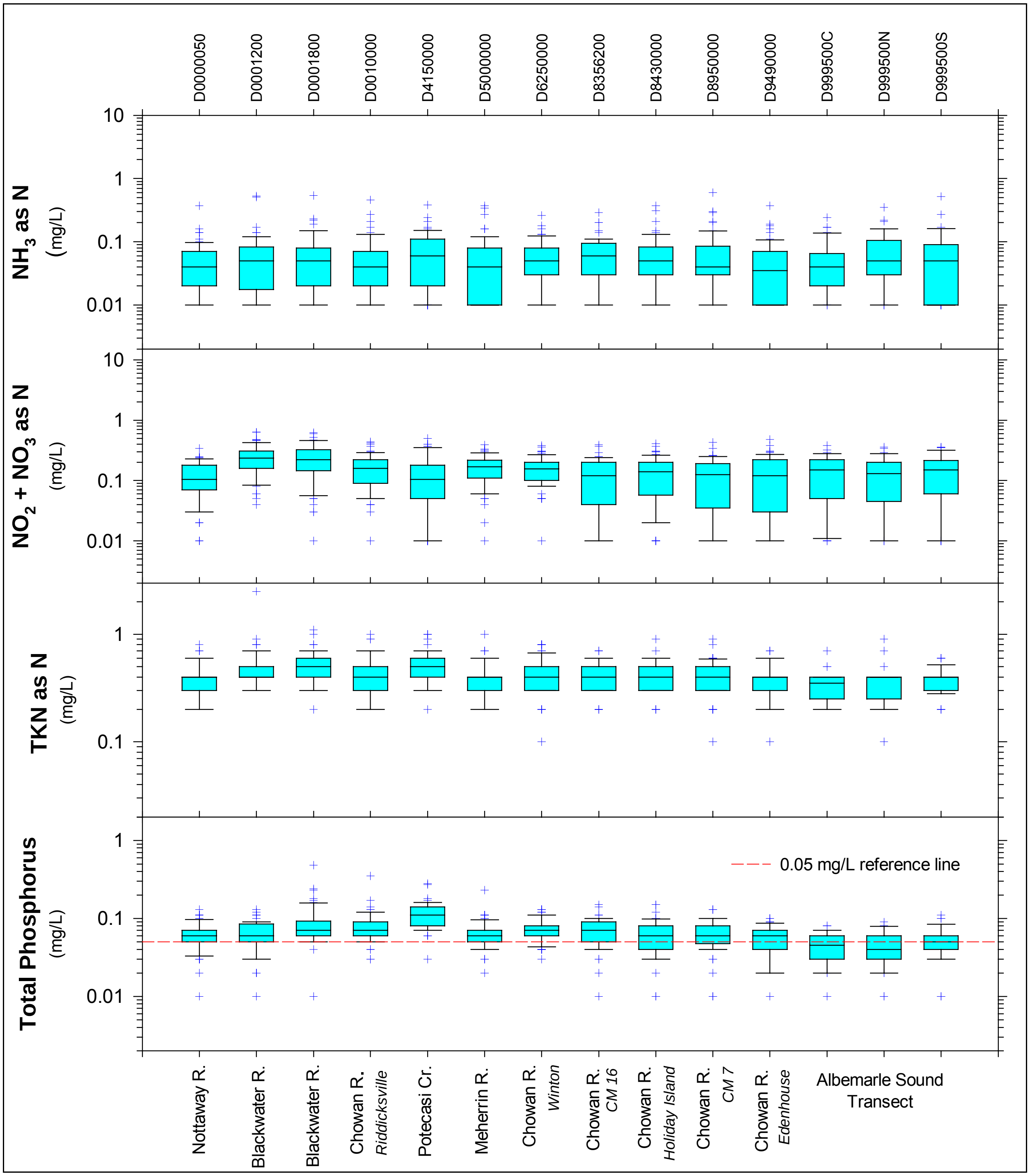



**Figure 37.** **Ammonia-nitrogen (NH3), total Kjeldahl nitrogen (TKN), nitrite+nitrate–nitrogen ($NO_2$+$NO_3$), and total phosphorus in the Chowan River basin, 1995 - 2000.**

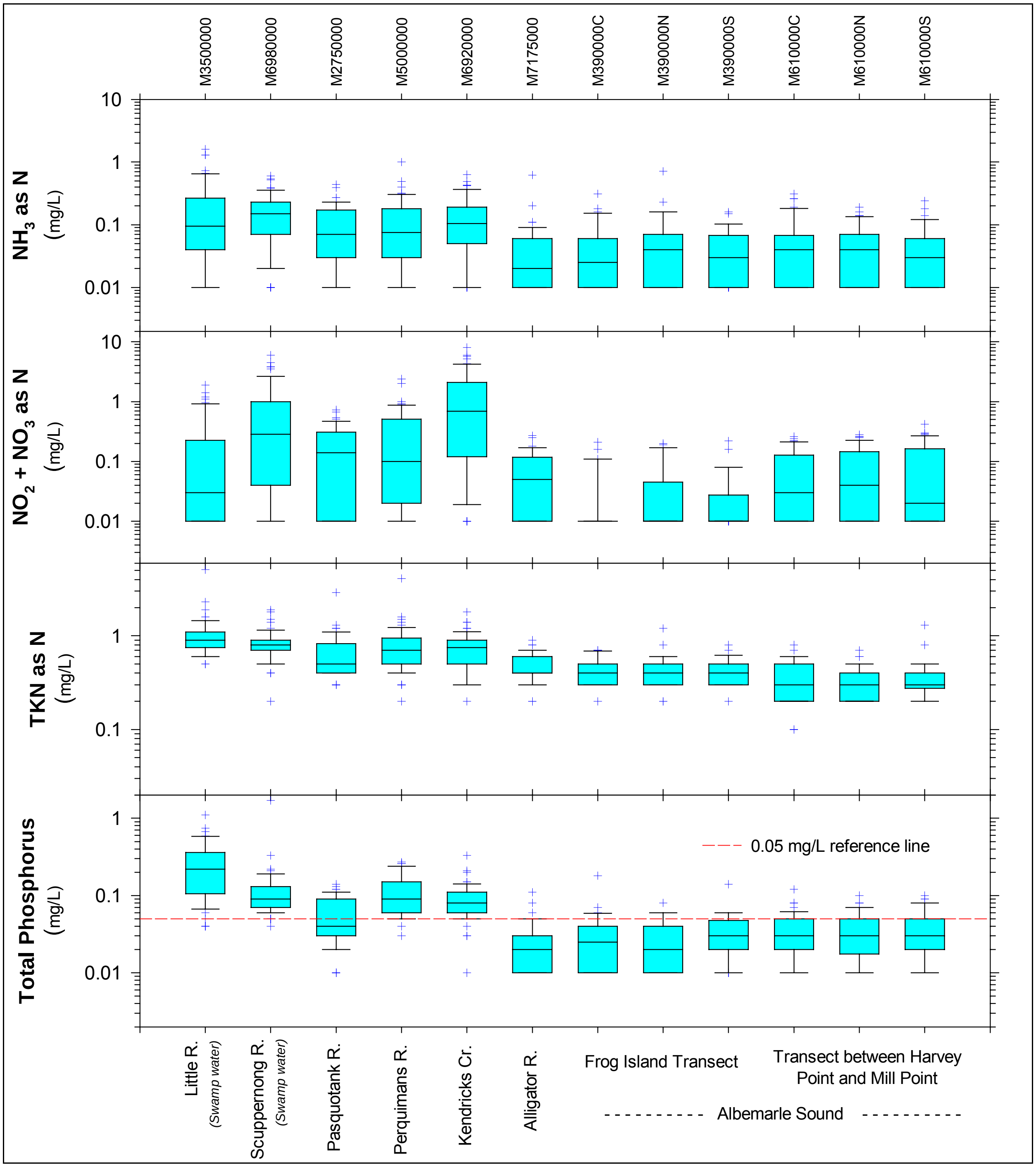
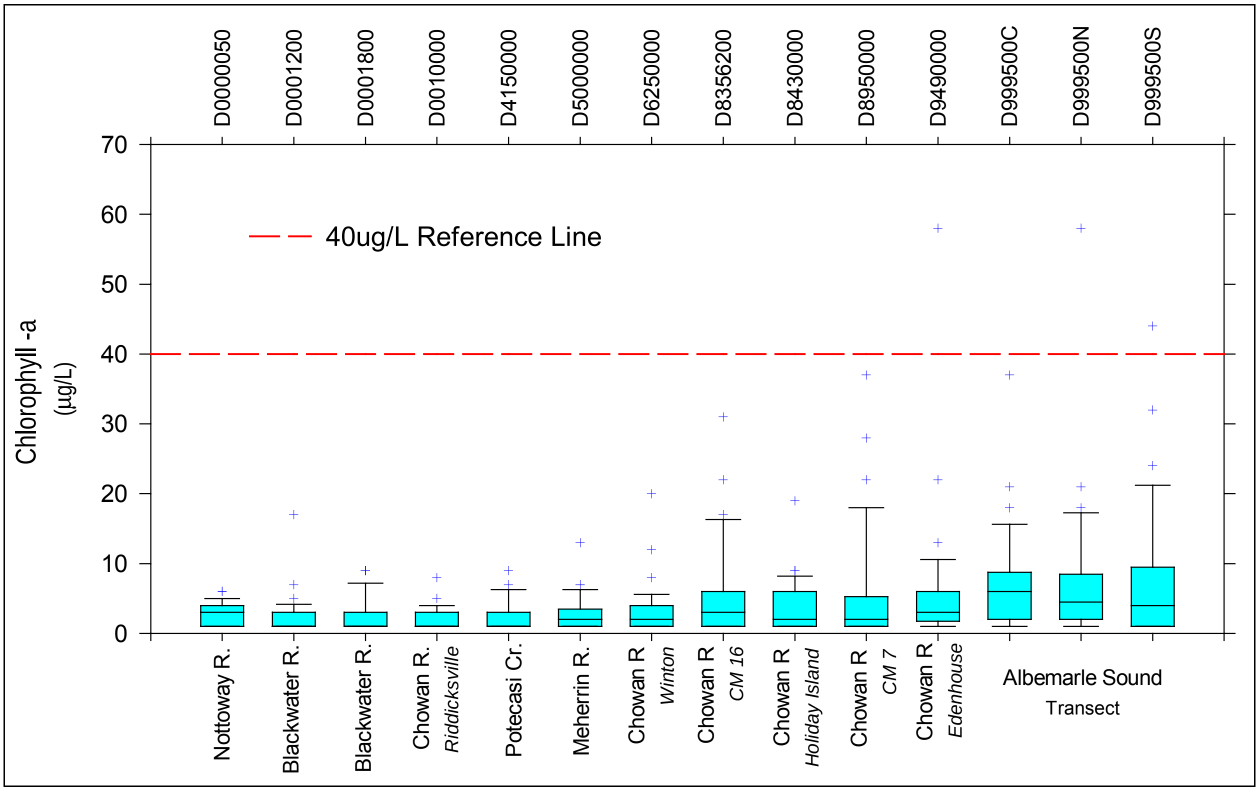



**Figure 38.** **Ammonia-nitrogen (NH3), total Kjeldahl nitrogen (TKN), nitrite+nitrate–nitrogen ($NO_2$+$NO_3$), and total phosphorus in the Pasquotank River basin, 1995 - 2000.**

**Table 43. Summary of chlorophyll *a* concentrations (µg/L) for the Chowan River and Pasquotank River basins, 1995 - 2000.**

| Subbasin/ Station | Location | N | N<RL | N>40 | %>40 | Percentiles Min | 10 | 25 | 50 | 75 | 90 | Max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **01** | | | | | | | | | | | | |
| D0000050 | Nottaway R | 30 | 9 | 0 | 0.0 | 1 | 1 | 1 | 3 | 4 | 5 | 6 |
| D0001200 | Blackwater R- Cherry Grove | 33 | 10 | 0 | 0.0 | 1 | 1 | 1 | 1 | 3 | 5 | 17 |
| D0001800 | Blackwater R - Wyanoke | 31 | 6 | 0 | 0.0 | 1 | 1 | 1 | 1 | 3 | 8 | 9 |
| D0010000 | Chowan R - Riddicksville | 34 | 10 | 0 | 0.0 | 1 | 1 | 1 | 1 | 3 | 4 | 8 |
| D6250000 | Chowan R - Winton | 33 | 7 | 0 | 0.0 | 1 | 1 | 1 | 2 | 4 | 7 | 20 |
| D8356200 | Chowan R - Gatesville | 32 | 8 | 0 | 0.0 | 1 | 1 | 1 | 3 | 6 | 17 | 31 |
| **02** | | | | | | | | | | | | |
| D4150000 | Potecasi Cr | 22 | 8 | 0 | 0.0 | 1 | 1 | 1 | 1 | 3 | 7 | 9 |
| D5000000 | Meherrin R | 32 | 9 | 0 | 0.0 | 1 | 1 | 1 | 2 | 4 | 7 | 13 |
| **03** | | | | | | | | | | | | |
| D8430000 | Chowan R - Holiday Island | 33 | 8 | 0 | 0.0 | 1 | 1 | 1 | 2 | 6 | 9 | 19 |
| D8950000 | Chowan R at Colerain | 33 | 9 | 0 | 0.0 | 1 | 1 | 1 | 2 | 6 | 20 | 37 |
| **04** | | | | | | | | | | | | |
| D9490000 | Chowan R at Edenhouse | 33 | 7 | 1 | 3.0 | 1 | 1 | 2 | 3 | 6 | 12 | 58 |
| D999500C | Albemarle Sound - Mid | 31 | 4 | 0 | 0.0 | 1 | 1 | 2 | 6 | 9 | 17 | 37 |
| D999500N | Albemarle Sound - N Shore | 32 | 4 | 1 | 3.1 | 1 | 1 | 2 | 5 | 9 | 18 | 58 |
| D999500S | Albemarle Sound - S Shore | 32 | 6 | 1 | 3.1 | 1 | 1 | 1 | 4 | 10 | 23 | 44 |
| **50** | | | | | | | | | | | | |
| M2750000 | Pasquotank R | 8 | 0 | 0 | 0.0 | 2 | 2 | 2 | 5 | 8 | 10 | 10 |
| 51 | | | | | | | | | | | | |
| M6980000 | Scuppernong R | 35 | 4 | 3 | 8.6 | 1 | 1 | 2 | 6 | 21 | 47 | 190 |
| M7175000 | Alligator R | 35 | 0 | 0 | 0.0 | 1 | 3 | 4 | 7 | 14 | 19 | 39 |
| **52** | | | | | | | | | | | | |
| M3500000 | Little R | 7 | 2 | 0 | 0.0 | 1 | 1 | 1 | 1 | 2 | 6 | 6 |
| M390000C | Albemarle S - Frog Island - Mid | 26 | 0 | 1 | 3.8 | 4 | 5 | 6 | 10 | 20 | 32 | 64 |
| M390000N | Albemarle S - Frog Island - N shore | 28 | 0 | 1 | 3.6 | 3 | 5 | 7 | 11 | 15 | 33 | 49 |
| M390000S | Albemarle S - Frog Island - S shore | 28 | 1 | 2 | 7.1 | 1 | 5 | 6 | 12 | 20 | 29 | 85 |
| M5000000 | Perquimans R | 7 | 0 | 0 | 0.0 | 1 | 1 | 1 | 2 | 8 | 8 | 8 |
| M610000C | Albemarle S - Harvey - Mid | 29 | 1 | 0 | 0.0 | 1 | 2 | 5 | 7 | 11 | 21 | 25 |
| M610000N | Albemarle S - Harvey - N shore | 28 | 0 | 0 | 0.0 | 2 | 3 | 5 | 8 | 11 | 19 | 22 |
| M610000S | Albemarle S - Harvey - S shore | 29 | 1 | 0 | 0.0 | 1 | 3 | 6 | 7 | 12 | 20 | 32 |
| **53** | | | | | | | | | | | | |
| M6920000 | Kendricks Cr | 4 | 0 | 0 | 0.0 | 4 | 4 | 4 | 4 | 11 | 13 | 13 |



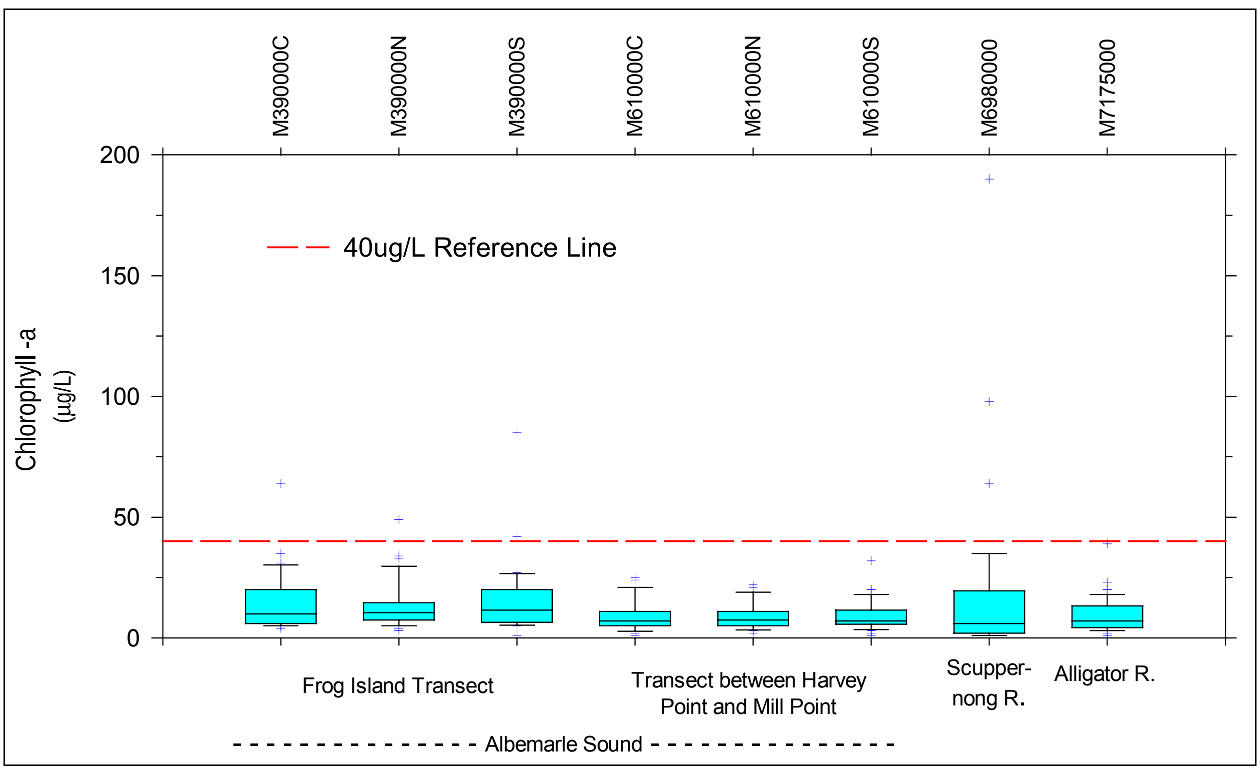




**Figure 39.** **Chlorophyll *a* concentrations from monitoring sites in the Chowan River (top) and Pasquotank River basin (bottom), 1995 - 2000. Only stations with 10 or more samples were graphed.**

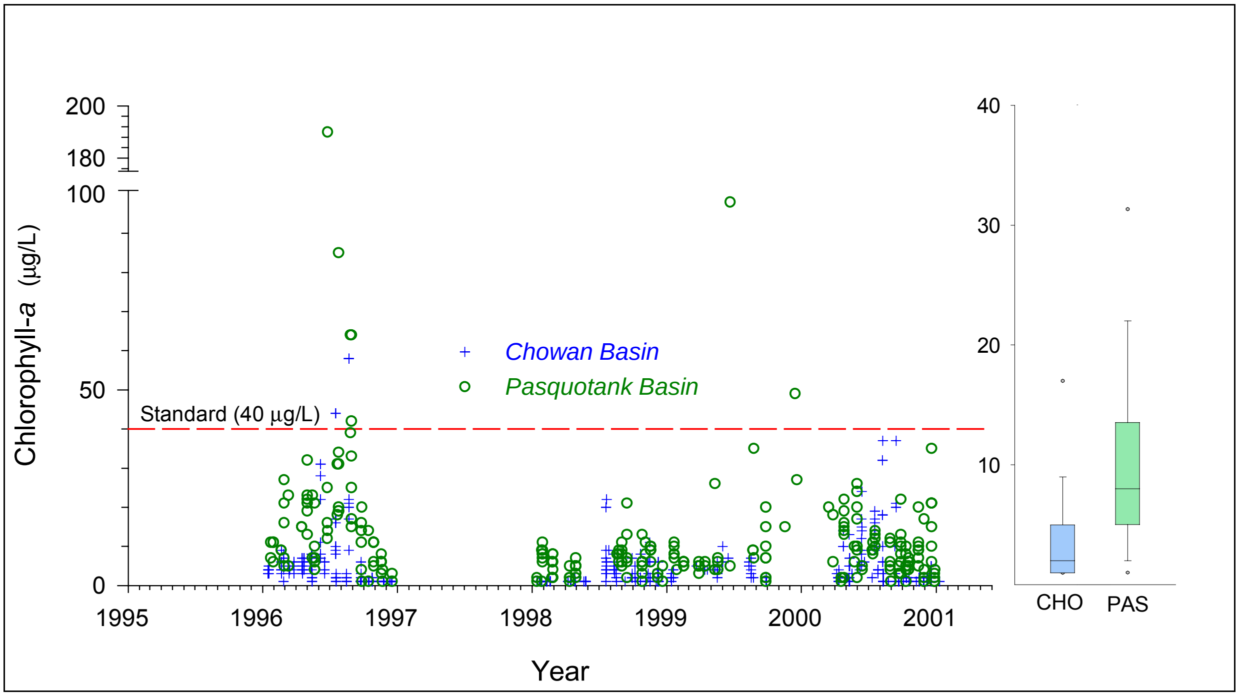



**Figure 40.** **Chlorophyll *a* concentrations from all stations, since 1996. Box and whisker plot depicting distribution of chlorophyll *a* between the Chowan River and Pasquotank River basins. Data from 1997 were not available.**

## AQUATIC TOXICITY MONITORING

Eight facility permits in the Chowan River and Pasquotank River basins currently require whole effluent toxicity (WET) monitoring (Figure 41; Table 44). Five facility permits have a WET limit; the other three facility permits specify monitoring with no limit.

Few facilities in these two relatively small basins have been assigned limits for whole effluent toxicity since 1987, the first year that whole effluent toxicity limits were written into permits in North Carolina (Table 44). The compliance rate of those facilities has been consistently high, with minor fluctuations in 1997 and 1998 (Figure 42; Table 45).

Piece Dye Acquisition Corporation (Subbasin Chowan 03) experienced failing chronic toxicity tests in August and September of 1998. Though no absolute cause-effect relationship was established, removal of algal growth in the wastewater treatment plant seemed to solve the toxicity problem. The facility has not failed a test since September 1998.

The Elizabeth City WWTP (Subbasin Pasquotank 50) experienced problems with whole effluent toxicity during 1997. The causes of these events are not clear. The facility has not failed a test since September 1997.

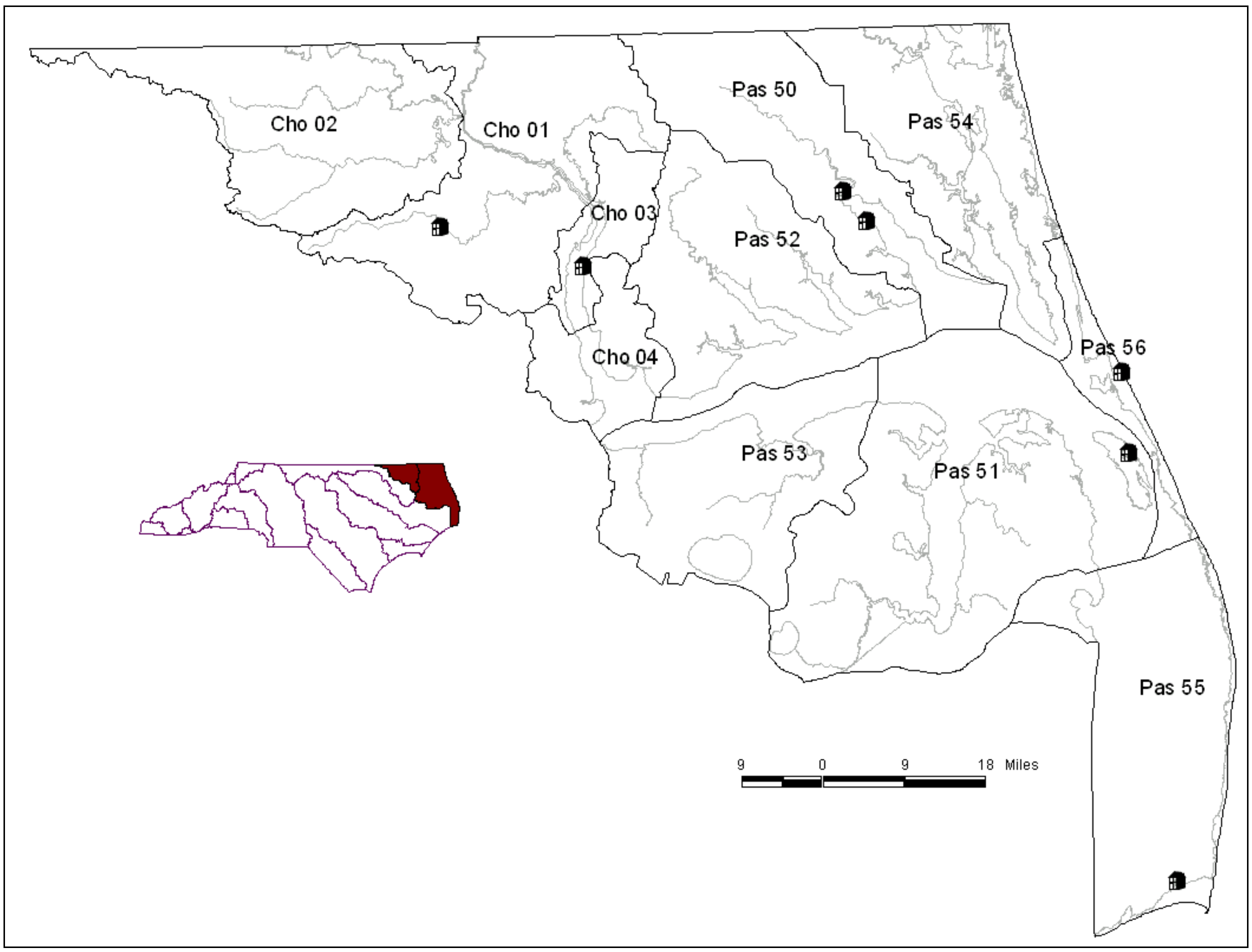



**Table 41. Facilities required to perform toxicity testing in the Chowan River and Pasquotank River basins.**

**Table 44. Facilities in the Chowan River and Pasquotank River basins required to perform whole effluent toxicity testing.**

| Subbasin/Facility | NPDES Permit No. | Receiving Stream | County | Flow (MGD) | IWC (%) | 7Q10 (CFS) |
|---|---|---|---|---|---|---|
| **Chowan 01** | | | | | | |
| Easco Aluminum | NC0086231/001 | Ahoskie Cr | Hertford | 0.024 | 2.40 | 3.0 |
| **Chowan 03** | | | | | | |
| Piece Dye Acquisition Corp. - 001 | NC0003867/001 | Chowan R | Chowan | 1.5 | NA | Tidal |
| **Pasquotank 50** | | | | | | |
| Elizabeth City WWTP | NC0025011/001 | Pasquotank R | Pasquotank | 4.5 | 10 | Tidal |
| US Coast Guard/002 | NC0079499/002 | Pasquotank R | Pasquotank | NA | NA | Tidal |
| **Pasquotank 51** | | | | | | |
| Manteo WWTP | NC0079057/001 | Shallowbag Bay | Dare | 0.6 | NA | Tidal |
| **Pasquotank 55** | | | | | | |
| Cape Hatteras Water Assoc. WTP | NC0085707/001 | Pamlico Sound | Dare | 1.8 | NA | Tidal |
| **Pasquotank 56** | | | | | | |
| Dare County-Reverse Osmosis/001 | NC0070157/001 | UT Atlantic Ocean | Dare | NA | 100 | 0.00 |
| Dare County-Reverse Osmosis/002 | NC0070157/002 | UT Atlantic Ocean | Dare | NA | 100 | 0.00 |

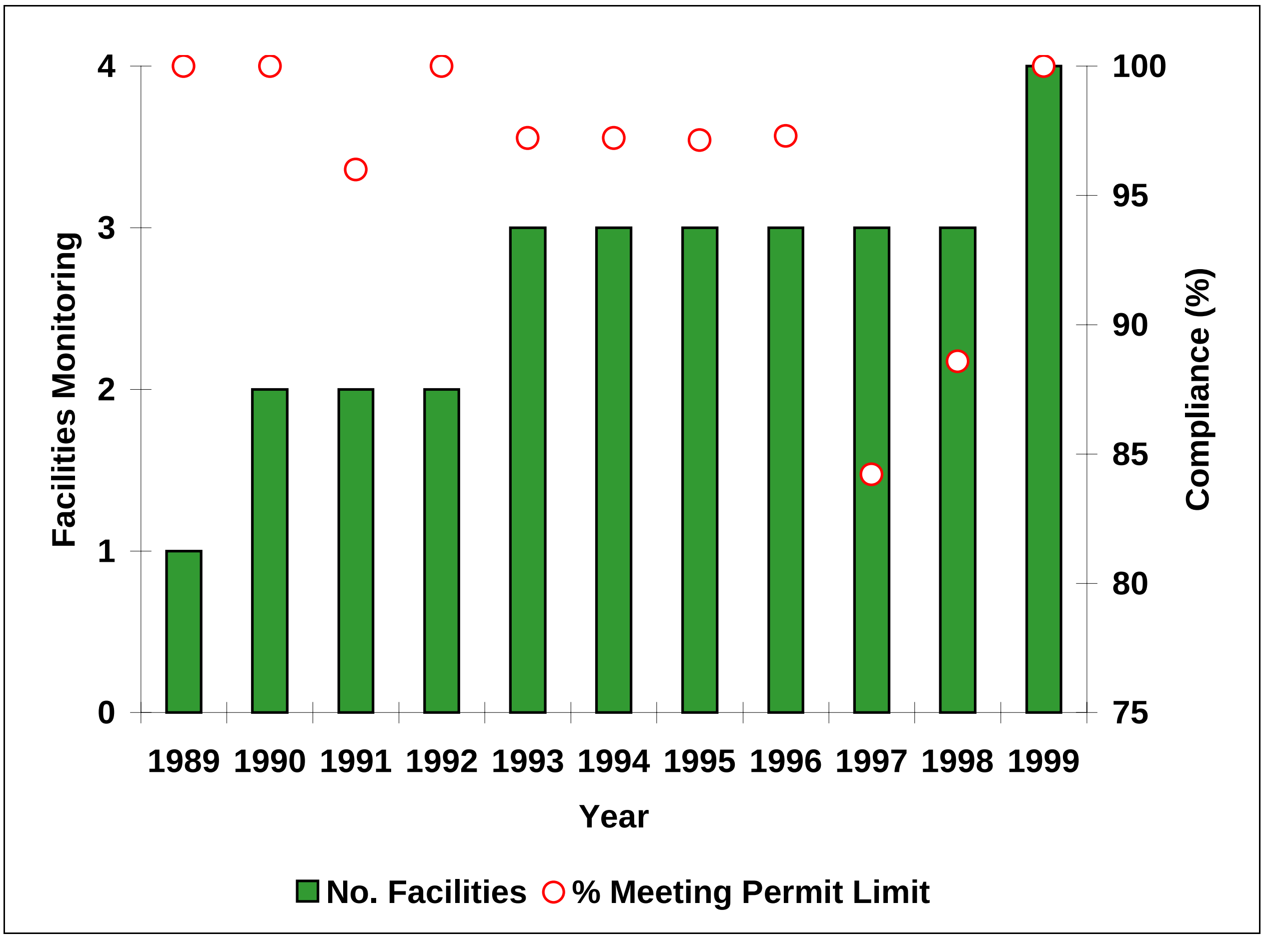



**Figure 42. Whole effluent toxicity monitoring in the Chowan River and Pasquotank River basins, 1989 - 1999. The compliance values were calculated by determining whether a facility was meeting its ultimate permit limit during the given time period, regardless of any SOCs in force.**

**Table 45. Compliance record of facilities performing whole effluent toxicity testing in the Chowan River and Pasquotank River basins.**

| Subbasin/Facility | NPDES Permit No. | Pre 2000 Passes[2] | Pre 2000 Fails | 2000 Passes | 2000 Fails |
|---|---|---|---|---|---|
| **Chowan 01** | | | | | |
| Easco Aluminum | NC0086231/001 | 3 | 0 | 4 | 0 |
| **Chowan 03** | | | | | |
| Piece Dye Acquisition Corp. -001 | NC0003867/001 | 42 | 3 | 3 | 0 |
| **Pasquotank 50** | | | | | |
| Elizabeth City WWTP | NC0025011/001 | 45 | 9 | 3 | 0 |
| US Coast Guard/002[1] | NC0079499/002 | 11 | 1 | 1 | 0 |
| **Pasquotank 51** | | | | | |
| Manteo WWTP | NC0079057/001 | 25 | 3 | 4 | 0 |
| **Pasquotank 55** | | | | | |
| Cape Hatteras Water Assoc. WTP | NC0085707/001 | 0 | 0 | 3 | 0 |
| **Pasquotank 56** | | | | | |
| Dare County - Reverse Osmosis/001[1] | NC0070157/001 | 18 | 4 | 3 | 0 |
| Dare County - Reverse Osmosis/002[1] | NC0070157/002 | 36 | 14 | 3 | 4 |

[1]Facility monitors whole effluent toxicity without a limit.
[2]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.

# REFERENCES


Burkholder, J. M. and H. B. Glasgow, Jr. 1997. *Pfiesteria piscicida* and other *Pfiesteria*-like dinoflagellates: behavior, impacts, and environmental controls. Limnology and Oceanography. 42: 1052 - 1075.

_____, and E. K. Hannon. 1998. The toxic *Pfiesteria* complex *vs*. mistaken identities. 5 pp. (unpublished manuscript).

Copeland, B. J., R. G. Hodson, S. R. Riggs, and J. E. Easley. 1983. Ecology of Albemarle Sound, North Carolina: an estuarine profile. US Fish & Wildlife Service, FWS/OBS-83/01, 68 pp.

Frost, C. 1982. Natural areas of Gates County, North Carolina. Coastal Energy Impact Program. Report No. 16.

Glasgow, H. B., J. M. Burkholder, J. Springer, and S. L. Morton. 2001. A new species of icthyotoxic *Pfiesteria* (Dinamoebales, Pyrrhophyta). Phycologia 40: 234 - 245.

Hackney, C. T., J. Grimley, M. Posey, and T. Alphin. 1998. Sediment contamination in North Carolina estuaries. UNC Wilmington, Center for Marine Science Research, Publication #198, 59 pp.

Lauritsen, D. and S. Mozley. 1983. Freshwater Asian clam *Corbicula fluminea* as a factor affecting nutrient cycling in the Chowan River, N.C. Water Resources Research Institute of North Carolina Report No. 192. 60 pp.

Lynch, J. M., and S. J. Peacock. 1982. Natural areas inventory of Hyde County, North Carolina, Coastal Energy Impact Program Report No. 28.

MacDonald, C. B. and A. N. Ash. 1981. Natural areas inventory of Tyrrell County, North Carolina. Coastal Energy Impact Program. Report No. 8.

NCDEH. 1998. Report of sanitary survey, Croatan Sound Area. North Carolina Division of Environmental Health. Raleigh, NC. 46 pp.

_____. 1999. Report of sanitary survey, Albemarle/Currituck Sound Areas. *Ibid*. 110 pp.

NCDEHNR. 1992. Standard operating procedures. Biological monitoring. Environmental Sciences Branch; Ecosystems Analysis Unit; Biological Assessment Group. April 1992. North Carolina Department of Environment, Health, and Natural Resources. Division of Environmental Management. Water Quality Section. Raleigh, NC.

_____. 1996a. Standard operating procedures manual, physical and chemical monitoring. February 1996. North Carolina Department of Environment, Health, and Natural Resources. Division of Environmental Management, Water Quality Section. Raleigh, NC.

_____. 1996b. Basinwide assessment report support document, Chowan and Pasquotank River Basins. *Ibid.*

_____. 1996c. Results of 1995 fish tissue mercury assessments. *Ibid.*

_____. 1997a. Standard operating procedures. Biological Monitoring. Environmental Sciences Branch. Ecosystems Analysis Unit. Biological Assessment Group. North Carolina Department of Environment, Health and Natural Resources. Division of Water Quality. Water Quality Section. Raleigh, NC.

_____. 1997b. Chowan River basinwide water quality management plan. Division of Environmental Management. Water Quality Section. Raleigh, NC.

NCDEM. 1982. Chowan/Albemarle action plan. North Carolina Division of Environmental Management. Raleigh, NC. 103 pp.

NCDENR. 1998. Standard operating procedures for phytoplankton sampling and enumeration. July 1998 (draft). North Carolina Department of Environment and Natural Resources. Division of Water Quality; Water Quality Section. Raleigh, NC.

_____. 2000a. North Carolina's 2000 §303(d) list. *Ibid.*

_____. 2000b. Annual report of fish kill events. *Ibid.*

_____. 2000c. Classifications and water quality standards assigned to the waters of the Pasquotank River Basin. 15A NCAC 2B .0317. *Ibid.*

NCDHHS. 2000. Active North Carolina fish consumption advisories. North Carolina Department of Health and Human Services. Raleigh, NC.

Peacock, S. J. and J. M. Lynch. 1982. Natural areas inventory of mainland Dare County, North Carolina. Coastal Energy Impact Program. Report No. 27.

Riggs, S. R., J. T. Bray, R. A. Wyrick, C. R. Kingman, D. V. Ames, J. C. Hamilton, and K. L. Owens. 1993. Heavy metals in organic-rich muds of the Albemarle Sound estuarine system. Albemarle-Pamlico Estuarine Study Report 93-02. 151 pp.

USEPA. 1995. Guidance for assessing chemical contaminant data for use in fish advisories. Vol. 1: Fish sampling and analysis. 2nd Edition. Washington, D.C. Office of Science and Technology. EPA 823-R-95-007.

_____. 1997. Mercury study report to Congress. Volume I: Executive summary. EPA-452/R-97-003. December. Office of Air Quality. Planning and Standards and Office of Research and Development, Research Triangle Park, NC.

USFDA. 1980. Action levels for poisonous or deleterious substances in human food and animal feed. Shellfish Sanitation Branch, Washington, D. C.

USDA. 1995. Eastern North Carolina cooperative river basin study. Natural Resources Conservation Service.

## GLOSSARY

| | |
|---|---|
| 7Q10 | A value which represents the lowest average flow for a seven day period that will recur on a ten year frequency. This value is applicable at any point on a stream. 7Q10 flow (in cfs) is used to allocate the discharge of toxic substances to streams. |
| Bioclass 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 insect orders (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, sandhills, and slate belt. |
| EPT | The insect orders (Ephemeroptera, Plecoptera, Trichoptera); as a whole, the most intolerant insects present in the benthic community. |
| EPT N | The abundance of Ephemeroptera, Plecoptera, Trichoptera insects present, using values of 1 for Rare, 3 for Common and 10 for Abundant. |
| EPT S | Taxa richness of the insect orders Ephemeroptera, Plecoptera and Trichoptera. Higher taxa richness values are associated with better water quality. |
| HQW | High Quality Waters. Waters rated as 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. |
| IWC | Instream Waste Concentration. The percentage of a stream comprised of an effluent calculated using permitted flow of the effluent and 7Q10 of the receiving stream. |
| Major Discharger | Greater than or equal to one million gallons per day discharge (≥ 1 MGD). |
| MGD | Million Gallons per Day, generally the unit in which effluent discharge flow is measured. |
| Minor Discharger | Less than one million gallons per day discharge (< 1 MGD). |

| | |
|---|---|
| NPDES | National Pollutant Discharge Elimination System. |
| NCBI (EPT BI) | North Carolina Biotic Index, EPT Biotic Index. A summary measure of the tolerance values of organisms found in the sample, relative to their abundance. Sometimes noted as the NCBI or EPT BI. |
| NCIBI | North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community. |
| NSW | Nutrient Sensitive Waters. 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. |
| SA Waters | Suitable for commercial shellfishing and all other tidal saltwaters uses. |
| SB Waters | Saltwaters protected for primary recreation which includes swimming on a frequent or organized basis and all Class SC waters. |
| SC Waters | Saltwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. All saltwaters shall be classified to protect these uses at a minimum. |
| 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. |
| WWTP | Wastewater treatment plant. |

## Appendix B1. Benthic macroinvertebrate sampling methods and criteria.

### Freshwater wadeable and flowing waters

Benthic macroinvertebrates can be collected from wadeable, freshwater, flowing waters using two sampling procedures. The Biological Assessment Unit's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (NCDEHNR 1997). 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 an EPT sampling procedure. [Note: "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution.] Four rather than 10 composite qualitative samples are taken at each site: 1 kick, 1 sweep, 1 leafpack and visual collections. Only EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification.

Several data-analysis summaries (metrics) can be produced from standard qualitative and EPT samples to detect water quality problems (Table B1). These metrics are based on the idea that unstressed streams and rivers have many invertebrate taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index.

For standard qualitative samples, EPT taxa richness (EPT S) is used with NCDWQ criteria to assign water quality scores. Higher EPT taxa richness values usually indicate better water quality. Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI).

Table B1 Benthos classification criteria for freshwater wadeable and flowing water systems in the coastal plain ecoregion.

| Metric | Sample type | Bioclass | Score |
|---|---|---|---|
| EPT S | 10-sample Qualitative | Excellent | > 27 |
| | | Good | 21 - 27 |
| | | Good-Fair | 14 - 20 |
| | | Fair | 7 - 13 |
| | | Poor | 0 - 6 |
| | 4-sample EPT | Excellent | > 23 |
| | | Good | 18 - 23 |
| | | Good-Fair | 12 - 17 |
| | | Fair | 6 –11 |
| | | Poor | 0 - 5 |
| Biotic Index (range 0 – 10) | 10-sample Qualitative | Excellent | < 5.47 |
| | | Good | 5.47 - 6.05 |
| | | Good-Fair | 6.06 - 6.72 |
| | | Fair | 6.73 - 7.73 |
| | | Poor | > 7.73 |

Both tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions. Water quality scores assigned with the biotic index numbers are combined with EPT taxa richness scores to produce a final bioclassification, using criteria for coastal plain streams. EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. If the EPT taxa richness score and the biotic index differ by one, the EPT abundance value is used to determine the final site rating.

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

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

**Boat Sampling and Coastal B Criteria**
Coastal B rivers are defined as waters in the coastal plain that are deep (nonwadeable) with little or no visible current under normal or low flow conditions and that have freshwater. Other characteristics may include open canopy, low pH, and low dissolved oxygen. These waters require a boat for sampling. These are usually large coastal plain rivers, including the lower sections of the Alligator, Chowan, Meherrin, Neuse, Pasquotank, Perquimans, Roanoke, Tar, South, Black, Waccamaw, Wiccacon, Northeast Cape Fear and Cape Fear rivers. In such habitats, petite Ponar dredge sampling replaces kick-net samples, but all other standard qualitative collections techniques are still useable.

The standard boat method still aims at 10 composite samples per site: three samples using a petite Ponar, three bank sweeps, one leafpack sample, two epifaunal collections of macrophytes and well-colonized logs, and visual collections from macrophytes, logs along the shore, and logs in the current.

The Biological Assessment Unit has limited data on Coastal B rivers and has had a difficult time gathering more data. Criteria have been developed based only on EPT taxa richness (Table B2), although using biotic index values and total taxa richness values were also evaluated. The criteria that are presented here will continue to be evaluated, and any bioclassifications derived from them should be considered tentative and not used for use support decisions.

**Table B2. Benthos classification criteria for freshwater nonwadeable, Coastal B systems in the coastal plain ecoregion.**

| Bioclassification | EPT S |
|---|---|
| Excellent | > 11 |
| Good | 9 - 11 |
| Good-Fair | 6 - 8 |
| Fair | 3 - 5 |
| Poor | > 3 |

### Swamp streams
Swamp streams are located in the coastal plain area and cease flowing during summer low-flow periods. This seasonal interruption in flow limits the diversity of the fauna, requiring special criteria to properly rate such streams. The swamp stream sampling method utilizes a variety of collection techniques to inventory the macroinvertebrate fauna at a site. Nine sweep samples (one series of three by each field team member) are collected from each of the habitat types: 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 should be substituted. A sweep for the swamp method is defined as the area that can be reached from a given standing location. Three log/debris washes also are 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, or Abundant) for each taxon. Sampling during winter flow periods provides the best opportunity for detecting impacts, and only winter benthos (February and March) data can be used to evaluate swamp streams.

A draft multi-metric system is being developed to evaluate swamp streams, using the NC Biotic Index (BI), habitat score, total taxa richness (S) and EPT abundance (EPT N). The system uses data from the Lumber, White Oak, Cape Fear, Neuse and Tar River basins. Other basins will need different criteria. Swamp streams are divided into two broad types: streams with a distinct channel and streams with a braided channel. EPT abundance and total taxa richness are expected to be lower in braided swamp streams. Stream pH also affects these metrics, and scoring criteria will likely be adjusted for all sites with pH < 5.5.

### Estuaries
Shallow (< 1.5 m) estuarine waters are sampled using a D-frame dip net with a 600 - 700 µm mesh bag. All available subtidal benthic habitats were swept for ten minutes. Some elutriation of the sample usually took place in the field to reduce sample volume, then the sample was preserved in 10 percent formalin with rose bengal added as a tissue stain.

At the laboratory, macroinvertebrates were separated from the sediment by visual examination. Macroinvertebrates were identified to the lowest practical taxonomic level, usually species. Abundance was recorded semi-quantitatively, with only a general indication of a taxon's abundance: Rare = 1 - 2; Common = 3 - 9; Abundant = 10 – 29; Very Abundant = 30 – 99; and Dominant > 100. No more than 100 individuals of any taxon were counted because the presence of a greater number of individuals of a particular taxa at a site was no more informative, but much more costly to enumerate.

A biotic index is calculated from the individual taxon's sensitivity values (ranging from 1 to 5) and weighted for abundance using a formula commonly used in calculating freshwater biotic indices (Chutter 1972, Hilsenhoff 1977, Lenat 1993):

$$BI = (\sum SV_i * N_i)/\text{Total } N$$

where $SV_i$ is the sensitivity value of the $i^{th}$ taxa, $N_i$ is the abundance of the $i^{th}$ taxa and Total N is the number of individuals in the sample. A high Estuarine Biotic Index (E BI) value indicates many intolerant taxa and good water quality at a location, while a low EBI is indicative of stressed conditions.

Amphipoda and Caridean shrimp taxa richness, as well as Total taxa richness, also are used to assess between-site differences. Many species at a location, particularly pollution intolerant taxa, indicate healthy conditions, while few species at a site indicate stressed conditions (Eaton, 2001).

References

Chutter, F. M. 1972. An empirical biotic index of the quality of water in South African streams and rivers. Water Research. 6: 19-30.

Eaton, L. E. 2001. Development and validation of biocriteria using benthic macroinvertebrates for North Carolina estuarine waters. Marine Pollution Bulletin. 42: 23-30.

Hilsenhoff, W. L. 1977. Use of arthropods to evaluate water quality in streams. Wisconsin Department of Natural Resources, Technical Bulletin No. 100.

Lenat, D. L. 1993. A biotic index for the southeastern United States: derivation and list of tolerance values, with criteria for assigning water-quality ratings. J. North American Benthological Society. 12: 279-290.

**Flow Measurement**

Changes in the benthic macroinvertebrate community are often used to help assess between-year changes in water quality. Some between-year changes in the macroinvertebrates, however, may be due largely to changes in flow. High flow years magnify the potential effects of nonpoint source runoff, leading to scour, substrate instability, and reduced periphyton. Low flow years may accentuate the effect of point source dischargers by providing less dilution of wastes.

For these reasons, all between-year changes in the biological communities are considered in light of flow conditions (high, low, or normal) for one month before the sampling date. Daily flow information is obtained from the closest available USGS monitoring site and compared to the long-term mean flows. High flow is defined as a mean flow greater than 140 percent of the long-term mean for that time period, usually July or August. Low flow is defined as a mean flow less than 60 percent of the long-term mean, while normal flow is 60%-140% of the mean. While broad scale regional patterns are often observed, there may be large geographical variation within the state, and large variation within a single summer period.

**Habitat Evaluation**

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

**Appendix B2. Benthic macroinvertebrate data collected in the Chowan River basin, 1983 - 2000. Basinwide monitoring sites are in bold.**

| Subbasin/Waterbody | Location | County | Index No. | Date | S | EPT S | BI | EPT BI | BioClass |
|---|---|---|---|---|---|---|---|---|---|
| **01** | | | | | | | | | |
| **Chowan R** | nr Riddicksville | Hertford | 25 | 07/31/00 | 46 | 7 | 7.33 | 5.84 | Good-Fair |
| | | | | 08/10/95 | 52 | 8 | 7.79 | 5.89 | Good-Fair |
| | | | | 07/11/90 | 58 | 14 | 7.28 | 5.34 | Excellent |
| | | | | 07/13/88 | 66 | 10 | 7.16 | 6.15 | Good |
| | | | | 07/07/86 | 63 | 10 | 7.51 | 6.27 | Good |
| | | | | 07/17/84 | 65 | 9 | 6.77 | 5.37 | Good |
| **Chowan R** | nr Gatesville | Gates | 25 | 08/01/00 | 62 | 9 | 7.22 | 4.70 | Good |
| **Cole Cr** | NC 58 | Gates | 25-12-7 | 02/10/00 | 47 | 4 | 7.60 | 7.00 | Not Rated |
| **Wiccacon R** | SR 1433 | Hertford | 25-14 | 08/01/00 | 66 | 6 | 7.88 | 6.80 | Fair |
| | | | | 08/06/95 | 55 | 5 | 7.72 | 7.44 | Fair |
| | | | | 02/16/95 | 27 | 2 | 8.55 | 6.82 | Not Rated |
| | | | | 07/10/89 | 47 | 2 | 7.93 | 7.34 | Poor |
| | | | | 07/09/87 | 60 | 3 | 7.99 | 7.95 | Fair |
| | | | | 07/26/85 | 59 | 5 | 7.91 | 7.02 | Fair |
| | | | | 07/20/83 | 56 | 4 | 7.87 | 6.72 | Fair |
| Ahoskie Cr | NC 42 | Hertford | 25-14-1 | 08/09/95 | 61 | 7 | 7.67 | 6.19 | Not Rated |
| | | | | 02/28/95 | 59 | 8 | 6.94 | 5.66 | Not Rated |
| **Stony Cr** | SR 1235 | Bertie | 25-14-1-6 | 02/10/00 | 43 | 2 | 7.21 | 6.34 | Not Rated |
| **Chinkapin Cr** | SR 1432 | Hertford | 25-14-3 | 02/10/00 | 60 | 8 | 6.98 | 6.22 | Not Rated |
| UT Chinkapin Cr | SR 1432 | Hertford | 25-14-3 | 04/03/86 | 36 | 1 | 8.02 | 5.78 | Not Rated |
| **02** | | | | | | | | | |
| Jacks Swp | SR 1301 | Northampton | 25-4-2-3 | 11/08/84 | 45 | 10 | 6.95 | 2.92 | Not Rated |
| **Kirbys Cr** | SR 1362 | Northampton | 25-4-4 | 02/17/00 | 54 | 12 | 6.25 | 5.10 | Not Rated |
| | | | | 03/11/97 | 53 | 18 | 5.71 | 4.65 | Not Rated |
| | | | | 02/28/95 | 62 | 11 | 6.69 | 5.86 | Not Rated |
| **Meherrin R** | SR 1175 | Hertford | 25-4-(5) | 07/31/00 | 59 | 10 | 7.68 | 6.41 | Good |
| | | | | 08/10/95 | 47 | 9 | 6.98 | 5.59 | Good |
| | | | | 02/15/95 | 48 | 9 | 6.95 | 5.46 | Good |
| | | | | 07/10/89 | 59 | 9 | 7.26 | 6.15 | Good |
| | | | | 07/09/87 | 73 | 10 | 7.47 | 5.84 | Good |
| | | | | 07/25/85 | 74 | 12 | 7.63 | 6.36 | Excellent |
| | | | | 07/21/83 | 60 | 9 | 7.28 | 6.04 | Good |
| **Potecasi Cr** | SR 1504 | Northampton | 25-4-8 | 02/09/00 | 24 | 1 | 6.97 | 7.78 | Not Rated |
| Potecasi Cr | NC 11 | Hertford | 25-4-8 | 07/10/89 | 66 | 11 | 7.18 | 6.07 | Not Rated |
| | | | | 07/07/86 | 53 | 6 | 7.34 | 5.95 | Not Rated |
| | | | | 07/17/84 | 53 | 7 | 6.88 | 5.12 | Not Rated |
| **Urahaw Swp** | NC 35 | Northampton | 25-4-8-4 | 02/09/00 | 20 | 0 | 6.83 | | Not Rated |
| **Cutawhiskie Swp** | SR 1141 | Hertford | 25-4-8-7 | 02/02/00 | 49 | 3 | 6.88 | 5.80 | Not Rated |
| | | | | 02/28/95 | 46 | 3 | 7.20 | 5.70 | Not Rated |
| | | | | 08/09/95 | 49 | 4 | 6.83 | 6.13 | Not Rated |
| **04** | | | | | | | | | |
| **Chowan R** | US 17 | Chowan | 25 | 08/01/00 | 29 | 6 | 6.61 | 4.65 | Good-Fair |
| | | | | 08/08/95 | 34 | 8 | 6.50 | 5.40 | Good-Fair |
| | | | | 06/11/90 | 41 | 11 | 6.32 | 4.87 | Good |
| | | | | 07/13/88 | 45 | 7 | 6.72 | 5.55 | Good-Fair |
| | | | | 07/08/86 | 38 | 6 | 6.81 | 5.55 | Good-Fair |
| | | | | 07/19/85 | 37 | 5 | 7.04 | 4.91 | Fair |
| | | | | 07/17/84 | 41 | 8 | 6.61 | 4.91 | Good-Fair |
| | | | | 07/13/83 | 42 | 8 | 7.08 | 5.06 | Good-Fair |
| **Eastmost Swp** | SR 1361 | Bertie | 25-24-1 | 02/22/00 | 56 | 5 | 7.42 | 6.68 | Not Rated |

**Appendix B3. Benthic macroinvertebrate data collected in the Pasquotank River basin, 1983 - 2000. Basinwide monitoring sites are in bold.**

| Subbasin/ Waterbody | Location | County | Index No. | Date | S | EPT S | BI (EBI) | EPT BI | BioClass |
|---|---|---|---|---|---|---|---|---|---|
| **50** | | | | | | | | | |
| Freshwater | | | | | | | | | |
| **Pasquotank R** | End of SR 1361 | Pasquotank | 30-3-(1) | 08/03/00 | 27 | 0 | 8.27 | --- | Not Rated |
| **Pasquotank R** | Goat Island | Pasquotank | 30-3-(3) | 08/02/00 | 31 | 4 | 8.09 | 6.83 | Not Rated |
| **Sawyers Cr** | SR 1200 | Camden | 30-3-6 | 02/18/00 | 27 | 0 | 7.65 | --- | Not Rated |
| **Areneuse Cr** | NC 343 | Camden | 30-3-13-(1) | 02/18/00 | 22 | 0 | 7.88 | --- | Not Rated |
| **Newbegun Cr** | SR 1132 | Camden | 30-3-16-(1) | 02/23/00 | 20 | 0 | 8.60 | | Not Rated |
| Estuarine | | | | | | | | | |
| Albemarle Sound | Frog Island | Pasquotank | 30 | 07/14/83 | 26 | 4 | 2.0 | 3.97 | Not Rated |
| Pasquotank R | US 158 | Pasquotank | 30-3-(7) | 08/08/95 | 17 | 1 | 1.9 | | Not Rated |
| | | | | 07/18/85 | 16 | 0 | 2.1 | --- | Not Rated |
| | | | | 07/19/83 | 35 | 1 | 1.7 | --- | Not Rated |
| Newbegun Cr | near mouth | Pasquotank | 30-3-16-(2) | 06/26/95 | 21 | 1 | 2.3 | --- | Not Rated |
| **51** | | | | | | | | | |
| Freshwater | | | | | | | | | |
| Alligator R | near Gum Neck | Tyrrell | 30-16-(7) | 08/07/95 | 22 | 2 | 8.27 | 6.32 | Not Rated |
| | | | | 07/17/85 | 26 | 3 | 7.92 | 4.64 | Not Rated |
| | | | | 07/24/84 | 35 | 4 | 7.72 | 5.19 | Not Rated |
| | | | | 06/22/83 | 31 | 4 | 7.80 | 4.69 | Not Rated |
| **NW Fk Alligator R** | Canoe trail mile 4 | Tyrrell | 30-16-8 | 03/01/00 | 13 | 0 | 8.20 | --- | Not Rated |
| **SW Fk Alligator R** | Canoe trail mile 2 | Tyrrell | 30-16-8-2 | 03/01/00 | 14 | 0 | 7.19 | --- | Not Rated |
| UT Billys Ditch | Off US 64, near landfill | Dare | 30-16-23-2-2-1 | 10/10/00 | 43 | 2 | 8.04 | 7.97 | Not Rated |
| UT Billys Ditch | Off US 64, east of NWR (Reference) | Dare | 30-16-23-2-2-1 | 10/10/00 | 33 | 2 | 8.42 | 6.67 | Not Rated |
| UT Hooker Gut | Off US 64, #8 | Dare | 30-16-23-2-2 | 01/06/99 | 24 | 2 | 8.81 | 9.26 | Not Rated |
| Callaghan Cr | At bend | Dare | 30-20-4 | 06/27/95 | 23 | 0 | 8.21 | --- | |
| UT Callaghan Cr | Below landfill, #3 | Dare | 30-20-4 | 01/06/99 | 2 | 0 | 9.25 | --- | Not Rated |
| UT Callaghan Cr | Ditch off Cub Rd, #2A | Dare | 30-20-4 | 10/10/00 | 37 | 2 | 8.86 | 5.45 | Not Rated |
| UT Callaghan Cr | Bear Rd Ditch below Cub Rd Ditch, #6 | Dare | 30-20-4 | 01/06/99 | 31 | 2 | 8.42 | 7.63 | Not Rated |
| Estuarine | | | | | | | | | |
| Alligator R | US 64 | Dare | 30-16-(21.5) | 06/28/95 | 13 | --- | 2.4 | --- | Not Rated |
| Croatan Sound | Mann's Harbor | Dare | 30-20-(2) | 06/27/95 | 25 | --- | 2.1 | --- | Not Rated |
| | | | | 07/17/85 | 16 | --- | 1.8 | --- | Not Rated |
| Spencer Cr | Across from Ferry | Dare | 30-20-3 | 06/27/95 | 19 | --- | 2.1 | --- | Not Rated |
| | | | 30-20-4 | 10/10/00 | 31 | 0 | 8.77 | --- | Not Rated |
| Shallowbag Bay | Along shore near outfall | Dare | 30-21-3 | 06/26/95 | 15 | --- | 1.8 | --- | Not Rated |
| Broad Cr | North side, near point | Dare | 30-21-7 | 06/27/95 | 35 | --- | 2.0 | --- | Not Rated |
| Mill Cr | Wanchese Harbor | Dare | 30-21-8 | 06/27/95 | 18 | --- | 2.1 | --- | Not Rated |
| **52** | | | | | | | | | |
| Freshwater | | | | | | | | | |
| **Little R** | SR 1221 | Perquimans | 30-5-(1) | 02/11/00 | 24 | 0 | 7.95 | --- | Not Rated |
| Little R | US 17 | Perquimans | 30-5-(1) | 07/18/85 | 44 | 2 | 8.48 | 7.22 | Not Rated |
| | | | | 08/18/83 | 46 | 2 | 8.54 | 7.22 | Not Rated |
| **Burnt Mill Cr** | NC 37 | Chowan | 30-8-1 | 02/22/00 | 37 | 0 | 7.90 | --- | Not Rated |
| | | | | 02/27/95 | 41 | 2 | 7.69 | 8.81 | Not Rated |
| Perquimans R | SR 1111 | Perquimans | 30-6-(1) | 02/22/00 | 26 | 0 | 7.56 | | Not Rated |

## Appendix B3 (continued).

| Subbasin/ Waterbody | Location | County | Index No. | Date | S | EPT S | BI (EBI) | EPT BI | BioClass |
|---|---|---|---|---|---|---|---|---|---|
| **52** | | | | | | | | | |
| **Perquimans R** | 2 miles above Hertford | Perquimans | 30-6-(1) | 08/02/00 | 44 | 4 | 8.03 | 6.01 | Not Rated |
| | US 17 | Perquimans | 30-6-(3) | 08/08/95 | 41 | 6 | 7.23 | 3.46 | Not Rated |
| | | | | 07/11/90 | 49 | 8 | 7.71 | 6.01 | Not Rated |
| | | | | 07/12/88 | 42 | 5 | 7.66 | 6.20 | Not Rated |
| | | | | 07/09/86 | 36 | 5 | 7.72 | 4.81 | Not Rated |
| | | | | 07/18/85 | 38 | 6 | 7.65 | 5.65 | Not Rated |
| | | | | 07/20/83 | 36 | 4 | 8.07 | 4.72 | Not Rated |
| Estuarine | | | | | | | | | |
| Little R | At Hobbs Landing | Pasquotank | 30-5-(2) | 06/26/95 | 28 | 1 | 2.3 | --- | Not Rated |
| **53** | | | | | | | | | |
| Kendricks Cr | US 64 | Washington | 30-9-(1) | 10/26/00 | 36 | 0 | 7.60 | --- | Not Rated |
| Kendricks Cr | NC 308, near Mackeys | Washington | 30-9-(2) | 07/16/84 | 55 | 4 | 7.97 | 6.76 | Not Rated |
| | | Washington | | 06/21/83 | 42 | 3 | 8.46 | 7.31 | Not Rated |
| **Main Canal** | SR 1180 | Washington | 30-9-4 | 02/23/00 | 31 | 1 | 8.63 | 9.84 | Not Rated |
| | | Washington | | 02/27/95 | 31 | 2 | 7.07 | 8.02 | Not Rated |
| **Deep Cr** | SR 1302 | Washington | 30-14-2 | 02/23/00 | 28 | 1 | 7.06 | 6.37 | Not Rated |
| **Scuppernong R** | SR 1155 | Washington | 30-14-4-(1) | 08/03/00 | 49 | 2 | 8.13 | 6.06 | Not Rated |
| Scuppernong R | SR 1105 | Tyrrell | 30-14-4-(1) | 08/07/95 | 46 | 3 | 7.66 | 7.74 | Not Rated |
| | | | | 06/21/83 | 46 | 1 | 8.37 | 5.77 | Not Rated |
| **54** | | | | | | | | | |
| Estuarine | | | | | | | | | |
| Currituck Sound | Off Mackey Island | Currituck | 30-1 | 07/19/93 | 13 | --- | 3.0 | --- | Not Rated |
| Currituck Sound | Knotts Island | Currituck | 30-1 | 06/19/95 | 27 | 2 | 2.0 | 4.67 | Not Rated |
| | | | | 07/19/93 | 26 | 4 | 2.7 | 2.31 | Not Rated |
| Currituck Sound | Near Estuarine Reserve | Currituck | 30-1 | 06/20/95 | 29 | 2 | 2.2 | 2.29 | Not Rated |
| | | | | 07/20/93 | 32 | 2 | 2.5 | 1.38 | Not Rated |
| Currituck Sound | South of Corolla | Currituck | 30-1 | 06/20/95 | 31 | 3 | 1.8 | 3.67 | Not Rated |
| Currituck Sound | Off Aydlett | Currituck | 30-1 | 06/20/95 | 28 | 1 | 2.2 | 3.50 | Not Rated |
| Currituck Sound | Poplar Landing | Currituck | 30-1 | 07/20/93 | 31 | 4 | 2.4 | 7.24 | Not Rated |
| North R | East side near mouth | Currituck | 30-2 | 06/26/95 | 27 | 2 | 2.1 | 7.21 | Not Rated |
| **55** | | | | | | | | | |
| Estuarine | | | | | | | | | |
| Pamlico Sound | Near Pea Island | Dare | 30-22 | 06/27/95 | 76 | --- | 2.8 | --- | Not Rated |
| **56** | | | | | | | | | |
| Estuarine | | | | | | | | | |
| Currituck Sound | US 158 | Currituck | 30-1 | 06/20/95 | 28 | --- | 2.3 | --- | Not Rated |
| | | | | 07/20/93 | 29 | --- | 2.7 | --- | Not Rated |

## Appendix F1. Fish community sampling methods and criteria.

### 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 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.

### Nonwadeable Streams - Small Boat Sampling Methods

At each site, a 400 m section of stream is measured off into 100 m segments. There are four segments along each shore line and two segments down the center of the stream. For each of the 100 m segments, fish are collected and processed the same as those collected using the wadeable stream method. The last collection technique used at each location, is a timed catfish collection effort outside the measured stream reach. Data from each of the 100 meter segments and the catfish sampling are currently treated as a separate subsample.

### Evaluation and Scoring Criteria

The scoring criteria, metric performance, and fish community ratings are currently being revised for wadeable streams in the coastal plain. Evaluation protocols for nonwadeable streams sampled with the small electrofishing boat are currently in development.

## Appendix F2. Fish community structure data collected in the Chowan River and Pasquotank River basins, 1995-2000. Current basinwide sites are bold.

| Subbasin/Waterbody | Location | County | Index No. | Date | NCIBI Score | NCIBI Rating |
|---|---|---|---|---|---|---|
| 01 | | | | | | |
| Sarem Cr | Above Cole Cr | Gates | 25-12 | 08/29/00 | --- | Not Rated |
| Ahoskie Cr | NC 42 | Hertford | 25-14-1 | 05/23/00 | --- | Not Rated |
| | | | | 02/28/95 | --- | Not Rated |
| Chinkapin Cr | SR 1432 | Hertford | 25-14-3 | 05/24/00 | --- | Not Rated |
| 02 | | | | | | |
| Cutawhiskie Swp | SR 1141 | Hertford | 24-4-8-8 | 05/24/00 | --- | Not Rated |
| | | | | 02/28/95 | --- | Not Rated |

**Appendix FT1. Fish tissue criteria.**

In evaluating fish tissue analysis results, several different types of 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 (USEPA) recommended screening values, and criteria adopted by the North Carolina State Health Director (Table 1). Individual parameter 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 Water Quality Section.

The FDA levels were developed to protect humans from the chronic effects of toxic substances consumed in foodstuffs and thus employ a "safe level" approach to fish tissue consumption. Presently, the FDA has only developed metals criteria for mercury.

The US 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 US 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 for issuing an advisory. Although the USEPA has suggested a screening value of 0.7 ppt (pg/g) for dioxins, the State of North Carolina currently uses a value of 3.0 ppt in issuing an advisory.

**Table 1. Fish tissue criteria. All wet weight concentrations are reported in parts per million (ppm, µg/g), except for dioxin which is in parts per trillion (ppt, pg/g).**

| Contaminant | FDA Action Levels | US EPA Screening Values | NC Health Director |
|---|---|---|---|
| Metals | | | |
| Cadmium | | 10.0 | |
| Mercury | 1.0 | 0.6 | 1.0 |
| Selenium | | 50.0 | 5.0 |
| Organics | | | |
| Aldrin | 0.3 | | |
| Chlorpyrifos | | 30 | |
| Total chlordane | | 0.08 | |
| Cis-chlordane | 0.3 | | |
| Trans-chlordane | 0.3 | | |
| Total DDT[1] | | 0.3 | |
| 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 | | |
| Dieldrin | | 0.007 | |
| Dioxins (total) | | 0.7 | 3.0 |
| Endosulfan (I and II) | | 60.0 | |
| Endrin | 0.3 | 3.0 | |
| Heptachlorepoxide | | 0.01 | |
| Hexachlorobenzene | | 0.07 | |
| Lindane | | 0.08 | |
| Mirex | | 2.0 | |
| Total PCBs | | 0.01 | |
| PCB-1254 | 2.0 | | |
| Toxaphene | | 0.1 | |

[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 FT2. Wet weight concentrations of mercury (Hg), arsenic (As), total chromium (Crt), copper (Cu), nickel (Ni), lead (Pb), and zinc (Zn) in fish tissue from the Chowan River (Subbasin 01) near Gatesville, Gates County, August 2000.[1]**

| Species | 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) |
|---|---|---|---|---|---|---|---|---|---|
| *Amia calva* | 35.2 | 462 | 0.26 | 0.24 | 0.25 | 0.28 | ND | ND | 2.6 |
| *Amia calva* | 44.3 | 788 | 0.50 | 0.34 | 0.14 | 0.27 | ND | ND | 2.7 |
| *Ictalurus catus* | 35.0 | 407 | 0.28 | ND | 0.19 | 0.42 | ND | ND | 4.1 |
| *Ictalurus punctatus* | 60.0 | 2175 | 0.15 | 0.28 | 0.20 | 1.8 | 0.32 | 0.13 | 14 |
| *Ictalurus punctatus* | 60.0 | 2175 | 0.29 | ND | 0.22 | 0.64 | 0.41 | 0.48 | 14 |
| *Lepomis microlophus* | 24.5 | 318 | 0.32 | ND | 0.24 | 0.56 | ND | ND | 6.2 |
| *Lepomis microlophus* | 27.0 | 381 | 0.48 | ND | 0.23 | 0.25 | ND | ND | 6.9 |
| *Lepomis microlophus* | 27.8 | 415 | 0.32 | ND | 0.20 | 0.25 | ND | ND | 5.3 |
| *Micropterus salmoides* | 29.0 | 300 | 0.43 | ND | 0.22 | 0.40 | ND | ND | 6.3 |
| *Micropterus salmoides* | 29.1 | 340 | 0.46 | 0.11 | 0.20 | 0.27 | 0.12 | ND | 4.9 |
| *Micropterus salmoides* | 30.0 | 321 | 0.48 | 0.13 | 0.22 | 0.47 | ND | ND | 6.1 |
| *Micropterus salmoides* | 30.1 | 362 | 0.50 | 0.13 | 0.17 | 0.21 | ND | 0.25 | 11 |
| *Micropterus salmoides* | 32.1 | 435 | 0.47 | 0.11 | 0.21 | 0.53 | 0.15 | ND | 5.0 |
| *Micropterus salmoides* | 33.0 | 491 | 0.48 | ND | 0.26 | 0.48 | 0.19 | ND | 4.2 |
| *Micropterus salmoides* | 35.2 | 504 | 0.67 | ND | 0.25 | 0.10 | ND | ND | 2.7 |
| *Micropterus salmoides* | 40.6 | 824 | 0.79 | ND | 0.27 | 0.12 | ND | ND | 3.6 |
| *Micropterus salmoides* | 41.1 | 1028 | 0.48 | ND | 0.19 | 0.14 | ND | ND | 3.3 |
| *Micropterus salmoides* | 42.5 | 1163 | 0.75 | 0.25 | 0.67 | 0.47 | 0.98 | 0.80 | 16 |
| *Micropterus salmoides* | 42.5 | 1163 | 0.86 | 0.14 | < 0.20 | 0.21 | ND | ND | 3.1 |
| *Micropterus salmoides* | 45.0 | 1312 | 0.65 | ND | 0.24 | 0.13 | ND | ND | 3.0 |
| *Perca flavescens* | 24.0 | 195 | 0.62 | 0.14 | 0.23 | 0.40 | ND | ND | 5.2 |
| *Perca flavescens* | 25.0 | 208 | 0.52 | 0.11 | 0.23 | 0.18 | 0.11 | ND | 4.3 |
| *Perca flavescens* | 25.1 | 255 | 0.52 | 0.11 | 0.31 | 0.54 | ND | ND | 4.9 |
| *Perca flavescens* | 27.0 | 260 | 0.61 | 0.11 | 0.25 | 0.63 | ND | ND | 5.0 |
| *Perca flavescens* | 28.2 | 317 | 0.30 | ND | 0.27 | 0.36 | ND | ND | 9.5 |
| *Perca flavescens* | 28.2 | 317 | 0.61 | 0.12 | 0.20 | 0.35 | ND | ND | 5.1 |

[1]Cadmium was non-detectable in all samples.

ND = non detect; detection level for arsenic = 1.0 µg/g, nickel = 0.5µg/g, and lead = 0.5 µg/g.

## Appendix L1. Lake assessment program.

### Collection Methods

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

### Data Interpretation

Numerical indices are often 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 1982). 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:

$$TON_{Score} = ((\mathrm{Log}\ (TON) + 0.45)/0.24)*0.90$$

$$TP_{Score} = ((\mathrm{Log}\ (TP) + 1.55)/0.35)*0.92$$

$$SD_{Score} = ((\mathrm{Log}\ (SD) - 1.73)/0.35)*-0.82$$

$$CHL_{Score} = ((\mathrm{Log}\ (CHL) - 1.00)/0.48)*0.83$$

$$NCTSI = TON_{Score} + TP_{Score} + SD_{Score} + CHL_{Score}$$

In general, NCTSI scores relate to trophic classifications (Table L1). When scores border between classes, best professional judgment is used to assign an appropriate classification. NCTSI scores may be skewed by highly colored water typical of dystrophic lakes. Some variation in the trophic state of a lake between years is not unusual because of the potential variability of data collections which usually involve sampling a limited number of times during the growing season.

**Table L1. Lakes classification criteria.**

| NCTSI Score | Trophic classification |
|---|---|
| < -2.0 | Oligotrophic |
| -2.0 – 0.0 | Mesotrophic |
| 0.0 – 5.0 | Eutrophic |
| > 5.0 | Hypereutrophic |

Lakes are classified for their "best usage" and are subject to the state's water quality standards. Primary classifications are C (suited for aquatic life propagation /protection and secondary recreation such as wading), B (primary recreation, such as swimming, and all class C uses), and WS-I through WS-V(water supply source ranging from highest watershed protection level I to lowest watershed protection V, and all class C uses).

Lakes with a CA designation represent water supplies with watersheds that are considered Critical Areas (i.e., an area within 0.5 mile and draining to water supplies from the normal pool elevation of reservoirs, or within 0.5 mile and draining to a river intake).

Supplemental classifications may include SW (slow moving Swamp Waters where certain water quality standards may not be applicable), NSW (Nutrient Sensitive Waters subject to excessive algal or other plant growth where nutrient controls are required), HQW (High Quality Waters rated excellent based on biological and physical/chemical characteristics), and ORW (Outstanding Resource Waters - unique and special waters of exceptional state or national recreational or ecological value). A complete listing of these water classifications and standards can be found in Title 15 North Carolina Administrative Code, Chapter 2B, Section .0100 and .0200.

## Appendix L2. Surface waters data collected from Phelps Lake, 1995 - 2000.[1]

| Date | Station | Dissolved oxygen (mg/L) | Temperature (°C) | pH (s.u.) | Conductivity (µmhos/cm) | Secchi depth (m) |
|---|---|---|---|---|---|---|
| 08/21/00 | PAS012B | 8.7 | 24.6 | 4.4 | 135 | 1.9 |
| 08/21/00 | PAS012C | 8.6 | 24.4 | 4.5 | 136 | 1.4 |
| 08/21/00 | PAS012D | 8.3 | 24.9 | 4.4 | 135 | 1.1 |
| 07/05/00 | PAS012B | 7.3 | 27.7 | 4.6 | 137 | 1.3 |
| 07/05/00 | PAS012C | 7.4 | 27.4 | 4.5 | 138 | 1.4 |
| 07/05/00 | PAS012D | 7.2 | 28.9 | 4.6 | 136 | 0.5 |
| 06/26/00 | PAS012B | 7.9 | 27.9 | 4.4 | 140 | 1.0 |
| 06/26/00 | PAS012C | 7.8 | 27.6 | 4.4 | 139 | 0.8 |
| 06/26/00 | PAS012D | 7.8 | 27.7 | 4.5 | 138 | 0.5 |
| 07/23/96 | PAS012B | 7.7 | 28.8 | 4.6 | 125 | 1.0 |
| 07/23/96 | PAS012C | 7.6 | 29.0 | 4.3 | 123 | 1.4 |
| 07/23/96 | PAS012D | 7.5 | 29.0 | 4.4 | 122 | 1.4 |
| 06/24/96 | PAS012B | 7.8 | 27.8 | 4.3 | 123 | 1.5 |
| 06/24/96 | PAS012C | 7.9 | 27.8 | 4.4 | 123 | 1.2 |
| 06/24/96 | PAS012D | 7.4 | 27.7 | 4.4 | 122 | 0.9 |
| 08/10/95 | PAS012B | 8.4 | 25.7 | 4.7 | 102 | 1.7 |
| 08/10/95 | PAS012C | 8.2 | 25.8 | 4.3 | 102 | 2.0 |
| 08/10/95 | PAS012D | 8.3 | 25.7 | 4.4 | 101 | 1.8 |

[1]Samples are collected 0.15 m below the surface.

## Appendix L3. Photic zone data collected from Phelps Lake, 1995 - 2000.[1]

| Date | Station | TP | TKN | $NH_3$ | $NO_x$ | TN | TON | TIN | Chl a | Total Solids | Suspended Solids | Turbidity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08/21/00 | PAS012B | < 0.01 | 0.3 | 0.07 | 0.04 | 0.34 | 0.23 | 0.11 | | 99 | 3 | 2.3 |
| 08/21/00 | PAS012C | < 0.01 | 0.5 | 0.01 | 0.03 | 0.53 | 0.49 | 0.04 | | 94 | 2 | 2.3 |
| 08/21/00 | PAS012D | 0.01 | 1.8 | 0.03 | 0.08 | 1.88 | 1.77 | 0.11 | | 88 | < 1 | 3.5 |
| 07/05/00 | PAS012B | 0.01 | 0.2 | 0.03 | 0.10 | 0.30 | 0.17 | 0.13 | | 100 | 4 | 3.6 |
| 07/05/00 | PAS012C | 0.01 | 0.2 | < 0.01 | 0.08 | 0.28 | 0.20 | 0.09 | | 92 | 5 | 2.8 |
| 07/05/00 | PAS012D | 0.03 | 0.3 | 0.01 | 0.12 | 0.42 | 0.29 | 0.13 | | | | 8.7 |
| 06/26/00 | PAS012B | 0.01 | 0.2 | < 0.01 | 0.05 | 0.25 | 0.20 | 0.06 | | 100 | 10 | 4.7 |
| 06/26/00 | PAS012C | < 0.01 | 0.3 | < 0.01 | 0.01 | 0.31 | 0.30 | 0.02 | | 110 | 9 | 4.8 |
| 06/26/00 | PAS012D | 0.02 | 0.4 | < 0.01 | 0.01 | 0.41 | 0.40 | 0.02 | | 130 | 41 | 14.0 |
| 07/23/96 | PAS012B | 0.02 | 0.2 | 0.06 | < 0.01 | 0.21 | 0.14 | 0.07 | | 82 | 2 | 2.4 |
| 07/23/96 | PAS012C | 0.02 | 0.2 | 0.06 | < 0.01 | 0.21 | 0.14 | 0.07 | | 80 | 10 | 4.2 |
| 07/23/96 | PAS012D | 0.01 | 0.3 | 0.05 | < 0.01 | 0.31 | 0.25 | 0.06 | | 75 | 4 | 1.2 |
| 06/24/96 | PAS012B | 0.02 | 0.6 | 0.05 | 0.04 | 0.64 | 0.55 | 0.09 | | 76 | 12 | 2.7 |
| 06/24/96 | PAS012C | 0.02 | 0.2 | < 0.01 | < 0.01 | 0.21 | 0.20 | 0.01 | | 76 | 9 | 3.0 |
| 06/24/96 | PAS012D | 0.01 | 0.4 | 0.06 | 0.05 | 0.45 | 0.34 | 0.11 | | 73 | 6 | 3.2 |
| 08/10/95 | PAS012B | < 0.01 | 0.2 | 0.01 | < 0.01 | 0.21 | 0.19 | 0.02 | 3 | 63 | 1 | < 1.0 |
| 08/10/95 | PAS012C | < 0.01 | 0.1 | 0.01 | < 0.01 | 0.11 | 0.09 | 0.02 | 3 | 59 | < 1 | < 1.0 |
| 08/10/95 | PAS012D | < 0.01 | 0.2 | < 0.01 | < 0.01 | 0.21 | 0.20 | 0.01 | 4 | 64 | 5 | 1.4 |

[1]Abbreviations are TP = total phosphorus, TKN = total Kjeldahl nitrogen, $NH_3$ = ammonia nitrogen, $No_x$ = nitrate + nitrite nitrogen, TON = total organic nitrogen, TIN = total inorganic nitrogen, and Chl *a* = chlorophyll *a*. Units of measure are mg/L, except for chlorophyll *a* which is µg/l and turbidity which is NTU. Photic zone samples are taken through the water column between 0.15 m below the surface and twice the Secchi depth.

**Appendix P1. Summary of samples collected in the Chowan River and Pasquotank River basins during 1996 - 2000 and suspected as algal blooms.**

| Basin/Subbasin/ Waterbody/Station | Date | Biovolume ($mm^3/m^3$) | Density (cells/ ml) | Dominant Algae[1] | Concurrent Fish Kill? | *Pfiesteria*-likes? (cells/ml) |
|---|---|---|---|---|---|---|
| **CHOWAN** | | | | | | |
| **03** | | | | | | |
| **Chowan River** | | | | | | |
| D8950000 | 07/22/98 | 8287 | 4679 | CYA,CRY,CHR | | |
| CM 5 | 07/11/00 | 11959 | 6935 | CYA (surface) | | |
| Catherine Cr | 07/11/00 | 2995 | 7516 | CYA (surface) | | |
| D8430000 | 07/18/00 | 2485 | 23963 | DIN,CHR | | |
| D8950000 | 07/18/00 | 57799 | 32434 | BAC,CHR | | |
| **04** | | | | | | |
| **Edenton Bay** | | | | | | |
| 2081145015 | 08/22/96 | NQ | NQ | CYA | no | |
| **Chowan River** | | | | | | |
| D9490000 | 07/21/98 | 493 | 3775 | CRY,CHR,BAC | | |
| D995000N | 05/11/00 | 14,826 | 23,236 | BAC,CHR | | |
| D995000S | 06/13/00 | 2,743 | 41,208 | BAC,CHR | | |
| D995000N | 06/13/00 | 7,618 | 56,820 | BAC,CRY,CHR | | |
| CM 2 | 07/11/00 | 1759 | 10202 | CYA (surface) | | |
| Hwy 17 bridge | 07/11/00 | 21618 | 21058 | CYA (surface) | | |
| **PASQUOTANK** | | | | | | |
| **50** | | | | | | |
| **Camden Canal** | | | | | | |
| Camden-3 | 09/25/97 | NQ | NQ | NO | low DO | |
| **Treasure Pt Canal** | | | | | | |
| Treasure Pt Canal | 07/19/00 | 271187 | 36852 | CYA | no | |
| **51** | | | | | | |
| **Bray's Farm Pond** | | | | | | |
| Bray's Pond | 03/08/00 | NQ | NQ | CHL, bacteria | low DO | |
| **52** | | | | | | |
| **Albemarle Sound** | | | | | | |
| 2081179005 | 07/25/96 | 4092 | 64482 | CYA | no | |
| **Fields Pond** | | | | | | |
| Fields -1 | 04/28/97 | 7142 | 12582 | EUG | no | |
| **Albemarle Sound** | | | | | | |
| Albemarle-A - off Wade Point | 08/18/99 | 2383 | 28501 | CYA,CHR | yes | 274 (autotrophs) |
| Albemarle-B - off Harvey Point | 08/18/99 | 1067 | 21421 | DIN,CHR | yes | 116 (autotrophs) |
| **Perquimans River** | | | | | | |
| Perquimans-1 | 09/13/99 | NQ | NQ | NQ | fish w/sore | 23 (autotrophs) |
| Perquimans-1 | 07/19/00 | 3209 | 26988 | BAC,CRY | no | |
| **54** | | | | | | |
| **Currituck Sound** | | | | | | |
| Atlantic-1 | 09/17/97 | NQ | NQ | only Pf-like counted | clam kill | 0 |
| Atlantic-2 | 09/17/97 | NQ | NQ | only Pf-like counted | clam kill | 0 |

[1]Abbreviations
BAC - Bacillariophyceae (diatom)
CHL - Chlorophyceae (green algae)
CHR - Chrysophyceae (golden brown algae)
CRY - Cryptophyceae (cryptomonads)
CYA - Cyanophyceae (blue-green algae)
DIN - Dinophyceae (dinoflagellates)
EUG - Euglenophyceae (euglenoids)
Pf-likes - *Pfiesteria*-like dinoflagellates
NS - not sampled
NQ - not quantified