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Neuse River

Basinwide Water Quality Plan

North Carolina
Department of Environment
and Natural Resources

Division of Water Quality
Water Quality Section December, 1998

Michael F. Easley, Governor
William G. Ross Jr., Secretary
North Carolina Department of Environment and Natural Resources

Alan W. Klimek, P.E. Director
Division of Water Quality

April 22, 2003

Thank you for your interest in North Carolina's water quality issues. Enclosed is the basinwide water quality plan that you recently requested from the Division of Water Quality (DWQ).

The basinwide planning program aims to identify and restore full use to impaired waters, identify and protect highly valued resource waters, and protect the quality and intended uses of North Carolina's surface waters while allowing for sound economic planning and reasonable growth. North Carolina relies on the input and experience of its public to ensure that the water quality plans are effective. DWQ coordinates plan development; however, plan implementation and effectiveness entails the coordinated efforts and endorsement of many agencies, groups, local governments, and the general public. Your participation is essential for us to achieve our goals.

Our website (http://h2o.enr.state.nc.us/wqs/) provides detailed information on our program, other basin plans, current events, publications, and rules and regulations. Please visit us at this site.

DWQ appreciates your interest in water quality issues, and we hope to continue working with you into the future. Please contact me if you have any further questions or ideas on specific basins at (919) 733-5083, ext. 354.

Sincerely,

Darlene Kucken

Darlene Kucken
Basinwide Planning Program Coordinator

Enclosure

ADDENDUM: Use Support Changes for the Neuse River Basin
March 2000

The fully supporting but threatened (support-threatened, ST) category is no longer used as a use support rating. In the past, ST was used to identify a water that was fully supporting but had some notable water quality problems. ST could represent constant, degrading, or improving conditions. North Carolina's use of ST was very different from that of the US Environmental Protection Agency (EPA), which uses it to identify waters that are characterized by declining water quality. In addition, the US EPA requires the inclusion of ST waters on the 303(d) list in its proposed revision (August, 1999) to the 303(d) list rules (Appendix II). Due to the difference between US EPA's and North Carolina's definitions of ST, North Carolina no longer uses this term. Because North Carolina has used fully supporting but threatened as a subset of fully supporting (FS) waters, those waters formerly called ST are now rated FS. This change is reflected in the 305(b) report for 2000. Based on this change, use support ratings for all basins have been altered.

Use support ratings of Hare Snipe Creek (source to dam at Lake Lynn, subbasin 02), Southwest Creek (subbasin 05), Mill Creek (subbasin 06), Beaverdam Swamp (subbasin 11), and Little Chinquapin Branch (subbasin 11) have been revised based on new biological information. These streams were formerly rated PS but are now not rated (NR). These revised ratings are reflected in the 2000 303(d) list and 305(b) report.

Revised use support ratings for the Neuse River basin are presented below.

Freshwater Streams and Rivers

Table 3.3 Summary of Use Support Ratings by Subbasin in the Neuse River Basin (*Found on p. 72 of this plan.*)

Subbasin	Fully Supporting	Partially Supporting	Not Supporting	Not Evaluated	Total Miles
03-04-01	505.3	37.6	19.2	26.1	588.2
03-04-02	345.0	67.8	24.6	104.6	542.0
03-04-03	125.4	0	0	0	125.4
03-04-04	193.6	0	0	0	193.6
03-04-05	231.8	15.8	10.2	87.0	344.8
03-04-06	187.2	20.9	5.6	18.6	232.3
03-04-07	326.5	98.3	4.5	192.7	622.0
03-04-08	50.6	18.5	0	55.9	125.0
03-04-09	0.0	10.9	45.1	100.6	156.6
03-04-10	4.1	0	0	93.5	97.6
03-04-11	29.4	79.8	0	169.6	278.8
03-04-12	136.7	0	0	0	136.7
03-04-13	0	0	0	0	0
03-04-14	0	0	0	0	0
Total	2135.6	349.6	109.2	848.6	3443.0
Percent	62	11	3	24	100

Estuaries

Table 3.6 Use Support Ratings and Causes and Sources of Pollution in Estuarine Waters in the Neuse River Basin
(Found on p. 83 of this plan.)

Area Name	DEH Area	Total Acres	Subbasin	Overall Use Support			Major Causes		Major Causes		Source Descriptions
				FS	PS	NS	Fecal	Chl *a*	Point	Nonpoint	
Neuse River	F1	13,700	03-04-10	12,800	900	0	900		P	**NP**	Urban runoff, marinas, ag runoff, WWTP
Merrimon	F2	39,000	03-04-10	37,525	1,475	0	1,475			**NP**	Ag, forestry/wildlife
West Bay	F3	22,000	03-04-14	21,988	12	0	12			**NP**	Wildlife
Cedar Island	F4	63,000	03-04-14	62,987	13	0	13			**NP**	Ferry, marina
Oriental	F5	19,000	03-04-10	18,149	851	0	851		P	**NP**	Urban, marina, ag, septic, WWTP
Bay River	F6	20,000	03-04-13	19,663	337	0	337		P	**NP**	Urban, septic, wildlife, marina, ag (animals), WWTP
Open	F7	122,000	03-04-13 & 14	122,000	0	0			n/a	n/a	
Neuse River	F8	10,500	03-04-10	1,050	9,450	0		9,450	P	**NP**	Urban runoff, ag (crop/animals), WWTP, atmosphere
Neuse River	F9	19,500	03-04-10	0	19,500	0		19,500	P	**NP**	
Totals		328,700		296,162	32,538	0	3,588	28,950			
Percent (%)				90.1	9.9	0.0	1.1	8.8			

Note:
1) **DEH Area** is a shellfish management area monitored by the Division of Environmental Health's (DEH) Shellfish Sanitation Branch.
2) **Subbasins** indicate which subbasin(s) each DEH is located. The subbasins are identified by their last two digits (e.g., subbasin 03-04-10 = 10). DEH area F7 is split between subbasins 13 (about 40,000 acres) and 14 (about 82,000 acres).
3) Under **Overall Use Support**: **FS** = Fully Supporting; **PS** = Partially Supporting; and **NS** = Not Supporting.
4) **Major Causes** refers to major causes of pollution for waters rated as NS or PS under Overall Use Support. **Fecal** refers to fecal coliform bacteria (meaning some shellfish areas closed to harvesting because of unacceptable levels of fecal coliform bacteria). **Chl *a*** refers to chlorophyll *a* (an indicator of algal blooms).
5) **Major Sources** indicate whether causes of pollution are from point sources (**P**) or nonpoint sources (**NP**). **Bold lettering** indicates which source is predominant.
6) **Source Descriptions** list those specific sources which may be contributing to the impairment. WWTP = wastewater treatment plants, and atmosphere refers to atmospheric nitrogen (may come from fossil fuel emissions, nitrification of animal wastes or other sources).

Lakes

Lake Rogers, Lake Ben Johnson, Falls of the Neuse Reservoir, Lake Crabtree, Bass Lake, Holts Lake, Wendell Lake, Buckhorn Reservoir, Lake Wilson, Silver Lake, Toisnot Reservoir, and Wiggins Mill Reservoir are now considered fully supporting. *(Refer to Table 3.7 on p. 85 of this plan.)*

Neuse Basinwide Water Quality Plan

July 1999

Prepared by:

North Carolina
Division of Water Quality
Water Quality Section
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(919) 733-5083 ext. 354

This document was approved and endorsed by the NC Environmental Management Commission on December 9, 1998 to be used as a guide by the NC Division of Water Quality in carrying out its Water Quality Program duties and responsibilities in the Neuse River Basin. It is the first five-year update to the original Neuse Basinwide Water Quality Management Plan approved by the NC Environmental Management Commission February 11, 1993.

500 copies of this document were printed at a cost of $5,116.69 or $10.23 per copy.

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Executive Summary

Introduction and Goals of this Plan

This document is the first five-year update of the original Neuse Basinwide Water Quality Management Plan that was approved by the North Carolina Environmental Management Commission in February 1993. As in the original plan, the primary goals of the basinwide planning approach are to: 1) identify and restore full use to impaired surface waters in the Neuse River basin; 2) identify and protect highly valued resource waters; and 3) protect those waters that are presently unimpaired while accommodating reasonable economic growth. These goals are discussed in more detail in Chapter 4 of Section A.

In response to comments of participants of Neuse River basin workshops and others during the development of this plan, the plan's format has been revised from that of the original. Much of the general information contained in the original plan has been replaced by more detailed information specific to the basin and its fourteen subbasins (Section B). A greater emphasis has been placed on presenting available information on the causes and sources of pollution on impaired waters in order to encourage restoration efforts at the local level.

Since the original plan was approved in 1993, there have been a series of events affecting water quality in the Neuse River Basin. The most notable were large fish kills in the lower river during the summer of 1995 that were accompanied by outbreaks of the toxic dinoflagellate, *Pfiesteria piscicida*. These kills prompted the General Assembly to pass a package of new environmental laws and hastened the development of new comprehensive nutrient sensitive waters rules for the Neuse River Basin. These rules are intended to reduce nitrogen loading to the Neuse River estuary by thirty percent within five years.

Water Quality Overview

While the nutrient-related water quality problems in the lower Neuse continue to be the most highly publicized, they are not the only problems. Over 80% of the freshwater streams in the basin that have been monitored are either impaired or rated as fully supporting but threatened. A major cause of this impairment, especially in the upper basin, is population growth and urbanization, and every indication is that this strong growth will continue for decades to come. Below is a brief summary of recent water quality conditions as compared to those reported in the 1993 plan. The information is summarized in the form of Use Support Ratings. Use support ratings assess how well the waters in the basin are supporting uses such as swimming and fishing. More details are provided in Section 3-C., Chapter 3, Section A of the plan.

Use Support Definitions:

FS - Fully Supporting
ST - Fully Supporting but Threatened
PS - Partially Supporting
NS - Not supporting
Impaired - Waters rated NS and PS
Supporting - Waters rated FS and ST

It is important to keep in mind that these data are highly variable and not statistically valid. For example, the lakes and freshwater stream data may be based on single biological samples taken at five-year intervals. The estuarine ratings are generally based on monthly chemical samples or shellfish water closure information from the NC Division of Environmental Health's Shellfish Sanitation Branch. See Section 3-C.2 for further information on interpretation of use support data.

For estuarine waters, an additional 3,900 acres were rated impaired based on nutrient-related problems as compared to 1993. However, the acreage of impaired estuarine waters based on shellfish water closures (fecal coliform bacteria) decreased by 1700 acres. This was associated

with the reopening of South River to shellfish harvesting. Overall, there was a slight net increase of impaired waters in the Neuse estuary as shown below.

Estuarine Waters Use Support Comparisons between the 1993 and 1998 Plans (Acres)

	FS	ST	PS	NS	Total
1993	281610 (86%)	16,767 (5%)	30,323 (9%)	0 (0%)	328,700 (100%)
1998	281,212 (86%)	14,950 (5%)	32,538 (10%)	0 (0%)	328,700 (100%)

For monitored freshwater streams, there was an apparent decrease in the number of impaired stream miles from 1993 (40 percent) to 1998 (34 percent) and a corresponding increase in the number of fully supporting stream miles from 1993 (60 percent) to 1998 (66 percent). However, within the fully supporting (FS) category, the percentage of streams considered fully supporting but threatened (ST) increased by 19 percent from 1993 to 1998 to 50 percent of all streams. There are a number of factors that could have contributed to this change other than just water quality. Water quality degradation associated with development is a possible factor, but other factors could include the limited amount of data, variations in sampling methods between the two sampling periods and changes in stream conditions associated with weather at the time of the sampling.

Monitored Freshwater Stream Use Support Comparisons between the 1993 and 1998 Plans (Stream Miles)

	FS	ST	PS	NS	Total
1993	321 (29%)	346 (31%)	371 (33%)	74 (7%)	1112 (100%)
1998	210 (16%)	661 (50%)	350 (26%)	104 (8%)	1325 (100%)

For the lakes data, there appeared to be some overall improvement from 1993 to 1998. In 1993 there were three lakes that were not supporting (NS) their uses and 8 lakes (or 32 percent) that were considered impaired. In 1998, 5 lakes (17 percent) were considered impaired, and none were rated as not supporting. However, while these results appear to be encouraging, longer-term monitoring will be needed to confirm whether this is a solid trend or the results of other factors such as those discussed above.

Lakes Use Support Comparisons between the 1993 and 1998 Plans (Nos. of Lakes)

	FS	ST	PS	NS	Total
1993	8 (32%)	9 (36%)	5 (20%)	3 (12%)	25 (100%)
1998	12 (41%)	12 (41%)	5 (17%)	0	29 (100%)

More People and More Hogs Pose Tough Challenges in Protecting Water Quality in the Neuse Basin

So what does the future hold? Several years ago, Raleigh was named the top-rated city in the US to live by Money magazine, and in 1997, Forbes magazine rated the Triangle as the best place to do business in the country. According to the 1997 World Almanac, Raleigh was the fourth fastest-growing city of the largest 100 cities in the United States. The North Carolina Office of State Planning projects the population in Wake County will grow by over 60 percent in the next 20 years. The population in the entire basin is projected to increase by 36 percent during that time. As the population grows, so will the need for water and wastewater service. But many streams are unable to assimilate additional wastewater. And as watersheds are urbanized, the quality of the streams they drain into generally declines unless efforts are made to minimize these impacts through use of effective best management practices.

The hog population in the basin has also been growing. Between 1990 and 1998, the hog population in the Neuse River Basin increased by almost 250 percent. A statewide moratorium imposed by the General Assembly is currently in effect on the creation of new hog farms. It is scheduled to end by the Fall of 2001. Research is currently underway to determine what effects the hog operations may be having on water quality through stormwater runoff, groundwater and the atmosphere. Additional research is being conducted to improve waste treatment, control odors and eliminate open lagoons.

Restoration of Impaired Waters Is a High Priority

It should be noted that the federal government is placing increased pressures on North Carolina and other states to restore their impaired waters in accordance with section 303(d) of the federal Clean Water Act. While current mandates to the states are to develop restoration strategies or specify total maximum daily loads (TMDLs) of pollutants for impaired water bodies within the next eight to thirteen years, deadlines for restoration may not be far off. A nutrient reduction TMDL has already been approved by the Environmental Protection Agency for the Neuse River. Rules to meet the required thirty percent reduction in nitrogen loading to the river are now being implemented.

To achieve the goal of restoring impaired streams throughout the basin, the state, in partnership with local governments, the agriculture community, industry, property owners and other stakeholders will need to work together in identifying and controlling the causes and sources of water quality impairment within smaller watersheds. While this task appears daunting in light of the number of impaired streams and lakes in the basin, it becomes much more manageable when the responsibilities are shared across the basin. It is also recognized that the costs of restoration will be high, but over $300 million are available through programs such as the Clean Water Management Trust Fund, the NC Agricultural Cost Share Program, the NC Wetlands Restoration Program and the recently approved, federally-funded Conservation Reserve Enhancement Program (CREP). Additional funding is also being made available under Section 319 of the Clean Water Act through a new program called Unified Watershed Assessments (UWA). The UWA program was launched as part of the President's 1998 Clean Water Action Plan. The Contentnea Creek watershed is one of five high priority watersheds identified across the state.

If We Are to Restore and Protect the Waters of the Neuse River Basin, It Can No Longer Be Business as Usual.

In addition to the tremendous challenges ahead in balancing the growth in the basin with the restoration of its waters, it is also clear that if we are to prevent more waters from becoming impaired in the future, and if the nutrient-related problems in the lower basin and lakes are to be solved, it can no longer be business as usual in the Neuse. Citizens, industry and local government will all need to make adjustments in their day-to-day activities from properly applying fertilizer on lawns and crops to paying higher sewer bills for better wastewater treatment and incorporating state-of-the art stormwater best management practices into new developments. Section C of this plan outlines many water quality accomplishment and initiatives that have been achieved in the Neuse Basin since the last basinwide plan was approved. These actions provide a foundation on which future initiatives and successes can be built.

Section A

General Basinwide Information

Chapter 1:
Introduction

The North Carolina Division of Water Quality (DWQ) initiated basinwide planning activities in 1990, when it established a basinwide NPDES permitting schedule. In 1991, it then began conducting water quality monitoring for the first basinwide plan to be published in 1993 (for the Neuse River basin). Since then, DWQ has produced basinwide plans for the state's 16 other river basins. Figure 1.1 is a map of North Carolina's river basins.

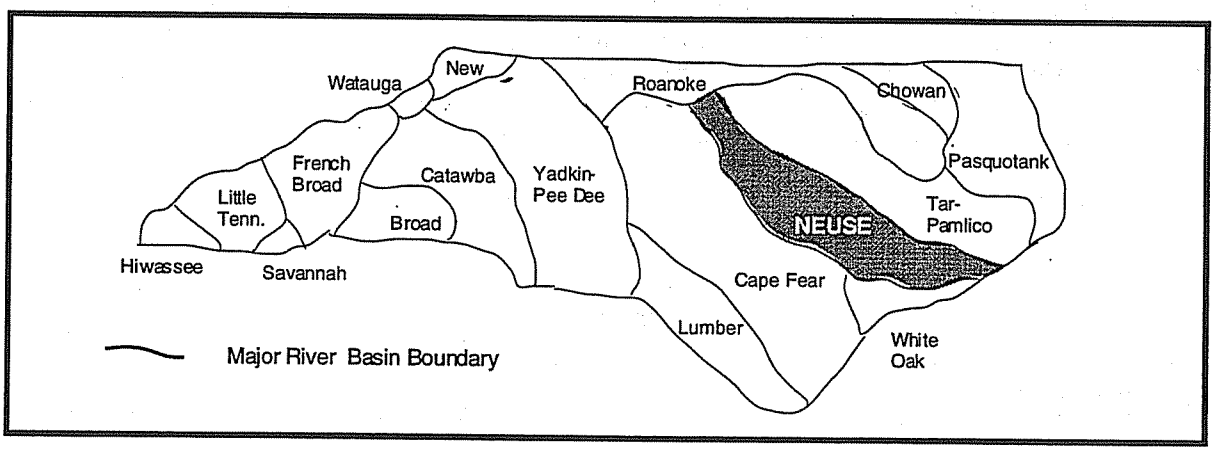


Figure 1.1 Map of North Carolina's River Basins

DWQ is now preparing "Round Two" of the basinwide plans. These new plans will have a greater emphasis on reporting the progress made since the "Round One" plans were produced, although it should be remembered that only two years elapsed since the last plan was approved in 1993 and the second round of monitoring occurred in 1995. Some other changes include a more "user-friendly" format and more discussion of nonpoint sources, which are now the leading cause of water quality problems throughout the state.

This chapter provides a brief description of basinwide planning and how the plans benefit both DWQ and the public.

1-A. *Why* DWQ Writes Basinwide Plans

DWQ's primary responsibility is to protect and restore the best uses of all of the state's streams, rivers, lakes, and estuaries. In order to help reach that goal, DWQ writes and implements basinwide plans for each river basin in the state. DWQ uses each basinwide plan to coordinate its major activities to protect water quality for that basin.

In addition to enabling DWQ to become more effective, basinwide plans are intended to serve citizens, policymakers, and the regulated community. DWQ makes an effort, through public workshops and meetings, to educate the public about water quality and obtain information about their needs and interests. This plan includes the opinions and concerns expressed by those attending the public workshops and DWQ's responses.

Citizens, policymakers, local governments, interest groups, and regulated communities can utilize the basinwide plan to obtain information about the following items:

⇒ status of the basin's waters,
⇒ updates on programmatic changes and initiatives since the first basinwide plan,
⇒ current major water quality issues,
⇒ recommended management strategies for the basin as a whole, waters of special interest, problem pollutants, and specific land uses, and
⇒ current initiatives that are addressing water quality issues in the basin.

The major activities that DWQ uses basinwide plans to coordinate are listed in Figure 1.2. The DWQ Water Quality Section has four major branches (Environmental Sciences, Planning, Point Source and Non-Discharge) as well as seven regional offices. Although each branch and regional office has its own responsibilities, it is very important that their activities be coordinated so that DWQ's programs can be consistent, effective and efficient. Basinwide plans also assist DWQ staff by identifying waters where there is the greatest need for improved management. Thus, DWQ and other agencies can direct financial and technical assistance and other resources toward the waters that show the greatest need.

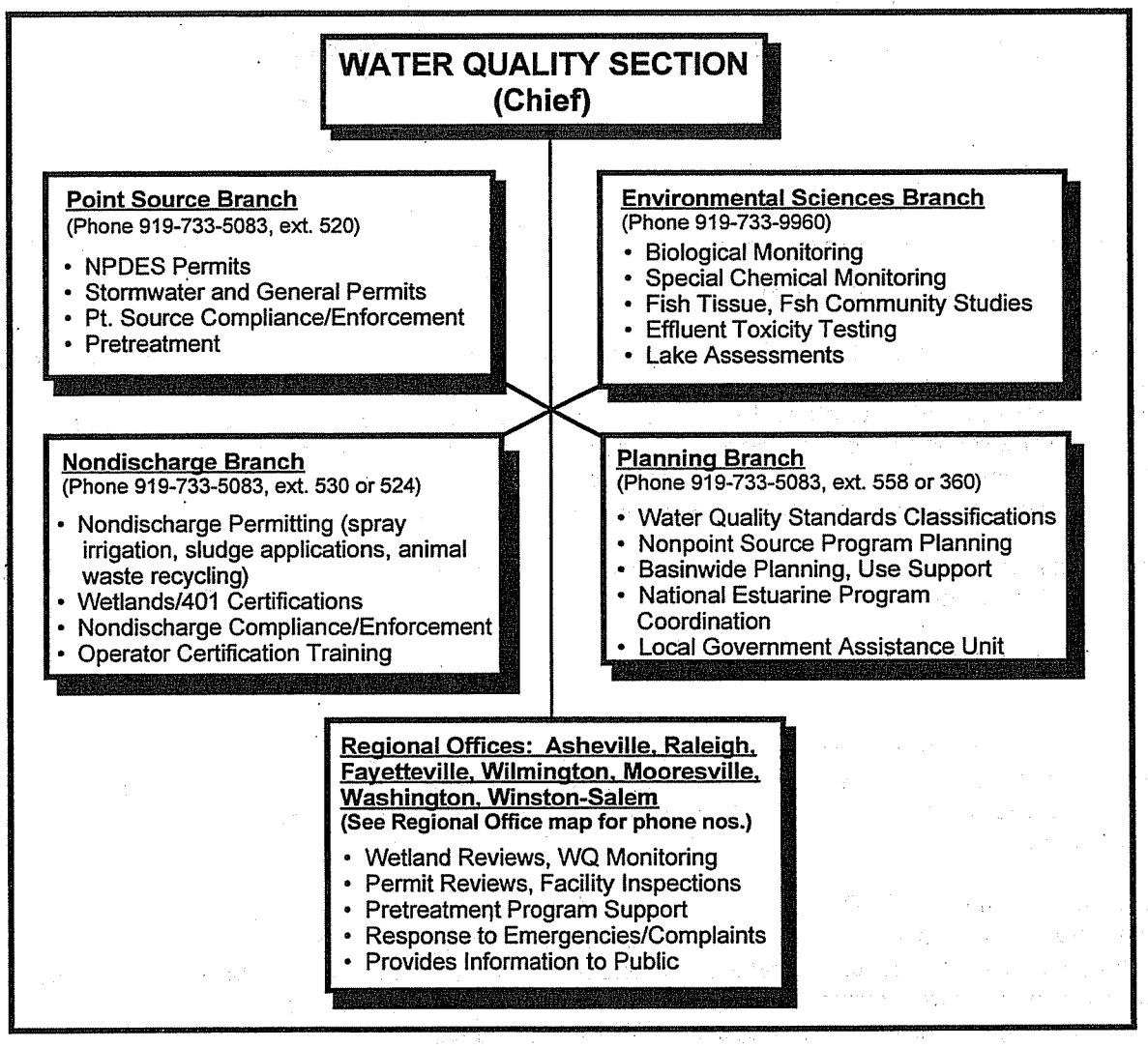


Figure 1.2 The Water Quality Section of DWQ

1-B. *How* DWQ Writes the Basinwide Plans

DWQ staff in the Planning Branch take the lead in writing the basinwide plans. However, the other parts of DWQ as well as other agencies and groups help to provide the information and recommendations that are included in the basinwide plans.

The phases of the five-year basinwide planning process are outlined in Figure 1.3 below.

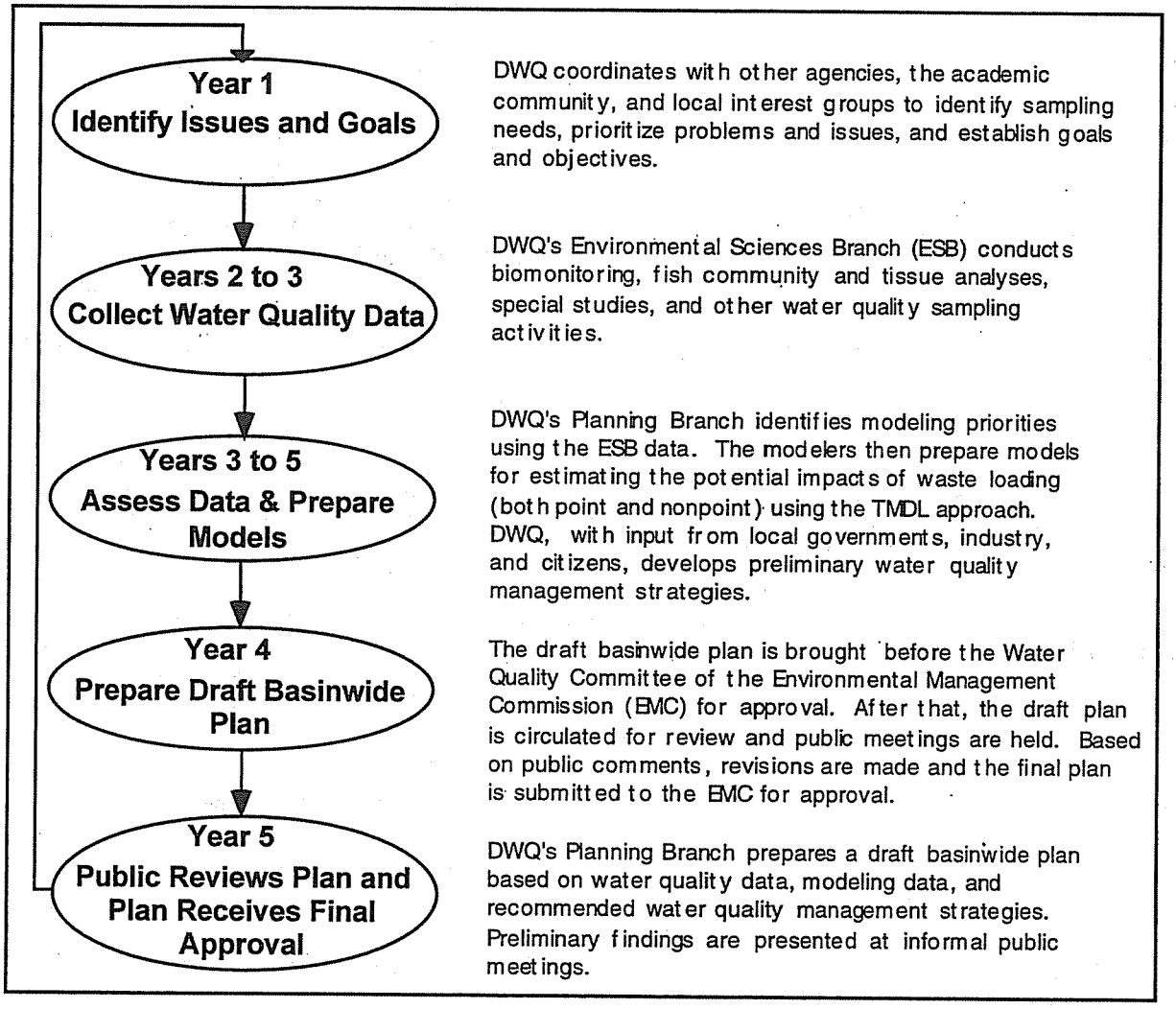


Figure 1.3 The Basinwide Planning Process

1-C. How DWQ *Implements* the Basinwide Plans

DWQ has different processes for implementing the basinwide plans for point and nonpoint sources. The reason for this difference is simply that point and nonpoint sources are different:

⇒ *Point source* pollution is usually associated with wastewater treatment plant facilities that discharge treated effluent through pipes or other well-defined points of discharge.

⇒ *Nonpoint source* pollution is carried from diverse sources by stormwater or snowmelt as it enters streams, rivers, lakes, and estuaries. Many types of land use activities can cause

nonpoint source pollution, including urban areas, construction, crop production, animal feeding lots, failing septic systems, landfills, roads and parking lots.

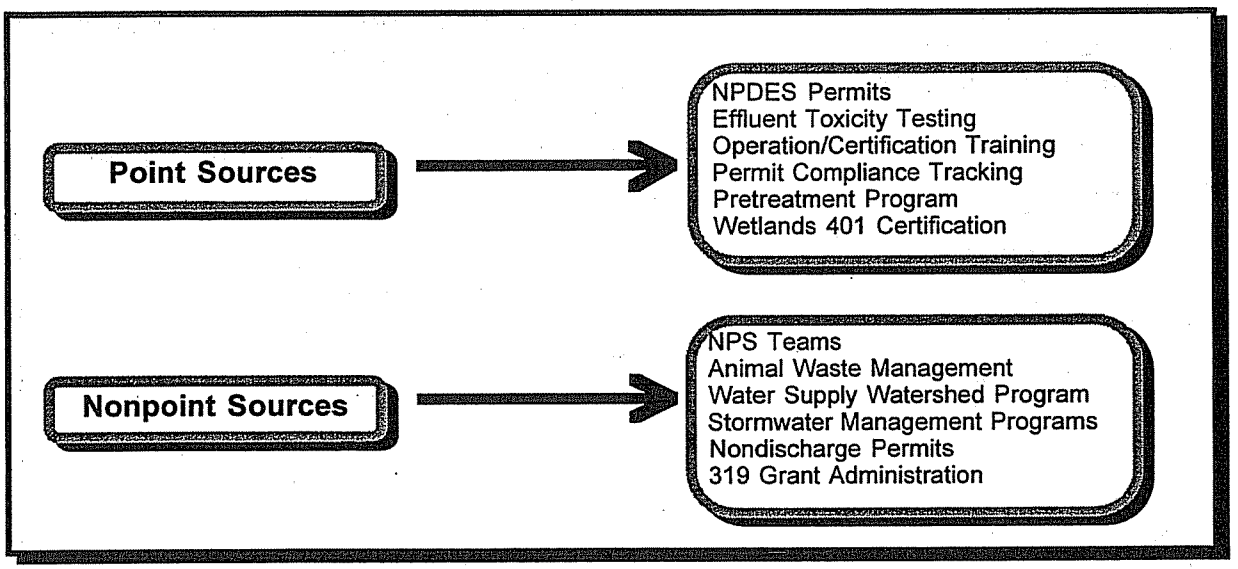


Figure 1.4 DWQ Programs for Point and Nonpoint Sources

DWQ requires that *point sources* that discharge to the state's surface waters have a National Pollution Discharge Elimination System (NPDES) permit. Within several months after the basinwide plan is completed, DWQ issues NPDES permits. The permit includes effluent limits that define the load of specific pollutants that may be discharged.

All point sources have a monitoring requirement. The majority of facilities collect their own monitoring data and submit monthly reports to DWQ. NPDES facilities are required to monitor for all pollutants for which they have limits as well as other pollutants that may be present in their wastewater. In addition to the monthly data submitted, all major dischargers are required to perform an annual scan of the priority pollutants.

In addition to NPDES permitting, other DWQ programs for point sources are:

- Effluent toxicity testing: A type of effluent monitoring required by DWQ for large or industrial discharge facilities that may discharge toxic substances. It is used to determine toxicity of effluent on aquatic life in a controlled laboratory setting. If the effluent is determined to be toxic, then follow-up toxicity testing may be required at the plant to identify the cause and source and take remedial action.
- Operator certification and training program: DWQ assists in organizing training for wastewater treatment plant operators.
- Permit compliance tracking: Most dischargers are required to report their monitoring data to DWQ on a monthly basis. If a plant does not meet its permitted limits, DWQ may take enforcement action.
- Pretreatment program: DWQ assists local governments in developing local pretreatment programs that protect their WWTPs and the environment from the hazardous or toxic wastes discharged into their sewage systems.
- Section 401 certifications: DWQ is responsible for reviewing and issuing Section 401 certifications that are required for activities that may result in a discharge to navigable waters or wetlands.

- Emergency response: DWQ regional offices respond to emergencies at wastewater treatment plants and assist in organizing necessary clean-up efforts.

Since *nonpoint source* pollution is so widespread and diverse, DWQ does not have the authority nor the staff to address all of the nonpoint source issues in any basin. One effort has been for the Planning Branch to organize one or more locally-based Nonpoint Source (NPS) Teams for each basin. The number of NPS Teams depends on the basin's size, with the Neuse having three NPS teams. Each NPS team includes representatives of nonpoint source agencies, local governments, industries, and interest groups. In addition to the NPS Teams, DWQ programs for nonpoint sources are:

- Animal waste regulations: these regulations stipulate that animal production facilities of a certain size (depending on the type of animal) must be registered and obtain certified animal waste management plans. DWQ and the Division of Soil and Water must inspect these facilities to ensure that they have been built and are being maintained in accordance with the regulations.
- Water Supply watershed protection: This program requires local governments with water supply watersheds in their jurisdictions to work with DWQ to develop programs to protect their water supplies from nonpoint source pollution.
- Stormwater management program: DWQ administers a stormwater permitting program for new developments located in coastal areas, high quality waters, and outstanding resource waters. In addition, DWQ administers the NPDES stormwater program for industries and municipalities over 100,000 in population. A statewide stormwater program is in development.
- Non-discharge permits: DWQ administers a non-discharge permitting program for such activities as land application of sludge, spray irrigation of wastewater, sanitary sewer lines, pump stations, and some on-site wastewater disposal systems.
- Grant administration: DWQ administers Section 319 grant moneys provided by EPA to fund innovative projects that demonstrate nonpoint source control practices, restoration projects, and educational programs.

In addition to guiding DWQ's nonpoint source programs, basinwide plans can assist agencies responsible for agriculture, forestry, wildlife, coastal resources, and construction by providing water quality data and priority areas for management measures. Basinwide plans also document the current and future initiatives of nonpoint source agencies and thus provide an opportunity for coordination and cooperation.

1-D. Guide to Using the Basinwide Plan

This basinwide plan has been significantly changed since "Round One." Some additional information has been provided -- the glossary, workshop comments and responses, current initiatives, and success stories. At the same time, DWQ staff have removed most of the repetitive information about agency programs (which will eventually be described in a separate document).

This "Round Two" plan also has a new organization scheme designed to allow easier access to water quality information and to allow readers to see the connection between water quality data and recommended management strategies.

Table 1.1 List of Nonpoint Source Programs

PROGRAM	LOCAL	STATE	FEDERAL
AGRICULTURE:			
Agriculture Cost Share Program	SWCD	SWCC, DSWC	
NC Pesticide Law of 1971		NCDA	
Pesticide Disposal Program		NCDA	
Animal Waste Management	SWCD	DWQ, DSWC, CES	NRCS
Laboratory Testing Services		NCDA	
Watershed Protection (PL-566)			NRCS
1985 ,1990 and 1995 Farm Bills			USDA
- Conservation Reserve Program; Conservation Compliance; Sodbuster/Swampbuster; Conservation Easement; Wetland Reserve; Water Quality Incentive Program			
URBAN			
Coastal Stormwater Program		DWQ	
ORW, HQW, NSW Management Strategies		DWQ	
Water Supply Watershed Protection Program	city, county	DWQ	
Stormwater Control Program	city, county	DWQ	EPA
CONSTRUCTION			
Sedimentation and Erosion Control	ordinance	DLR, DOT	
Coastal Area Management Act	ordinance	DCM	
Coastal Stormwater Program		DWQ	
ON-SITE WASTEWATER DISPOSAL			
Sanitary Sewage Systems Program	county	DEH	
SOLID WASTE DISPOSAL			
Resource Conservation and Recovery Act			EPA
Solid Waste Management Act of 1989	city, county	DSWM	
FORESTRY			
Forest Practice Guidelines		DFR	
National Forest Management Act			NFS
Forest Management Program Services		DFR	
Forestry Best Management Practices		DFR	
Forest Stewardship Program		DFR	
MINING			
Mining Act of 1971		DLR	
HYDROLOGIC MODIFICATION			
Clean Water Act (Section 404)		DCM, DWQ	COE
Rivers and Harbors Act of 1899			COE
Dam Safety Permit		DLR	
WETLANDS:			
Wetlands Restoration Program		DWQ	
Clean Water Act (Sections 401 and 404)		DWQ	COE
Wetland Reserve Program			USDA

COE: US Army Corps of Engineers
DWQ: Division of Water Quality
DFR: Division of Forest Resource
DSW: Division of Soil and Water
USDA: US Department of Agriculture
DCM: Division of Coastal Management
DLR: Division of Land Resources
DOT: Department of Transportation
DSWM: Division of Solid Waste Mgt.
NCDA: NC Department of Agriculture
NRCS: Natural Resources Conservation Service
SWCC: Soil and Water Cons. Commission
SWCD: Soil and Water Conservation District

The plan has been simplified so that it includes three major parts and appendices. **Section A** provides the foundation for understanding the rest of the plan and information about the basin and its water quality. **Section B** includes separate sections for each subbasin. Within each subbasin section in Section B, there are discussions of each one of the major "waters of interest," which include waters that were listed as impaired in 1993, waters that are currently impaired, and/or waters that have special resource or recreational value. **Section C** then will present the current and future water quality initiatives as well as contacts for obtaining more information.

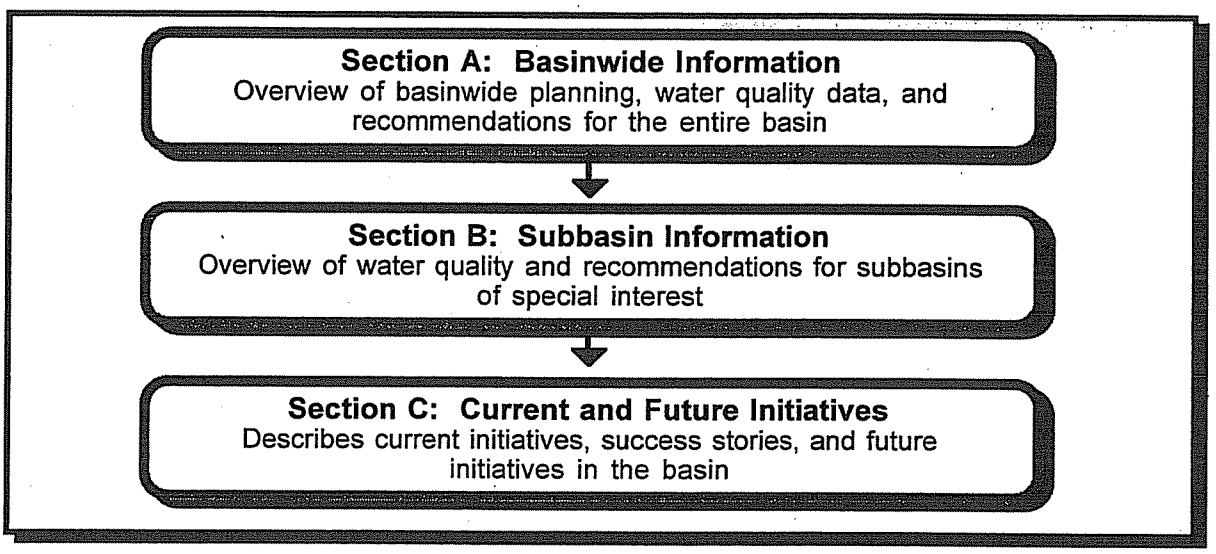


Figure 1.5 Organization of Basin Plan

1-E. How the Public Can Get Involved

In order for the plans to be accurately written and effectively implemented, it is important for citizens and other stakeholders to participate in the planning process. DWQ staff offer several opportunities for the public to meet and provide input into the plans:

- Public workshops: At workshops, DWQ staff present information about basinwide planning and the water quality of the basin before writing the plan. Attendees break into smaller groups where they can ask questions, share their concerns and discuss appropriate solutions with DWQ staff. Five workshops in three cities (including daytime and evening workshops) were held during the development stage of this plan.
- Public meetings: Held after the draft basinwide plan has been prepared. DWQ staff present more detailed information about the basinwide plan and its major recommendations. Then, the public is invited to comment and ask questions.
- Informal meetings/communication: Staff are available to meet or discuss issues by phone with interested stakeholders throughout the planning and review process.
- Staff are available to meet with your organization upon request.

There are many other avenues for getting involved with water quality protection in the Neuse Basin. There are citizen groups such as the Neuse River Foundation and adopt-a-stream programs such as those offered by Raleigh and the state's Steam Watch Program. Citizens are also encouraged to voice their opinions at public rules hearings, participate in stream clean ups and take steps at home to minimize water pollution. For further information, please contact the Basinwide Coordinator at 919-733-5083 (ext. 360).

Chapter 2:
Neuse Basin Overview

2-A. General Description

The Neuse River basin is the third largest river basin in North Carolina and is one of only four major river basins whose boundaries are located entirely within the state. It encompasses approximately 6,192 square miles. There are 3,443 miles of freshwater streams, 328,700 acres classified as salt waters, and thousands of acres of impoundments including Falls Lake Reservoir. The basin is subdivided into 14 subbasins.

The Neuse River basin originates in north central North Carolina in Person and Orange Counties (Figure 2.1). The river's mainstem once began at the confluence of the Flat and Eno Rivers; however, the first 22 miles of the mainstem are impounded behind the Falls Lake Reservoir dam.

Neuse Basin Statistics

Area: *6,192 sq. miles*
Stream Miles: *3,443*
No. of Counties: *24 (17 counties with >5% of area in basin)*
No. of Subbasins: *14*
Population (1990): *1,015,511*
Est. Pop. (1996): *1,175,032*
Proj. Pop. (2017): *1,593,937*
% increase (1996-2017): *36%*
Pop. Density (1996): *186 persons/ sq. mile*

Falls Lake is a large multi-use reservoir that was constructed by the US Army Corps of Engineers in the early 1980s. The dam is located about 10 miles northeast of Raleigh. Once past the dam, the Neuse flows about 185 miles southeasterly past the cities of Smithfield, Goldsboro and Kinston until it reaches tidal waters near Streets Ferry upstream of New Bern. Major tributaries of the Neuse include Crabtree Creek, Swift Creek, Little River (Wake/Johnston/Wayne Counties), Contentnea Creek and the Trent River. At New Bern, the river broadens dramatically and changes from a free-flowing river to a tidal estuary that eventually flows into Pamlico Sound.

2-B. Physiographic Regions

The Neuse Basin is divided into two physiographic regions, the Piedmont and Coastal Plain. The upper third of the Neuse basin, generally west of Interstate 95 (I-95) is located in the Piedmont (Figure 2.4) while that portion of the basin to the east of I-95 is located in the Coastal Plain. These regions are differentiated based on many factors such as soils, climate, geology, hydrology and ecology. These differences, which affect farming practices, development patterns, water supply sources and water quality, are discussed below.

Piedmont

The Piedmont is typified by rolling topography with broad ridges, sharply indented stream valleys, and low gradient streams composed of a series of sluggish pools separated by riffles and occasional small rapids. Stream floodplains are relatively narrow and mostly forested. There are no natural lakes in the region. Highly-erodible clay soils are common. Soils in the Piedmont region are underlain by a fractured rock formation with limited water storage capacity which offers only a limited supply of groundwater. Streams in the Piedmont tend to have low summer flows which limit their capacity to assimilate oxygen-consuming wastes from wastewater discharge facilities.

Streams in the Piedmont tend to have low summer flows which limit their capacity to assimilate oxygen-consuming wastes from wastewater discharge facilities and stress aquatic life.

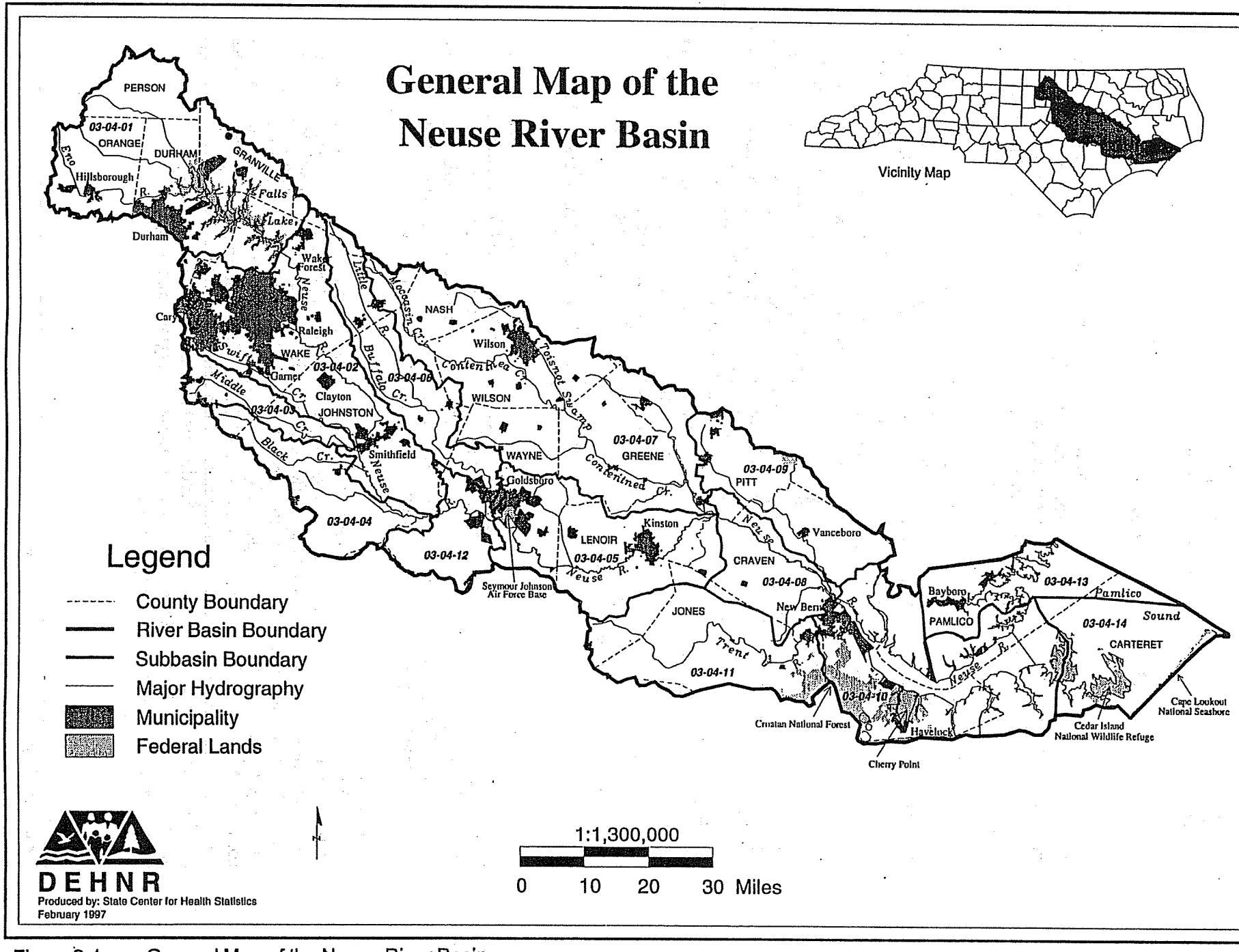


Figure 2.1 General Map of the Neuse River Basin

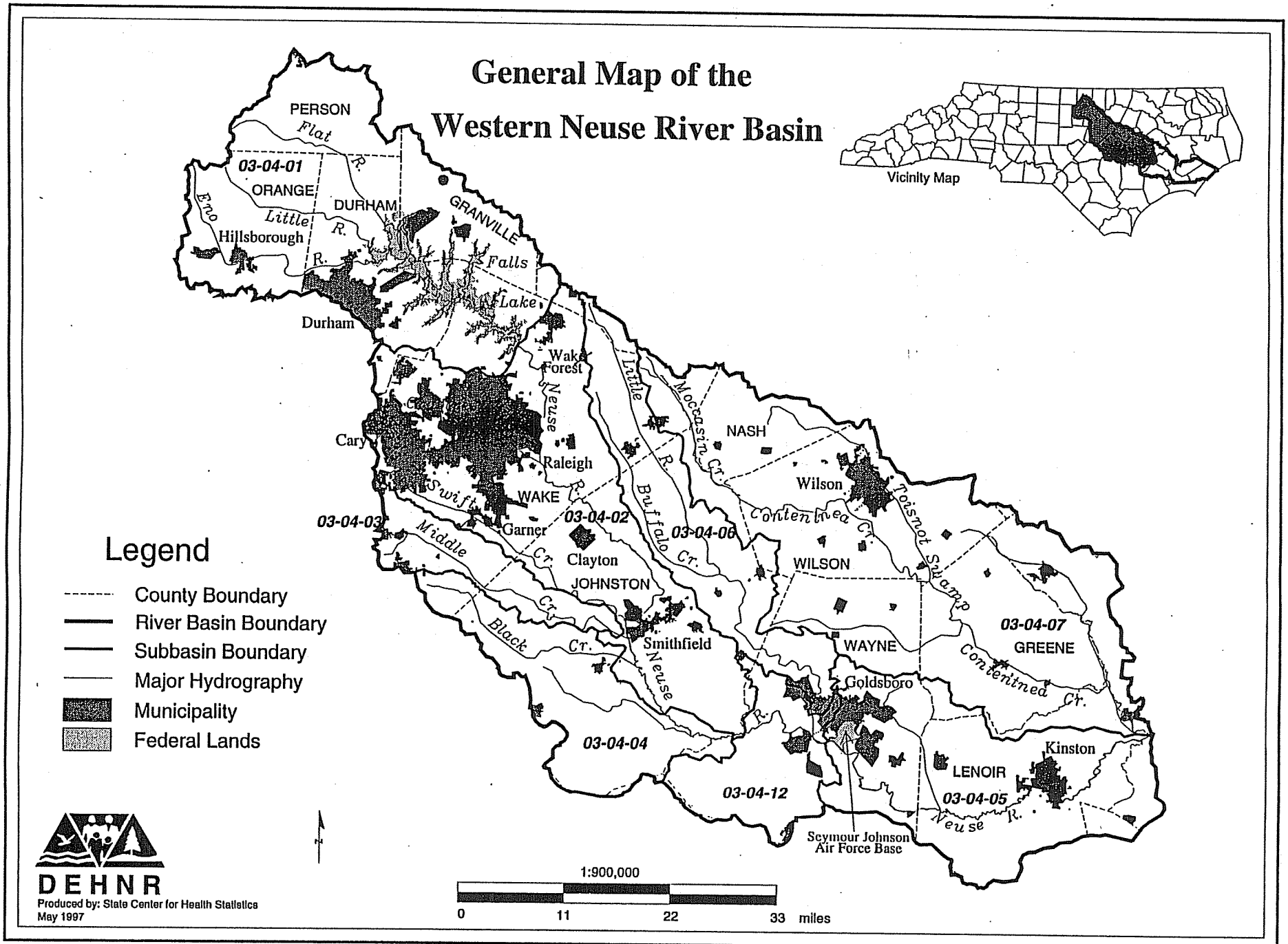


Figure 2.2 General Map of the Western Neuse River Basin

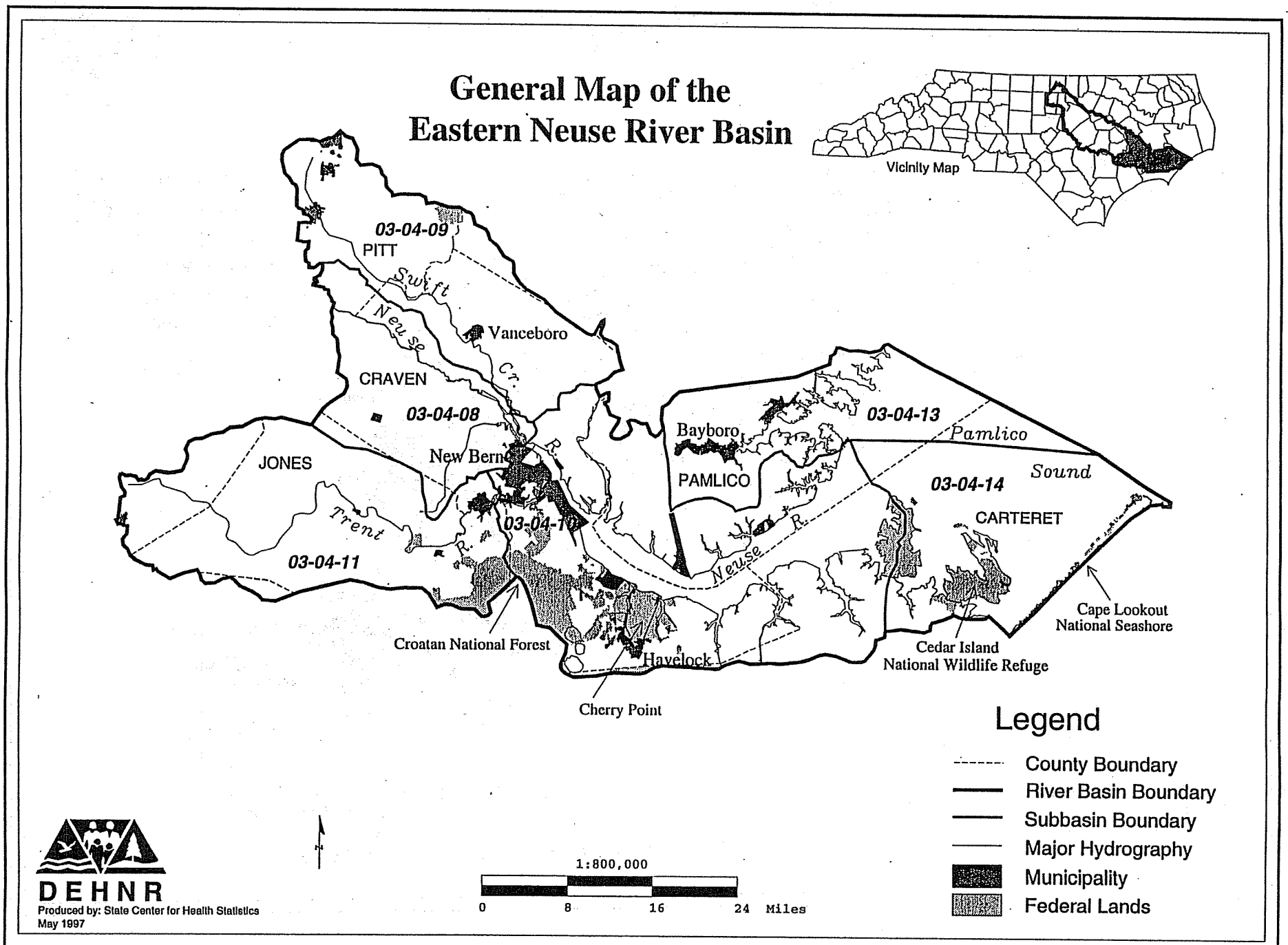


Figure 2.3 General Map of the Eastern Neuse River Basin

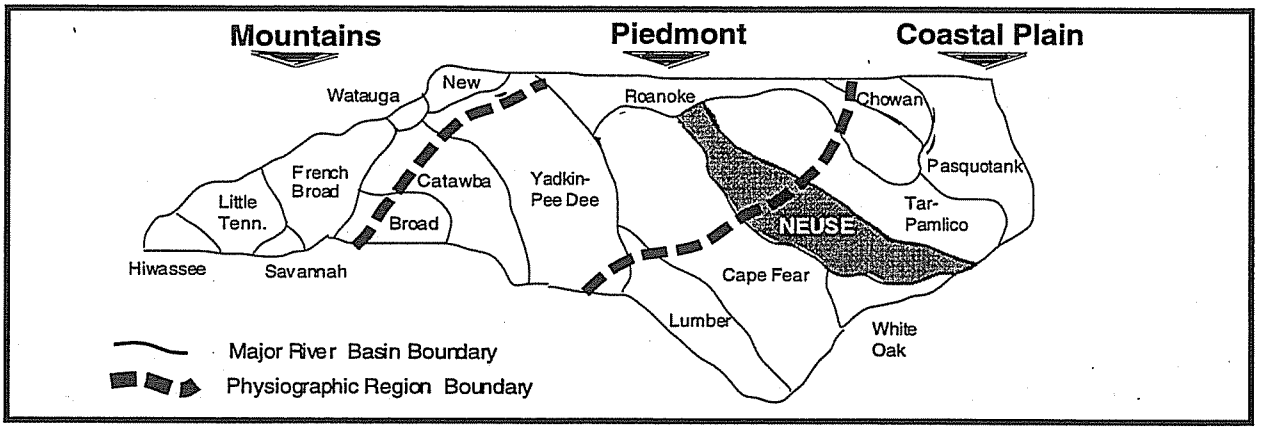


Figure 2.4 Major River Basins and Physiographic Regions of North Carolina

The Piedmont portion of the basin, encompassing much of the Raleigh-Durham area, is the most populated and industrialized region in the basin and has the highest concentration of wastewater discharges. Water needs are provided primarily by man-made surface water impoundments owing to the relatively low availability of groundwater associated with the underlying rock formations. In addition to providing a water supply source, many of these impoundments, such as Falls Lake, Lake Wheeler and Lake Crabtree, offer other important uses such as recreation, flood control, and fish and wildlife habitat. There are also numerous millponds that were once used as an important energy source for early industrial facilities in this region. Despite the increasingly urban nature of the region, agricultural activity remains widespread, and forests occupy over one third of the land area.

Coastal Plain

The Coastal Plain, in contrast to the Piedmont, is characterized by flat terrain, "blackwater streams", low-lying swamplands and productive estuarine areas. Streams in the Coastal Plain, including the mainstem of the Neuse, are much more meandering, slower-moving, have lower banks, and are often lined by extensive swamps, bottomland hardwood forests or marshes. This is particularly true in the lower eastern half of this region sometimes referred to as the outer Coastal Plain. Streams flowing through swampland areas are naturally discolored by tannic acid from decomposing plant material and become tea-colored, hence the name "blackwater". The Coastal Plain is underlain by deep sands, and groundwater is more abundant. In light of the increased abundance of groundwater, permeable soils and flat terrain, there are few surface water impoundments.

The Coastal Plain is characterized by relatively flat terrain and meandering, swamp-lined streams. It is underlain by deep sands, and groundwater is the primary water source. The inner Coastal Plain is largely agricultural while the outer Coastal Plain is heavily forested.

Forestry and agriculture are the primary land use activities in the Coastal Plain. Agriculture tends to be more concentrated in the central portion of the basin. Field ditches are widely used to provide adequate drainage for crops. Urban areas are relatively small, although growth of the coastal towns such as New Bern and Havelock is rapid. Primary cities in the Coastal Plain include Smithfield, Wilson, Goldsboro, Kinston and New Bern. The open waters of the Neuse estuary are used heavily for recreational boating and fishing, as well as commercial fishing and shellfish harvesting. Land and water uses throughout the basin are discussed in more detail in the following section.

2-C. General Land Cover/Land Use Patterns

The most current land cover classifications for the Neuse Basin have become available through the NC Center for Geographic Information and Analysis (CGIA). Five cover classes plus and an Other category are presented in Table 2.1. They include Cultivated Cropland, Forest/Wetlands, Developed, Managed Herbaceous/Pasture and Water. These classifications were interpreted from 30 meter resolution, two scenes (winter and summer), infrared LANDSAT imagery covering 1993-1995. The current land use/cover database distinguishes cultivated lands from pasture and/or open grass areas.

The 1993 Neuse Basinwide Plan presented land cover information for eight land covers: Agriculture, Forest, Wetland, Urban, Open Water, Scrub and Shadow. Land cover type classes were determined based on single scene, infrared LANDSAT imagery from 1987-88. In the original 1987-88 landcover database the "Agriculture" class included croplands and open grass areas such as fields, pasture lands and golf courses. Urban areas have been addressed differently from the 1987-88 land cover type data. The current land cover has a Developed category. This includes all lands within municipal boundaries as well as those urban lands having 50 percent or more impervious area outside of municipal boundaries. A comparison of four land cover categories between the 1987 and 1993-95 datat is presented below.

	Landsat (93-95)	Landsat (1987)
Agriculture	*25.9%	34.7%
Forest/Wetlands/Scrub	56.1%	49.6%
Urban/Developed	7.6%	5.1%
Water	10.2%	10.4%

* includes Managed Herbaceous/Pasture

A third land cover type has been prepared by the US Department of Agriculture, Natural Resources Conservation Service (NRCS) as part of the the National Resources Inventories (NRI) of 1982 and 1992. Unlike the information presented above, which is based on interpretation of satellite imagery, these data are based on statistical analyses of on-the-ground surveys conducted by NRCS staff around the country. Because of the methodology used in generating the data, they are not reliable for small areas such as counties or subbasins; however, their usefulness increases substantially when applied to a larger areas such as eigh-digit watersheds or the Neuse Basin. There is a reasonably good correlation between the NRI data and the land covers above.

Figure 2.5 presents a comparison of land cover in the Neuse Basin between 1982 and 1992 based on the NRI data. The data show a 75.6 percent increase in developed lands and a 234.2 percent increase in noncultivated croplands over the ten-year period. Forestland and cultivated cropland both declined. Results of the 1997 NRI should be able in the Fall of 1999. Data will be accessible over the internet for the 1982, 87, 92 and 97 inventories. Additional information can be obtained by contacting the NRCS office in Raleigh at (919) 873-2100.

Table 2.1 Land Cover in the Neuse River Basin (1993-95)

	Developed		Cultivated Lands		Managed Herb./Past		Forest/Wetlands		Waters		Other		Totals	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
03-04-01	35,980.8	7.29%	16,867.1	3.42%	67,319.2	13.64%	358,384.7	72.59%	13,124.9	2.66%	2,001.9	0.41%	493,678.6	12.38%
03-04-02	128,081.1	29.54%	56,639.0	13.06%	13,085.5	3.02%	231,832.9	53.48%	3,035.5	0.70%	856.7	0.20%	433,530.7	10.87%
03-04-03	18,518.4	21.96%	14,836.9	17.60%	1,614.6	1.91%	48,281.6	57.26%	965.2	1.14%	106.7	0.13%	84,323.3	2.11%
03-04-04	3,556.0	1.89%	86,224.3	45.88%	371.6	0.20%	95,604.8	50.87%	2,043.3	1.09%	134.0	0.07%	187,933.9	4.71%
03-04-05	26,088.6	8.18%	116,222.7	36.45%	9,208.4	2.89%	164,578.4	51.62%	2,678.6	0.84%	43.6	0.01%	318,820.2	7.99%
03-04-06	6,356.2	3.15%	66,445.6	32.97%	7,379.0	3.66%	119,711.0	59.40%	1,609.1	0.80%	47.4	0.02%	201,548.4	5.05%
03-04-07	26,472.8	4.11%	256,704.4	39.82%	16,480.6	2.56%	341,012.4	52.89%	3,921.0	0.61%	144.9	0.02%	644,736.0	16.17%
03-04-08	5,851.7	3.94%	39,075.8	26.31%	1,716.5	1.16%	100,025.6	67.34%	1,761.1	1.19%	117.9	0.08%	148,548.6	3.72%
03-04-09	6,650.9	3.13%	48,135.8	22.66%	2,089.0	0.98%	154,917.7	72.94%	540.5	0.25%	61.3	0.03%	212,395.1	5.33%
03-04-10	28,367.1	6.26%	47,601.0	10.51%	3,925.4	0.87%	254,351.2	56.17%	118,261.2	26.12%	335.1	0.07%	452,840.9	11.35%
03-04-11	4,144.2	1.45%	70,294.3	24.68%	6,861.3	2.41%	202,621.3	71.13%	865.9	0.30%	65.6	0.02%	284,852.5	7.14%
03-04-12	5,687.1	4.10%	56,773.3	40.97%	2,932.1	2.12%	71,706.7	51.74%	1,479.5	1.07%	4.2	0.00%	138,583.0	3.47%
03-04-13	6,849.5	3.96%	21,121.0	12.20%	600.1	0.35%	58,211.4	33.62%	86,315.4	49.84%	71.4	0.04%	173,168.7	4.34%
03-04-14	180.2	0.08%	2,915.4	1.37%	137.6	0.06%	35,301.6	16.56%	171,642.7	80.53%	2,952.8	1.39%	213,130.2	5.34%
Totals	**302,784.4**	**7.59%**	**899,856.5**	**22.56%**	**133,720.7**	**3.35%**	**2,236,541.3**	**56.08%**	**408,243.9**	**10.24%**	**6,943.3**	**0.17%**	**3,988,090.3**	**100.00%**

Notes:

Developed = Includes all unmapped municipal areas (inside incorporated limits) plus areas outside municipalities with greater than 50% synthetic cover.
Cultivated = Areas occupied by row & root crops cultivated in distinguishable rows & patterns. Also includes non-row crops such as wheat & fallow land.
Managed Herbaceous/Pasture = Areas covered by grasses, forbs, small shrubs, etc. Includes managed & unmanaged lands such as pasture, golf courses, cemeteries, cultivated berries and vineyards. Also includes herbaceous wetlands.
Forest/Wetlands = Predominatly wooded areas, not included in other categories, with vegetation generally > 3 meters high and with at least 25% crown density. Includes both upland and wetland wooded areas but does not include herbaceous wetlands.
Water = Areas with greater than 50% open water
Other = Areas of uncolidated sediment, exposed rock and indeterminate.

Data are based on Landsat satellite imagery; summer and winter scenes from 6/93 to 1/95; 30 meter resolution
Land cover categories shown above have been consolidated by NCDWQ from 23 classes plus unmapped municipal areas.

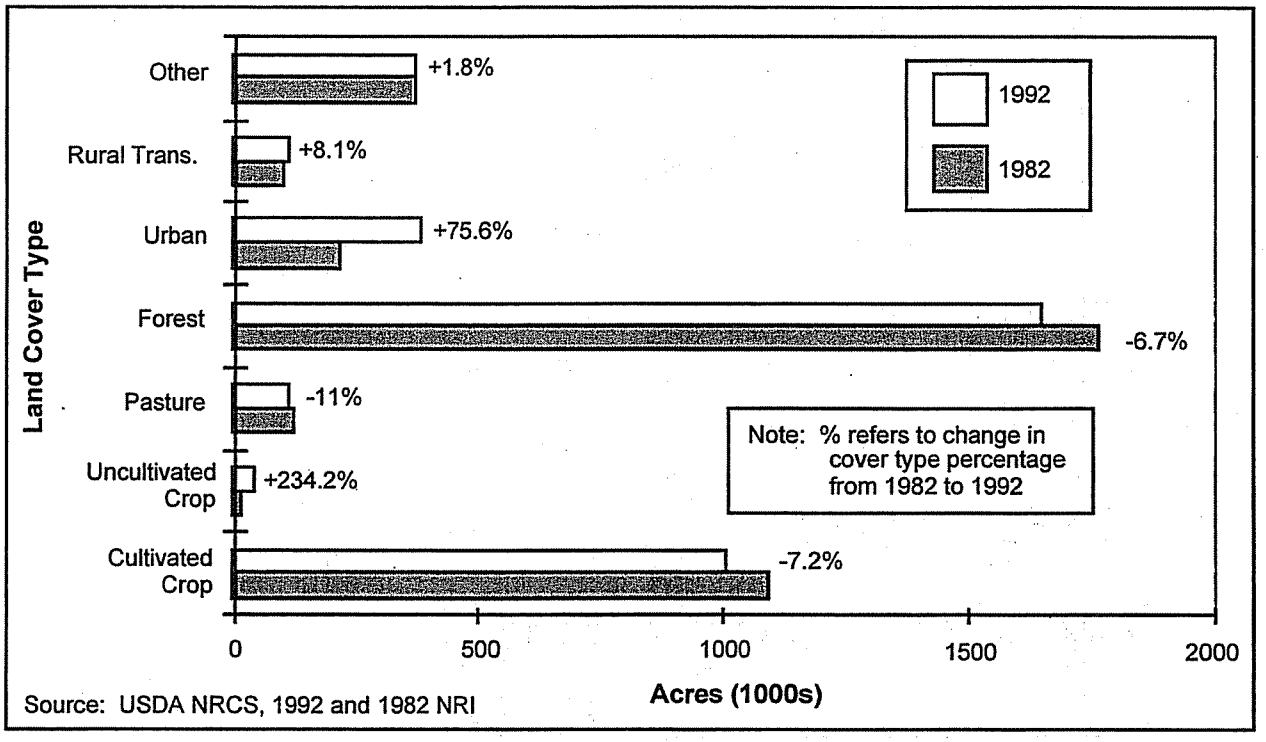


Figure 2.5 Land Cover Changes from 1982 to 1992 in Subbasins 01 through 12 of the Neuse River Basin

2-D. Population and Growth Trends in the Basin

The Neuse River basin, with an estimated 1996 population of 1,195,763, encompasses roughly one sixth of the state's total population. Table 2.2 presents census data for 1970, 1980 and 1990 for each of the subbasins. It also includes land areas and population densities (persons/square mile) by subbasin based on the *land area* (excludes open water) for each subbasin. Most of the population is concentrated in the urbanized upper basin (Figure 2.6) although the population growth rate of the lower Neuse in the vicinity of New Bern and Havelock has also been significant. This is revealed in Figure 2.7 which compares census data over the 20-year period from 1970 to 1990. Figures 2.6 and 2.7 are based on information contained in Table 2.2.

Table 2.3 presents 1990 census population data and 1996 Office of State Planning estimated populations for all the municipalities in the basin. Table 2.4 presents similar information for those 17 counties that have more than five percent of their land area in the basin. This table also includes projected populations, by county, through the year 2016. These increases range from a low -1.0 percent for Jones County to over 60 percent for Wake County. Table 2.5 presents a very rough estimate of 1996 subbasin populations and projected subbasin populations for 2016. It is based on applying the growth rates of counties located in the subbasins to the 1990 subbasin populations from Table 2.2. Table 2.5 indicates that by 2016 the present Neuse basin population will increase by 35.2 percent to 1,616,924.

Table 2.2 Neuse Subbasin Population (1970, 1980 and 1990) and Land Area Summaries

	POPULATION (No. of Persons)			POPULATION DENSITY (Persons/Sq. Mile)			LAND AND WATER AREAS			
							Total Land and Water Area		Water Area	Land Area
SUBBASIN	1970	1980	1990	1970	1980	1990	Acres	Sq. Miles	(Sq. Miles)	(Sq. Miles)
03-04-01	116,323	134,700	163,228	157	182	221	493,868	772	32	739
03-04-02	226,555	291,284	390,804	313	402	539	464,479	726	1	724
03-04-03	10,017	12,023	23,461	76	92	179	84,085	131	0	131
03-04-04	16,093	17,937	20,974	58	65	76	177,568	278	0	277
03-04-05	85,772	100,279	101,418	173	202	205	319,046	499	3	496
03-04-06	27,337	34,218	40,906	86	108	129	202,767	317	0	317
03-04-07	102,787	110,422	115,397	102	110	115	644,756	1,007	0	1,007
03-04-08	8,793	9,147	11,620	39	40	51	148,071	231	3	229
03-04-09	17,646	21,581	29,073	53	65	87	212,949	333	0	333
03-04-10	38,818	58,596	67,708	75	113	131	449,306	702	183	519
03-04-11	12,357	14,152	14,466	28	32	33	283,763	443	1	443
03-04-12	29,446	25,323	31,126	161	138	170	117,269	183	0	183
03-04-13	3,446	4,647	4,521	24	32	31	177,034	277	132	145
03-04-14	1,128	1,357	809	19	23	14	215,130	336	277	59
TOTALS	696,518	835,666	1,015,511	97	115	141	3,990,091	6,234	633	5601.8

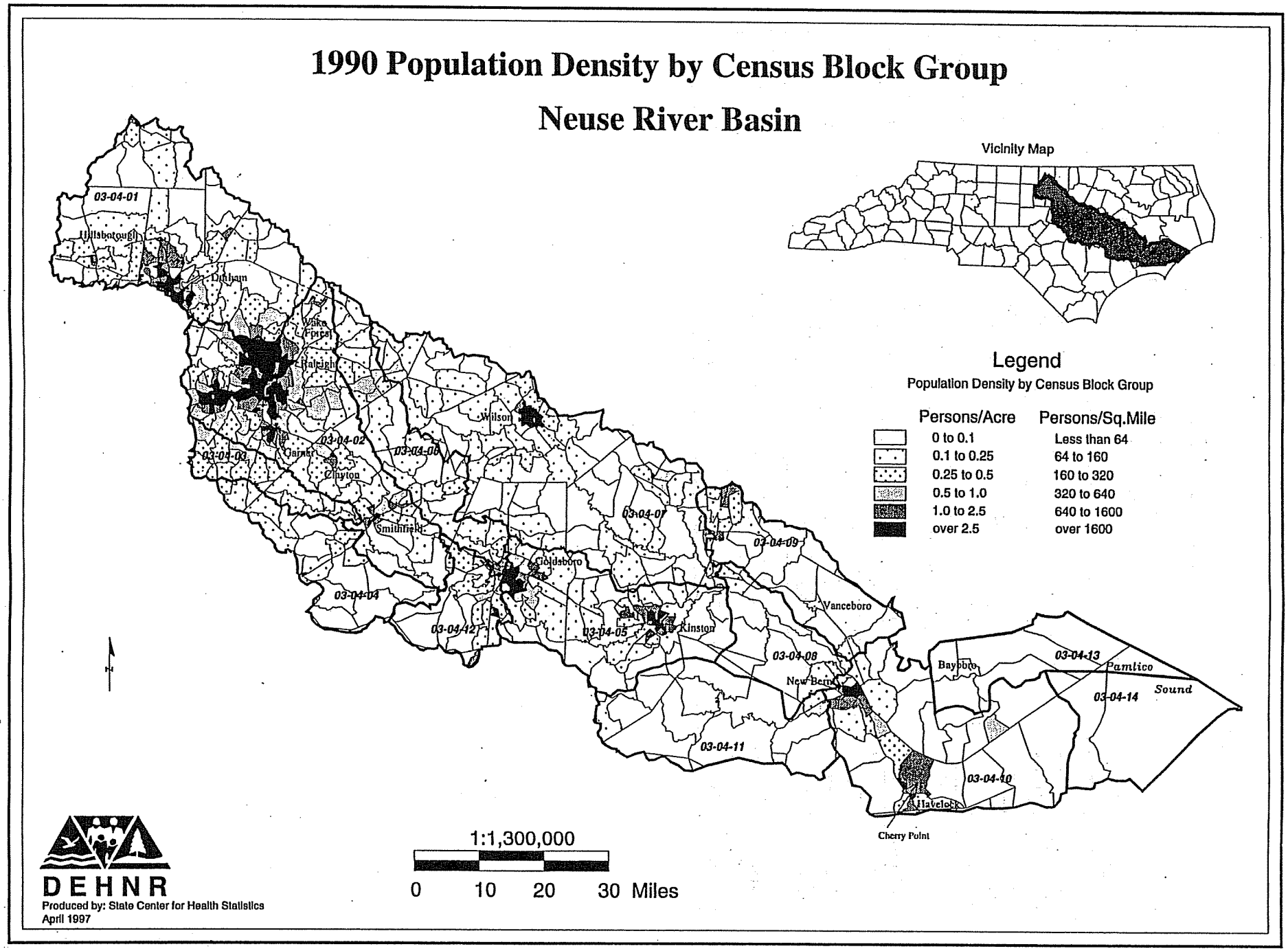


Figure 2.6 1990 Population Density by Census Tract

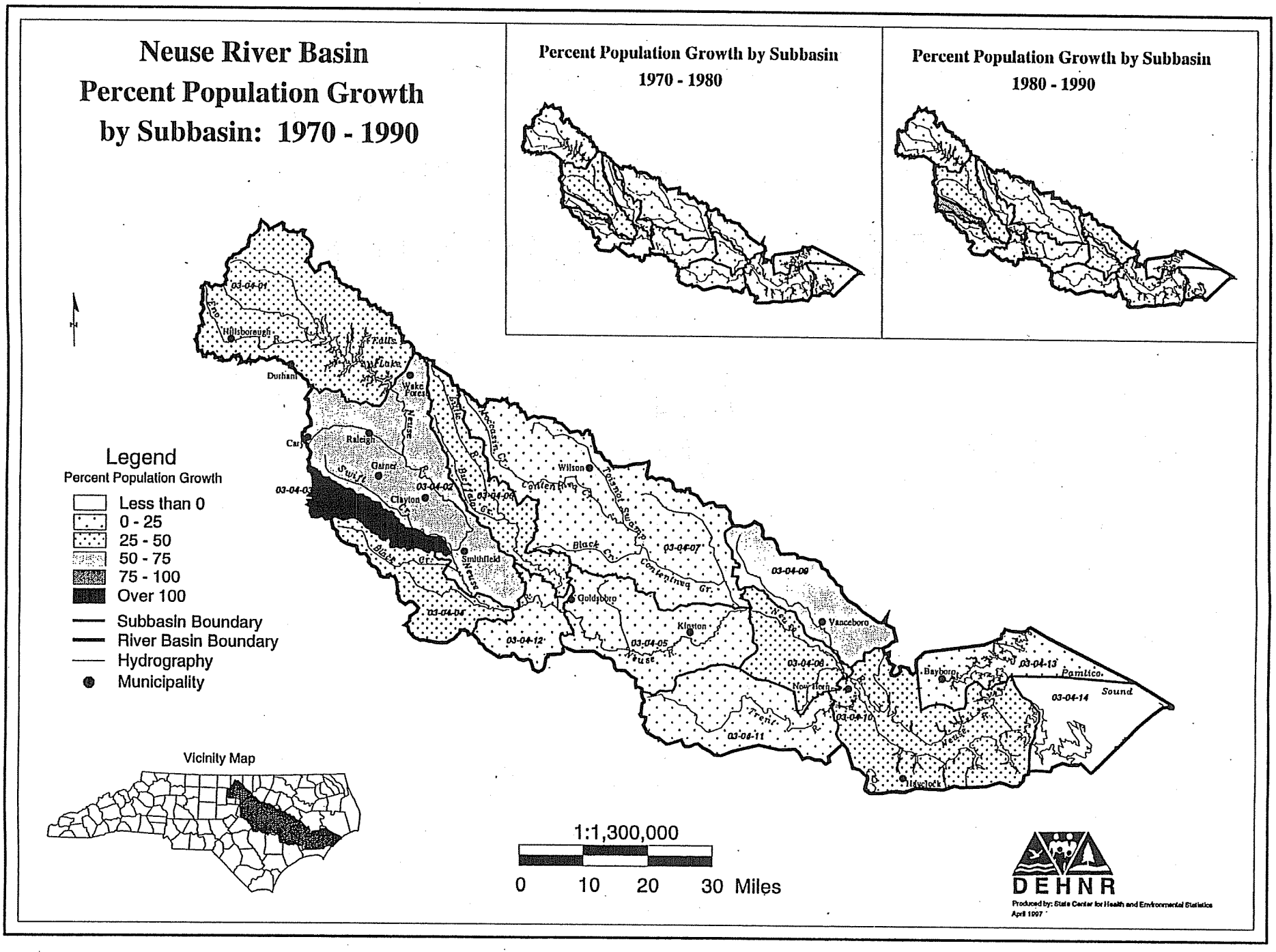


Figure 2.7 Percent Population Growth by Subbasin Between 1970 and 1990

Table 2.3 Municipal Populations in the Neuse River Basin (1990 and 1996)

Municipality	Population 1990	Population *1996	% Change
ALLIANCE	681	673	-1.2
APEX	4,789	8,490	77.3
ARAPAHOE	450	460	2.2
AYDEN	4,883	4,898	0.3
BAILEY	553	561	1.4
BAYBORO	733	758	3.4
BENSON	3,044	3,561	17.0
BLACK CREEK	669	705	5.4
BRIDGETON	498	523	5.0
CARY	44,397	69,489	56.5
CLAYTON	4,756	6,810	43.2
COVE CITY	497	579	16.5
CREEDMOOR	1,506	1,814	20.5
DOVER	451	455	0.9
DURHAM	136,612	149,373	9.3
EUREKA	282	294	4.3
FARMVILLE	4,446	4,442	-0.1
FOUNTAIN	445	467	4.9
FOUR OAKS	1,308	1,727	32.0
FREMONT	1,710	1,792	4.8
FUQUAY-VARINA	4,447	5,804	30.5
GARNER	14,716	17,582	19.5
GOLDSBORO	40,709	48,260	18.5
GREENVILLE	46,305	58,900	27.2
GRIFTON	2,393	2,540	6.1
HAVELOCK	20,300	21,335	5.1
HILLSBOROUGH	4,263	4,823	13.1
HOLLY SPRINGS	1,024	4,852	373.8
HOOKERTON	422	465	10.2
KENLY	1,549	1,788	15.4
KINSTON	25,295	25,635	1.3
KNIGHTDALE	1,884	3,465	83.9
LA GRANGE	2,805	3,004	7.1
LUCAMA	933	969	3.9
MAYSVILLE	892	935	4.8
MESIC	310	307	-1.0
MICRO	417	468	12.2
MIDDLESEX	730	939	28.6
MINNESOTT BEACH	266	294	10.5
MORRISVILLE	1,489	2,123	42.6
NEW BERN	17,363	21,799	25.5
ORIENTAL	786	868	10.4
PIKEVILLE	598	766	28.1
PINE LEVEL	1,217	1,336	9.8
PINK HILL	547	581	6.2
POLLOCKSVILLE	299	288	-3.7
PRINCETON	1,181	1,478	25.1
RALEIGH	212,092	260,189	22.7
RIVER BEND	2,408	2,699	12.1
ROLESVILLE	572	695	21.5
ROXBORO	7,332	7,469	1.9
SARATOGA	342	338	-1.2
SELMA	4,600	5,506	19.7
SEVEN SPRINGS	163	169	3.7
SIMS	124	117	-5.6
SMITHFIELD	7,540	11,082	47.0
SNOW HILL	1,378	1,485	7.8
STANTONSBURG	782	803	2.7
STEM	249	275	10.4
STONEWALL	279	276	-1.1
TRENT WOODS	2,366	4,240	79.2
TRENTON	230	214	-7.0
VANCEBORO	946	1,017	7.5
VANDEMERE	315	318	1.0
WAKE FOREST	5,832	7,793	33.6
WALNUT CREEK	623	734	17.8
WALSTONBURG	188	235	25.0
WENDELL	2,921	3,556	21.7
WILSON	36,930	40,807	10.5
WILSON'S MILLS	587	713	21.5
WINTERVILLE	3,069	3,624	18.1
YOUNGSVILLE	424	503	18.6
ZEBULON	3,173	4,211	32.7
TOTALS	**701,315**	**848,543**	**21.0**

* Estimated population (Source: Office of State Planning)

Table 2.4 Population and Growth Data for Counties in the Neuse River Basin

County	Population 1990	Estimated Population 1996	Estimated % Growth 1990-1996	Projected Population July 2016	Projected % Growth 1996-2016
CARTERET	52,553	58,341	11.0	76,059	30.4
CRAVEN	81,613	87,174	6.8	102,558	17.6
DURHAM	181,854	194,956	7.2	248,293	27.4
FRANKLIN	36,414	42,738	17.4	60,230	40.9
GRANVILLE	38,341	41,921	9.3	51,104	21.9
GREENE	15,384	17,180	11.7	18,541	7.9
JOHNSTON	81,306	99,215	22.0	141,563	42.7
JONES	9,414	9,322	-1.0	9,331	0.1
LENOIR	57,274	59,262	3.5	58,729	-0.9
NASH	76,677	86,026	12.2	108,486	26.1
ORANGE	93,851	106,045	13.0	142,187	34.1
PAMLICO	11,368	12,010	5.6	13,138	9.4
PERSON	30,180	32,514	7.7	36,555	12.4
PITT	108,480	119,236	9.9	159,905	34.1
WAKE	426,301	539,187	26.5	871,716	61.7
WAYNE	104,666	112,386	7.4	124,824	11.1
WILSON	66,061	68,460	3.6	72,294	5.6
Totals	**1,471,737**	**1,685,973**	**14.6**	**2,295,513**	**36.2**

(Source: NC Office of State Planning, 1998)

Table 2.5 Estimated 1996 and Projected 2016 Population Data for Subbasins in the Neuse

Subbasin	Population 1990	Estimated Population 1996	Estimated % Growth 1990-1996	Projected July 2016	Projected % Growth 1996-2016
01	163,228	179,551	10.0	224,439	25.0
02	390,804	488,505	25.0	757,183	55.0
03	23,461	29,326	25.0	45,456	55.0
04	20,974	25,588	22.0	36,514	42.7
05	101,418	107,503	6.0	113,953	6.0
06	40,906	51,133	25.0	79,255	55.0
07	115,397	124,629	8.0	137,092	10.0
08	11,620	12,410	6.8	14,594	17.6
09	29,073	31,050	6.8	36,515	17.6
10	67,708	71,770	6.0	89,713	25.0
11	14,466	14,466	0.0	14,466	0.0
12	31,126	54,159	74.0	60,171	11.1
13	4,521	4,774	5.6	6,402	34.1
14	809	898	11.0	1,171	30.4
Totals	**1,015,511**	**1,195,763**	**17.7**	**1,616,924**	**35.2**

Note: Estimated and Projected Growth percentages are based on the growth percentages, presented in Table 2.4, for the county, or counties, that comprise each subbasin.

2-E. Natural Heritage Resources and Special Resource Waters

2-E.1 Rare Aquatic and Aquatic-Related Species

The Neuse River basin contains many rare plants and animals. Five animals of aquatic or wetland habitats are federally listed. Of these, the manatee, loggerhead (turtle), piping plover and bald eagle are found primarily in estuarine habitats, whereas the dwarf wedgemussel occurs in the Piedmont and upper Coastal Plain. Of the three wetland plants that are federally listed, one (seabeach amaranth) occurs along the coast, one occurs in freshwater areas in the tidewater zone (Virginia jointvetch), and one occurs scattered over the Coastal Plain (rough-leaf loosestrife). Especially noteworthy are the number of state-listed mollusk species, nearly all of which are freshwater mussels. Figure 2.8 (parts a and b) shows the locations of rare species in the Neuse River Basin. Species are listed in Table 2.6.

Rare Aquatic Animals - Vertebrates

The manatee (*Trichechus manatus*) is a sporadic visitor to estuarine waters in the basin. The species does not breed in the state but individuals are sighted every few years, even as far inland as New Bern. The American alligator (*Alligator mississippiensis*) is present in the lower Neuse Basin, primarily in Croatan National Forest and Cherry Point Marine Corps Air Station. Loggerhead turtles (*Caretta caretta*) nest along coastal beaches and forage in the ocean and in most of the sounds. Estuaries and tidal marshes are the preferred habitat for the other rare aquatic reptiles in the basin -- diamondback terrapin (*Malaclemys terrapin*) and Carolina salt marsh snake (*Nerodia sipedon williamengelsi*). An especially significant aquatic amphibian is the Neuse River waterdog (*Necturus lewisi*), which is endemic to the Neuse and Tar systems in the upper Coastal Plain and lower Piedmont.

Another aquatic vertebrate species endemic to North Carolina is the Carolina madtom (*Noturus furiosus*). Like the Neuse River waterdog, this small fish lives only in the Neuse and Tar basins. Among the other rare fishes in the Neuse basin, the Roanoke bass (*Ambloplites cavifrons*) and Carolina darter (*Etheostoma collis*) have restricted ranges, being limited mainly to the Piedmont and upper Coastal Plain of southern Virginia and North Carolina.

Rare Aquatic Animals - Mollusks

Good water quality in the Neuse River Basin is critical to the survival of a large number of rare freshwater mussels. Fourteen species of rare freshwater mussels, plus one rare snail [panhandle pebblesnail (*Somatogyrus virginicus*)] are known from the Neuse Basin, and one species, the dwarf wedgemussel (*Alasmidonta heterodon*), is federally-listed as Endangered. The majority of the Neuse Basin mollusks, including the dwarf wedgemussel, inhabit small streams. Many of the larger rivers in the state, such as the main stem of the Neuse, no longer support populations of rare mussels because of high amounts of sedimentation and pollution. Most populations of the rare mollusk species occur in the Piedmont and upper Coastal Plain, in rapidly developing areas such as the Research Triangle. The future of these populations is uncertain.

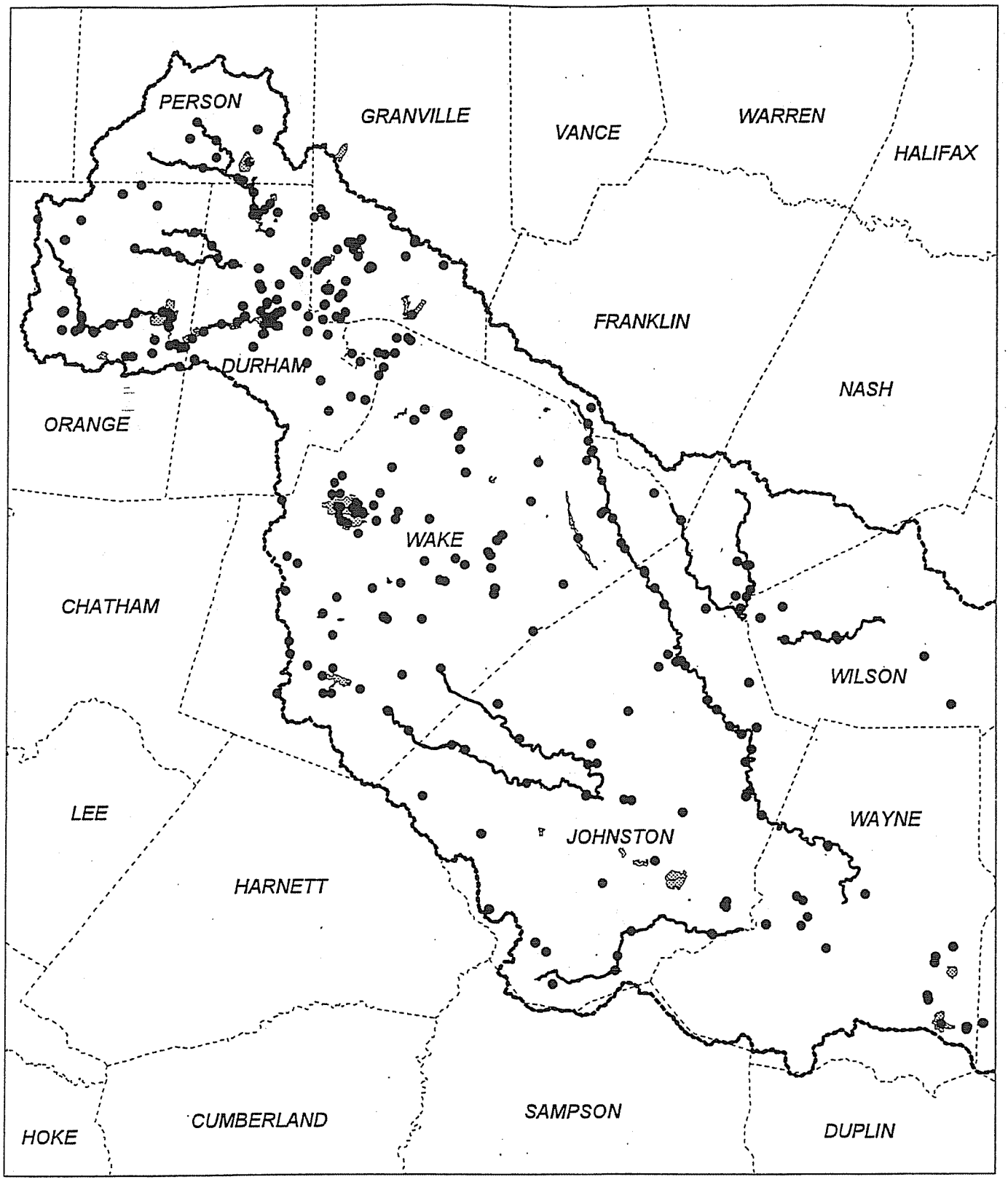


Figure 2.8a Map of Rare Species and Significant Natural Areas in the Upper Neuse River Basin

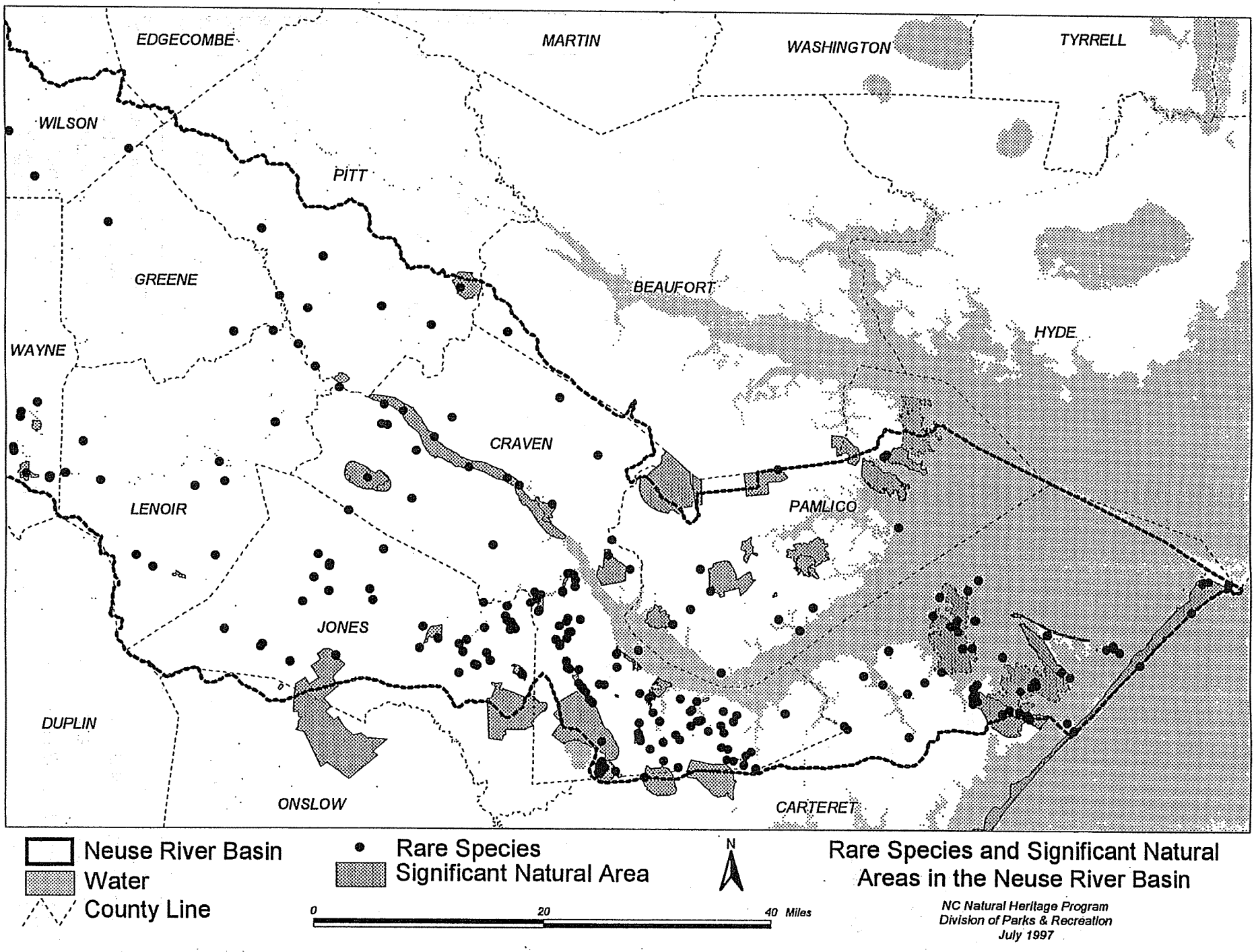


Figure 2.8b Map of Rare Species and Significant Natural Areas in the Lower Neuse River Basin

Table 2.6 Rare Aquatic Animal Species in the Neuse River Basin
(Source: NC Natural Heritage Program, 1997)

Common Name	Scientific Name	Listing Status: State	Federal
MAMMALS			
Manatee	Trichechus manatus	E	E
REPTILES			
American Alligator	Alligator mississippiensis	T	T(S/A)
Loggerhead	Caretta caretta	T	T
Diamondback Terrapin	Malaclemys terrapin	SC	
Carolina Salt Marsh Snake	Nerodia sipedon williamengelsi	SC	
AMPHIBIANS			
Neuse River Waterdog	Necturus lewisi	SC	
FISHES			
Roanoke Bass	Ambloplites cavifrons	SR	
Carolina Darter	Etheostoma collis	SC	
Least Brook Lamprey	Lampetra aepyptera	SC	
Bridle Shiner	Notropis bifrenatus	SC	
Carolina Madtom	Noturus furiosus	SC	
MOLLUSKS			
Dwarf Wedgemussel	Alasmidonta heterodon	E	E
Triangle Floater	Alasmidonta undulata	T	
Alewife Floater	Anodonta implicata	SC	
Yellow Lance	Elliptio lanceolata	T	
Cape Fear Spike	Elliptio marsupiobesa	T	
Roanoke Slabshell	Elliptio roanokensis	T	
Atlantic Pigtoe	Fusconaia masoni	T	
Yellow Lampmussel	Lampsilis cariosa	T	
Eastern Lampmussel	Lampsilis radiata	SC	
Green Floater	Lasmigona subviridis	E	
Eastern Pondmussel	Ligumia nasuta	SC	
Panhandle Pebblesnail	Somatogyrus virginicus	SR	
Squawfoot	Strophitus undulatus	T	
Notched Rainbow	Villosa constricta	SR	
Eastern Creekshell	Villosa delumbis	SR	
CRUSTACEANS			
Graceful Clam Shrimp	Lynceus gracilicornis	SR	
Tar River Crayfish	Procambarus medialis	SR	
Croatan Crayfish	Procambarus plumimanus	SR	

Abbreviations: E = Endangered; T = Threatened; PT = Proposed Threatened; T(S/A) = Threatened Due to Similarity of Appearance; SC = Special Concern; C = Candidate; SR = Significantly Rare.

Rare Wetland and Bottomland Animals and Plants

The Neuse River Basin contains many dozens of other rare animals and rare plants, dependent on wetlands or open water for their existence. The bald eagle (*Haliaeetus leucocephalus*) is a Federally Threatened species that nests mainly in estuarine habitats, but it also nests in the Piedmont at large reservoirs such as Falls Lake. It forages for fishes on both fresh and brackish waters of lakes, large rivers and sounds. The Federally Threatened piping plover (*Charadrius*

melodus) nests on barrier islands and sand flats, and it forages on tidal flats and shores. Many other state-listed bird species nest in coastal regions and feed in tidal marshes or in estuaries; these include herons, egrets, ibises, pelicans, terns and skimmers.

Among the fifty-two rare wetland plants in the Neuse Basin, three are federally-listed as Threatened or Endangered. The rough-leaf loosestrife (*Lysimachia asperulifolia*), which is found in savannas and pocosin ecotones, is restricted to southeastern North Carolina and adjacent South Carolina. In Virginia and other states north of North Carolina, the Federally Threatened Virginia jointvetch (*Aeschynomene virginica*) grows in tidal freshwater marshes; in this state, however, the species is found mostly in ditches and other moist disturbed soil. The seabeach amaranth (*Amaranthus pumilus*) grows on sand flats, near the ends of barrier islands. Its seeds are carried in ocean water to other beaches and flats. Because the species is an annual and occurs in the ever-changing environment of sand flats, populations of seabeach amaranth fluctuate tremendously from year to year. Probably the most imperiled rare plant in the basin is the Godfrey's sandwort (*Minuartia godfreyi*), which is State Endangered. The only extant population in North Carolina is in a tidal marsh near New Bern, and within its range in the southeastern states it is known from only a few locations. Most of the other rare plants in the Neuse Basin grow in wet soils of savannas, pocosins and flatwoods, and are only indirectly affected by water quality and quantity.

Wetland Communities

Because the Neuse River spans two physiographic provinces -- the coast and the lower Piedmont -- the river basin contains a wide array of natural communities, both upland and wetland. The basin contains the full array of estuarine wetland communities, such as Salt Marsh, Brackish Marsh and Estuarine Fringe Loblolly Pine Forest. The basin also contains a few good examples of Tidal Freshwater Marsh, notably at the junction of the Trent and Neuse rivers near New Bern. In addition, the northernmost Pine Savanna natural communities remaining in good condition are here; these are located in Croatan National Forest.

Nonriverine forested wetlands are prominent in the lower part of the basin. Pamlico County, in particular, contains high-quality remnant stands of Nonriverine Swamp Forest and Nonriverine Wet Hardwood Forest. Often mixed with these nonriverine hardwood forests are communities of pocosin vegetation, such as Pond Pine Woodland, High Pocosin, Bay Forest and Low Pocosin. This association is especially notable in the Croatan National Forest.

A variety of riverine communities are represented in the basin, although they are not as mature and high-quality as those in the Roanoke River Basin. Examples of Cypress--Gum Swamp and Bottomland Hardwood communities are located on the Neuse floodplain upstream of New Bern in northwestern Craven County and below Smithfield in Johnston County. In the Piedmont, some of the best examples of Piedmont/Mountain Swamp Forest were destroyed by the creation of Falls Lake, but remnants of this rare natural community still exist in streams above the flooded portion of the lake.

2-E.2 Significant Natural Heritage Areas

The North Carolina Natural Heritage Program (NHP) compiles the NC Department of Environment and Natural Resources' (DENR) list of Significant Natural Heritage Areas as required by the Nature Preserve Act (NCGS Chapter 113-A-164 of Article 9A). The list is based on the program's inventory of natural diversity in the state (DEHNR, 1997). Natural areas are evaluated on the basis of the occurrences of rare plant and animal species, rare or high-quality natural communities, and geologic features. The global and statewide rarity of these elements and the quality of their occurrence at a site relative to other occurrences determines a site's significance rating. The sites included on this list are the best representatives

of the natural diversity of North Carolina, and therefore, have priority for protection. Inclusion on the list does not imply that any protection or public access exists.

Figure 2.8 (a and b) shows the Significant Natural Heritage Areas in the Neuse Basin. Highlighted below are certain Significant Natural Heritage Areas known by the NHP as Aquatic Habitats. They are stream segments or other bodies of water that contain significant natural resources, such as a high diversity of rare aquatic animal species. Also, described in groups below are several Significant Natural Heritage Areas that contribute to the maintenance of water quality in the Neuse Basin. More complete information on Significant Natural Heritage Areas and Aquatic Habitats may be obtained from the NHP.

Significant Natural Heritage Areas: Aquatic Habitats

Eno River. This river in Orange and Durham counties supports fourteen rare animals: two fishes, one amphibian, eight mussels, one snail, and two dragonflies. It contains the only currently known North Carolina population of the panhandle pebblesnail (*Somatogyrus virginicus*). Eno River State Park protects much of the land along the river, but protection is still needed for the land bordering the river's headwaters.

Flat River. Ten rare animal species -- one fish, one amphibian, and eight mussels -- make their home in this river in Person and Durham counties. While the lower portions of the river are protected by NC State University's Hill Forest, protection is lacking for the lands along the upper portions of the river.

Swift Creek. This stream in southern Wake and Johnston counties contains eleven rare animals: one rare fish and ten rare mussels, including the Federally Endangered dwarf wedgemussel. Although there are several protected areas along the stream above Lake Wheeler, all of the rare animals live in the creek below Lake Benson, where there are no lands protected along the creekbanks. Thus, protection efforts are greatly needed downstream of Lake Benson.

Turkey Creek. This stream in Nash and northwestern Wilson counties contains one rare amphibian and six rare mussel species, including the Federally Endangered dwarf wedgemussel. Though there is a protected site in its floodplain, there are no protected areas along the banks of the creek; thus, protection efforts are greatly needed.

Little River. Beginning in Franklin County, the Little River flows through Wake, Johnston and Wayne counties. It contains twelve rare animals: three fishes, one amphibian and eight mussels, including several populations of the Federally Endangered dwarf wedgemussel. The only protected site along the river is Mitchells Mill State Natural Area in Wake County. A reservoir, which will impact some of these rare species, will be constructed on the river downstream from Mitchells Mill State Natural Area. Aquatic species would benefit from protection efforts along the River.

Middle Creek. This tributary in southern Wake and Johnston counties contains eleven rare animals: two fishes, one amphibian and eight mussels, including the Federally Endangered dwarf wedgemussel. Most of the creek flows through private, unprotected lands.

Moccasin Creek. This stream runs along the boundaries of Wake, Franklin, Nash and Johnston counties and contains one rare amphibian and four rare mussel species, one of which is the Federally Endangered dwarf wedgemussel. Except for a very small nature preserve in Johnston County, there are no protected lands along this creek; thus, protection efforts are greatly needed.

In addition to the reservoir to be constructed on the Little River, a number of reservoirs are being planned for other streams in the Neuse River basin. Some impact to mussel populations on

Turkey Creek and Moccasin Creek are expected with the proposed expansion of Buckhorn Reservoir.

Significant Natural Heritage Areas: Terrestrial and Wetland

Cedar Island Marshes; Cherry Point Piney Island; Jones Island; and Pamlico Point Marshes and Impoundments. These four sites collectively consist of thousands of acres of primarily brackish marsh where the Neuse River merges with Pamlico Sound. Large numbers of the rare and secretive black rail (*Laterallus jamaicensis*) nest in these marshes, as do large numbers of other marsh birds. The first two sites, in Carteret County, are in federal ownership, whereas most of the latter two sites, which are in Pamlico County, are in private ownership except for a portion of Pamlico Point owned by the NC Wildlife Resources Commission.

Sweetwater Creek Natural Area and Trent River/Brice Creek Marshes. These two natural areas lie in close proximity near the mouth of the Trent River, near New Bern. Extensive examples of the uncommon wetland community Tidal Freshwater Marsh are present at the sites, and the former site contains the only known location of the globally rare Godfrey's sandwort (*Minuartia godfreyi*) in the state. Both sites are in private ownership and are in need of protection.

Neuse River Floodplain and Bluffs. This floodplain corridor, extending for approximately 20 air miles from New Bern upstream to Pitt County, consists mostly of swamp forests with a few marl outcrops present on vertical riverbanks. A few sections of the floodplain are owned by the NC Wildlife Resources Commission, and there are two privately-owned Registered Natural Heritage Areas as well. Nonetheless, protection is needed for at least 95% of this floodplain/buffer natural area.

Cliffs of the Neuse State Park. This relatively small State Park protects about two miles of shoreline along the Neuse River in southeastern Wayne County. The park is best known for its high bluff and wetland communities such as bottomland forest and swamp forest.

Neuse River/Brogden Bottomlands; Cowbone Oxbows; and Sage Pond/Neuse River Floodplain. These are the three most important sites in the floodplain of the Neuse in southeastern Johnston County. The floodplain is remarkably wide (up to 4 miles) in this part of the basin; even though much of the floodplain forests have been cut over, considerable acreage still remains in swamp and bottomland forest. This portion of the river contains several oxbow lakes, which are rare in North Carolina. No parts of this natural area are in public or otherwise protected ownership; thus, protection effort is greatly needed.

William B. Umstead State Park. This State Park protects nearly 5400 acres of forestland in the upper part of the Neuse River Basin. Crabtree Creek flows for several miles through the park, which features bottomland hardwoods as well as several rhododendron bluffs along the creekbank.

Eno River State Park and Occoneechee Mountain. The State Park protects more than eight miles of river frontage, mostly in various upland communities. Occoneechee Mountain is located upstream of the park, opposite the town of Hillsborough. A portion of this monadnock, one of the highest hills in the eastern Piedmont, is owned by the Town of Hillsborough, and the Division of Parks and Recreation is working to acquire other portions of the mountain not yet owned.

2-E.3 Special Resource Waters

Presented below are a series of maps of high resource value waters. They include water supply watersheds in the western half of the basin (Figure 2.9), Outstanding Resource and High Quality

Waters in the Eastern half of the basin (Figure 2.10), anadromous fish spawning areas in the western and eastern halves of the basin (Figure 2.11 and 2.12), fishery nursery areas in the eastern half of the basin (Figure 2.13), SA waters (Figure 2.14) and closed SA waters (Figure 2.15)

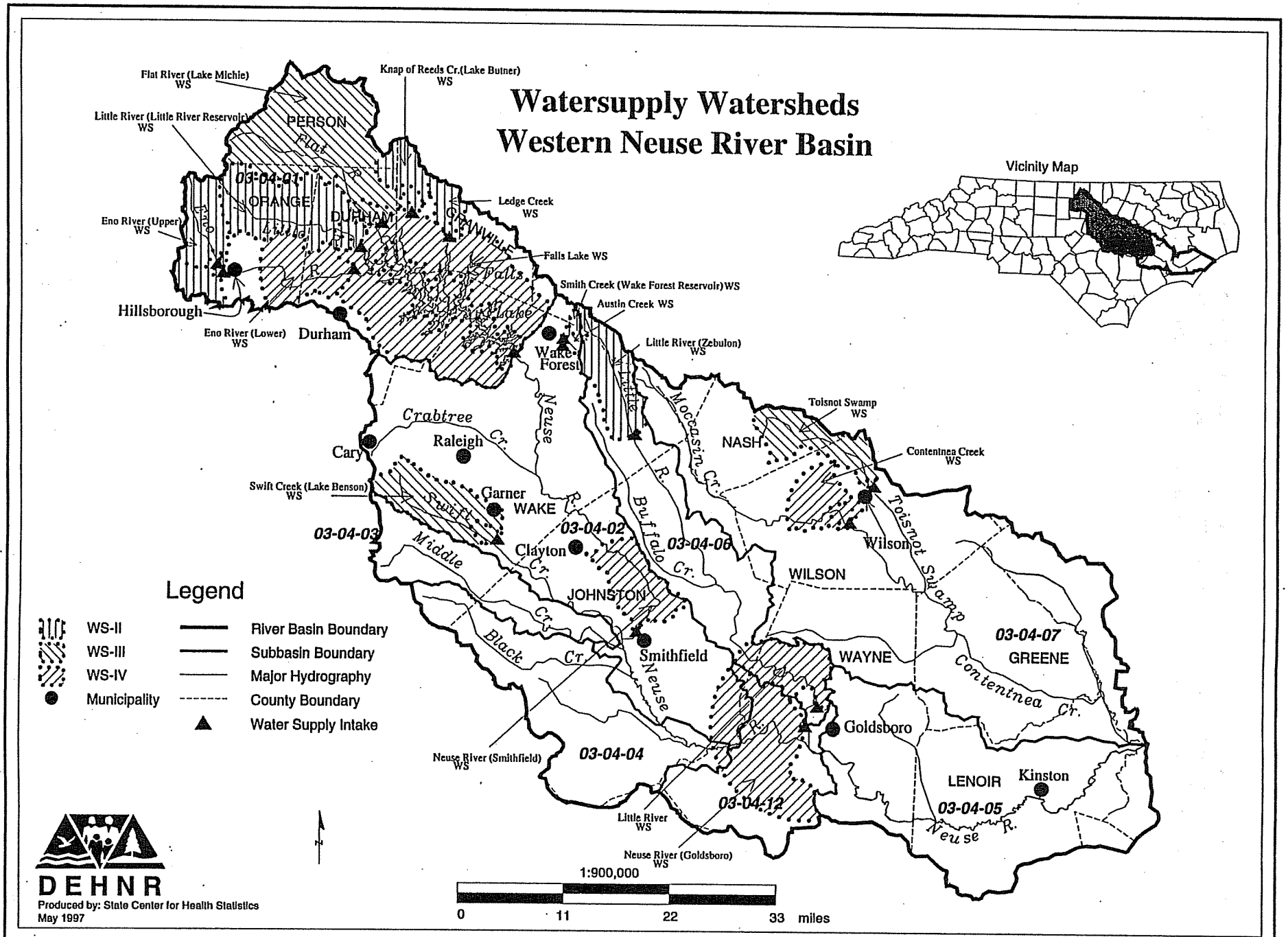


Figure 2.9 Water Supply Watersheds in the Western Neuse River Basin

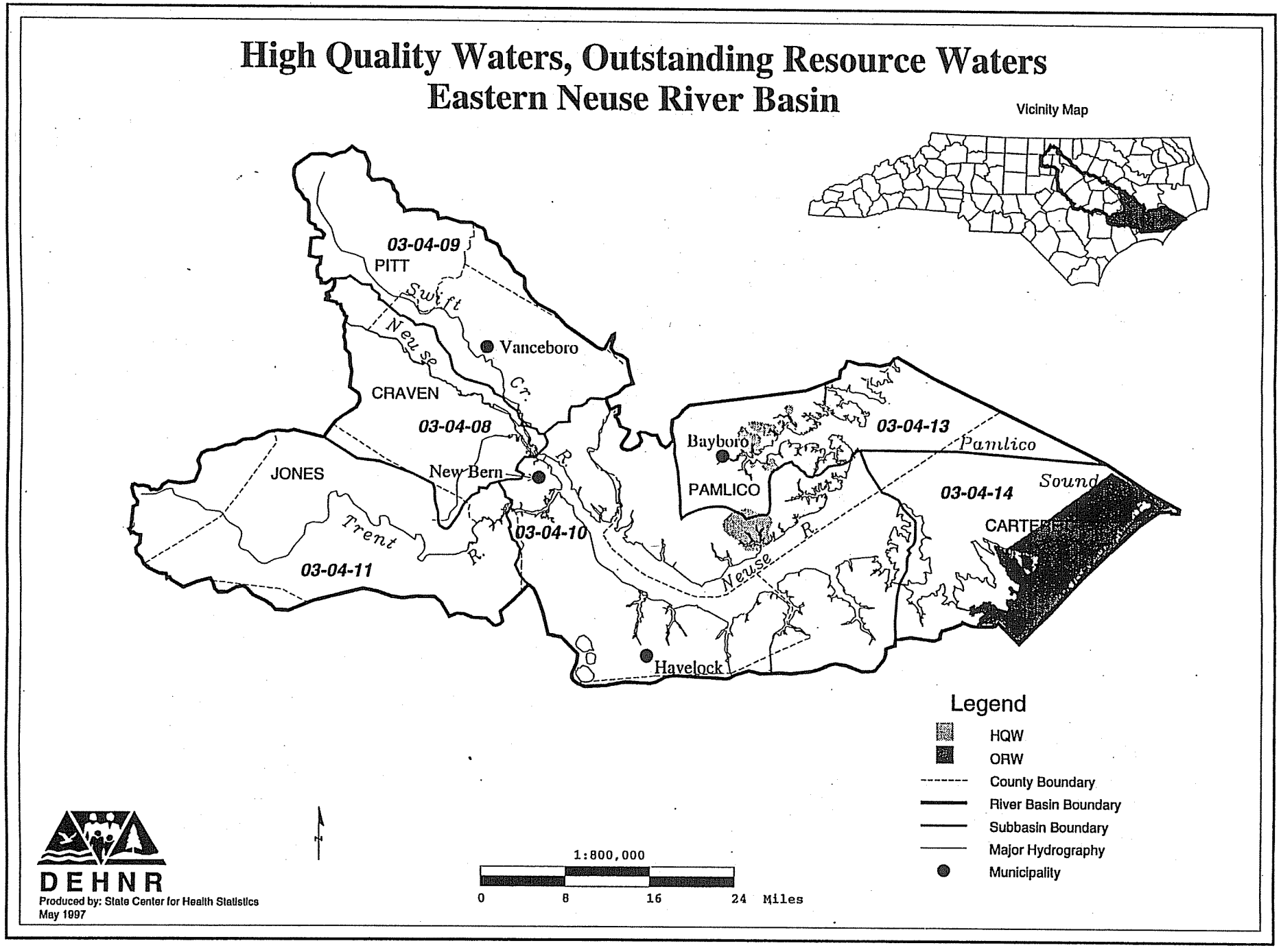


Figure 2.10 High Quality and Outstanding Resource Waters in the Eastern Neuse River Basin

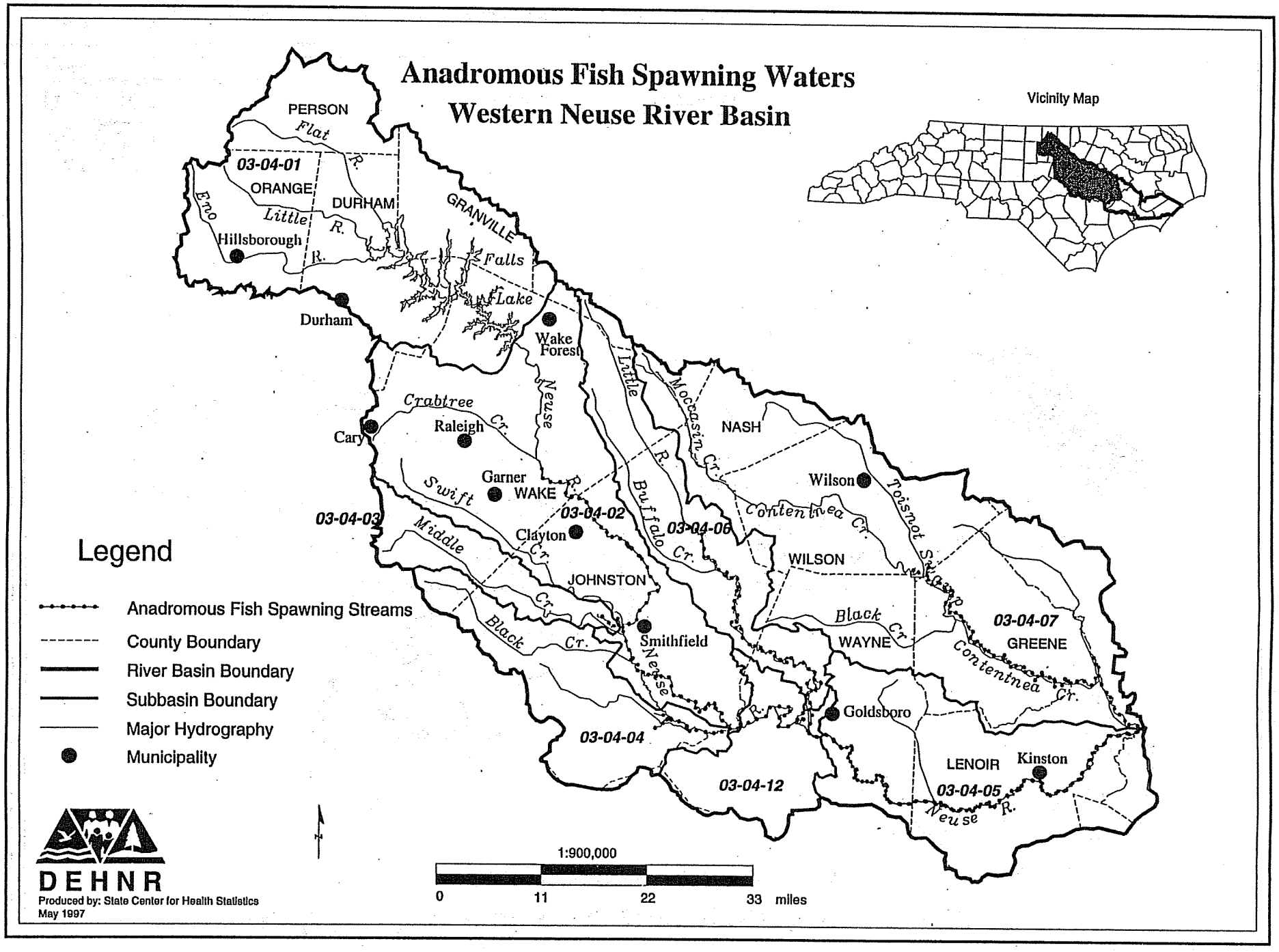


Figure 2.11 Anadromous Fish Spawning in the Western Neuse River Basin

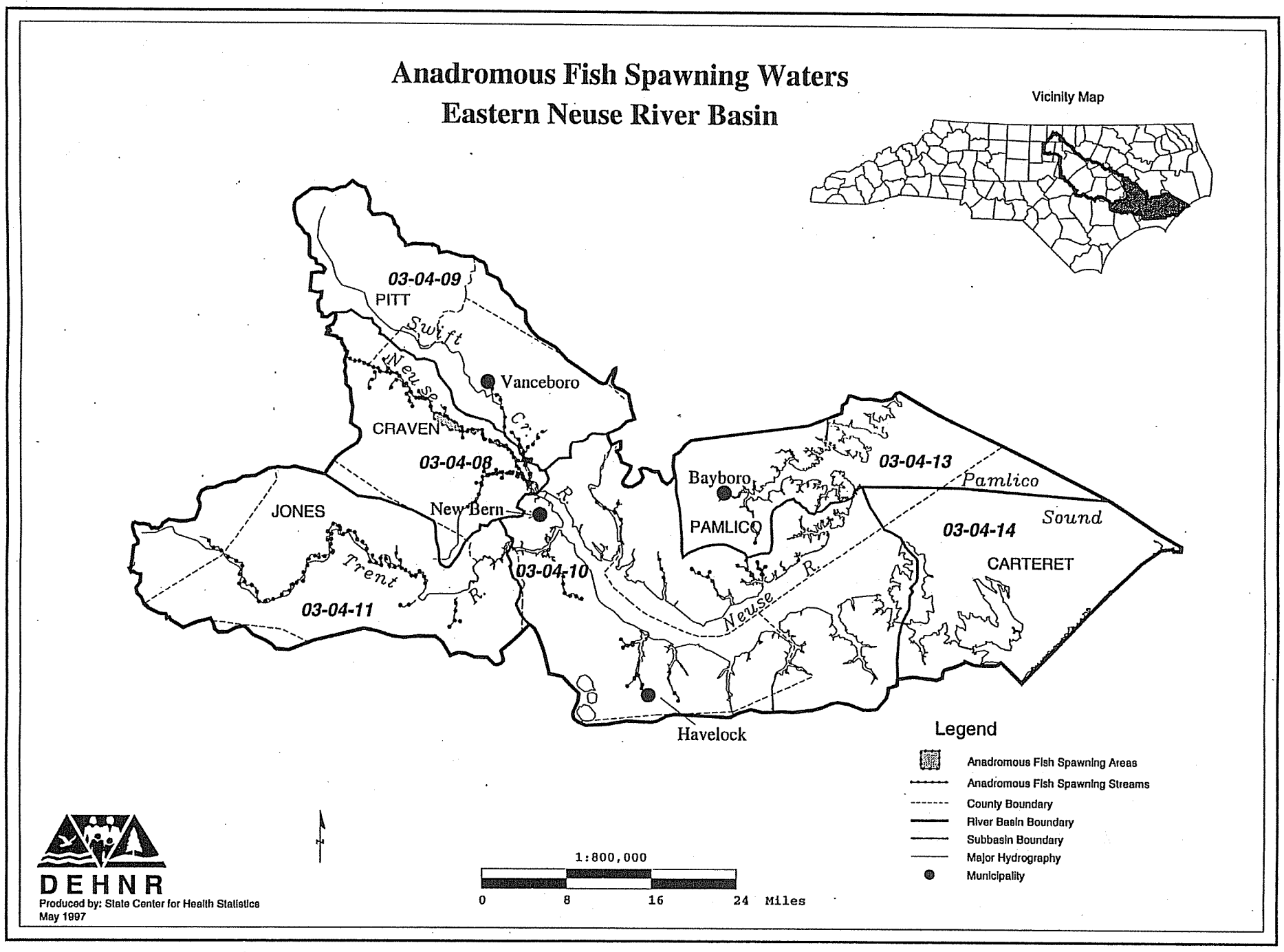


Figure 2.12 Anadromous Fish Spawning in the Eastern Neuse River Basin

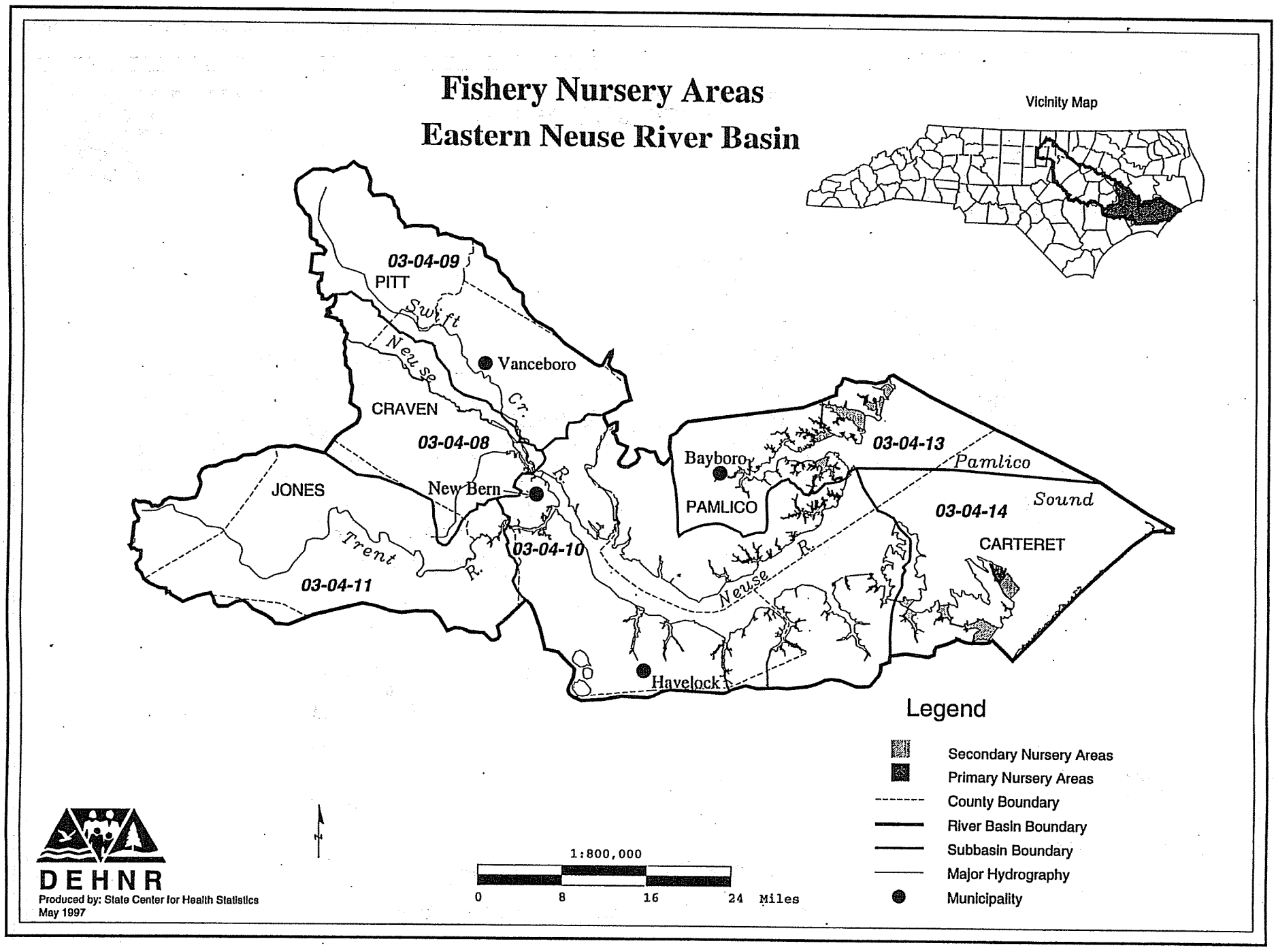


Figure 2.13 Fishery Nursery Areas in the Eastern Neuse River Basin

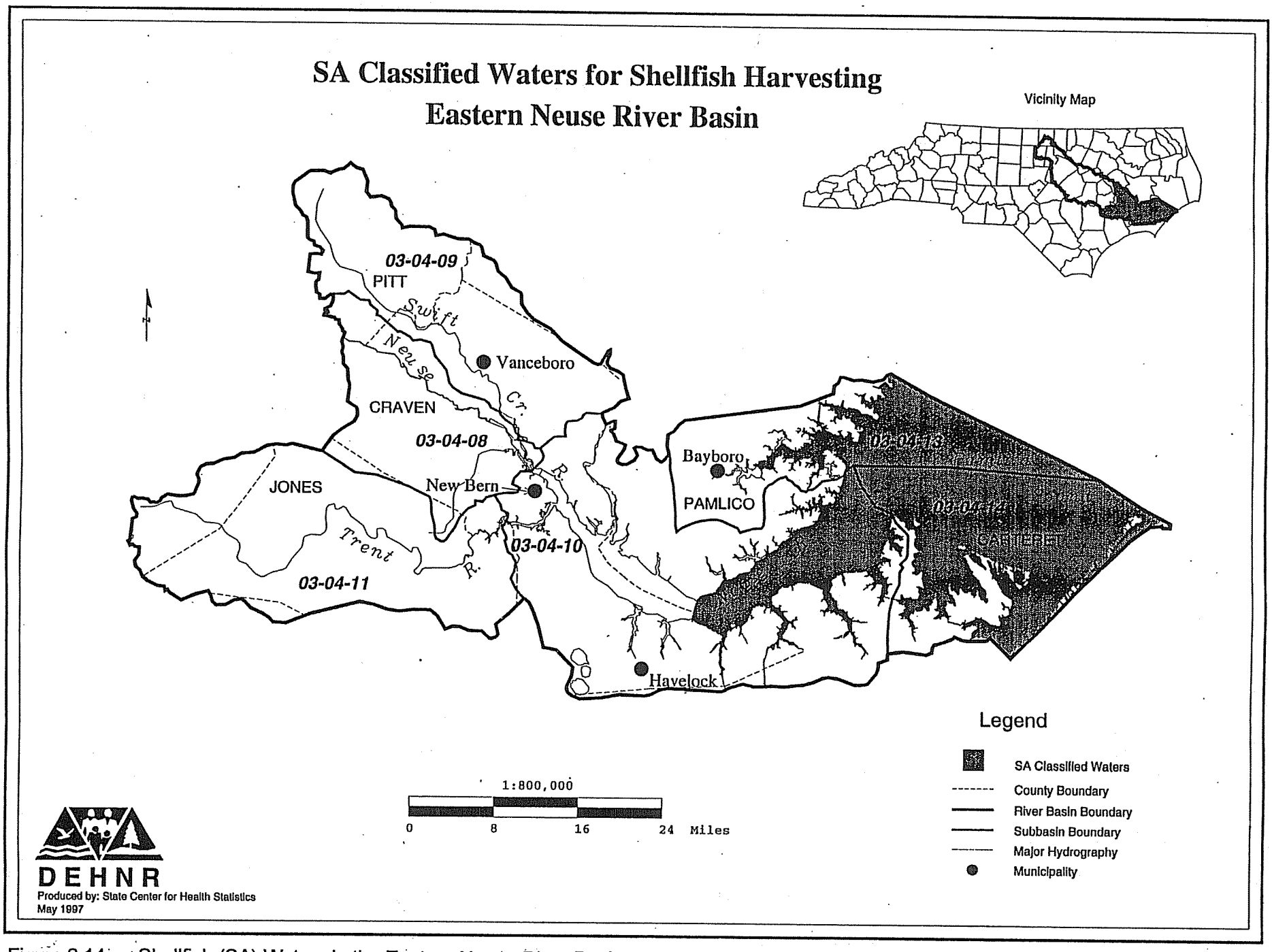


Figure 2.14 Shellfish (SA) Waters in the Eastern Neuse River Basin

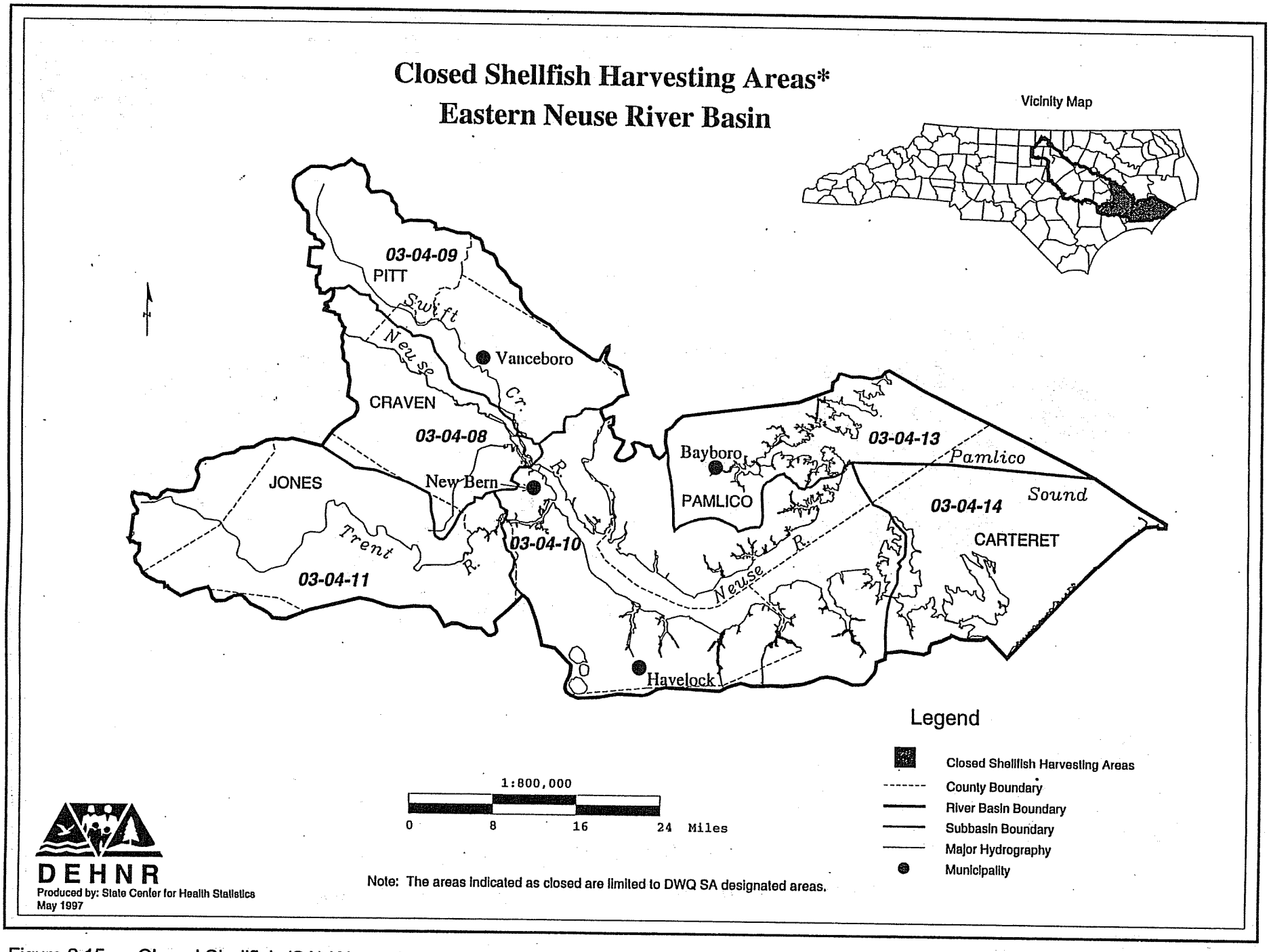


Figure 2.15 Closed Shellfish (SA) Waters in the Eastern Neuse River Basin

2-F. Animal Operations

In 1992, the Environmental Management Commission adopted a rule modification (15A NCAC 2H.0217) to establish procedures for managing and reusing animal wastes from intensive livestock operations. The rule applies to new, expanding or existing feedlots with animal waste management systems designed to serve animal populations of at least the following size: 100 head of cattle, 75 horses, 250 swine, 1,000 sheep or 30,000 birds (chickens and turkeys) with a liquid waste system. The deadline for submittal of registrations to DWQ for existing facilities was December 31, 1993.

Senate Bill 1217, ratified in 1996 by the General Assembly, required any operator of an animal operation with a dry litter animal waste management system involving 30,000 or more birds to develop an animal waste management plan by January 1998. The plan must consist of three specific items: 1) periodic testing of soils where waste is applied; 2) development of waste utilization plans; and 3) completion and maintenance of records on-site for three years.

The NC Department of Agriculture, Veterinary Division provided information on animal capacity by subbasin (Table 2.7). According to these data, the swine population in the Neuse Basin increased by almost 260 percent from 555,344 in 1990 to 1,986,524 in 1998.

Table 2.7a summarizes the number of registered animal operations and total animal population for that portion of each county in the Neuse Basin based on registration information submitted to the Division of Water Quality through July 1998. Figures 2.16 and 2.17 show the general location of these registered operations in the upper and lower portions of the basin, respectively. The location information is obtained from a variety of sources, so the location of individual operations may not be specific to a county. These data reflect only those operations required to be registered and therefore do not represent the total number of animals in each county. Also, information is not available on about ten percent of the registered operations in the basin at the time the data were provided.

Table 2.7 Total Swine, Dairy and Poultry Capacity at Animal Operations in the Neuse Basin for Years Between 1990 and 1998 (NC Department of Agriculture)

	Total Swine Capacity				Total Dairy Capacity		Total Poultry Capacity	
Subbasin	1998	1996	1994	1990	1998	1993	1998	1994
01	13,249	13,699	14,960	6,216	2,705	3,469	405,575	289,675
02	24,297	32,711	19,905	17,010	706	706	429,439	279,064
03	4,550	4,493	5,893	4,719	0	377	138,032	138,000
04	175,037	152,578	91,124	50,116	0	0	985,640	747,260
05	595,186	499,222	339,331	104,495	818	1,044	5,473,510	5,551,352
06	38,415	46,136	17,709	14,822	214	214	478,607	449,264
07	634,346	548,398	354,066	222,106	220	422	4,466,000	3,517,050
08	54,619	55,656	44,431	27,724	0	150	471,000	480,000
09	101,145	104,578	105,696	34,269	0	0	130,300	130,300
10	17,152	17,166	17,565	4,783	0	0	32,000	32,000
11	328,528	270,761	184,822	69,084	0	0	546,549	472,000
Totals	1,986,524	1,745,398	1,195,502	555,344	4,663	6,382	13,556,652	12,085,965

Notes: Subbasin 05 includes totals for Subbasin 05 and 12. Subbasin 10 includes totals for Subbasins 10, 13 and 14.

Table 2.7a Registered Animal Operations and Animal Population by County in the Neuse River Basin through July 1998 (NC Division of Water Quality)

TYPE OF OPERATION	COUNTIES																	
	BEAU	CRAV	DUPL	DURH	FRAN	GRAN	GREE	JOHN	JONE	LENO	NASH	ORAN	PERS	PITT	SAMP	WAKE	WAYN	TOTALS
CATTLE																		
Operations	0	0	0	2	1	1	0	0	0	0	0	6	1	0	0	1	1	13
Animals	0	0	0	520	1,600	250	0	0	0	0	0	890	120	0	0	267	160	3,807
POULTRY																		
Operations	0	0	0	0	1	0	0	0	3	0	0	2	0	0	0	0	1	7
Animals	0	0	0	0	50,000	0	0	0	12,400	0	0	120,000	0	0	0	0	70,000	252,400
SHEEP																		
Operations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Animals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWINE																		
Operations	1	1	5	0	1	1	98	54	41	69	15	3	7	32	9	4	126	467
Animals	400	3,200	24,560	0	5,760	1,256	348,154	149,203	204,876	231,759	8,205	4,860	2,259	95,277	30,255	1,913	440,846	1,552,783
TOTALS																		
Operations	1	1	5	2	3	2	98	54	44	69	15	11	8	32	9	5	128	487
Animals	400	3,200	24,560	520	57,360	1,506	348,154	149,203	217,276	231,759	8,205	125,750	2,379	95,277	30,255	2,180	511,006	1,808,990

Source: NC Division of Water Quality (July 1998)

Note: These data represent the number of operations and animals located in the *Neuse Basin portion* of each county.

Operations = Total number of operations (registered)

Animals = number of animals based on the design capacity of the operations

"Poultry" includes chicken and turkeys

"Cattle" includes both dairy and non-dairy.

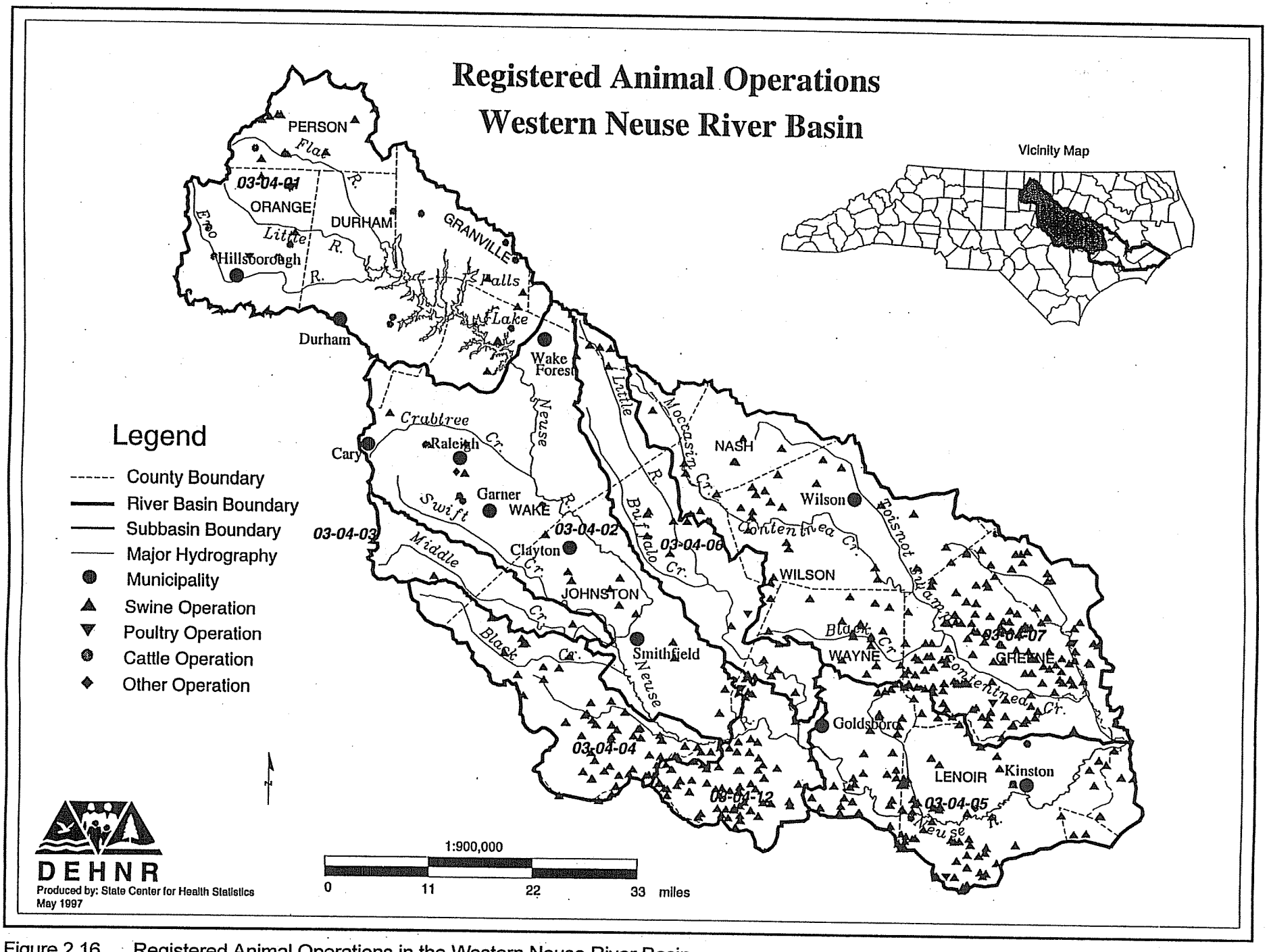


Figure 2.16 Registered Animal Operations in the Western Neuse River Basin

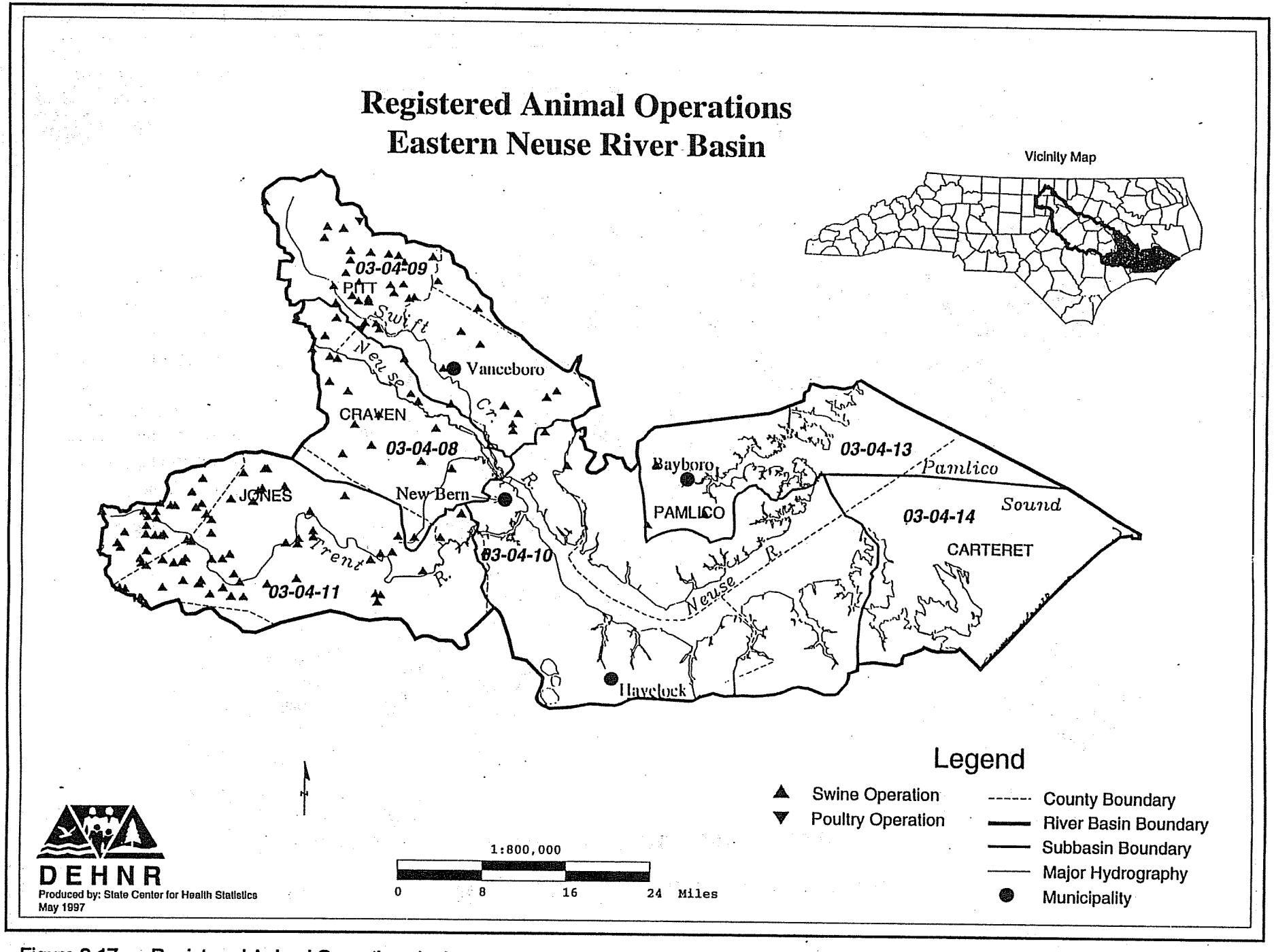


Figure 2.17 Registered Animal Operations in the Eastern Neuse River Basin

2-G. Permitted Wastewater and Stormwater Discharge Facilities

These facilities are commonly referred to as point sources. Point sources refers to a discharge that enter surface waters through a pipe, ditch or other well-defined point of discharge. The term applies to wastewater and stormwater discharges from a variety of sources. Wastewater point source discharges include municipal (city and county) and industrial wastewater treatment plants and small domestic wastewater treatment systems that may serve schools, commercial offices, residential subdivisions and individual homes. Stormwater point source discharges include stormwater collection systems for municipalities which serve populations greater than 100,000 and stormwater discharges associated with certain industrial activities as defined in the Code of Federal Regulations [40 CFR 122.26(a)(14)]. The primary pollutants associated with point source discharges are oxygen-demanding wastes, nutrients, sediment, color and toxic substances including chlorine, ammonia and metals.

Point source dischargers in North Carolina must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the state. Discharge permits are issued under the NPDES program which is delegated to North Carolina by the EPA.

There are 450 permitted NPDES wastewater discharges in the Neuse River basin. There are 186 individual permits and 264 discharges covered under general permits. Table 2.8 lists the wastewater discharges in the Neuse River basin along with a summary of general information. The locations of these permitted facilities are shown in Figures 2.18 and 2.19.

Table 2.8 Summary of NDPES Discharges by Categories and Subbasins

	SUBBASIN												
FACILITY CATEGORIES	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**TOTAL**
Total Facilities	**208**	**103**	**18**	**5**	**21**	**8**	**34**	**4**	**6**	**38**	**3**	**2**	**450**
NC00 Facilities	23	64	17	3	14	6	23	3	3	27	2	1	186
NCG Facilities	185	39	1	2	7	2	11	1	3	11	1	1	264
Total Permitted Flow (MGD)	27.03	78.65	14.50	1.50	26.18	1.32	21.47	32.44	0.25	11.49	0.40	1.40	216.63
*Major Discharges	3	6	3	1	4	0	4	1	0	4	0	1	27
Total Permitted Flow (MGD)	26.50	74.70	14.20	1.50	24.95	0.00	20.20	32.00	0.00	9.80	0.00	1.40	205.25
*Minor Discharges	20	58	14	2	10	6	19	2	3	23	2	0	159
Total Permitted Flow (MGD)	0.53	3.95	0.30	0.00	1.23	1.32	1.27	0.44	0.25	1.69	0.40	0.00	11.38
100% Domestic Wastewater	14	30	9	0	3	4	11	1	0	11	2	0	85
Total Permitted Flow (MGD)	23.76	7.82	12.67	0.00	0.05	0.79	0.92	0.02	0.00	3.19	0.40	0.00	49.61
Municipal Facilities	3	7	3	1	6	2	10	0	1	7	1	0	41
Total Permitted Flow (MGD)	26.50	71.55	14.20	1.50	22.54	0.80	21.14	0.00	0.25	6.65	0.07	0.00	165.20
Major Process Industrial	0	2	0	0	1	0	0	1	0	1	0	1	6
Total Permitted Flow (MGD)	0.00	5.05	0.00	0.00	3.60	0.00	0.00	32.00	0.00	0.10	0.00	1.40	42.15
Minor Process Industrial	1	2	1	0	2	0	2	0	1	5	0	0	14
Total Permitted Flow (MGD)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02
Nonprocess Industrial	3	22	3	0	3	1	1	1	0	1	0	0	35
Total Permitted Flow (MGD)	0.12	0.13	0.03	0.00	0.03	0.01	0.01	0.43	0.00	0.00	0.00	0.00	0.76
* NC00 / Individual permit facilities													

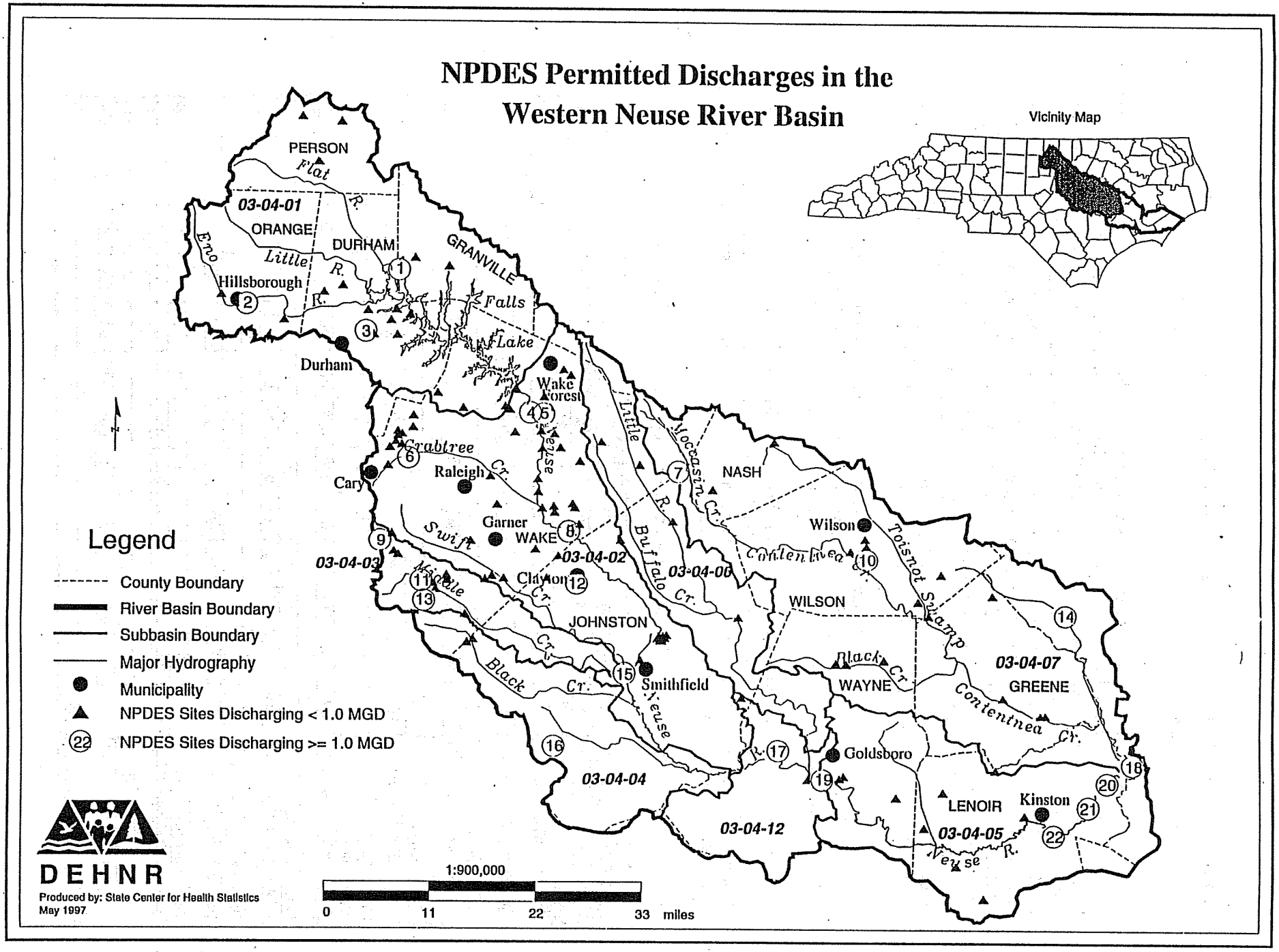


Figure 2.18 NPDES Permitted Discharges in the Western Neuse River Basin

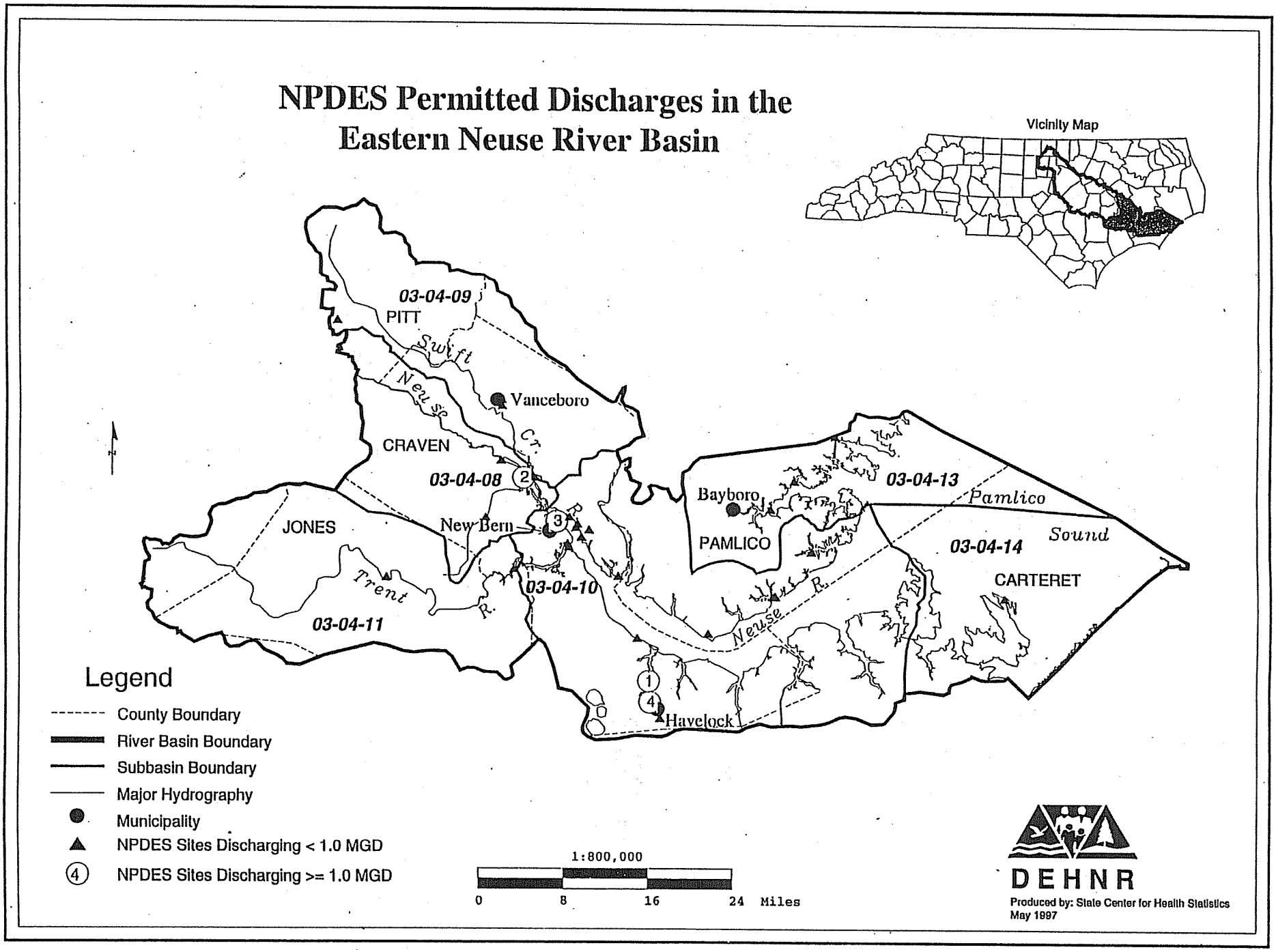


Figure 2.19 NPDES Permitted Discharges in the Eastern Neuse River Basin

Table 2.9 Major NPDES Dischargers in the Neuse River Basin

Map No.	Permit No.	Facility	Design Flow MGD	Stream
1	NC0026824	DHR - John Umstead Hospital WWTP	3.5	Knap of Reeds Creek
2	NC0026433	Town of Hillsborough WWTP	3.0	Eno River
3	NC0023841	Durham North Water Reclamation Facility	20.0	Ellerbe Creek
4	NC0001376	Burlington Industries - Wake Plant	5.0	Neuse River
5	NC0030759	Town of Wake Forest - Smith Creek WWTP	6.0	Neuse River
6	NC0048879	Town of Cary-North WWTP	12.0	Crabtree Creek
7	NC0079316	Town of Zebulon - Little Creek WWTP	1.85	UT Mocassin Creek
8	NC0029033	City of Raleigh - Neuse River WWTP	60.0	Neuse River
9	NC0064050	Town of Apex - Middle Creek WWTP	3.6	UT Middle Creek
10	NC0023906	Town of Wilson WWTP	12.0	Contentnea Creek
11	NC0065102	Town of Cary-South WWTP	16	Middle Creek
12	NC0025453	Town of Clayton WWTP	1.9	Little Creek
13	NC0066516	Town of Fuquay Varina WWTP (Proposed)	6.0	Terrible Creek
14	NC0029572	Town of Farmville WWTP	3.5	Little Contentnea Creek
15	NC0030716	Central Johnston County WWTP	4.99	Neuse River
16	NC0020389	Town of Benson WWTP	1.5	Hannah Creek
17	NC0003417	CP&L - Lee S.E. Power Plant	1.4	Neuse River
18	NC0032077	Contentnea Sewerage District WWTP	2.85	Contentnea Creek
19	NC0023949	City of Goldsboro WWTP	10.1	Neuse River
20	NC0003760	E.I. Dupont - Kinston/NC HWY 11 Plant	3.6	Neuse River
21	NC0024236	City of Kinston-Northside WWTP	4.5	Neuse River
22	NC0020541	City of Kinston-Peachtree WWTP	6.75	Neuse River
Discharges in eastern portion of basin				
1	NC0003816	US MCAS Cherry Point	3.5	Slocum Creek
2	NC0003191	Weyerhaeuser - New Bern Plant	32.0	Neuse River
3	NC0025348	City of New Bern WWTP	4.7	Neuse River
4	NC0021253	City of Havelock WWTP	1.9	East Prong Slocum Creek

Note: Map No. refers to facility location numbers shown on Figures 2.19 and 2.20

Stormwater Point Source Discharges in the Neuse River Basin

Excluding construction general permits, there are 399 general stormwater permits issued within the river basin. Activities covered under general stormwater permits include: construction; mining/borrow pits; metal waste recycling and manufacture of metal products and equipment; manufacture of timber products; apparel, printing, paper, leather and rubber products manufacturing; food, tobacco, cleaning preparations, perfumes, cosmetics, drug manufacturing and public warehouse storage; manufacture of stone, clay, glass and concrete products; vehicle maintenance, transportation, postal service activities, public warehousing, petroleum bulk stations and terminals; manufacture of paints, varnishes, lacquers, enamels and allied products; used automobile parts and scrap yards; wastewater treatment works; landfills; nonmetal waste scrap and recycling; ready mixed concrete production; manufacture of asphalt paving mixtures and blocks; production of textile mill products; furniture and fixture manufacturing; ship and boat building and repairing and marinas. There are 17 individual stormwater permits issued in the basin. A list of general information on these stormwater dischargers in the Neuse River basin is provided in Table 2.10.

The primary source of concern from industrial facilities is the contamination of stormwater from contact with exposed materials. In addition, poor housekeeping can lead to significant contributions of sediment and other pollutants which have a detrimental effect on the water quality in receiving streams.

Table 2.10 Summary of Individual NPDES Stormwater Permits in the Neuse River Basin

Permit No.	Facility Name	Receiving Stream	County
NCS000043	Loxco	UT Mill Creek	Wayne
NCS000136	Mallinckrodt	Neuse River	Wake
NCS000175	AET Corp.	UT Little Ledge Creek	Granville
NCS000191	E. Carolina Metal Treating, Inc.	Rocky Branch	Wake
NCS000211	Weyerhauser Co.	Neuse River	Craven
NCS000223	EnviroChem	Middle Creek	Wake
NCS000226	Zema Corp.	Richland Creek	Wake
NCS000254	Square D Co.	Marks Creek	Wake
NCS000268	Athol Co.	UT Picture Creek	Granville
NCS000282	Cargill, Inc.	UT Rocky Branch & Walnut Cr.	Wake
NCS000286	NC State University	Rocky Branch	Wake
NCS000294	Southern States Cooperative	UT Robertson Creek	Granville
NCS000298	Cargill, Inc.	Hominy Swamp	Wilson
NCS000299	Cargill, Inc.	Hominy Swamp	Wilson
NCS000303	Waukesha Electric Systems	Neuse River	Wayne
NCS000338	Vigoro Industries, Inc.	UT Hominy Swamp	Wilson
NCS000341	Perstorp Flooring, Inc.	White Oak Creek	Wake
NCS000245	City of Raleigh	Neuse River & Others	Wake
NCS000249	City of Durham	Neuse River & Others	Durham

There are currently two municipalities in the Neuse River basin that are covered by a NPDES stormwater permit, the City of Raleigh and the City of Durham. Only the northern part of Durham drains to the Neuse River basin. The rest of the city drains to the Cape Fear River basin. Both cities have comprehensive stormwater management programs in place. These programs consist of a variety of components, including illicit connection identification, public education, analytical monitoring and stormwater discharge characterization. Both of these permits are scheduled for renewal in July 1999.

The proposed Neuse River Nutrient Sensitive Waters Management Strategy Rules will become effective on August 1, 1998 pending approval by the Rules Review Commission and the North Carolina General Assembly. Rule .0235 for urban stormwater management will require 10 cities and 5 counties to develop and implement a stormwater management program for controlling nutrient loading to the river. The affected local governments are Cary, Durham, Garner, Goldsboro, Havelock, Kinston, New Bern, Raleigh, Smithfield, Wilson, Durham County, Johnston County, Orange County, Wake County and Wayne County. In the case of Durham and Raleigh, their existing NPDES permit will be modified to include nutrient management requirements. The affected municipalities will have to develop a nutrient management plan based upon a model that DWQ will provide within 12 months of the final rule. The local governments will then have 12 months to tailor the DWQ model to their needs and must implement the plan within 18 months of availability of the DWQ model. The plan will include controlling nutrient export from new development, protecting riparian buffers, implementing educational programs, identification and removal of illegal discharges, and the identification of suitable locations for stormwater treatment retrofits.

2-H. Septic Systems

Septic tank soil absorption systems are a widely-used method of domestic wastewater disposal in North Carolina. These systems can provide safe and adequate treatment of wastewater;

however, improperly placed, constructed or maintained septic systems can serve as a significant source of pathogenic bacteria and nutrients. These pollutants may enter surface waters both through or over the soil. They may also be discharged directly to surface waters through *straight pipes* (i.e., direct pipe connections between the septic system and surface waters). These types of discharges, if unable to be eliminated, must be permitted under the NPDES program and be capable of meeting effluent limitations specified to protect the receiving stream water quality which includes a requirement for disinfection. A number of these permitted discharging systems are located in Durham County and may be a source of water quality impairment in the Little Lick Creek and Ellerbe Creek watersheds.

On-site wastewater disposal is most prevalent in rural portions of the basin and at the fringes of urban areas. Nutrients from failing septic systems can also contribute to eutrophication problems in some impoundments and coastal waters.

The On-Site Wastewater Section of the NC Division of Environmental Health has recently completed a study to determine the numbers and distribution of households in the Neuse River Basin that are served by septic systems. The information is based on census data reports that pull together information by county and census block groups.

The On-Site group has summarized the information by county and results are displayed below in Figure 2.20. Overall, 58.3 percent of households in the basin are served by sewer systems, 40.2 percent are served by septic systems, and 1.5 percent are served by other means (e.g., straight pipes, outhouses, etc.). Further information may be obtained by contacting the Non-Point Source Pollution Program Coordinator in the On-Site Wastewater Section.

2-I. Water Supplies

Table 2.11 summarizes existing and projected water use data compiled by the NC Division of Water Resources from preliminary public water supply plans prepared by local governments and public water authorities. These data project that water use will more than double from 136.2 million gallons per day in 1992 to 287 million gallons per day by 2020. In 1992, 43 percent of water use was residential, 34 percent was non-residential, 11 percent was bulk use and 9 percent was unaccounted for. According to a 1995 USGS report, 73.2 percent of residential water used in the Neuse River basin came from surface waters and 26.8 was from groundwater.

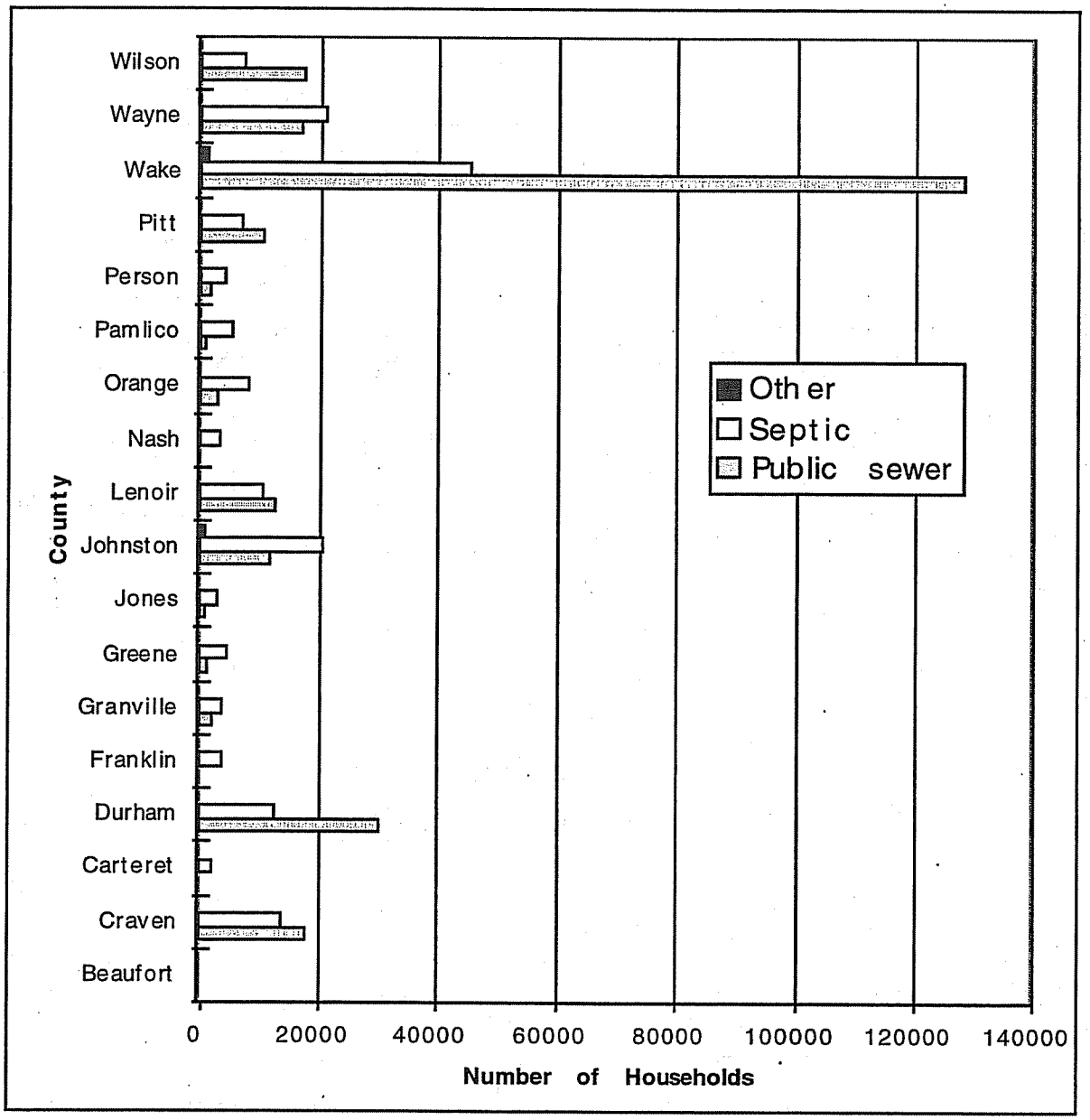


Figure 2.20 Comparison by County of Households in the Neuse River Basin Served by Septic Tanks, Public Treatment Systems and Others

Table 2.11 Preliminary Water Use and Population Served Information for Local Governments in the Neuse River Basin (2 pages)

System	County	Plan Completed	Population Served				1992 Water Use in MGD by Type					Future Water Use, MGD		
			1992	2000	2010	2020	AveDay	Res.	Non-Res.	Bulk Sales	Unacc-For	2000	2010	2020
MERRIMON COMM	CARTERET	Yes	71	75	80	85	0.006	0.006	0	0	0	0.007	0.007	0.008
COVE CITY	CRAVEN	Yes	595	649	717	777	0.041	0.033	0.004	0	0.004	0.045	0.049	0.053
CRAVEN CO	CRAVEN	Yes	17696	22617	24879	26869	1.799	1.249	0.514	0	0.036	2.159	2.649	3.72
DOVER	CRAVEN	No	451	440	429	419	0.021	0.019	0	0	0.002	0.02	0.02	0.019
FIRST CRAVEN SD	CRAVEN	Yes	3036	5784	6090	6595	0.294	0.21	0.029	0	0.054	0.406	0.41	0.45
HAVELOCK	CRAVEN	Yes	10260	12860	14620	18715	1.158	0.985	0.168	0	0.005	1.452	1.651	2.113
NEW BERN	CRAVEN	Yes	20950	23700	28440	34130	3.43	1.85	1.58	0	0	3.9	4.6	5.6
VANCEBORO	CRAVEN	Yes	959	1059	1159	1209	0.127	0.05	0.05	0	0.027	0.168	0.176	0.184
DURHAM	DURHAM	Yes	140000	195000	238000	279000	23.32	10.8	8.4	0	4.1	30.1	36	41.9
FRANKLIN WSA	FRANKLIN	Yes	20	2800	3500	4000	0.32	0	0.288	0.035	0	2	2.3	3
YOUNGSVILLE	FRANKLIN	Yes	500	600	650	700	0.049	0.027	0.004	0	0.018	0.059	0.064	0.069
COZART SD	GRANVILLE	Yes	612	1056	1100	1200	0.024	0.024	0	0	0	0.041	0.042	0.046
CREEDMOOR	GRANVILLE	Yes	1752	1900	2100	2300	0.199	0.111	0.083	0.001	0.003	0.222	0.254	0.29
JOHN UMSTEAD HOSPITAL	GRANVILLE	Yes	7500	11900	14160	16000	1.863	0.722	0.897	0.137	0.107	3.2	3.9	4.6
LYON STATION SD	GRANVILLE	No	170	200	220	240	0.12	0.01	0.11	0	0	0.107	0.121	0.136
GREENE CO RWS	GREENE	Yes	6127	6435	6760	7100	0.68	0.492	0.078	0.043	0.079	1.052	1.383	1.906
HOOKERTON	GREENE	Yes	558	575	585	595	0.048	0.035	0.004	0.001	0.009	0.048	0.049	0.05
SNOW HILL	GREENE	Yes	2000	2100	2202	2310	0.573	0.15	0.149	0.222	0.054	0.888	1.166	1.607
SOUTH GREENE	GREENE	Yes	2316	2432	2554	2682	0.222	0.192	0.021	0	0	0.231	0.247	0.258
WALSTONBURG	GREENE	Yes	240	240	240	240	0.033	0.03	0.002	0	0	0.032	0.032	0.032
BENSON	JOHNSTON	Yes	2880	3300	3910	4630	0.98	0.3	0.61	0	0.07	1.137	1.245	1.363
CLAYTON	JOHNSTON	Yes	4930	5980	7570	9580	0.863	0.648	0	0	0.215	1.118	1.454	1.861
FOUR OAKS	JOHNSTON	Yes	2390	2740	3250	3840	0.162	0.111	0.035	0	0.016	0.187	0.223	0.265
JOHNSTON CO	JOHNSTON	Yes	21784	21770	25500	30670	1.825	0.032	0.018	1.775	0	3.377	4.131	4.982
KENLY	JOHNSTON	Yes	1780	1920	2100	2300	0.237	0.066	0.148	0	0.023	0.256	0.281	0.309
MICRO	JOHNSTON	Yes	600	646	708	776	0.042	0.026	0.011	0	0.005	0.045	0.049	0.054
PINE LEVEL	JOHNSTON	Yes	1430	1540	1690	1850	0.115	0.095	0.013	0	0.007	0.124	0.136	0.149
PRINCETON	JOHNSTON	Yes	1190	1280	1400	1530	0.128	0.079	0.012	0	0.036	0.138	0.152	0.166
SELMA	JOHNSTON	Yes	4330	4410	5220	6180	0.793	0.371	0.355	0	0.067	0.897	1.077	1.282
SMITHFIELD	JOHNSTON	Yes	8906	12050	12850	13650	3.287	1.501	0.032	1.754	0	2.069	2.211	2.355
WHITLEY HEIGHTS	JOHNSTON	Yes	180	220	220	220	0.011	0.011	0	0	0	0.013	0.013	0.013
JONES CO	JONES	Yes	6791	6619	6487	6356	0.521	0.481	0	0	0.04	0.518	0.502	0.492
POLLOCKSVILLE	JONES	Yes	700	700	700	700	0.061	0.045	0.01	0.006	0	0.061	0.061	0.061
DEEP RUN	LENOIR	Yes	9231	9765	9971	10180	0.867	0.732	0.025	0	0.11	0.913	0.935	0.959
KINSTON	LENOIR	Yes	24282	26249	28627	33071	4.8	2.68	1.48	0	0.64	7.26	10.52	14.41
LA GRANGE	LENOIR	Yes	3505	3622	3742	3866	0.378	0.251	0.121	0	0.006	0.406	0.442	0.485
NORTH LENOIR WC	LENOIR	Yes	9370	15411	31261	50586	0.81	0.703	0.065	0	0.424	2.126	3.661	5.592
PINK HILL	LENOIR	Yes	699	728	762	795	0.1	0.088	0.011	0	0	0.105	0.112	0.119
BAILEY	NASH	Yes	553	864	949	1026	0.079	0.036	0.043	0	0	0.101	0.109	0.116
MIDDLESEX	NASH	Yes	732	985	1082	1170	0.074	0.046	0.026	0	0.002	0.099	0.108	0.116
HILLSBOROUGH	ORANGE	Yes	10090	12200	14800	21907	1.46	0.536	0.723	0.003	0.198	1.81	2.15	2.61
ORANGE-ALAMANCE WS	ORANGE/ALAM	Yes	11000	13800	17300	20800	0.722	0.433	0.166	0.002	0.121	0.91	1.201	1.599
ORIENTAL	PAMLICO	Yes	864	913	964	1020	0.098	0.07	0.016	0	0.012	0.104	0.11	0.117
PAMLICO CO	PAMLICO	Yes	11272	11790	12446	12865	0.758	0.562	0.067	0.002	0.127	0.762	0.848	0.92
ROXBORO	PERSON	Yes	11257	14397	17900	20560	4.101	0.528	3.197	0	0.376	6.27	8.27	10.84
AYDEN	PITT	Yes	5457	6644	7650	8637	0.549	0.342	0.178	0	0.029	0.705	0.922	1.233
FARMVILLE	PITT	Yes	6443	9292	10700	12081	1.712	0.595	1.026	0.51	0.04	2.471	3.563	5.25

Table 2.11 Preliminary Water Use and Population Served Information for Local Governments in the Neuse River Basin (2 pages)

System	County	Plan Completed	Population Served				1992 Water Use In MGD by Type					Future Water Use, MGD		
			1992	2000	2010	2020	AveDay	Res.	Non-Res.	Bulk Sales	Unacc-For	2000	2010	2020
FOUNTAIN	PITT	Yes	435	627	722	815	0.051	0.037	0.01	0	0.004	0.058	0.065	0.07
GREENVILLE	PITT	Yes	57000	65300	75200	84900	8.71	3.14	4.7	0	0.87	10.41	12.42	14.93
WINTERVILLE	PITT	Yes	3598	4611	5569	6381	0.32	0.246	0.071	0	0.003	0.397	0.473	0.541
GRIFTON	PITT/LENOIR	Yes	2417	3015	3374	3722	0.213	0.154	0.02	0	0.039	0.265	0.297	0.327
APEX	WAKE	Yes	5200	10897	21954	45334	0.716	0	0	0.024	0.02	1.56	3.13	6.48
CARY	WAKE	Yes	52403	77700	107735	139359	6.015	0	0	1.333	0.035	7.3	10.8	16.7
FUQUAY VARINA	WAKE	Yes	4300	9153	14133	19319	0.542	0.38	0.112	0	0.05	1.32	2.22	3.09
GARNER	WAKE	Yes	17000	21000	26100	31500	1.904	1.17	0.334	0.25	0.15	2.3	2.9	3.6
HOLLY SPRINGS	WAKE	No	1784	5500	6500	7500	0.145	0.108	0.108	0	0.022	0.495	0.585	0.675
KNIGHTDALE-1	WAKE	Yes	2126	4470	7306	10834	0.512	0.261	0.139	0.19	0	1.066	1.784	2.503
KNIGHTDALE-2	WAKE	Yes	420	420	420	420	0.074	0	0	0	0	0.074	0.074	0.074
MORRISVILLE	WAKE	Yes	1751	4500	6000	7500	0.314	0.094	0.223	0	0	0.863	1.151	1.439
RALEIGH	WAKE	Yes	233500	316700	421300	513700	37.97	16.21	12.34	8.39	1.03	42.68	56.2	68.5
ROLESVILLE	WAKE	Yes	700	1043	1280	1521	0.054	0.046	0	0	0.008	0.075	0.092	0.11
WAKE FOREST	WAKE	Yes	6309	10221	16536	23678	0.84	0.452	0.133	0.039	0.217	1.52	2.32	3.18
WENDELL	WAKE	Yes	3518	4210	4985	5902	0.328	0.233	0.084	0	0.011	0.393	0.465	0.551
ZEBULON	WAKE	No	3648	4827	6580	8300	0.738	0.205	0.395	0.075	0.063	1.4	1.7	1.8
FORK TOWNSHIP SD	WAYNE	Yes	7500	8500	9000	9500	0.774	0.512	0.082	0.175	0.005	1.2	1.4	1.6
FREMONT	WAYNE	Yes	1720	2214	2286	2328	0.18	0.142	0	0.008	0.03	0.34	0.35	0.36
GOLDSBORO	WAYNE	Yes	44056	49096	56898	65561	5.575	1.822	2.573	0	1.179	6.8	9.1	12.7
MOUNT OLIVE	WAYNE	Yes	6127	6433	6755	7092	1.099	0.093	0.542	0.058	0.406	0.885	0.914	0.945
PIKEVILLE	WAYNE	Yes	950	1008	1041	1060	0.075	0.063	0.005	0	0.007	0.08	0.084	0.086
SOUTHERN WAYNE SD	WAYNE	Yes	6331	8671	9338	9360	0.331	0.328	0	0	0.003	0.569	0.613	0.615
WALNUT CREEK	WAYNE	Yes	643	844	1211	1586	0.105	0.102	0.003	0	0	0.138	0.197	0.257
WAYNE WD	WAYNE	Yes	18596	29970	30933	31726	1.26	1.01	0	0	0.25	2.68	2.76	2.81
WEST MOUNT OLIVE	WAYNE	Yes	856	908	937	954	0.058	0.056	0	0	0.002	0.062	0.064	0.065
BLACK CREEK	WILSON	Yes	1320	1370	1393	1398	0.16	0.09	0.01	0	0.06	0.166	0.169	0.17
LUCAMA	WILSON	Yes	957	993	1010	1014	0.095	0.087	0.008	0	0	0.098	0.1	0.1
SARATOGA	WILSON	No Plan	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SIMS	WILSON	No	300	320	340	360	0.022	0.022	0	0	0	0.024	0.027	0.03
STANTONSBURG	WILSON	Yes	914	1047	1065	1069	0.095	0.087	0	0.001	0.007	0.108	0.109	0.11
WILSON	WILSON	Yes	40000	44000	53000	62000	7.44	2.7	3.24	0.1	1.4	10.7	14.8	18.8
Total			904,838	1,181,825	1,479,145	1,791,705	136.6	58.2	45.9	15.1	12.9	176.1	227.0	287.0
							100%	43%	34%	11%	9%			

Source: State water supply plan database, Division of Water Resources, DEHNR (not published)

The Division of Water Resources is preparing a State Water Supply Plan that contains information from water supply plans prepared by local governments as required by GS 143-355 (l) and (m).

Chapter 3:
Summary of Basinwide Water Quality Data

This chapter provides an overview of water quality and use support ratings in the Neuse River Basin including water quality comparisons between the 1993 and 1998 basinwide plans. It is divided into three major sections. Detailed water quality summaries by subbasin are presented in Chapters 1 through 14 of Section B of this plan.

Section 3-A. Water Quality Goals from 1993: How did we do? - This section summarizes efforts to restore and protect water quality using comparisons of water quality and use support ratings between the 1993 basinwide plan and this present draft plan. It also discusses progress in achieving a number of water quality protection goals presented in the 1993 plan.

Section 3-B. Water Quality Data Summary - Briefly describes the major DWQ water quality monitoring programs and summarizes the information for the basin (including after-effects of Hurricane Fran). The information is derived primarily from the Basinwide Assessment Report Support Document for the Neuse River Basin (DENR, 1996) prepared by DWQ's Environmental Assessment Branch.

Section 3-C. Use Support Ratings - Defines use support ratings and summarizes information in a series of tables, figures and a 3-page color use support map. Information is broken down by freshwater streams, lakes and saltwaters. A comparison with 1993 monitored use support data is presented.

One of the primary goals of the basin assessment program is to sample the same streams every five (or in this case, four) years to evaluate any changes in water quality, especially those resulting from implementation of management strategies. However, it must be kept in mind that the original Neuse River Basinwide Water Quality Management Plan was approved in February 1993, with NPDES discharge permit issuance for subbasins 01 and 02 in April/May 1993 and the remainder of the basin in 1994. Almost all of the biological water quality data presented in the chapter was collected in 1995. Therefore, a maximum of two years had elapsed between implementation of the management plan and the second environmental assessment of the basin.

3-A. Water Quality Goals from 1993: How Did We Do

Section 3-A.1 compares overall water quality in the basin between the 1993 basin plan and this current plan based on use support ratings (see Section 3-C). The following sections (3-A.2 through 3-A.5) provide follow-up information on programmatic water quality protection goals that were presented in the 1993 basinwide plan. Chapter 4 presents goals and recommended management strategies for the upcoming basinwide cycle.

3-A.1 Restoring and Protecting Water Quality

A comparison of use support data (see Section 3-C for more details) from this draft and the 1993 Neuse Basinwide Water Quality Management Plan provides some insights into water quality changes. It is important to keep in mind that these data are highly variable and not statistically valid. For example, the lakes and freshwater stream data may be based on single biological samples taken at five-year intervals. The estuarine ratings are generally based on monthly chemical samples or shellfish water closure information from the NC Division of Environmental Health's Shellfish Sanitation Branch. See Section 3-C.2 for further information on interpretation of use support data.

Use Support Definitions:

FS - Fully Supporting
ST - Fully Supporting but Threatened
PS - Partially Supporting
NS - Not supporting
Impaired - Waters rated NS and PS
Supporting - Waters rated FS and ST

For estuarine waters there was a very slight percentage increase (0.7 percent) in the acreage of impaired waters. The acreage of impaired estuarine waters increased by approximately 2,200 acres. It is of note that the acreage of impaired estuarine waters based on shellfish water closures (fecal coliform bacteria) decreased by 1700 acres while the acreage of impaired waters from algae blooms (based on chlorophyll *a* concentrations) increased by about 3,900 acres.

Estuarine Waters Use Support Comparisons between the 1993 and 1998 Plans (Acres)

	FS	ST	PS	NS	Total
1993	281610 (86%)	16,767 (5%)	30,323 (9%)	0 (0%)	328,700 (100%)
1998	281,212 (86%)	14,950 (5%)	32,538 (10%)	0 (0%)	328,700 (100%)

For monitored freshwater streams there appears to be some overall improvement. There was a decrease in the number of impaired stream miles from 1993 to 1998 (40 percent versus 34 percent) and a corresponding increase in the number of fully supporting stream miles (60 percent versus 66 percent). However, within the fully supporting category, the percentage of streams considered fully supporting but threatened (ST) increased by 19 percent from 1993 to 1998.

Monitored Freshwater Stream Use Support Comparisons between the 1993 and 1998 Plans (Stream Miles)

	FS	ST	PS	NS	Total
1993	321 (29%)	346 (31%)	371 (33%)	74 (7%)	1112 (100%)
1998	210 (16%)	661 (50%)	350 (26%)	104 (8%)	1325 (100%)

For the lakes data, there was some overall improvement seen from 1993 to 1998. In 1993, there were three lakes that were not supporting (NS) their uses, and 8 lakes (or 32%) that were considered impaired (total of partially supporting and not supporting categories). In 1998, 5 lakes (17 percent) were considered impaired, and none were rated not supporting.

Lakes Use Support Comparisons between the 1993 and 1998 Plans (Nos. of Lakes)

	FS	ST	PS	NS	Total
1993	8 (32%)	9 (36%)	5 (20%)	3 (12%)	25 (100%)
1998	12 (41%)	12 (41%)	5 (17%)	0	29 (100%)

3-A.2 General Point Source Goals

- Use long-term control efforts to reduce wastewater pollutant contributions.
  NPDES permits have been issued consistent with recommendations in the 1993 Neuse Basinwide Plan to reduce nutrients and oxygen-consuming wastes. NDPES permitting strategies from the 1993 plan are included in Chapter 4 of Section A of this plan. New nutrient permit limits have been recommended pursuant to the new nutrient sensitive waters (NSW) rules (see Chapter 5, Section A). DWQ has also continued to recommend against new discharges into streams where no new discharges were recommended in the 1993 plan.
- Seek more efficient and creative ways to recycle treatment plant by-products (including treated effluent).
  Since 1993, the Environmental Management Commission has passed new rules that allow more freedom for municipal wastewater treatment plants to reuse/recycle treated effluent.
- Keep abreast of and utilize the most advanced and cost-effective methods of wastewater treatment. *State-of-the-art nitrogen, phosphorous and BOD removal are now being phased in at many wastewater treatment plants in the basin. Effluent toxicity testing continues. Since Hurricane Fran, many plants have worked to improve backup or standby power for their plants and to make them more resistant to flood damage.*

3-A.3 General Nonpoint Source Goals

- Develop and use more effective controls for urban nonpoint source pollution.
  Since 1993, two major developments have occurred that will require preparation of new urban stormwater control rules for the state and for the Neuse River Basin. First, the Clean Responsibility Act, passed by the NC General Assembly in 1996, requires that a comprehensive statewide urban stormwater control program be developed. This includes a provision for individual local governments to develop stormwater ordinances for their jurisdictions that must include certain requirements and be approved by the state. Second, the new Neuse NSW rules include a provision that requires certain counties and municipalities in the Neuse basin to develop stormwater controls that will reduce nitrogen loading by 30 percent (see Chapter 5, Section A for brief description and references for further information). This document stresses the need for urban stormwater runoff controls, particularly in light of the tremendous growth that is occurring, and is predicted to continue to occur, in the Neuse River basin.
- Continue to work with the agricultural, forestry and development communities to reduce nutrients, sediment and chemicals.
  Major strides have been made in this area for nutrient reductions through the new NSW rules. In addition, the Sedimentation Control Commission and Division of Land Resources are working on improving sediment control in the state. This is being done through requesting funding to hire more inspectors, improving education, supporting sediment control research, and examining ways of strengthening the sedimentation control regulations (see Section 1-I of Chapter 1, Section C).
- Implement the Water Supply Watershed Protection Program, federal and state stormwater controls, and animal waste controls.
  All of these programs are being implemented. Significant strengthening of the animal waste control rules has occurred resulting from legislation passed by the General Assembly, new rules passed by the Environmental Management Commission (EMC) and increased funding that has been used to hire more animal operation inspectors. There is currently a moratorium on construction of new swine operations. This moratorium will be revisited by the General Assembly in 1999.
- Seek innovative solutions such as nutrient trading programs between point and nonpoint sources.
  Innovative, cost-effective solutions are being sought through implementation of the new NSW rules.
- Include the public in the long-range planning process.
  Public input has been a major part of the new NSW rules. Two rounds of public hearings, in addition to workshops, were held in order to solicit public input. Input from these meetings had significant impacts on the rules. For example, based on feedback from the agricultural community

during the first round of public meetings, much more flexibility was incorporated into the rules for farmers to meet nutrient reduction goals. In addition, five public workshops were held during the process of developing this plan. This input helped shape the organization and layout this plan as well as helping to define it contents.

3-A.4 Pollutants of Concern

- Metals: Independent research through the Albemarle-Pamlico Estuarine Program had identified a number of locations in the lower Neuse where bottom sediments had been found to have elevated levels of metals leading to the following recommendations:

  1. Monitoring in the areas of concern should continue. *Monitoring has continued and no adverse effects have been seen in aquatic life.*
  2. Metals discharges from wastewater treatment plants will continue to be closely monitored and controlled. *Metals concentrations continued to be monitored and whole effluent toxicity testing is being conducted at plants thought to be significant sources of metals.*
  3. Whole effluent toxicity testing should be continued. *This is being done as noted above.*
  4. DWQ should continue to strengthen the pretreatment program. *This is being done.*

- Oxygen-Consuming Wastes: To address this issue, additional controls on Neuse River BOD loadings from dischargers are required to maintain the instream dissolved oxygen standard of 5 mg/l. The recommendations are:

  1. For the Neuse Mainstem from Falls Dam to Streets Ferry, advanced tertiary treatment levels should be required for municipalities. Industries should be required to attain an equivalent level of treatment.
  2. For the Neuse Tributaries below Falls Dam, NPDES allocations should minimize BOD loading to the mainstem. Where a discharge is close to the mouth of the tributary, the permittee should not be given limits more stringent than for mainstem dischargers unless required to protect water quality standards in the tributaries.
  3. Additional requirements for dischargers are listed in the charts to follow.

  These recommendations were followed during permit renewal in 1993 and 1994. They continue to apply in the 1998 and 1999 permit renewal period. See Chapter 4 of Section A for a table summarizing the NDPES permitting recommendations carried over from the 1993 plan.

- Nutrients: Since point sources have already reduced nutrient loadings and make up a relatively small percentage of total nutrient loading, the state should focus its efforts on nonpoint sources of nutrients. The recommendations are:

  1. DWQ should target nonpoint nutrients for implementation of best management practices. *This is being done through formation of middle and lower Neuse nonpoint teams and targeting of Section 319 nonpoint source funds.*
  2. DWQ should work with the appropriate agencies to identify the sources and solutions to nonpoint nutrient pollution. *This has and continues to be done through development and implementation of the NSW regulations and through the NPS teams.*
  3. DWQ should reevaluate its nutrient strategy for the basin as more information is obtained about BMP effectiveness. *This has been done through the development of the NSW rules, and there has been a major shift in emphasis from controlling phosphorus to controlling nitrogen.*

3-A.5 Other Goals

- Better Control of Urban and Industrial Stormwater Runoff. *This is still a major need for better stormwater controls, but as indicated in 3-A.3 above, legislative and regulatory mandates have been issued that will lead to new stormwater programs both statewide and in the Neuse River basin.*
- Better Management of Livestock Waste. *Major legislative and regulatory actions have occurred over the past five years that have improved overall management of livestock waste management. This includes more restrictive permitting, more livestock operation inspectors and more severe penalties for illegal waste disposal.*
- Address Shellfish Water Closures. *Efforts have been made to identify sources of fecal coliform pollution, including septic tanks, improperly treated wastewater, urban nonpoint source pollution, runoff from livestock operations and waterfowl. There was a 1700-acre decrease in the acreage of closed shellfish waters in the basin. The South River near Open Grounds Farms is a good example of a waterbody that has been reopened to shellfish harvesting.*
- Address Noncompliance Issues. *DWQ has continued to work on improving permit compliance through better screening of effluent violations, streamlining enforcement actions, imposing automatic penalties and adding new inspectors. DWQ is also expanding its training and certification program for wastewater treatment plant, animal operations and sanitary sewerline conveyance system operators.*

3-B. Water Quality Data for the Basin

DWQ's monitoring program integrates biological, chemical and physical data assessment to provide information for basinwide planning. Below is a list of major monitoring programs discussed in this plan.

- Benthic macroinvertebrate monitoring (Section 3-B.1)
- Fish population and tissue monitoring(Section 3-B.2)
- Lakes assessment (including phytoplankton monitoring) (Section 3-B.3)
- Aquatic toxicity monitoring
- Ambient monitoring (covering the period 1991-1995) (Section 3-B.4)
- Lower Neuse Basin Association (3-B.5)

3-B.1 Benthic Macroinvertebrates

Benthic macroinvertebrates, or benthos, are organisms that live in and on the bottom substrates of rivers and streams. These organisms are primarily aquatic insect larvae. The use of benthos data has proven to be a reliable monitoring tool, as benthic macroinvertebrates are sensitive to subtle changes in water quality. Since many of these organisms have life cycles of six months to one year, the effects of short-term pollution (such as a spill) will generally not be overcome until the following generation appears. The benthic community also integrates the effects of a wide array of potential pollutant mixtures. Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample. Likewise, ratings can be assigned with a North Carolina Biotic Index (BI). This index summarizes tolerance data for all taxa in each collection.

Comparisons of 1991 and 1995 Benthic Data

The benthic macroinvertebrate database is an excellent source of water quality information, as these bottom dwelling organisms are good integrators of water quality over their life span. Since 1983, 460 benthos samples have been collected from 229 sites in the Neuse River basin and bioclassifications have been given to most of those samples (See Appendix III for complete listing). During the 1995 basin assessment, benthos were collected from 57 sites during the

summer, from 25 sites in the winter (where flows may be too low in summer to provide accurate assessments), and from 11 estuarine sites that cannot be rated at this time. Of the 77 benthos sites that were assigned bioclassifications in 1995, there were 3 Excellent sites, 19 Good sites, 27 Good-Fair sites, 17 Fair sites and 11 Poor sites.

Trends in water quality were evaluated at 55 benthos sites sampled in 1995 with prior data (48 of these were 1991 basin sites), with the majority (41) showing no change in water quality in recent years. This number includes seven sites that had a recent change in bioclassification, but where this change appeared to be due to between-year differences in flow, rather than to a change in water quality. Discussions in each subbasin give details of what changes might have been flow rated.

Recent improvements in water quality were observed only in subbasin 02 at two sites on Crabtree Creek. Crabtree Creek may have benefited from improvements in wastewater treatment. However, long-term improvements (since 1984) have been observed in the Eno River, the Neuse River (Clayton to Streets Ferry) and in Knap of Reeds Creek. Most of these changes are associated with improved wastewater treatment.

Recent declines in water quality were observed at eleven benthos sites. These fall into two groups: streams affected by development or urbanization (Tom's Creek, Swift Creek near Cary) and coastal plain streams. The coastal plain sites include the lower part of the Little River (2 sites), Contentnea Creek (2 sites), Nahunta Swamp, Core Creek, Swift Creek (2 sites), Clayroot Swamp and Core Creek. In some cases, these trends are based on only two data points, and must be viewed with caution. Long-term problems were observed in the Trent River, possibly due to changes in its hydrology.

3-B.2 Fish Community Structure Assessment

The fish communities of the Neuse River Basin were sampled using methods that were developed for the application of the North Carolina Index of Biotic Integrity (NCIBI) (NCDEHNR, 1995). At each sample site, a representative section of stream, 200 m in length, was selected, measured, and the fish in the stream were collected with one or two backpack electrofishing units depending upon the stream's width.

The NCIBI is a modification of the Index of Biotic Integrity initially proposed by Karr (1981) and Karr et al. (1986). The 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 necessarily directly correlate to water quality. A stream with excellent water quality, but poor to fair habitat would not rate excellent with this index. However, a stream which rated Excellent on the NCIBI would be expected to have excellent water quality. The NCIBI scores are used to determine the ecological integrity class of the stream from which the sample was collected. NCIBI scores for the Neuse Basin are presented in Figures 3.1 and 3.2.

Neuse Basin Fish Community Structure Overview and Changes Since 1991

Approximately 92 species of fish have been collected from the Neuse River Basin in North Carolina (Menhinick, 1991). Five of these species have been given special protection status by the North Carolina Wildlife Resources Commission or the North Carolina Natural Heritage Program under the North Carolina State Endangered Species Act (G.S. 113-331 to 113-337) (LeGrand and Hall, 1995). The Atlantic sturgeon (*Acipenser oxyrhynchus*), the Carolina darter (*Etheostoma collis*), the Carolina madtom (*Noturus furiosus*), the Least brook lamprey (*Lampetra aepyptera*), and the Bridle shiner (*Notropis bifrenatus*) are all listed as "Special Concern". The Carolina madtom and the Least brook lamprey are considered imperiled in North Carolina because of some factor(s) making them very vulnerable to extirpation from the state. The Atlantic sturgeon and the Carolina darter are considered rare or uncommon in the state. The Bridle shiner, although it has not been collected in recent years, is still suspected to be extant in the lower Neuse River basin. Seven specimens of the Carolina darter were collected from Smith Creek (Neuse 01 at SR 1710), and one specimen of the Carolina madtom was collected from Contentnea Creek (Neuse 07 at NC 42) in 1995.

What is the NCIBI?

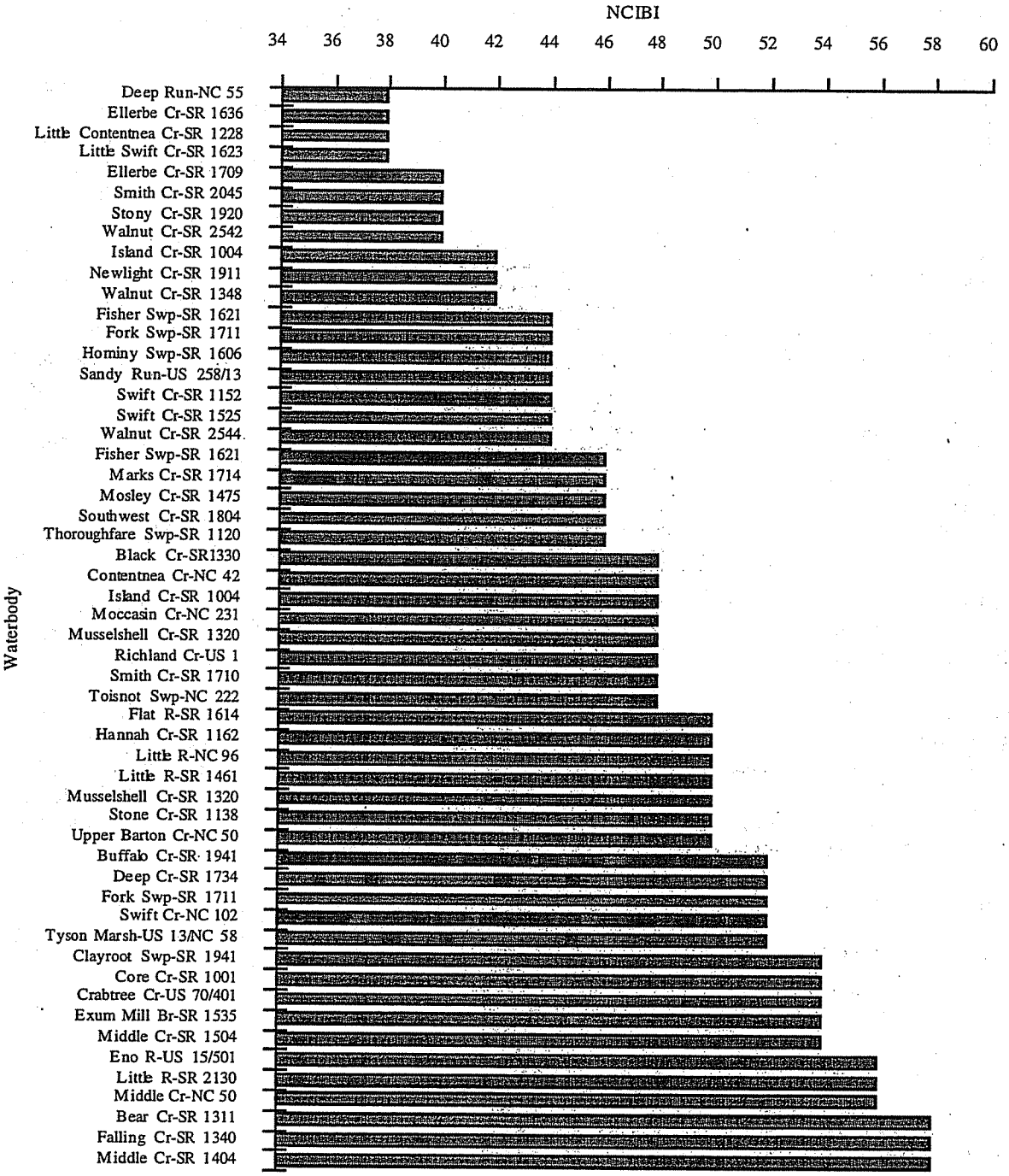
NCIBI stands for **Index of Biotic Integrity**. It is a method of assessing a stream's biological integrity by examining the structure of the fish community.

50 sites, in 11 subbasins were sampled in the Neuse in 1995 with the following results:

Good-Excellent: 8 sites
Good: 20 sites
Fair-Good: 5 sites
Fair: 14 sites
Poor-Fair: 3 sites

In 1995, 50 sites in 11 of the 14 subbasins were sampled and assessed using the North Carolina Index of Biotic Integrity. The Index of Biotic Integrity for these 50 sites ranged between 38 (Poor-Fair) and 58 (Excellent). The distribution of the rankings were: Poor-Fair--3 sites, Fair--14 sites, Fair-Good--5 sites, Good--20 sites, Good-Excellent--8 sites and Excellent--3 sites (one site was not rated). Note: These rankings do not reflect the distribution for all streams within the Neuse River basin, only those that were sampled during 1995.

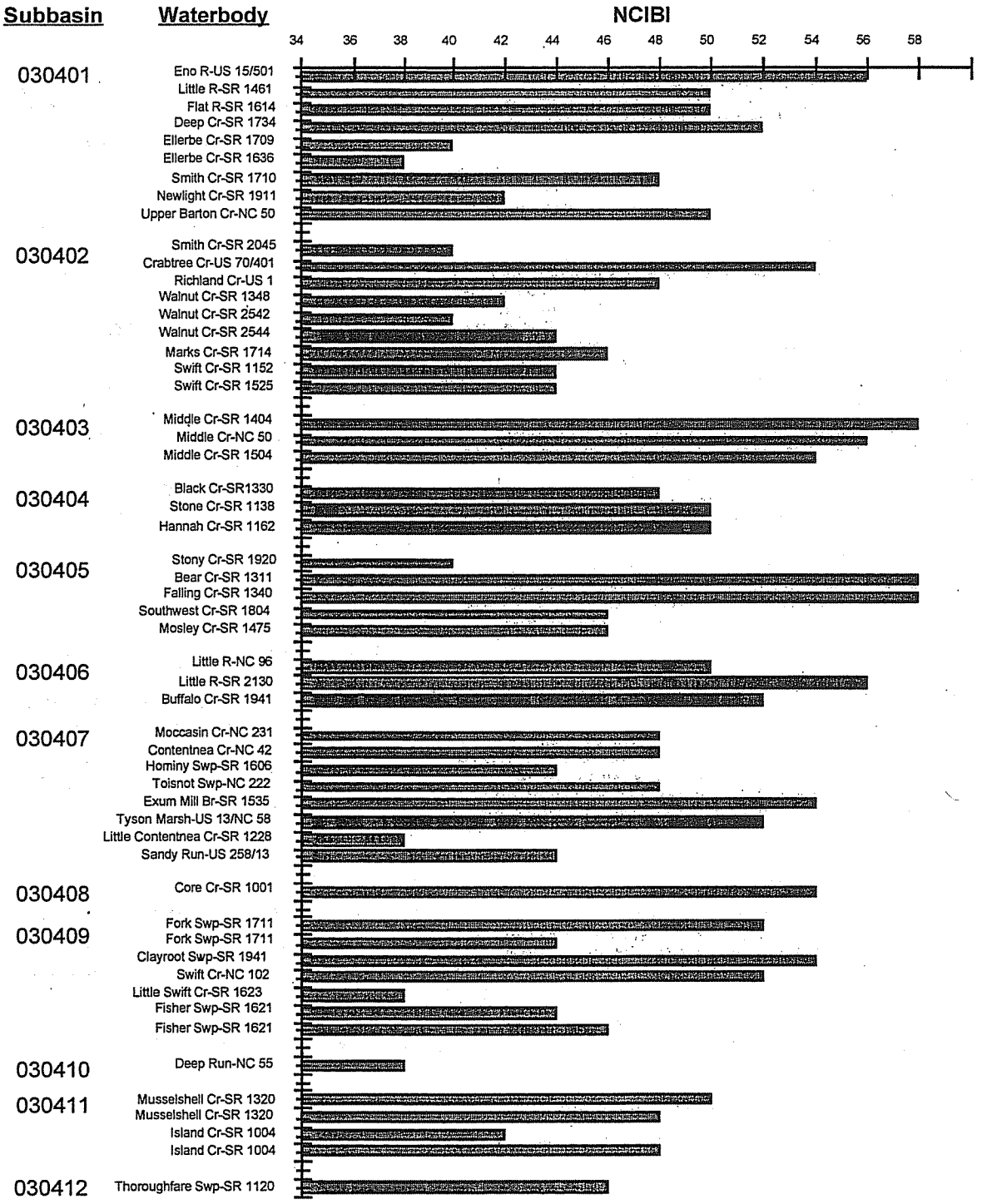
In contrast, fish community assessment sampling in the Neuse basin in 1991 resulted in collections from only 21 sites. Thirteen of those sites were resampled in 1995, with 5 having no change in rating, 5 indicating improvement, and 3 having a lower rating.



Integrity classes for NCIBI Scores:

58-60 =	Excellent	45-47 =	Fair-Good	28-34 =	Poor
53-57 =	Good-Excellent	40-44 =	Fair	23-27 =	Very Poor-Poor
48-52 =	Good	35-39 =	Poor-Fair	22-dec =	Very Poor

Figure 3.1 Rankings of Streams in the Neuse River Basin Based on Fish Community Assessments (NC Index of Biotic Integrity)



Integrity classes for NCIBI Scores:

58-60 =	Excellent	45-47 =	Fair-Good	28-34 =	Poor
53-57 =	Good-Excellent	40-44 =	Fair	23-27 =	Very Poor-Poor
48-52 =	Good	35-39 =	Poor-Fair	22-dec =	Very Poor

Figure 3.2 Rankings of Streams in the Neuse River Basin Based on Fish Community Assessments (NC Index of Biotic Integrity) and Grouped by Subbasin, 1995

3-B.3 Lakes Assessment Program

The North Carolina Lake Assessment Program seeks to protect these waters through monitoring and pollution prevention and control. Data are used to determine the *trophic state* of each lake, a relative measure of nutrient enrichment and productivity, and whether the designated uses of the lake have been threatened or impaired by pollution.

Lake Trophic States

Oligotrophic - Nutrient-poor and low biological productivity. More typical of cold-water lakes.
Mesotrophic - Intermediate nutrient availability and biological productivity.
Eutrophic - Nutrient-rich and highly productive.
Hypereutrophic - Extreme productivity characterized by algal blooms or dense macrophyte populations (or both) frequently having a high level of sedimentation.

In 1995, 22 of 29 lakes in the basin were determined to be Eutrophic with one lake (Lake Wendell) being hypereutrophic.

Lake Eutrophication: Lakes which are nutrient-rich and which support high levels of algal or macrophyte growth are often referred to as eutrophic. Eutrophication is a natural process which occurs as lakes and reservoirs gradually accumulate nutrients and sediments. As lakes age, they generally become more nutrient-rich and biologically productive. Nutrients, soil or organic matter added by human activities can greatly accelerate this process. This is sometimes referred to as cultural eutrophication. As a group, reservoirs tend to have higher inflows and nutrient and sediment loads than natural lakes and are thus more likely to be eutrophic. In North Carolina this is especially true of piedmont reservoirs.

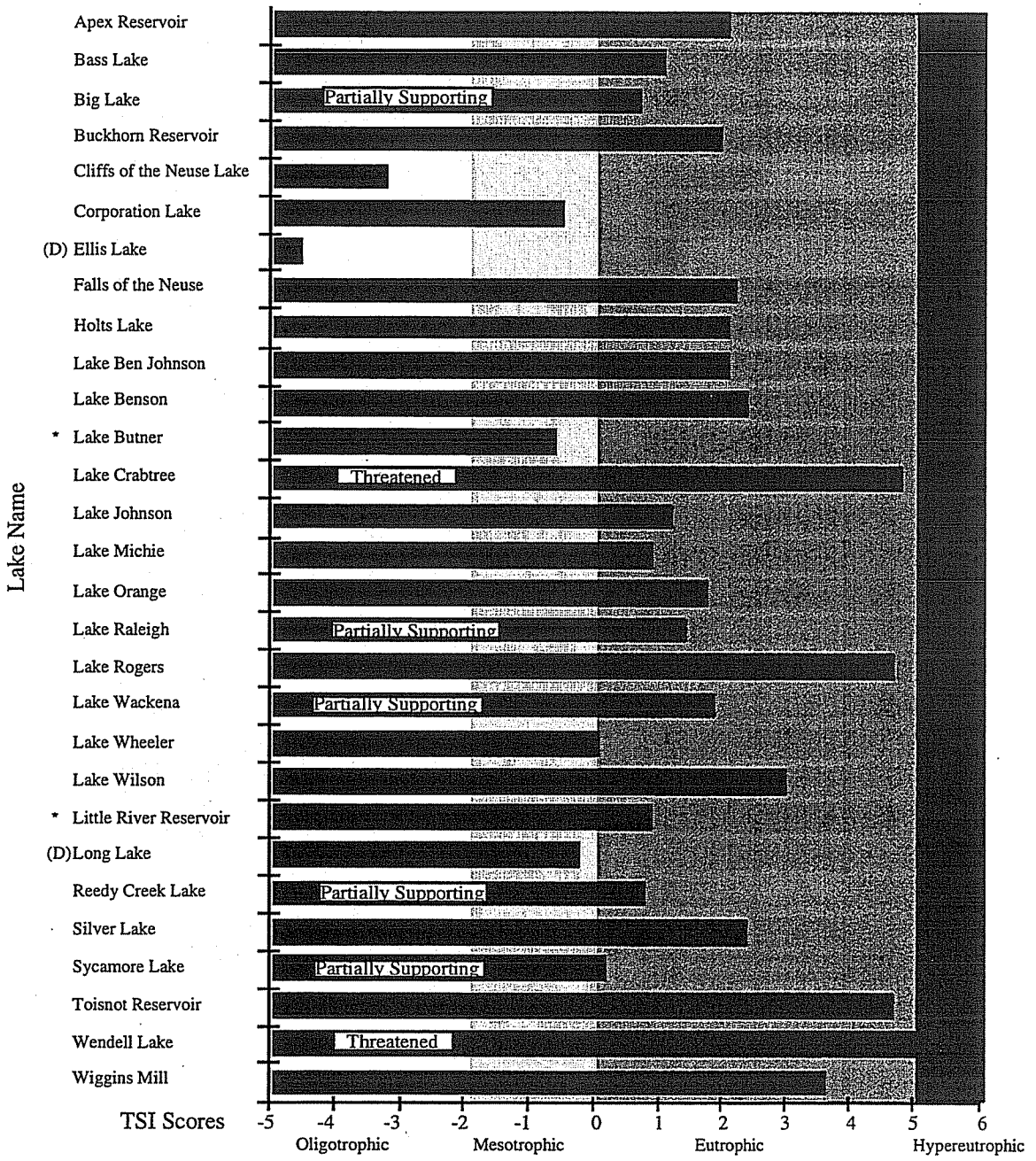
There were 29 lakes in the Neuse River Basin sampled as part of the Lakes Assessment Program. Numerical indices are often used to evaluate the trophic state of lakes. An index was developed specifically for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NCDNRCD, 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 these parameters are used to produce a NCTSI score for each lake.

Figure 3.3 shows the most recent NCTSI scores for the 29 lakes of the Neuse River basin. Lake Butner and Little River Reservoir were monitored intensively during the growing seasons of 1992 through 1993 as part of the reference lake program. This monitoring was to determine if this lake was representative of a minimally impacted lake in the region of the state in which it is located. All of the lakes were sampled most recently in 1995.

The classical lake succession sequence (Figure 3.4) is usually depicted as a unidirectional progression corresponding to a gradual increase in lake productivity from oligotrophy to hypereutrophy.

Comparisons of 1991 and 1995 Lakes Data

Twenty-nine lakes were sampled in 1995, and 11 had no change in their use support designation compared to 1991. Improvements in use support were found at 14 lakes, while 4 had lower use support designations. In 1995, 22 of the 29 lakes were supporting their designated uses; two lakes were fully supporting but threatened; and five lakes were partially supporting their uses. Two lakes were oligotrophic; four lakes were mesotrophic; 22 lakes were eutrophic; and one lake was hypereutrophic. Increasing eutrophication was noted at Lake Johnson and Lake Raleigh. The most eutrophic lakes sampled in 1995 were Wendell Lake, Lake Crabtree, Lake Rogers, Toisnot Reservoir and Wiggins Mill. Algal blooms were recorded at six



Notes: 1) All lakes sampled in 1995, 2) * Reference Lake, 3) D) Dystrophic Lake

Figure 3.3 Neuse Basin - TSI Scores (Last Assessment Date)

lakes, and nuisance growths of *Hydrilla* also were found at six lakes. The *Hydrilla* problem was most evident in lakes near Raleigh, in subbasin 02. Nuisance growths of other macrophytes occur in the lower portion of the Trent River.

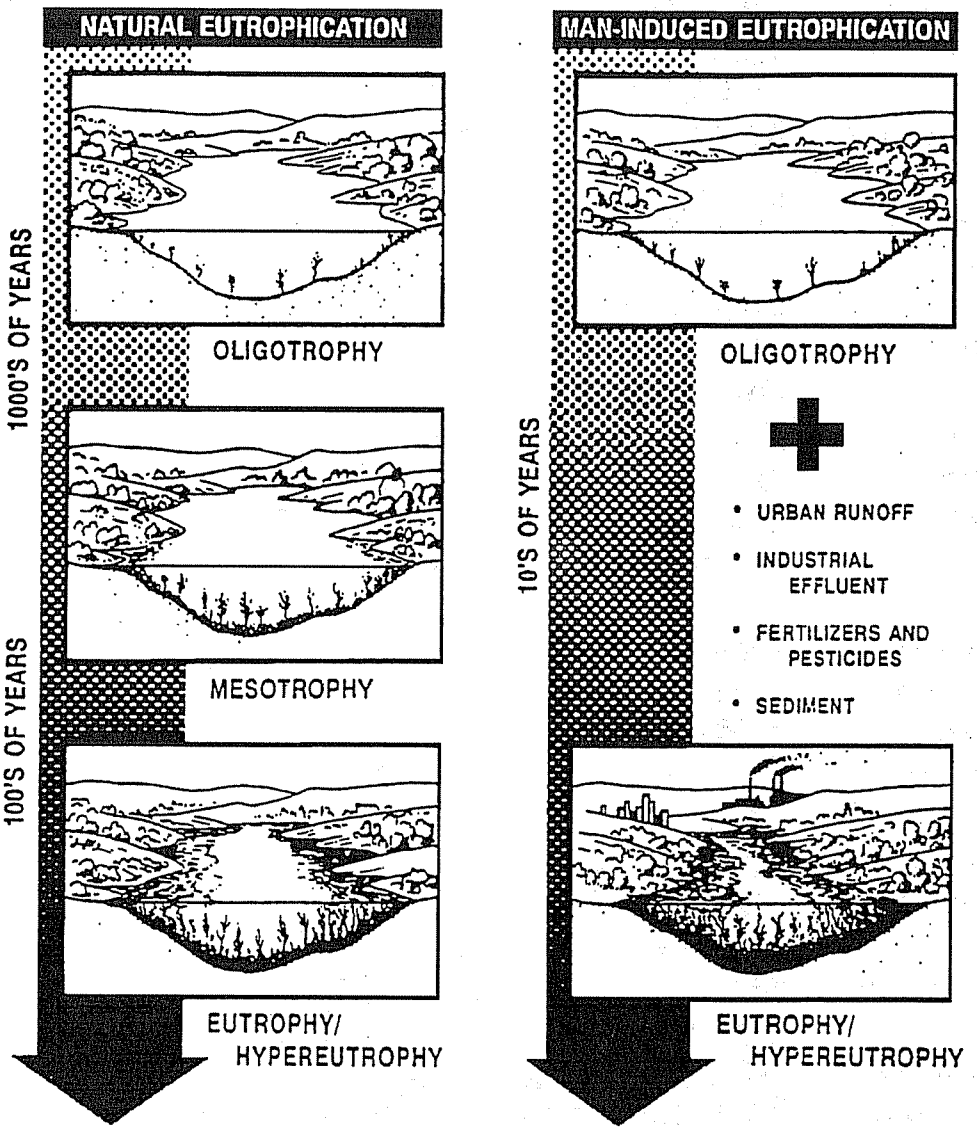


Figure 3.4 Natural versus Man-Induced Eutrophication

3-B.4 Ambient Monitoring Station Summary

North Carolina has 46 ambient stations in the Neuse River Basin. All stations for the basin are listed in Table 3.1 below. For this section, the stations have been divided into six groups, Upper Neuse River Drainage (nine stations), Neuse River Mainstem (16 stations), Neuse River Tributaries (seven stations), Contentnea Creek Drainage (four stations), Crabtree Creek Drainage (three stations), Coastal Tributaries (seven stations). A narrative summary of ambient water quality observations is provided below, after the table.

Table 3.1 Ambient Monitoring System Stations Within the Neuse Basin.

Primary No	STORET No	Station Name	Subbasin
Upper Neuse River Drainage			
02085070	J0770000	ENO RIVER NEAR DURHAM NC	030401
02085079	J0810000	ENO RIVER AT SR 1004 NEAR DURHAM NC	030401
0208521324	J0820000	LITTLE RIVER AT SR 1461 NEAR ORANGE FACTORY NC	030401
0208524169	J0840000	LITTLE RIVER RESERVOIR AT SR 1628 AT ORANGE FACTORY	030401
02085477	J1070000	FLAT RIVER NEAR QUAIL ROOST NC	030401
02086501	J1100000	FLAT RIVER AT SR 1004 NEAR WILLARDSVILLE NC	030401
02086624	J1210000	KNAP OF REEDS CREEK NEAR BUTNER NC	030401
02086849	J1330000	ELLERBE CREEK AT SR 1636 NEAR DURHAM	030401
0208700780	J1530000	LITTLE LICK CREEK AT SR 1814 NEAR DURHAM NC	030401
Neuse River Mainstem			
02087183	J1890000	NEUSE RIVER NEAR FALLS NC	030402
02087500	J4170000	NEUSE RIVER AT NC HWY 42 NEAR CLAYTON NC	030402
02087570	J4370000	NEUSE RIVER AT SMITHFIELD NC	030402
02089000	J5970000	NEUSE RIVER AT SR 1915 NEAR GOLDSBORO NC	030405
02089500	J6150000	NEUSE RIVER AT NC HWY 11 BYPASS AT KINSTON NC	030405
02091814	J7850000	NEUSE RIVER AT SR 1470 NEAR FORT BARNWELL NC	030408
02091836	J7930000	NEUSE RIVER AT SR 1400 AT STREETS FERRY NC	030408
02092092	J8250000	NEUSE R BELOW SWIFT CR NR ASKIN	030408
02092109	J8290000	NEUSE RIVER AT MTH OF NARROWS NR WASHINGTON FORKS	030408
02092162	J8570000	NEUSE RIVER AT US HWY 17 AT NEW BERN NC	030410
02092584	J8900800	NEUSE R AT LIGHT #22 NEAR FAIRFIELD HARBOUR NC	030410
02092586	J8902500	NEUSE RIVER AT MOUTH OF BROAD CREEK NR THURMAN NC	030410
0209262905	J8910000	NEUSE RIVER AT LIGHT #11 NEAR RIVERDALE NC	030410
0209265810	J9530000	NEUSE RIVER AT LIGHT #9 NR MINNESOTT BEACH NC	030410
02092674	J9810000	NEUSE RIVER AT MILE #12 NEAR ORIENTAL NC	030410
02092682	J9930000	NEUSE RIVER AT MOUTH NEAR PAMLICO NC	030410
Neuse River Tributaries			
0208732544	J3300000	PIGEON HOUSE CK AT DORTCH ST AT RALEIGH-TECH SER	030402
0208772185	J4510000	SWIFT CREEK AT NC HWY 42 NEAR CLAYTON NC	030402
02088000	J5000000	MIDDLE CREEK AT NC HWY 50 NEAR CLAYTON NC	030403
02088500	J5850000	LITTLE RIVER NEAR PRINCETON NC	030406
02091970	J8150000	CREEPING SWAMP AT NC HWY 43 NEAR VANCEBORO NC	030409
02092084	J8210000	SWIFT CREEK AT MOUTH NEAR ASKIN	030408
0209205053	J8230000	SWIFT CREEK AT NC HWY 43 NEAR STREETS FERRY NC	030408
Contentnea Creek Drainage			
02090380	J6740000	CONTENTNEA CREEK NEAR LUCAMA NC	030407
02091500	J7450000	CONTENTNEA CREEK AT NC HWY 123 AT HOOKERTON NC	030407
02091702	J7739550	LITTLE CONTENTNEA CREEK AT SR 1125 NEAR FARMVILLE	030407
0209176690	J7810000	CONTENTNEA CREEK NR SR 1800 AT GRIFTON NC	030407
Crabtree Creek Drainage			
02087251	J2850000	CRABTREE CREEK AT SR 1795 NEAR UMSTEAD STATE PARK	030402
0208726005	J3000000	CRABTREE CREEK AT SR 1649 NEAR RALEIGH NC	030402
02087324	J3290000	CRABTREE CREEK AT US HWY 1 AT RALEIGH NC	030402
Coastal Tributaries			
02092500	J8690000	TRENT RIVER NEAR TRENTON	030411
02092554	J8730000	TRENT RIVER AT POLLOCKSVILLE NC INACT-750409	030411
0209256050	J8770000	TRENT RIVER ABOVE REEDY BRANCH NEAR RHEMS NC	030410
0209266890	J9690000	BACK CREEK AT SR 1300 NEAR MERRIMON NC	030410
0209268905	J9938000	WEST THOROFARE BAY AT CM R '10WB' NR ATLANTIC	030414
0209268920	J9940000	THOROFARE CANAL AT NC HWY 12 NEAR ATLANTIC NC	030414
0208460480	J9950000	BAY RIVER AT LIGHT #5 NEAR VANDEMERE NC	030413

Upper Neuse River Drainage

The Durham Eno WWTP's NPDES permit was rescinded in August 1994, and the subsequent changes in water quality were recorded by AMS sites above and below the plant site. Dissolved oxygen, turbidity and solids and total phosphorus record no noticeable change to the absence of the plant discharge. However, the total nitrogen does show a noticeable drop in concentration during 1994.

The plant improvements in the Durham Northside WWTP can also be seen in the data from the Ellerbe Creek AMS site. There is no noticeable change in dissolved oxygen concentration. However, there is a drop in both total nitrogen and phosphorus in early 1995.

For the upper region of the Neuse River in general, dissolved oxygen concentrations are relatively similar for all the sites with slightly lower concentrations found in the lower Flat River, Knap of Reeds Creek, Ellerbe Creek and Little Lick Creek. The last three sites are also those with very high concentrations of total nitrogen and phosphorus. In addition to those three sites, the site at Eno River at SR 1004 has slightly higher concentrations than the other upper Neuse site, but this may be the result of the Durham Eno WWTP discharge that has since been

removed from the creek. Generally the lower Flat River, Knap of Reeds, Ellerbe Creek and Little Lick Creek had the largest percentage of water quality standard excursions in this drainage. These excursions occurred in manganese, dissolved oxygen, turbidity and fecal coliform [specific discussion of fecal coliforms takes place at the end of this section].

Neuse River Mainstem

Dissolved oxygen distributions for the mainstem gradually decrease in concentration along the mainstem until the river widens into the estuary at New Bern. At this point, concentrations return to near the level at Falls and remain at that level to the mouth. Excursions below the criterion for dissolved oxygen are few with exceptions being at the Askin and Narrows sites.

The phosphorus concentrations leaving Falls Lake were very low, but they increase at the Clayton site. There is a gradual decrease to Fort Barnwell where the concentration again increases. Another decrease occurs in the estuary from Thurman to the mouth.

Total nitrogen concentrations show a similar pattern to total phosphorus. Nitrogen is very low from Falls Lake; increases suddenly at Clayton, below Raleigh's wastewater treatment plant (1995 data); decreases to Fort Barnwell; increases slightly at Streets Ferry; and gradually decreases in the estuary from New Bern to the mouth.

Neuse River Tributaries

Dissolved oxygen concentration distributions show some low concentrations at the Crabtree Creek Umstead site. Other sites with low concentrations are Contentnea, Little Contentnea, Swift Creeks and Creeping Swamp. However, these sites are all in swamp waters and are expected to have naturally low dissolved oxygen and pH. In terms of nutrients, there are high concentrations of total phosphorus and in sites in and below Raleigh. Crabtree Creek at SR 1649 and US 1 and Pigeon House Branch all have relatively high nutrient concentrations, especially total nitrogen. Total nitrogen concentrations are also high at Middle Creek. Tributaries with high total phosphorus concentrations are generally those in the Contentnea Creek drainage, Contentnea Creek, Little Contentnea Creek and Creeping Swamp. Effects of urban nonpoint source pollution can also be seen at Pigeon House Branch, with the highest number of samples above the action levels for copper (69.8%) and zinc (62.3%) and one of four sites with one exceedence of the nickel criterion.

Coastal Tributaries

Generally, the Trent River and Back Creek have lower dissolved oxygen concentrations and higher concentrations of total phosphorus and nitrogen. These differences may be reflected in the nature of the waters of these three sites versus the sites in Thorofare Bay and Bay River. There are marked differences in pH and salinity defining the estuarine nature of Thorofare Bay and the site at Bay River.

Fecal Coliform Bacteria

Fecal coliform bacteria behave differently than most other water quality parameters, and these differences must be considered when using them to evaluate water quality. Available information was reviewed to identify potentially impaired waters and locate potential sources of pollutants in order that targeting efforts and appropriate management strategies can be developed. As sampled in the ambient monitoring system, fecal coliform bacteria are most useful as a screening tool to estimate the cumulative inputs from multiple sources, but in some instances can be used to locate a single large source of bacteria.

The earlier the regional offices are provided summary information listing the high priority stations relative to bacteria; the sooner they can initiate investigations and/or take corrective action either through the regulatory process or in targeting efforts from nonpoint source agencies. Summaries of fecal coliform results were provided each regional office in May of 1995. These data will be updated in this and each subsequent Basinwide Assessment Report and will include any additional data collected by staff during the five-year cycle.

Summary fecal coliform information is listed in Table 3.2. The primary screening tool used in establishing priority is the geometric mean. Sites with 10 or more fecal coliform samples within the last 5 years, that have a geometric mean exceeding 200/100 ml, are considered highest priority. This information will be reflected in the Use Support Rating for that stream or river.

Table 3.2 Fecal Coliform Summary Data for the Neuse River Basin 1991 to 1995

Site	Total Samples	Geometric Mean	Samples >200/100 ml	Percent >200/100 ml	First Sample	Last Sample
ENO RIVER NEAR DURHAM NC	17	49.3	3	17.6	8/23/94	12/11/95
ENO RIVER AT SR 1004 NEAR DURHAM NC	20	87.5	5	25.0	8/23/94	12/14/95
LITTLE RIVER AT SR 1461 NEAR ORANGE FACTORY NC	55	57.9	11	20.0	4/22/91	12/11/95
LITTLE RIVER RESERVOIR AT SR 1628 AT ORANGE FACTORY	54	14.6	1	1.9	4/22/91	12/11/95
FLAT RIVER NEAR QUAIL ROOST NC	19	62.0	3	15.8	2/22/94	12/11/95
FLAT RIVER AT SR 1004 NEAR WILLARDSVILLE NC	17	25.1	0	0.0	8/23/94	12/11/95
KNAP OF REEDS CREEK NEAR BUTNER NC	21	276.6	11	52.4	8/23/94	12/14/95
ELLERBE CREEK AT SR 1636 NEAR DURHAM	19	199.6	7	36.8	8/23/94	12/14/95
LITTLE LICK CREEK AT SR 1814 NEAR DURHAM NC	15	134.9	7	46.7	8/23/94	12/14/95
NEUSE RIVER NEAR FALLS NC	15	16.7	1	6.7	9/28/94	12/21/95
CRABTREE CREEK AT SR 1795 NEAR UMSTEAD STATE PARK	51	34.1	3	5.9	5/17/91	12/21/95
CRABTREE CREEK AT REEDY CREEK STATE PARK	42	50.2	5	11.9	5/17/91	5/9/95
CRABTREE CREEK AT US HWY 1 AT RALEIGH NC	15	365.7	10	66.7	9/28/94	12/21/95
PIGEON HOUSE CK AT DORTCH ST AT RALEIGH-TECH SER	15	405.0	12	80.0	9/28/94	12/21/95
NEUSE RIVER AT NC HWY 42 NEAR CLAYTON NC	14	257.0	7	50.0	9/12/94	10/25/95
NEUSE RIVER AT SMITHFIELD NC	14	293.6	8	57.1	9/12/94	10/25/95
SWIFT CREEK AT NC HWY 42 NEAR CLAYTON NC	13	139.8	5	38.5	9/12/94	9/28/95
MIDDLE CREEK AT NC HWY 50 NEAR CLAYTON NC	14	168.3	4	28.6	9/12/94	10/25/95
LITTLE RIVER NEAR PRINCETON NC	14	120.2	3	21.4	9/12/94	10/25/95
CONTENTNEA CREEK NEAR LUCAMA NC	14	24.9	0	0.0	9/12/94	10/25/95
SWIFT CREEK AT MOUTH NEAR ASKIN	46	25.7	2	4.3	12/10/91	11/13/95
NEUSE R BELOW SWIFT CR NR ASKIN	46	23.2	1	2.2	12/10/91	11/13/95
NEUSE R AT MOUTH OF NARROWS NR WASHINGTON FORKS NC	44	25.1	2	4.5	1/9/92	11/13/95
TRENT RIVER NEAR TRENTON	14	75.2	2	14.3	5/9/95	12/11/95
TRENT RIVER ABOVE REEDY BRANCH NEAR RHEMS NC	53	19.6	3	5..0	4/9/91	11/13/95
NEUSE RIVER AT LIGHT #9 NR MINNESOTT BEACH NC	22	13.6	1	4.5	2/16/94	12/5/95
BACK CREEK AT SR 1300 NEAR MERRIMON NC	30	141.8	16	53.3	1/16/92	12/13/95
NEUSE RIVER AT MILE #12 NEAR ORIENTAL NC	53	10.6	0	0.0	4/8/91	12/5/95
NEUSE RIVER AT MOUTH NEAR PAMLICO NC	52	10.2	0	0.0	4/8/91	12/5/95
WEST THOROFARE BAY AT CM R '10WB' NR ATLANTIC	26	10.1	0	0.0	7/29/93	12/4/95
THOROFARE CANAL AT NC HWY 12 NEAR ATLANTIC NC	35	14.0	1	2.9	1/23/91	12/4/95
BAY RIVER AT LIGHT #5 NEAR VANDEMERE NC	45	11.7	1	2.2	12/11/91	12/5/95

There are five sites that have a geometric mean greater than 200/100 ml. They are Knap of Reeds Creek, Crabtree Creek at US 1, Pigeon House Branch, Neuse River at Clayton and Neuse River at Smithfield. The site on Ellerbe Creek has a mean very near 200/100 ml and this site should be considered also.

3-B.5 Lower Neuse Basin Association

The concept of the Lower Neuse Basin Association (LNBA) and discharger associations, that are forming in the various river basins in North Carolina, is to integrate instream sampling requirements as set forth in their NPDES permits with the Division of Water Quality's (DWQ) basinwide management strategy. Rather than each discharger conducting instream sampling, one organization (e.g., contract lab) will conduct all the sampling and perform the required analyses. Monitoring sites and parameters can be established such that instream monitoring is more efficient, effective, basin-oriented and yields better quality, more usable data. The increased efficiency should provide economic incentive for dischargers to join the coalition, and the data will benefit both DWQ and the discharging facilities.

A legal agreement referred to as the Memorandum of Agreement (MOA) between DWQ and the LNBA was agreed to on July 27, 1994. As long as the MOA is in effect, instream sampling for

the association will be conducted by the contract organization. However, if a member decides to quit the Association, the discharger would automatically become responsible for their own instream sampling as specified in their NPDES permit.

LNBA currently has 49 sites in the Neuse River Basin. There are two sites, Neuse River at Clayton and Neuse River at Fort Barnwell, that overlap DWQ sites. At these two sites for the data from 1995, there is favorable comparison. For example there are 9 common parameters sampled at the Clayton site with 119 samples for DWQ and 97 samples for LNBA. The percentage exceedence for these parameters was 5.9% for DWQ and 5.2% for LNBA. Fort Barnwell had only 4 common parameters with 58 samples for DWQ and 41 for LNBA. The percentage here was 19% for DWQ and 12.2% for LNBA. For the small data set available at this time, there is very favorable comparison between the DWQ and LNBA. As that data set becomes larger, it will be an invaluable addition to the basin assessment process.

3-B.6 Water Quality Effects of Hurricane Fran

The following information was gleaned from a May 1997, 38-page report called *Summary of Water Quality Effects of the 1996 Hurricanes in North Carolina* by the NC Division of Water Quality's Environmental Sciences Branch.

Severe climatic conditions including hurricanes Bertha and Fran dominated summer and fall 1996 weather patterns in eastern and piedmont North Carolina. These storms produced exceptional amounts of rainfall in several parts of the state including most of the coastal plain and during hurricane Fran, westward to the Research Triangle Area and beyond. Floodplains of streams and rivers were inundated by rising water of streamflows which exceed the 500-year recurrence intervals in some areas, including Flat River at Bahama above Falls Lake and in Middle Creek near Clayton.

The Neuse River experienced some of the state's most severe and prolonged flooding during the aftermath of Hurricane Fran. Investigators reported 14 fish kills in the basin during 1996 and 10 (71 percent) could be directly attributed to the effects of Fran. Cumulative rainfall amounts after the storm exceeded 6 to 18 inches in many parts of the basin, especially north, around Wake and Durham Counties. Inputs of organic material and the resulting depletion of DO was responsible for nearly all kills associated with the hurricane. Because of the widespread effects of the hurricane, fish kills occurred throughout the entire Neuse basin from Falls Lake to below New Bern. Significant kill events associated with Fran include Upper Falls Lake in Granville County, Contentnea Creek in Wilson County, the Neuse River near Goldsboro and Falling Creek in Wayne County. Only one significant kill on Swift Creek in Craven County was associated with the aftermath of Hurricane Bertha.

Another excellent source of information on the hurricane is a September 1996 report (Open-File Report 96-499) by the United States Geological Survey (USGS) entitled *Aftermath of Hurricane Fran in North Carolina-Preliminary Data on Flooding and Water Quality*. Copies can be obtained from USGS Office in Raleigh. (website: http://nc.water.usgs.gov/)

3-C. Use Support Ratings Summary

3-C.1 Introduction to Use Support

Waters are classified according to their best intended uses. Determining how well a waterbody supports its designated uses (*use support* status) is another important method of interpreting water quality data and assessing water quality.

Surface waters (streams, lakes or estuaries) are rated as either *fully supporting* (FS), *fully supporting but threatened* (ST), *partially supporting* (PS) or *not supporting* (NS). The terms refer to whether the classified uses of the water (such as water supply, aquatic life protection and swimming) are fully supported, partially supported or are not supported. For instance, waters classified for fishing and water contact recreation (Class C) are rated as fully supporting, if data used to determine use support (such as chemical/physical data collected at ambient sites or benthic macroinvertebrate bioclassifications) did not exceed specific criteria. However, if these criteria were exceeded, then the waters would be rated as ST, PS or NS, depending on the degree of exceedence.

Streams rated as either partially supporting or nonsupporting are considered *impaired*. A waterbody is fully supporting but threatened (ST) for a particular designated use when it fully supports that use now, but may not in the future unless pollution prevention or control action is taken. Although threatened waters are currently supporting uses, they are treated as a separate category from waters fully supporting uses. Streams which had no data to determine their use support were listed as not rated (NR).

For the purposes of this document, the term *impaired* refers to waters that are rated either partially supporting or not supporting their uses based on specific criteria discussed more fully below. There must be a specified degree of degradation before a stream is considered impaired. This differs from the word impacted, which can refer to any noticeable or measurable change in water quality, good or bad.

3-C.2 Interpretation of Data

The assessment of water quality presented below involved evaluation of available water quality data to determine a waterbody's use support rating. In addition, an effort was made to determine likely causes (e.g., sediment or nutrients) and sources (e.g., agriculture, urban nonpoint source pollution, point sources) of pollution for impaired waters. Data used in the use support assessments include biological data, chemical physical data, lakes assessment data and monitoring data. Although there is a general procedure for analyzing the data and determining a waterbody's use support rating, each stream segment is reviewed individually, and best professional judgment is applied during these determinations.

Interpretation of the use support ratings compiled by DWQ should be done with caution. The methodology used to determine the ratings must be understood, as should the purpose for which the ratings were generated. The intent of this use support assessment was to gain an overall picture of the water quality, to see how well these waters support the uses for which they were classified, and to determine the relative contribution made by different categories of pollution within the basin. In order to comply with guidance received from EPA to identify likely sources of pollution for all impaired stream mileage, DWQ used the data mentioned above.

The data are not intended to provide precise conclusions about pollutant budgets for specific watersheds. Since the assessment methodology is geared toward general conclusions, it is important not to manipulate the data to support policy decisions beyond the accuracy of these data. For example, according to this report, nonpoint source pollution is the greatest source of water quality degradation. However, this does not mean that there should be no point source control measures. All categories of point and nonpoint source pollution have the potential to cause significant water quality degradation if proper controls and practices are not utilized.

The threat to water quality from all types of activities heightens the need for point and nonpoint source pollution control. It is important to consider any source (or potential source) of pollution in developing appropriate management and control strategies. The potential for

further problems remains high as long as the activity in question continues carelessly. Because of this potential, neglecting one pollution source in an overall control strategy can mask the benefits achieved from controlling all other sources.

3-C.3 Assessment Methodology - Freshwater Bodies

Many types of information were used to determine use support assessments and to determine causes and sources of use support impairment. A use support data file is maintained for each of the 17 river basins. In these files stream segments are listed as individual records. All existing data pertaining to a stream segment is entered into its record. In determining the use support rating for a stream segment, corresponding ratings are assigned to data values where this is appropriate. The following data and the corresponding use support ratings are used in the process. (Note: The general methodology for using this data and translating the values to use support ratings corresponds closely to the 305(b) guidelines with some minor modifications.)

Biological Data

Benthic Macroinvertebrate Bioclassification

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups Ephemeroptera, Plecoptera and Trichoptera (EPT S) and the Biotic Index which summarizes tolerance data for all taxa in each collection. Use support ratings are assigned to each bioclassification as follows:

Bioclassification	Rating
Excellent	Fully Supporting
Good	Fully Supporting
Good-Fair	Fully Supporting but Threatened
Fair	Partially Supporting
Poor	Not Supporting

Fish Community Structure

The North Carolina Index of Biotic Integrity (NCIBI) is a method for assessing a stream's biological integrity by examining the structure and health of its fish community. The index incorporates information about species richness and composition, trophic composition, fish abundance and fish condition. Use support ratings are assigned to each category of the NCIBI as follows:

NCIBI	Rating
Excellent	Fully Supporting
Good-Excellent	Fully Supporting
Good	Fully Supporting
Fair-Good	Fully Supporting but Threatened
Fair	Partially Supporting
Poor-Fair	Partially Supporting
Poor	Not Supporting
Very Poor-Poor	Not Supporting
Very Poor	Not Supporting

Phytoplankton and Algal Bloom Data

Prolific growths of phytoplankton, often due to high concentrations of nutrients, sometimes result in "blooms" in which one or more species of alga may discolor the water or form visible mats on top of the water. Blooms may be unsightly and deleterious to water quality, causing fish kills, anoxia, or taste and odor problems. An algal sample with a biovolume larger than

5,000 mm3/m3, density greater than 10,000 units/ml, or chlorophyll *a* concentration approaching or exceeding 40 micrograms per liter (the NC state standard) constitutes a bloom. A waterbody is rated ST if the biovolume, density and chlorophyll *a* concentrations are approaching bloom concentrations. If an algal bloom occurs, the waterbody is rated PS.

Chemical/Physical Data

Chemical/physical water quality data are collected through the Ambient Monitoring System as discussed above. The data are downloaded from STORET to a desktop computer for analysis. Total number of samples and percent exceedences of the NC state standards are used for use support ratings. Percent exceedences correspond to use support ratings as follows:

Standards Violation	Rating
Criteria exceeded <10%	Fully Supporting
Criteria exceeded 11-25%	Partially Supporting
Criteria exceeded >25%	Not Supporting

It is important to note that some waters may exhibit characteristics outside the appropriate standards due to natural conditions. These natural conditions do not constitute a violation of water quality standards.

Lakes Program Data

As discussed earlier, assessments have been made for all publicly accessible lakes, lakes which supply domestic drinking water, and lakes where water quality problems have been observed.

Sources and Cause Data

In addition to the above data, existing information was entered for potential sources of pollution (point and nonpoint). It is important to note that not all impaired streams will have a potential source and/or cause listed for them. Staff and resources do not currently exist to collect this level of information. Much of this information is obtained through the cooperation of other agencies (federal, state and local), organizations and citizens.

Point Source Data

Whole Effluent Toxicity Data

Many facilities are required to monitor whole effluent toxicity by their NPDES permit or by administrative letter. Streams that receive a discharge from a facility that has failed its whole effluent toxicity test may be rated ST (unless water quality data indicated otherwise), and have that facility listed as a potential source of impairment.

Daily Monitoring Reports

Streams which received a discharge from a facility significantly out of compliance with permit limits may be rated ST (unless water quality data indicate otherwise), and have that facility listed as a Point Source potential source of impairment.

Nonpoint Source Data

Information related to nonpoint source pollution (i.e., agricultural, urban and construction) was obtained from monitoring staff, other agencies (federal, state and local), 1988 nonpoint source workshops, land use reviews, and workshops held at the beginning of each basin cycle.

Problem Parameters

Causes of use support impairment (problem parameters), such as sedimentation and low dissolved oxygen, were also identified for specific stream segments. For ambient water quality stations, problem parameters were those parameters which exceeded the water quality standard >10% of the time for the review period. For segments without ambient stations, information from reports, other agencies and monitoring staff were used if it was available.

Monitored vs. Evaluated

Assessments were made on either monitored (M) or evaluated (E) basis depending on the level of information that was used. Streams are rated on a monitored basis if the monitored data are less than five years old. Streams are rated on an evaluated basis under the following conditions:

- If the only existing monitored data for a stream are more than five years old, they are used to rate the stream on an evaluated basis.
- If a stream is a tributary to a monitored segment of a stream rated fully supporting (FS) or fully supporting but threatened (ST), the tributary will receive the same rating on an evaluated basis. If a stream is a tributary to a monitored segment of a stream rated partially supporting (PS) or not supporting (NS), the stream is considered not rated (NR).

3-C.4 Assessment Methodology - Saltwater Bodies

Estuarine areas are assessed by the DEH shellfish management areas. The following data sources are used when assessing estuarine areas:

DEH Sanitary Surveys

The DEH is required to classify all shellfish growing areas as to their suitability for shellfish harvesting. Management areas are sampled and reviewed every three years to determine their classification, identify problems, determine management strategies, etc., and this is published in the Sanitary Survey. Growing waters are classified as follows:

- Approved Area - an area determined suitable for the harvesting of shellfish for direct market purposes.
- Conditionally Approved Open - waters that are normally open to shellfish harvesting but are closed on a temporary basis in accordance with management plan criteria.
- Conditionally Approved Closed - waters that are normally closed to shellfish harvesting but are open on a temporary basis in accordance with management plan criteria.
- Restricted Area - an area from which shellfish may be harvested only by permit and subjected to an approved depuration process or relayed to an approved area.
- Prohibited Area - an area unsuitable for the harvesting of shellfish for direct market purposes.

Chemical / Physical Data

Water quality data collected from estuarine ambient monitoring stations. Parameters are evaluated based on the salt waterbody classification and corresponding water quality standards.

Phytoplankton and Algal Bloom Data

Prolific growths of phytoplankton, often due to high concentrations of nutrients, sometimes result in "blooms" in which one or more species of algae may discolor the water or form visible mats on top of the water. Blooms may be unsightly and deleterious to water quality, causing fish kills, anoxia, or taste and odor problems. An algal sample with a biovolume larger than 5000 mm3/m3, density greater than 10,000 units/ml, or chlorophyll *a* concentration approaching or exceeding 40 micrograms per liter (the NC state standard) constitutes a bloom.

It is important to note that the DEH classifies all actual and potential growing areas (which includes all saltwater and brackish water areas) as to their suitability for shellfish harvesting, but different DWQ use classifications may be assigned to separate segments within a DEH management area. The DEH classifications and management strategies are only applicable to those areas that DWQ has assigned the use classification of SA. This will result in a difference of acreage between DEH areas classified as prohibited or restricted, and DWQ waterbodies rated PS. For example, if DEH classifies a 20-acre waterbody as prohibited, but only 10 acres have a DWQ use classification of SA, only those 10 acres classified as SA will be rated as partially supporting their uses. DWQ areas classified as SB and SC are rated using chemical/physical data and phytoplankton data.

Salt waterbodies are classified according to their best use. When assigning a use support rating, this classification is used with the above parameters as follows:

DWQ Class.	DEH Shellfish Class.	Chemical/Physical	Phytoplankton
Fully Supporting			
SA	Approved	standard exceeded ≤10% of measurements	no blooms
SB & SC	Does not apply	standard exceeded ≤10% of measurements	no blooms
Fully Supporting but Threatened			
SA	Conditionally Approved	no criteria	no blooms
SB & SC	Does not apply	no criteria	no blooms
Partially Supporting			
SA	Prohibited or Restricted	standard exceeded 11-25% of measurements	blooms
SB & SC	Does not apply	standard exceeded 11-25% of measurements	blooms
Not Supporting			
SA	Prohibited or Restricted	standard exceeded >25% of measurements	blooms
SB & SC	Does not apply	standard exceeded >25% of measurements	blooms

3-C.5 Assigning Use Support Ratings

At the beginning of each assessment, all data are reviewed by subbasin with the monitoring staff, and data are adjusted where necessary based on best professional judgment. Discrepancies between data sources are resolved during this phase of the process. For example, a stream may be sampled for both benthos and fish community structure, and the bioclassification may differ from the NCIBI (i.e., the bioclassification may be FS while the NCIBI

may be PS). To resolve this, the final rating may defer to one of the samples (resulting in FS or PS), or it may be a compromise between both of the samples (resulting in ST).

After reviewing the existing data, ratings are assigned to the streams. If one data source exists for the stream, the rating is assigned based on the translation of the data value as discussed above. If more than one source of data exists for a stream, the rating is assigned according to the following hierarchy:

Benthic Bioclassification/Fish Community Structure
Chemical/Physical Data
Monitored Data >5 years old
Compliance/Toxicity Data

This is only a general guideline for assigning use support ratings, and it is not meant to be restrictive. Each segment is reviewed individually, and the resulting rating may vary from this process based on best professional judgment, which takes into consideration site specific conditions.

After assigning ratings to streams with existing data, streams with no existing data were assessed. Streams that were direct or indirect tributaries to streams rated FS or ST received the same rating (with an evaluated basis) if they had no known significant impacts, based on a review of the watershed characteristics and discharge information. Streams that were direct or indirect tributaries to streams rated PS or NS, or that had no data, were assigned a Not Rated (NR) rating.

3-C.5 Revisions to Methodology Since 1994-95 305(b) Report

Methodology for determining use support has been revised. In the 1994-1995 305(b) Report, evaluated information from older reports and workshops were included in the use support process. Streams rated using this information were considered to be rated on an evaluated basis. In the current use support process, this older, evaluated information has been discarded, and streams are now rated using only monitored information (including current and older monitoring data). Streams are rated on a monitored basis if the data are less than five years old. Streams are rated on an evaluated basis under the following conditions:

- If the only existing data for a stream are more than five years old, they are used to rate the stream on an evaluated basis.
- If a stream is a tributary to a monitored segment of a stream rated fully supporting: (FS) or fully supporting but threatened (ST), the tributary will receive the same rating on an evaluated basis. If a stream is a tributary to a monitored segment rated partially supporting (PS) or not supporting (NS), the stream is considered not rated (NR).
- These changes resulted in a reduction in streams rated on an evaluated basis.

The basinwide process allows for concentrating more resources on individual basins during the monitoring phase. Therefore, more streams were monitored, and more information was available to use in the use support process.

3-C.6 Use Support for Freshwater Streams

Of the 3,443 miles of freshwater streams and rivers in the Neuse River basin, use support ratings were determined for 76% or 2629.4 miles. Approximately half of these determinations were based on monitored information and the other half on evaluated information. The remaining 24% of streams were unassessed.

Monitored and Evaluated		Monitored Only
SUPPORTING	**62%**	**66%**
Fully supporting	(21%)	(16%)
Fully support but threatened	(41%)	(50%)
IMPAIRED	**14%**	**34%**
Partially supporting	(11%)	(26%)
Not supporting	(3%)	(8%)
NOT RATED:	**24%**	

Table 3.3 and Figure 3.5 summarize the overall use support determinations for freshwater streams for 12 of the basin's 14 subbasins. Table 3.4 provides a detailed summary of the use support ratings for all monitored streams in the basin. A 3-page color map showing the use support ratings for all assessed streams in basin is presented in Figure 3.6 (a, b and c).

Table 3.3 Summary of Use Support Ratings by Subbasin in the Neuse River Basin

Subbasin	FS	ST	PS	NS	NR	Total Miles
30401	418	87.3	37.6	19.2	26.1	588.2
30402	77.8	267.2	70.7	24.6	101.7	542
30403	0	125.4	0	0	0	125.4
30404	0	193.6	0	0	0	193.6
30405	75.6	156.2	37.6	10.2	65.2	344.8
30406	0	187.2	22.1	5.6	17.4	232.3
30407	48.7	277.8	98.3	4.5	192.7	622
30408	0	50.6	18.5	0	55.9	125
30409	0	0	10.9	45.1	100.6	156.6
30410	0	4.1	0	0	93.5	97.6
30411	13.9	15.5	88.9	0	160.5	278.8
30412	73.5	63.2	0	0	0	136.7
30413	0	0	0	0	0	0
30414	0	0	0	0	0	0
TOTAL	707.5	1428.1	384.6	109.2	813.6	3443
PERCENTAGE	21	41	11	3	24	100

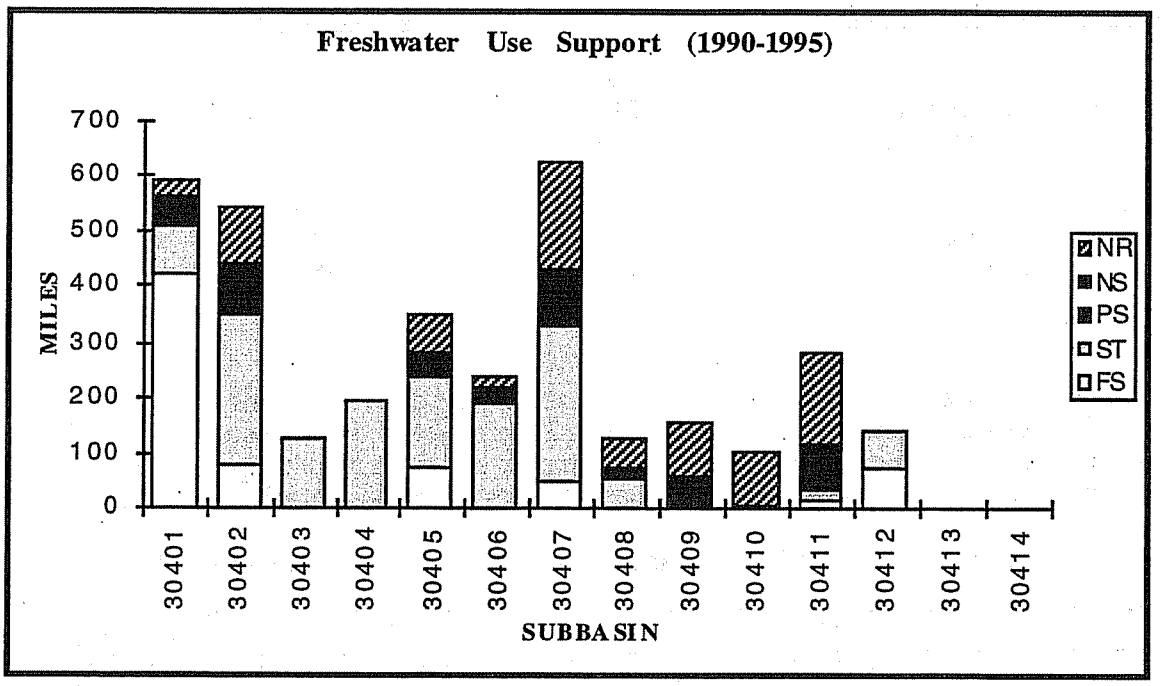


Figure 3.5 Graph Showing Distribution of Use Support Ratings by Subbasin

Table 3.4 Monitored Freshwater Streams in the Neuse River Basin (Sheet 1 of 4)

Name of Stream	Station Number	Station Location	Class	Index #	Sub-bas.	Miles	Chem. Rating 91-95	<----Benthic----> Bioclassification 91	92	93	94	95	Fish 91-95	Problem Para-meters	Overall Use Support Rating	Basis	Pot. Sources (P,NP)
Eno R		Eno R. at SR-1336, Or. Co.	WS II NSW	27-2-(1)	01	2		G-F				G-F			ST	M	NP
Eno R		Eno R. at 1st US 70 Byp brdg, Or. Co.	WS II NSW CA	27-2-(3.5)	01	3.4									ST	ME	NP
Sevenmile Cr		Sevenmile Cr at SR-1120, Or. Co.	WS II NSW	27-2-6-(0.5)	01	7		G-F				G			S	M	
Eno R		Eno R. at Hwy 86; ab WWTP; bel WWTP, Or.	C NSW	27-2-(7)	01	6.5					G-F				ST	M	NP
Sevenmile Cr			WS II NSW CA	27-2-6-(1.5)	01	0.5									S	ME	
Eno R		Eno R. 2nd US 70-Byp brdg; at Cabes Fd, Or. Co.	WS-IV&B NSW	27-2-(10)	01	16.4		E				E			S	M	
Eno R	2085070	Eno R. nr Dur., US Hwy 15/501, Dur Co.	WS-IV NSW	27-2-(19)	01	1.5	S					G			S	M	NP
Eno R			WS-IV NSW CA	27-2-(19.3)	01	0.5									S	ME	NP
Eno R	2085079	Eno R. at SR-1004, Dur. Co.	WS-IV NSW	27-2-(19.5)	01	4.3	S	G				G			S	M	NP
Eno R			WS-IV NSW CA	27-2-(20.5)	01	0.6									S	ME	NP
Little R			WS-II NSW	27-2-21-(1)	01	2.3									S	ME	NP
S. Fork Little R		S Fk Lit. R; SR 1538, Or.	WS-II NSW	27-2-21-2	01	18.9						G			S	M	
N. Fork Little R		N. Fork Lit. R. at SR 1519, Or. Co.	WS-II NSW	27-2-21-3a	01	6.5						F			PS	M	NP
N. Fork Little R		N. Fork Lit. R. at SR 1538, Or. Co, & SR-1461, Dur.	WS-II NSW	27-2-21-3b	01	12		G				G			S	M	
Little R	2.1E+07	Lit. R. SR 1461, Dur.	WS-II NSW	27-2-21-(3.5)	01	4.6	S	E				G			S	M	NP
Mountain Cr		Mountain Cr. SR 1466 & SR 1464, Dur. Co.	WS-II NSW	27-2-21-4-(1)	01	5					G-F				ST	M	
Mountain Cr			WS-II NSW CA	27-2-21-4-(2)	01	2									ST	ME	
Flat R (L. Michie)	2085477	Flat R. nr Quail Roost, SR 1737 & SR-1614, Dur. Co	WS-III NSW	27-3-(1)	01	9.5	S	E		G/E		G			S	M	NP
N. Flat R		N. Flat R. at SR 1144 & 1715, Per. Co.	WS-III NSW	27-3-2	01	12.7		G		G					S	M	P,NP
S. Flat R		South Flat R. at Hwy 157 & SR 1125, Per. Co.	WS-III NSW	27-3-3b	01	15.5				G					S	M	
Deep Cr		Deep Cr at SR 1717, 1715, 1734 Per. Co.	WS-III NSW	27-3-4	01	16.4				G		G			S	M	
Flat R	2086501	Flat R. nr Willardsville, SR-1622 & SR 1004 Dur. Co	WS-IV NSW	27-3-(8)	01	2.8						F		DO	PS	M	NP
Knap of Reeds Cr	2086624	Knap of Reeds Cr.: '85 SR 1004, '94 ab WWTP,	WS-IV NSW	27-4-(6)	01	6	ST	F			F				PS	M	NP
		'94 100m bel WWTP'87 recov site, Granville Co.															
Knap of Reeds Cr			WS-IV NSW CA	27-4-(8)	01	0.8									PS	ME	NP
Ellerbe Cr			C NSW	27-5-(0.3)	01	5.8									NS	ME	NP
Ellerbe Cr	2086849	Ellerbe Cr nr Dur., SR-1636/1709, Dur. Co.	WS-IV NSW	27-5-(0.7)	01	5.9	ST	P				P	F		NS	M	NP
Ellerbe Cr			WS-IV NSW CA	27-5-(2)	01	0.5									NS	ME	NP,P
Little Lick Cr	2.1E+08	Lit. Lick Cr at SR-1815 ab WWTP Dur. Co.	WS-IV NSW	27-9-(0.5)	01	6.5	PS	F/P				P		DO	NS	M	NP
Little Lick Cr			WS-IV NSW CA	27-9-(2)	01	0.5									NS	ME	NP
Lick Cr		Lick Cr at SR-1905, Dur. Co.	WS-IV NSW	27-11-(0.5)	01	9.9						F		Sed	PS	M	NP
Smith Cr			C NSW	27-12-2-(1)	01	3.2									S	ME	
Smith Cr		Smith Cr at SR-1710, Granville Co.	WS-IV NSW	27-12-2-(2)	01	4.9		G-F	G			G	G		S	M	
Smith Cr			WS-IV NSW CA	27-12-2-(3)	01	0.4									S	ME	
New Light Cr		New Light Cr at SR-1912, Wk. Co.	WS-IV NSW	27-13-(0.1)	01	8						G-F	F		PS	M	NP
New Light Cr			WS-IV NSW CA	27-13-(2)	01	0.6									PS	ME	NP
Upper Barton Cr		Upper Barton Cr at Hwy 50, Wk. Co	WS-IV NSW	27-15-(1)	01	5		G				G	G		S	M	
Upper Barton Cr			WS-IV NSW CA	27-15-(2)	01	0.7									S	ME	

Table 3.4 Monitored Freshwater Streams in the Neuse River Basin (Sheet 2 of 4)

Name of Stream	Station Number	Station Location	Class	Index #	Sub-bas.	Miles	Chem. Rating	<----Benthic----> Bioclassification					Fish	Problem Para-meters	Overall Use Support Rating	Basis	Pot. Sources (P,NP)
							91-95	91	92	93	94	95	91-95				
Lower Barton Cr		Lower Barton Cr SR 1844, Wk. Co	WS-IV NSW	27-16-(1)	01	6.8						G-F			ST	M	P
Lower Barton Cr			WS-IV NSW CA	27-16-(2)	01	0.6									ST	ME	P
Horse Cr			C NSW	27-17-(0.3)	01	2.8									S	ME	NP
Horse Cr		Horse Cr SR 1923, Wk. Co.	WS-IV NSW	27-17-(0.7)	01	5.8						G			S	M	NP
Horse Cr			WS-IV NSW CA	27-17-(2)	01	0.6									S	ME	NP
NEUSE R	2087183	Amb. = Neuse R. nr Falls,	C NSW	27-(20.7)	01	26.1	S	G-F				G-F/G			ST	M	NP, P
		Benthic = Neuse R. US 401 & US 64Wk.						G-F									
Richland Cr		Richland Cr at US 1, Wk. Co.	C NSW	27-21	02	8.6		G-F			G-F	G-F			ST	M	NP
Smith Cr		Smith Cr, SR 2049, 2044, & 2045 Wk.	C NSW	27-23-(2)	02	5.6						G-F	F		ST	M	NP
Toms Cr (Mill Cr)		Toms Cr at SR-2044, Wk. Co.	C NSW	27-24	02	4		G				F			PS	M	P,NP
Perry Cr		(Greshams L.)	B NSW	27-25-(1)	02	3.6									PS	ME	P,NP
Perry Cr		Perry Cr., SR 2006, Wk.	C NSW	27-25-(2)	02	2.3						F			PS	M	P,NP
Crabtree Cr		Crabtree Cr atNC 54, be Moorisville WWTP Wk. Co.	C NSW	27-33-(1)	02	5.8		F				P			NS	M	NP
Crabtree Cr		Crabtree Cr ab Cary WWTP, Wk. Co.	B NSW	27-33-(3.5)a	02	0.2					P			Sed	NS	M	NP
Crabtree Cr	2087251	Crabtree Cr I-40, Umstead Pk, Amb at 1795, Wk. C	B NSW	27-33-(3.5)b	02	5	PS				F	G-F		DO,Turb	PS	M	NP
Black Cr		Black Cr, Weston Pkwy, Wk.	C NSW	27-33-5	02	3.6					F				PS	M	NP
Sycamore Cr		Sycamore Cr SR 1649, Wk. Co.	B NSW	27-33-9	02	9.4		G-F						Sed	ST	M	NP
Crabtree Cr		Crabtree Cr at 1649, Wk. Co.	C NSW	27-33-(10)a	02	8.6		F			F				PS	M	NP
Crabtree Cr	2087323	Crabtree Cr at US 1, Fish at 70/401 Wk. Co.	C NSW	27-33-(10)b	02	7.2	PS					G-F	G-Exc	Fecal, Turb	ST	M	NP
Richlands Cr		Richland Cr a, SR-1649, Fish at US1Wk. Co.	C NSW	27-33-11	02	5.4		F					G		ST	M	
Hare Snipe Cr			B NSW	27-33-12-(1)	02	2.9									PS	ME	NP
Hare Snipe Cr		Hare Snipe, NC 70, Wk. Co.	C NSW	27-33-12-(2)	02	2.5						F			PS	M	NP
Mine Cr		Mine Cr, 1 mile ab L. Shelley, Wk. Co.	C NSW	27-33-14a	02	3.3						F			PS	M	NP
Mine Cr		Mine Cr, bel L. Shelley, Wk., Co.	C NSW	27-33-14b	02	1.5						P			NS	M	NP
Pigeon House Br	2.1E+08	Pigeon House Br at Raleigh, Dortch Street, Wk. Co.	C NSW	27-33-18	02	2.9	PS					P		Fecal,DO	NS	M	NP
Marsh Cr		Marsh Cr. nr US 1, Wk. Co.	C NSW	27-33-20	02	6.4						F		Sed	PS	M	NP
Walnut Cr			C NSW	27-34-(1.7)	02	1.3		G (fish)					F-95		PS	M	
Walnut Cr		Walnut Cr. at SR 1700, Wk. Co.	C NSW	27-34-(4)a	02	7.2					P			Sed	NS	M	NP
Walnut Cr		Walnut Cr. at SR 2544, SR 2551, Wk. Co.	C NSW	27-34-(4)b	02	3.4		F			F	F		Sed	PS	M	NP
NEUSE R		Neuse R. nr Clayton, NC Hwy 42	WS-V NSW	27-(36)	02	5.8									ST	ME	
Marks Cr (L. Myra)		Marks Cr at SR-1714, Johns. Co.	C NSW	27-38	02	11.7		G-F				G-F	F-G		ST	M	
NEUSE R	2087500	Neuse R. nr Clayton, NC Hwy 42	WS-IV NSW	27-(38.5)	02	14	ST	G				G		Fecal	ST	M	
NEUSE R			WS-IV NSW CA	27-(41.3)	02	0.7									ST	ME	NP
NEUSE R	2087570	Neuse R. at Smithfield, Johns. Co.	WS-V NSW	27-(41.7)	02	27.1	ST								ST	M	
Swift Cr		Swift Cr. at Old Raleight Rd, US1, Wk. Co.	WS-III NSW	27-43-(1)a	02	2.2		F				P		Sed	NS	M	NP
Swift Cr		Swift Cr at Holly Springs Rd.	WS-III NSW	27-43-(1)b	02	7						F	F	Sed	PS	M	NP
Swift Cr	2.1E+08	Swift Cr nr Clayton NC Hwy 42 & SR 1525, Johns.	C NSW	27-43-(8)a	02	26.9	S	F				G-F	F		ST	M	NP,P
Swift Cr		Swift Cr at SR-1501, Johns. Co.	C NSW	27-43-(8)b	02	5.4		G				G			S	M	

Table 3.4 Monitored Freshwater Streams in the Neuse River Basin (Sheet 3 of 4)

Name of Stream	Station Number	Station Location	Class	Index #	Sub-bas.	Miles	Chem. Rating 91-95	<----Benthic----> Bioclassification 91	92	93	94	95	Fish 91-95	Problem Para-meters	Overall Use Support Rating	Basis	Pot. Sources (P,NP)
Little Cr		Lit. Cr at SR-1562, Johns. Co.	C NSW	27-43-12	02	12		G-F				F		Sed	PS	M	NP
NEUSE R		Neuse R. at SR 1201, Johns. Co.	WS-IV NSW	27-(49.5)	02	25.8		G				G			S	M	
Middle Cr	2088000	Middle Cr, SR 1375 Wk., nr Clayton-NC50 Johns.,	C NSW	27-43-15-(4)	03	50	S	G-F				G-F/G-F	G-Ex		ST	M	P,NP
		Fish at SR 1404, NC 50, SR 1504						G-F									
Black Cr		Black Cr at SR-1330, Johns. Co.	C NSW	27-45-(2)	04	26.1		F				F	G		ST	M	
Mill Cr		Mill Cr at SR-1009, Johns. Co.	C NSW	27-52-(1)	04	14.1		G-F				G-F			ST	M	NP
Stone Cr		Stone Cr at SR-1138, Johns. Co.	C NSW	27-52-5	04	11.4						G-F	G		ST	M	
Hannah Cr		Hannah Cr at SR-1009, Johns. Co.	C NSW	27-52-6	04	20.5		F				G-F	G		ST	M	
Mill Cr			WS-IV NSW	27-52-(8.5)	04	2									ST	ME	NP
Thoroughfare Swp			C NSW	27-54-5-(0.3)	12	7.5									ST	ME	
Thoroughfare Swp		Thoroughfare Swp at SR 1120 Wayne Co.	WS-IV NSW	27-54-5-(1.5)	12	5.1							F-G		ST	M	
NEUSE R			WS-IV NSW CA	27-(55.5)	12	0.5									S	ME	
Little R		Lit. R. Off Nc 96, at Hwy 96, & SR 2224, Wk. Co.	WS-II NSW	27-57-(1)	06	16.4		G-F				G-F	G		ST	M	NP
Little R			WS-II NSW CA	27-(57.5)	06	0.5									ST	ME	NP
Little R	2088500	Lit. R. at SR-1722; Amb at SR 2320, Johns. Co.	WS-V NSW	27-57-(8.5)	06	44.1	S	G-F,G				G-F	G-Exc		ST	M	NP
Buffalo Cr		Buffalo Cr at SR-1007, Wk. Co.	B NSW	27-57-16-(2)	06	5.6		P						Sed	NS	M	NP
Buffalo Cr		Buffalo Cr at SR-1941 (L. Wend.), Johns. Co.	C NSW	27-57-16-(3)	06	20.9		F						Sed	PS	M	NP
Mill Cr		Mill Cr off SR 1390 ab/bel Kenly WWTP, Johns. Co.	C NSW	27-57-18	06	1.2		P							PS	M	NP
Little R		Lit. R. NC 581, Wayne	WS-IV NSW	27-57-(20.2)	06	20.5		G				G-F			ST	M	NP
Little R		Lit. R. off SR 1362, Wayne	WS-IV NSW CA	27-57-(21.1)	06	0.8					G-F				ST	M	
Little R		Lit. R. ab US 70, and at US 70, Wayne	C NSW	27-57-(21.2)	06	1.1					G/G-F				ST	M	
Little R			B NSW	27-57-(21.4)	06	1									ST	ME	NP
Little R			C NSW	27-57-(22)	06	2.2								Sed	ST	ME	
NEUSE R	2089000	Benthos at NC 117 and SR 1915	C NSW	27-(56)	05	65.6	S,S	G				G-F			ST	M	NP
	2089500	Amb at SR 1915 and NC 11 byp. at Kins., Wyn Co.															
Stony Cr		Stony Cr, SR 1920, Wayne	C NSW	27-62	05	10.2						P	F		NS	M	NP
Bear Cr		Bear Cr at SR-1311, Lnr. Co.	C Sw NSW	27-72	05	15.8		G-F				F		Sed	PS	M	NP
Falling Cr		Falling Cr at SR-1340, Lnr. Co.	C Sw NSW	27-77	05	13.9		G-F				G-F	E	Sed	ST	M	NP,P
S.west Cr (Kellys		Southwest Cr at SR-1804, Lnr. Co.	C Sw NSW	27-80	05	21.8		F				F	F-G		PS	M	NP
Stonyton Cr		Stonyton Cr at SR 1742, Lnr. co	C Sw NSW	27-81	05	11.1				Swp			F-93		ST	M	
Briery Run		Briery Run SR 1732, Lnr. Co	C Sw NSW	27-81-1	05	7.5				Swp			F-93		ST	M	
Mosley Cr		Mosley Cr at SR-1475, Cra. Co.	C Sw NSW	27-84	05	10.5							F-G		ST	M	
Contentnea Cr	2090380	Contentnea Cr nr Lucama (Buck Re.), Wil. Co.	WS-V NSW	27-86-(1)	07	9.1	PS							Sed, DO	PS	M	NP
Moccasin Cr		Moccasin Cr at SR-1131 & Hwy 231	C NSW	27-86-2	07	23.5		G-F				G-F	-G/91, G/9	Sed	ST	M	NP
		Fish at SR 1001, NC 231,Nash Co.															
Little Cr (W. Side)		Lit. Cr at Hwy 97, Nash Co.	C NSW	27-86-2-4	07	4.5		P							NS	M	NP
Turkey Cr		Turkey Cr at SR-1128, Wil. Co.	C NSW	27-86-3-(1)	07	22.5		G-F				G-F		Sed	ST	M	NP

Table 3.4 Monitored Freshwater Streams in the Neuse River Basin (Sheet 4 of 4)

Name of Stream	Station Number	Station Location	Class	Index #	Sub-bas.	Miles	Chem. Rating 91-95	<----Benthic----> Bioclassification 91	92	93	94	95	Fish 91-95	Problem Para-meters	Overall Use Support Rating	Basis	Pot. Sources (P,NP)
Beaverdam Cr		Beaverdam Cr at SR-1111/SR-1112, Nash Co.	C NSW	27-86-3-8	07	5.7		F/G-F						Sed	PS	M	NP,P
Contentnea Cr			WS-IV NSW	27-86-(4.5)	07	7.2								Sed	PS	ME	NP
Contentnea Cr		(Buckhorn Reservoir)	WS-IV NSW CA	27-86-(5.8)	07	4								Sed	PS	ME	NP
Contentnea Cr		Contentnea Cr nr Stantonsburg, Hwy 58, Wil. Co.	C Sw NSW	27-86-(7)a	07	18.2		G-F				F		Sed	PS	M	NP, P
Contentnea Cr	2091500	Amb/benthos at SR 1800 Grifton, Pitt Co.	C Sw NSW	27-86-(7)b	07	50.7	PS, PS	G				G-F		Sed,DO,pH	ST	M	NP
	2.1E+08	Amb. at NC 123 Hkrton., Gm Co.															
Hominy Swp		Hominy Sw SR 1606	C Sw NSW	27-86-8	07	10.5							F	Sed	ST	M	
Toisnot Swp		Toisnot Swp SR 1945	WS-III NSW	27-86-11-(1)	07	16.5							G- 91		S	M	
Toisnot Swp		Toisnot Swp at NC 42	WS-III NSW CA	27-86-11-(4.5	07	1							F-91		ST	M	
Toisnot Swp		Toisnot Swp at NC 222, Fish at US 264,& NC 222	C Sw NSW	27-86-11-(5)	07	14		F					G 91& 95		ST	M	
Nahunta Swp		From source to Contentnea Creek	C Sw NSW	27-86-14	07	27.1						F			PS	M	P, NP
Tyson Marsh		Tyson Marsh, US 13/NC 58	C Sw NSW	27-86-17	07	5.7							G		S	M	
Little Content. Cr	2091702	Lit. Content. Cr at SRs 1228 &1125 nr Frnville, Gr.	C Sw NSW	27-86-26	07	27	NS						P-F	DO	PS	M	NP
Sandy Run		Sandy Run US 258/13	C Sw NSW	27-86-26-5-1	07	9.4							F		ST	M	
NEUSE R	2,091,814	Amb. at SR 1470 nr Ft Barnwell, Cra. Co.	C Sw NSW	27-(85)	08	20	S, PS					G-F		DO, pH	ST	M	
	2,091,836	Amb/benthos at SR 1423 nr Streets Fry Cra. Co.															
Core Cr		Core Cr at Hwy 55, Cra. Co.	C Sw NSW	27-90	08	18.5		F				F	G-Exc	Sed	PS	M	NP
Swift Cr		Swift Cr at Hwy 102, Pitt Co.	C Sw NSW	27-97-(0.5)a	09	25.9		F				P	G		NS	M	NP
Swift Cr		Swift Cr SR-1478, & 118 nr Vanceboro, Cra. Co.	C Sw NSW	27-97-(0.5)b	09	10.9		G-F				F		Sed	PS	M	NP
Clayroot Swp		Clayroot Swp at SR-1941, Pitt Co.	C Sw NSW	27-97-5	09	12.6		F				P	G-Exc		NS	M	NP
Creeping Swp	2091970	Amb. on Creeping Swp nr Vanceboro, Hwy 43	C Sw NSW	27-97-5-3	09	6.6	NS						F-91	DO, pH, Chl a	NS	M	NP
		Fish at SR 1800 Cra. Co.															
Trent R	2092500	Trent R. nr Trenton, Hwy 58, fish at SR 1130,Jns. C	C Sw NSW	27-101-(1)	11	71.8	NS					G-F	G	DO	PS	M	NP
Beaverdam Swp		Beaverdam Swp, US Hwy 258, Lnr. Co.	C Sw NSW	27-101-3	11	4.7		F							PS	M	NP
Reedy Br		Reedy Br at Hwy 41, Jns. Co.	C Sw NSW	27-101-7	11	2.8		G-F							ST	M	NP
Lit Chinquapin Br		Lit. Chinquapin Cr at SR-1131, Jns. Co.	C Sw NSW	27-101-11	11	4.4		F					F		PS	M	NP
Beaver Cr		Beaver Cr at SR-1316, Jns. Co.	C Sw NSW	27-101-15	11	8		F							PS	M	NP
Mill Run		Mill Run at Hwy 58, Jns. Co.	C Sw NSW	27-101-23	11	4.2		G							S	M	NP
Island Cr		Island Cr at SR-1004, Jns. Co.	C Sw NSW	27-101-33	11	5.8		G				G	F		S	M	NP

Figure 3.6(a) Use Support Map of the Western Neuse River Basin

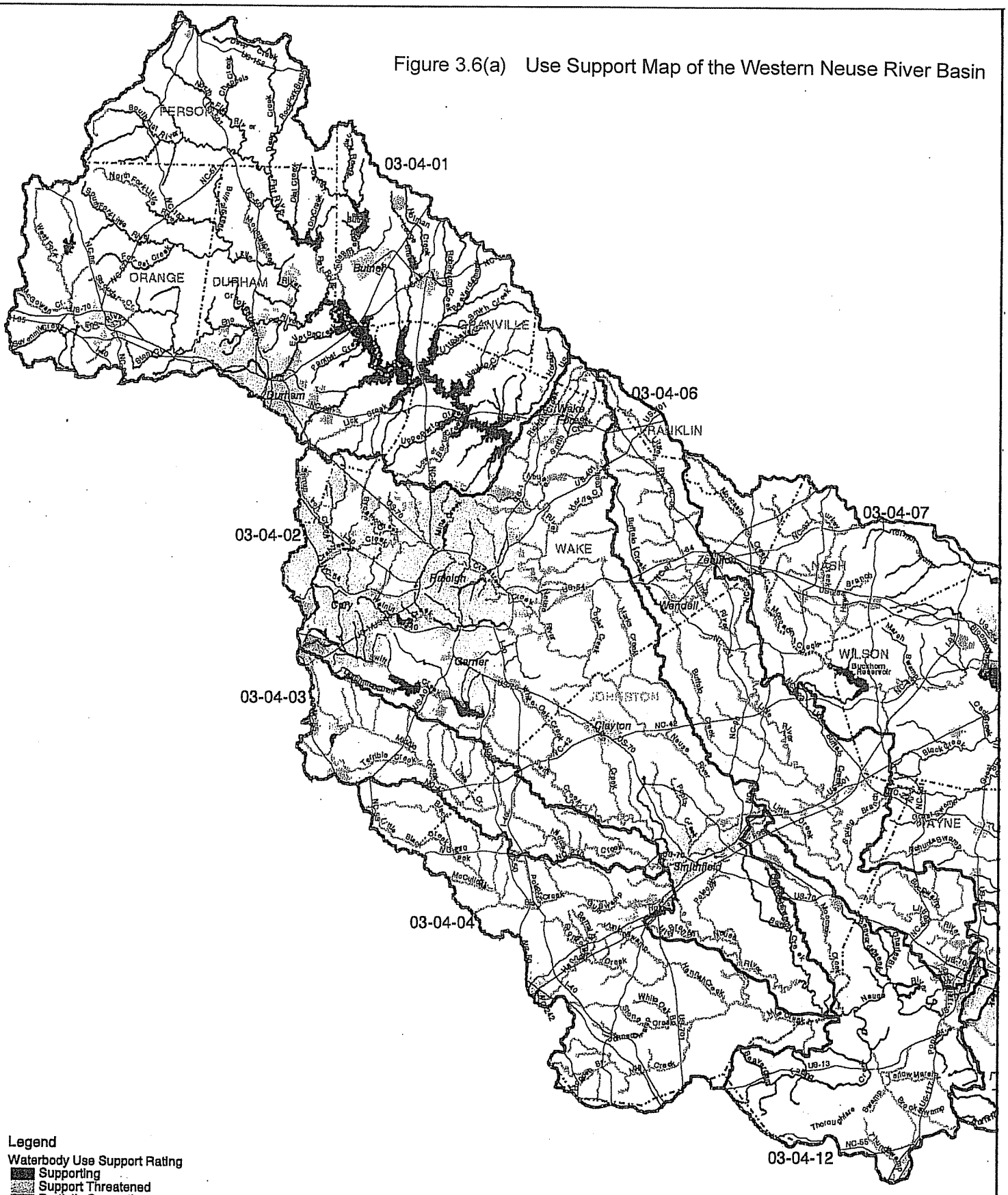
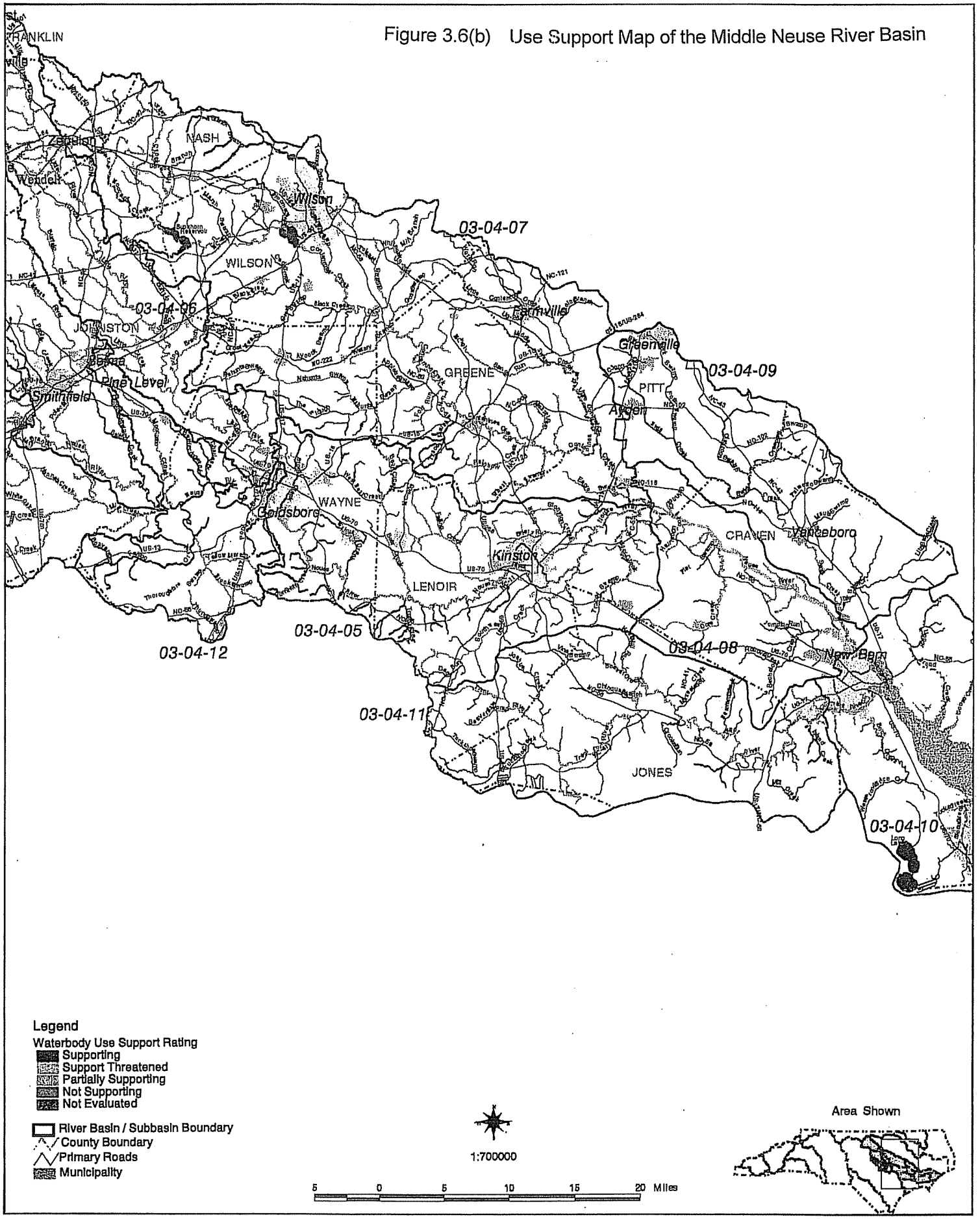


Figure 3.6(b) Use Support Map of the Middle Neuse River Basin



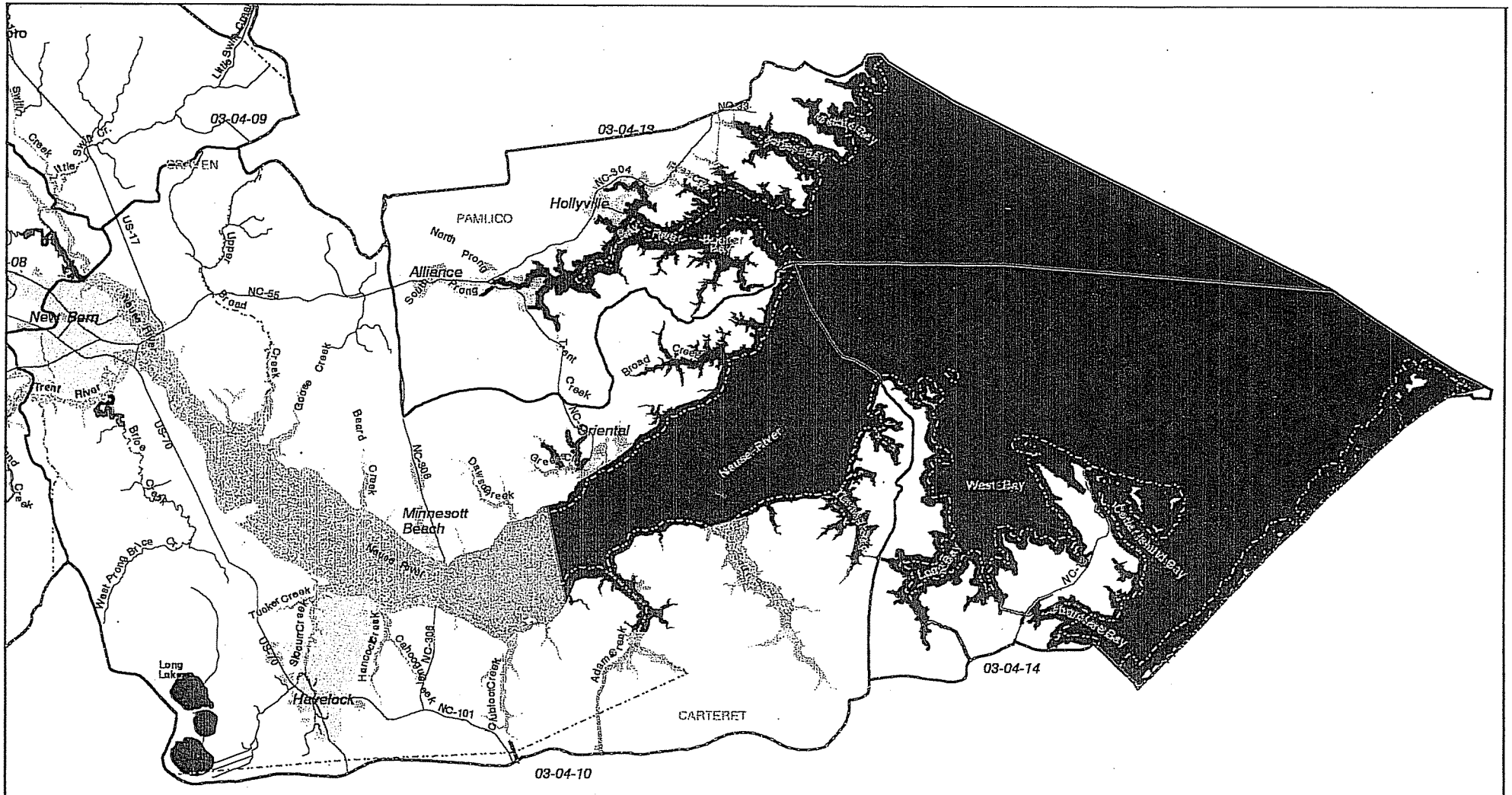


Figure 3.6(c) Use Support Map of the Eastern Neuse River Basin

1993 Versus 1998 Use Support Data

A direct comparison between the overall use support figures between the two basin plans can be misleading. It appears, at first, that water quality has improved substantially. The reason for this is that the use support methodology has changed significantly from 1993 to 1998, particularly in regard to use of evaluated data. Much of evaluated data relied upon in the 1993 basin plan was not used for the 1998 plan because it was considered outdated. A more meaningful apples-to-apples comparison between the two plans can be made by comparing the monitored data. Based on Table 3.5 below, the percentage of streams supporting their uses (FS and ST) has increased slightly (66% vs. 60%) while the number of impaired streams (PS and NS) had decreased slightly (34% vs. 40%). However, in 1998, there is a much higher percentage of fully supporting but threatened streams.

Table 3.5 Comparison Of Use Support Ratings Between the 1993 and 1998 Basin Plans Based on Monitored Stream Data

	FS		ST		PS		NS		Total Miles	
Subbasin	**1993**	**1998**	**1993**	**1998**	**1993**	**1998**	**1993**	**1998**	**1993**	**1998**
030401	111.2	146.1	39.8	52.4	12.3	34.6	28.0	19.2	191.3	252.3
030402	78.7	31.2	72.6	122.4	78.5	65.9	10.1	19.8	239.9	239.3
030403	11.3	0.0	30.9	50.0	0.0	0.0	0.0	0.0	42.2	50.0
030404	1.4	0.0	16.1	74.1	58.0	0.0	0.0	0.0	75.5	74.1
030405	10.5	0.0	72.5	108.6	21.8	37.6	0.0	10.2	104.8	156.4
030406	19.9	0.0	33.2	86.6	20.9	22.1	6.9	5.6	80.9	114.3
030407	54.0	22.2	51.7	131.6	58.6	71.2	21.8	4.5	186.1	229.5
030408	18.6	0.0	1.5	20.0	18.5	18.5	0.0	0.0	38.6	38.5
030409	0.0	0.0	25.0	0.0	31.0	10.9	0.0	45.1	56.0	56.0
*030410	0.0	0.0	0.0	0.0	21.4	0.0	0.0	0.0	21.4	0.0
030411	10.0	10.0	2.8	2.8	49.5	88.9	0.0	0.0	62.3	101.7
030412	5.4	0.5	0.0	12.6	0.0	0.0	7.2	0.0	12.6	13.1
*030413	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
*030414	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	321.0	210.0	346.1	661.1	370.5	349.7	74.0	104.4	1,111.6	1,325.2
PERCENTAGE	29%	16%	31%	50%	33%	26%	7%	8%	100%	100%

* No freshwaters were monitored in subbasins 13 and 14, and only very limited freshwater sampling was done in subbasin 10.

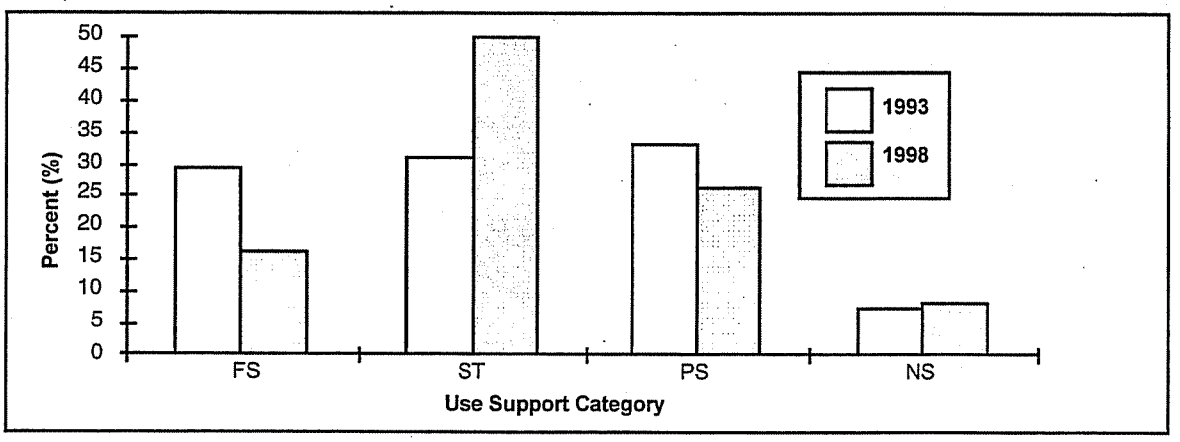


Figure 3.7 Graph Comparing Monitored Use Support Ratings Between 1993 and 1998 for Freshwater Streams

3-C.7 Use Support for Estuarine Waters

Use support determinations were made for 328,700 acres of saltwater in the Neuse River Basin. Approximately 90 percent of the saltwaters were rated as fully supporting. This includes 4.5 percent that are fully supporting but threatened. The remaining 10 percent were rated partially supporting. No waters were rated as not supporting their uses. Table 3.6 presents the use support determinations broken out by Division of Environmental Health (DEH) shellfish areas. It also includes probable causes and sources of use support impairment. A map of DEH areas is shown in Figure 3.8.

Chlorophyll *a* was the most widespread probable cause of impairment followed by fecal coliform bacteria. Chlorophyll *a* is an indicator of algal growth. The high chlorophyll *a* levels are indicative of nuisance algal bloom conditions from time to time in the lower Neuse during the summer. Algal blooms are stimulated, in part by excessive amounts of nutrients, especially nitrogen, reaching the estuary. The acreage of estuarine waters impaired as a result of high chlorophyll *a* concentrations increased by 3900 acres from the 1993 plan.

Elevated levels of fecal coliform bacteria are an indicator of water quality degradation that requires the closure of shellfishing areas. Approximately 3,588 acres of SA waters in the basin have been closed to shellfish harvesting by the DEH Shellfish Sanitation Branch. This is about 1700 acres less than in the 1993 plan.

Nonpoint source pollution is considered to be the primary pollution source in the impaired waters, although point sources also contribute, particularly to the chlorophyll *a* problem. Waters were impacted primarily by multiple nonpoint sources including agriculture, urban nonpoint source pollution, septic tanks and marinas. Atmospheric deposition of nitrogen and nutrients from shallow groundwater sources are also thought to contribute, although specific loadings are yet to be determined.

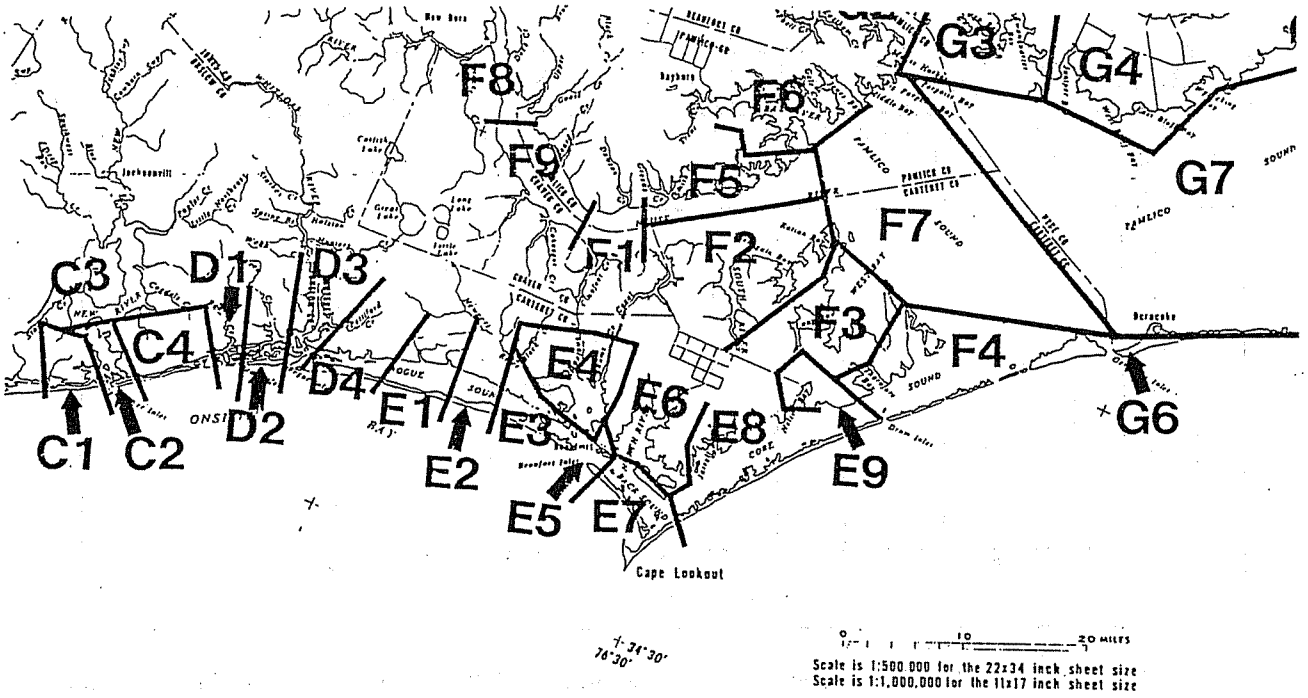


Figure 3.8 Map of DEH Areas in the Neuse River Basin

Table 3.6 Use Support Ratings and Causes and Sources of Pollution for Estuarine Waters in the Neuse River Basin

Area Name	DEH Area	Total Acres	Subbasin	Overall Use Support				Major Causes		Major Sources		Source Descriptions
				S	ST	PS	NS	Fecal	Chl *a*	Point	Non-point	
Neuse River	F1	13,700	10	0	12,800	900	0	900		P	NP	Urban runoff, marinas, ag runoff, WWTP
Merrimon	F2	39,000	10	36,425	1,100	1,475	0	1,475			NP	ag, forestry/wildlife
West Bay	F3	22,000	14	21,988	0	12	0	12			NP	wildlife
Cedar Island	F4	63,000	14	62,987	0	13	0	13			NP	ferry, marina
Oriental	F5	19,000	10	18,149	0	851	0	851		P	NP	Urban, marina, ag., septic, WWTP
Bay River	F6	20,000	13	19,663	0	337	0	337		P	NP	Urban, septic, wildlife, marina, ag (anmls.), WWTP
Open	F7	122,000	13 & 14	122,000	0	0	0			n/a	n/a	
Neuse River	F8	10,500	10	0	1,050	9,450	0		9,450	P	NP	Urban runoff, ag (crop/animals), WWTP, atmos.
Neuse River	F9	19,500	10	0	0	19,500	0		19,500	P	NP	Urban runoff, ag (crop/animals), WWTP, atmos.
Totals		328,700		281,212	14,950	32,538	0	3,588	28,950			
Percent (%)				85.6	4.5	9.9	0.0	1.1	8.8			

Notes:

1) **DEH Area** is a shellfish management area monitored by the Division of Environmental Health's (DEH) Shellfish Sanitation Branch
2) **Subbasins** indicates which subbasin(s) each DEH area is located. The subbasins are identified by their last two digits (e.g. subbasin 03-04-10 = 10). DEH area F7 is split between subbasins 13 (about 40,000 acres) and 14 (about 82,000 acres)
3) Under **Overall Use Support**: **S** = Supporting, **ST** = Supporting by Threatened, **PS** = Partially Supporting and **NS** = Not Supporting
4) **Major Causes** refers to major causes of pollution for waters rated as NS or PS under Overall Use Support. **Fecal** refers to fecal coliform bacteria (meaning some shellfish areas closed to harvesting because of unacceptably levels of fecal coliform bacteria). Chl a refers to chlorophyl a (an indicator of algal blooms)
5) Major Sources indicates whether causes of pollution are from point sources (**P**) or nonpoint sources (**NP**). **Bold lettering** indicates which source is predominant.
6) **Source Descriptions** lists those specific sources which may be contributing to the impairment. WWTP = wastewater treatment plants and atmos. refers to atmospheric nitrogen (may come from fossil fuel emissions, nitrification of animal wastes or other sources).

3-C.8 Use Support for Lakes

Twenty-four of the 29 lakes assessed during this basinwide cycle were supporting their designated uses (Table 3.7). This compares with 17 of 25 lakes supporting their uses in 1993. Twelve lakes were designated as fully supporting but threatened and five lakes were designated as partially supporting their uses. These five impaired lakes are presented below.

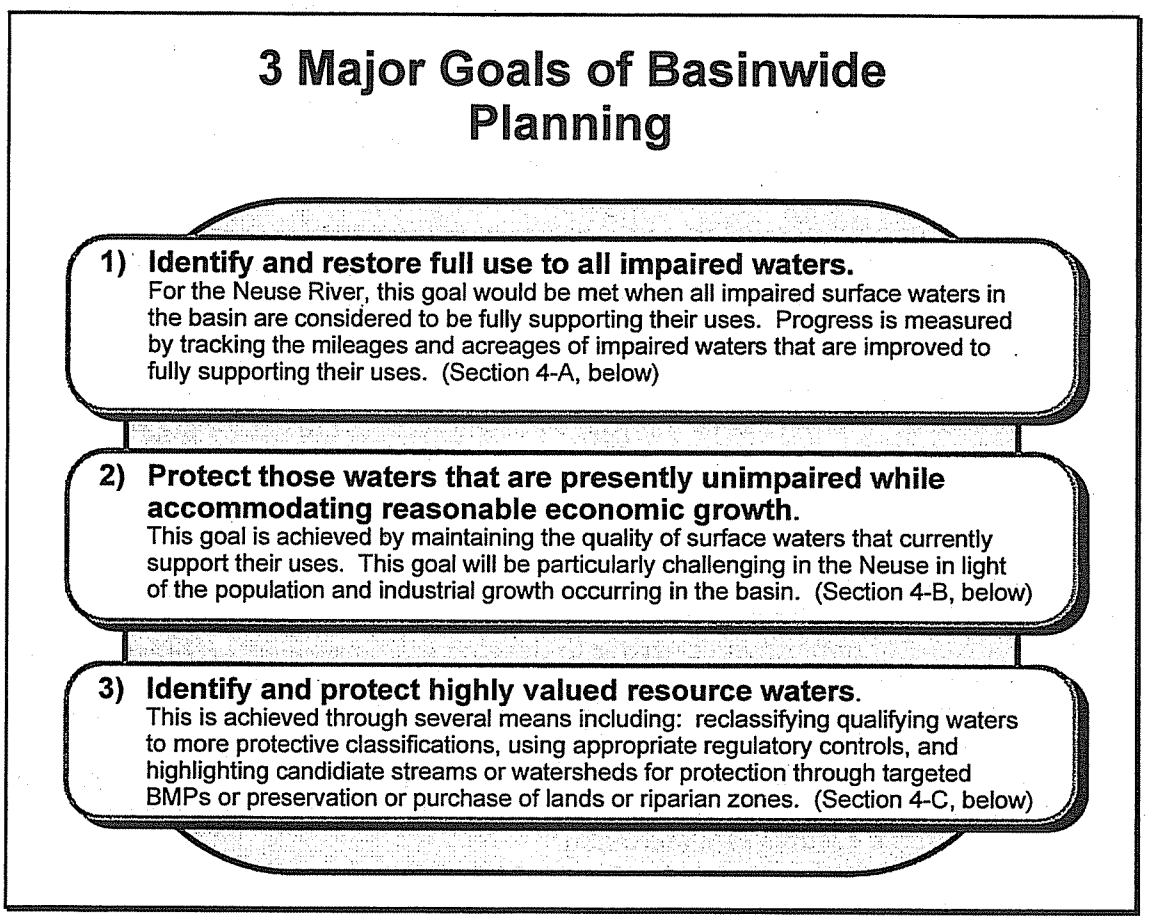
Lake Name	Status	Problem
Big Lake	Partially Supporting	Aquatic Macrophytes
Lake Raleigh	Partially Supporting	Aquatic Macrophytes
Reedy Creek Lake	Partially Supporting	Aquatic Macrophytes
Sycamore Lake	Partially Supporting	Aquatic Macrophytes
Lake Wackena	Partially Supporting	Nuisance Algal Mats

Table 3.7 Lakes Use Support in the Neuse River Basin

LAKE NAME	COUNTY NAME	SUB-BASIN	SIZE (acres)	CLASS	OVERALL USE SUPPORT	Use Support Categories				TROPHIC STATUS	PROBLEM PARAMETERS
						FISH CONSUMP.	AQ. LIFE & SECONDARY CONTACT	SWIM-MING	DRINK-ING WATER		
LAKE MICHIE	DURHAM	01	480	WS-NSW	S	S	S	n/a	S	EUTROPHIC	
LITTLE RIVER RESERVOIR	DURHAM	01	530	WS-CA-NSW	S(PTC)	S	S	n/a	S	EUTROPHIC	
LAKE BUTNER (LAKE HOLT)	GRANVILLE	01	374	WS-NSW	S	S	S	n/a	S	MESOTROPHIC	
LAKE ROGERS	GRANVILLE	01	140	WS-CA-NSW	T	S	S	n/a	S	EUTROPHIC	NOX AQ WEEDS,NUTRIENTS,SALINITY/TDS/CHLORIDES(140)
CORPORATION LAKE	ORANGE	01	28	WS-CA-NSW	S	S	S	n/a	S	MESOTROPHIC	
LAKE BEN JOHNSON	ORANGE	01	30	WS-CA-NSW	T	S	S	n/a	S	EUTROPHIC	
LAKE ORANGE	ORANGE	01	155	WS-NSW	S(PTC)	S	S	n/a	S	EUTROPHIC	
FALLS OF THE NEUSE RES.	WAKE	01	12490	WS,B-NSW-CA	T	S	S	S	S	EUTROPHIC	
APEX RESERVOIR	WAKE	02	75	WS-NSW	S(PTC)	S	S	n/a	S	EUTROPHIC	
BIG LAKE	WAKE	02	62	B-NSW	PS	S	PS	S	n/a	EUTROPHIC	NOX AQ PLANTS (62)
LAKE BENSON	WAKE	02	440	WS-CA-NSW	S(PTC)	S	S	n/a	S	EUTROPHIC	NOX AQ PLANTS (440)
LAKE CRABTREE	WAKE	02	500	B-NSW	T	S	S	S	n/a	EUTROPHIC	NUTRIENTS (500),SILTATION (500)
LAKE JOHNSON	WAKE	02	174	B-NSW	S	S	S	S	S	EUTROPHIC	
LAKE RALEIGH	WAKE	02	90	B-NSW	PS	S	PS	S	n/a	EUTROPHIC	SILTATION (90)
LAKE WHEELER	WAKE	02	550	WS-NSW	S	S	S	n/a	S	EUTROPHIC	
REEDY CREEK LAKE	WAKE	02	20	B-NSW	PS	S	PS	S	n/a	EUTROPHIC	NOX AQ PLANTS (20)
SYCAMORE LAKE	WAKE	02	20	B-NSW	PS	S	PS	S	n/a	EUTROPHIC	NOX AQ PLANTS (20)
BASS LAKE	WAKE	03	95	B-NSW	T	S	S	S	n/a	EUTROPHIC	
CLIFFS OF THE NEUSE LAKE	WAYNE	05	10	B-NSW	S	S	S	S	n/a	OLIGOTROPHIC	
LAKE WACKENA	WAYNE	05	165	C-NSW	PS	S	PS	n/a	n/a	EUTROPHIC	NOX AQ PLANTS (165)
HOLTS LAKE	JOHNSTON	06	373	B-NSW	T	S	S	S	n/a	EUTROPHIC	
WENDELL LAKE	JOHNSTON	06	100	C-NSW	T	S	S	n/a	n/a	HYPEREUTROPHIC	ORGANIC ENRICHMENT/DO, NUTRIENTS (100)
BUCKHORN RESERVOIR	WILSON	07	750	WS-NSW	T	S	S	n/a	S	EUTROPHIC	NUTRIENTS(750), NOX AQ PLANTS(750)
LAKE WILSON	WILSON	07	81	WS-NSW	T	S	S	n/a	S	EUTROPHIC	
SILVER LAKE	WILSON	07	75	WS-NSW	T	S	S	n/a	S	EUTROPHIC	
TOISNOT RESERVOIR	WILSON	07	10	WS-CA-NSW	T	S	S	n/a	S	EUTROPHIC	
WIGGINS MILL RESERVOIR	WILSON	07	200	WS-CA-NSW	T	S	S	n/a	S	EUTROPHIC	NUTRIENTS (200)
ELLIS LAKE	PAMLICO	10	1342	C-SW-NSW	S	S	S	n/a	n/a	DYSTROPHIC	
LONG LAKE	PAMLICO	10	1116	C-SW-NSW	S	S	S	n/a	n/a	DYSTROPHIC	

Chapter 4:
Goals, Issues and Recommendations

This Chapter outlines the three major goals of this basin plan, identifies priority issues associated with those goals, and presents recommendations to achieve them.



4-A. Goal 1: Restoring Impaired Waters

For the Neuse River, this goal would be met when all impaired surface waters in the basin are considered to be fully supporting their uses. Fully supporting is defined in Section 3-C of Chapter 3 (Section A). It includes the use support categories of Fully Supporting and Fully Supporting but Threatened. Impaired waters, also defined in Chapter 3, are those freshwater streams, lakes and estuarine waters that have a use support rating of Partially Supporting or Not Supporting their uses.

Significant progress has been made toward achieving this goal since passage of the federal Clean Water Act in 1972. However, most of these gains were through improvements at wastewater treatment plants. While there are still improvements to be made at plants to meet increased population demands and keep up with technological advances, most impairment is now the result of nonpoint source pollution.
Table 4.1 lists impaired streams in the basin, highlights probable impairment sources, indicates the 303(d) list priority rating (See Appendix II), and indicates whether the stream has been targeted under the Basinwide Wetland and Riparian Restoration Plan (BWRRP) for the Neuse

River Basin. A more detailed description of these impaired waters is presented in the subbasin descriptions in Section B of this plan.

4-A.1 Restoration Issues

Impaired waters in the Neuse Basin:

- 454 miles of monitored freshwater streams,
- five lakes,
- 2,538 acres of saltwaters

The major sources of freshwater stream impairment appear to include urban nonpoint source pollution, agricultural runoff (crop and animal production), wastewater discharges, and low flows associated with dam releases and possibly irrigation. Several important causes of impairment include sedimentation from construction and agriculture, instream erosion from excessive stormwater flow in urban areas, and oxygen-consuming wastes from wastewater discharges.

The primary causes of pollution in lakes is excessive nutrients that lead to nuisance algae blooms, low dissolved and/or excessive aquatic plant growth. Depending on the location of the lake, nutrients may come from point and/or nonpoint sources.

In the saltwaters, 90 percent of the impairment is estimated to be from nutrient-related problems. These include algae blooms including Pfiesteria, fish kills, and exceedences of chlorophyll *a* and dissolved oxygen standards. Nutrient sources are wide-ranging and include both point sources and nonpoint sources. The remaining ten percent of saltwater impairment is estimated to result from closure of shellfish waters due to elevated levels of fecal coliform bacteria.

There are several major issues associated with restoring impaired waters. The most fundamental is to be able to clearly document that the waters are impaired and to identify the cause(s) and source(s) of impairment in order to develop and implement an effective restoration plan. This requires having adequate monitoring data and sufficient familiarity with the watershed draining to the impaired waterbody to develop a site-specific restoration plan. In many cases, monitoring data and understanding of the watershed is inadequate for development of a restoration plan. Implementation is another important issue which involves having adequate funding, a willing local sponsor or property owner, and/or the authority to require that restoration measures be undertaken.

4-A.2 Recommendations

In recognition of the restoration issues discussed above, the following recommendations are presented.

- **Meet EPA's 303(d) Requirements as an Interim Goal for Restoring All Waters in the Basin**

As stated above, the long-range goal of the basinwide plan is to restore all waters in the basin to full use. As an interim step, North Carolina has committed to meet EPA's 303(d) requirements. The US Environmental Protection Agency (EPA), pursuant to Section 303(d) of the federal Clean Water Act, is requiring all states to develop strategies for the restoration of impaired waters called Total Maximum Daily Loads (TMDLs). Section 303(d) requirements and TMDLs are discussed in Appendix II of this plan. Appendix II also includes a list of all of the impaired waters in the basin for which a TMDL or management strategy must be developed. The Division of Water Quality has committed to develop a TMDL or management strategy for all of those waters on the 303(d) list that received a *high*, *medium* or *low* priority rating within

Table 4.1 Monitored Impaired Freshwater Streams and Selected Management Strategies (Sheet 1 of 2)

Name of Stream	Station Location	Class	Index #	Miles	Probable Sources							Problem Para-meters	Use Supp. Rating	303(d) List Priority	BWRRP Targeted W'shed	Chap. Ref. (Part B)	Comments
					Pt	Urb	Ag	Swp	Dam Rel	Oth	Unk NPS						
Subbasin 01																	
N. Fork Little R	at SR 1519, Or. Co.	WS-II	27-2-21-3a	6.5							■		PS	Monitor		Chapter 1	
Flat R	nr Willardsville, Dur. Co.	WS-IV	27-3-(8)	2.8					■			DO	PS	◍		"	
Knap of Reeds Cr	above WWTP	WS-IV	27-4-(6)	6.0					■				PS	Monitor		"	WQ above WWTP appears impacted by low dam release
Knap of Reeds Cr	below WWTP	WS-IV CA	27-4-(8)	0.8	■				■				PS	Monitor		"	Further WWTP improvements needed
Ellerbe Cr	Ab WWTP @ SR-1636, Dur. Co	C		5.8		■							NS	Monitor	■	"	Poor benthic/Fair fish. Impaired since sampling in 1979.
Ellerbe Cr	Bel WWTP @ SR 1709, Dur. Co.	WS-IV		5.9	■	■							NS	Monitor	■	"	Fish asess. improved from Poor to P-Fair after WWTP imp
Little Lick Cr	at SR-1815 ab WWTP Dur. Co.	WS-IV	27-9-(0.5)	6.5		■						DO	NS	◍	■	"	
Little Lick Cr		WS-IV CA	27-9-(2)	0.5	■	■							NS	Monitor	■	"	
Lick Cr	at SR-1905, Dur. Co.	WS-IV	27-11-(0.5)	9.9		■						Sed	PS	Monitor	■	"	
New Light Cr	at SR-1912, Wk. Co.	WS-IV	27-13-(0.1)	8.0							■		PS	Monitor		"	
New Light Cr		WS-IV CA	27-13-(2)	0.6							■		PS	Monitor		"	
Subbasin 02																	
Toms Cr (Mill Cr)	at SR-2044, Wk. Co.	C	27-24	4.0		■							PS	Monitor		Chapter 2	
Perry Cr	(Greshams L.)	B	27-25-(1)	3.6		■							PS	Monitor		"	
Perry Cr	at SR 2006, Wk.	C	27-25-(2)	2.3		■							PS	Monitor		"	
Crabtree Cr	bel. M'sville WWTP, Wk. Co.	C	27-33-(1)	5.8		■							NS	Monitor	■	"	
Crabtree Cr	ab Cary WWTP, Wk. Co.	B	27-33-(3.5)a	0.2		■			■			Sed	NS	◍	■	"	
Crabtree Cr	I-40, Umstead Pk, Wk. Co.	B	27-33-(3.5)b	5.0		■			■			DO,Turb	PS	◍	■	"	
Black Cr	Weston Pkwy, Wk.	C	27-33-5	3.6		■							PS	Monitor		"	
Crabtree Cr	at 1649, Wk. Co.	C	27-33-(10)a	8.6		■							PS	Monitor	■	"	
Hare Snipe Cr		B	27-33-12-(1)	2.9		■							PS	Monitor	■	"	
Hare Snipe Cr	at NC 70, Wk. Co.	C	27-33-12-(2)	2.5		■			■				PS	Monitor	■	"	
Mine Cr	1 mile ab L. Shelley, Wk. Co.	C	27-33-14a	3.3		■							PS	Monitor	■	"	
Mine Cr	below Shelley L., Wk., Co.	C	27-33-14b	1.5		■			■				NS	Monitor	■	"	
Pigeon House Br	at Raleigh, Dortch Street, Wk. Co.	C	27-33-18	2.9		■						Fecal,DO	NS	◍	■	"	
Marsh Cr	nr US 1, Wk. Co.	C	27-33-20	6.4		■						Sed	PS	○		"	
Walnut Cr		C	27-34-(1.7)	1.3		■							PS	Monitor	■	"	
Walnut Cr	at SR 1700, Wk. Co.	C	27-34-(4)a	7.2		■						Sed	NS	○	■	"	
Walnut Cr	at SR 2544, SR 2551, Wk. Co.	C	27-34-(4)b	3.4		■						Sed	PS	○	■	"	
Swift Cr	at Old Raleight Rd, US1, Wk. Co.	WS-III	27-43-(1)a	2.2		■						Sed	NS	●		"	
Swift Cr	at Holly Springs Rd.	WS-III	27-43-(1)b	7.0		■						Sed	PS	◍		"	
Little Cr	at SR-1562, Johns. Co.	C	27-43-12	12.0		■					■	Sed	PS	◍	■	"	

Table 4.1 Monitored Impaired Freshwater Streams and Selected Management Strategies (Sheet 2 of 2)

Name of Stream	Station Location	Class	Index #	Miles	Probable Sources							Problem Para-meters	Use Supp. Rating	303(d) List Priority	BWRRP Targeted W'shed	Chap. Ref. (Part B)	Comments
					Pt	Urb	Ag	Swp	Dam Rel	Oth	Unk NPS						
Subbasin 06																	
Buffalo Cr	at SR-1007, Wk. Co.	B	27-57-16-(2)	5.6		■						Sed	NS	◍	■	Chapter 6	
Buffalo Cr	at SR-1941 (L. Wend.), Johns. Co.	C	27-57-16-(3)	20.9		■						Sed	PS	◍	■	"	
Mill Cr	ab/bel Kenly WWTP, Johns. Co.	C	27-57-18	1.2		■							PS	Monitor		"	
Subbasin 05																	
Stony Cr	SR 1920, Wayne	C	27-62	10.2		■							NS	Monitor	■	Chapter 5	
Bear Cr	SR-1311, Lnr. Co.	C Sw	27-72	15.8			■					Sed	PS	○	■	"	
Southwest Cr (Kelly	at SR-1804, Lnr. Co.	C Sw	27-80	21.8			■						PS	Monitor	■	"	
Subbasin 07																	
Contentnea Cr	nr Lucama (Buck Re.), Wil. Co.	WS-V	27-86-(1)	9.1			■					Sed, DO	PS	◍		Chapter 7	
Little Cr (W. Side)	at Hwy 97, Nash Co.	C	27-86-2-4	4.5							■		NS	Monitor	■	"	
Beaverdam Cr	at SR-1111/SR-1112, Nash Co.	C	27-86-3-8	5.7	■							Sed	PS	◍		"	
Contentnea Cr		WS-IV	27-86-(4.5)	7.2			■					Sed	PS	Monitor	■	"	
Contentnea Cr	(Wiggins Mill Res.)	WS-IV CA	27-86-(5.8)	4.0			■					Sed	PS	Monitor	■	"	
Contentnea Cr	nr Stantonsburg, Hwy 58, Wil. Co.	C Sw	27-86-(7)a	18.2	■		■					Sed	PS	○	■	"	
Little Content. Cr	nr Frmville, Gr. Co.	C Sw	27-86-26	27.0			■					DO	PS	○	■	"	
Subbasin 08																	
Core Cr	at Hwy 55, Cra. Co.	C Sw	27-90	18.5				■			■	Sed	PS	○		Chapter 8	
Subbasin 09																	
Swift Cr	at Hwy 102, Pitt Co.	C Sw	27-97-(0.5)a	25.9		■	■	■					NS	○	■	Chapter 9	Quality decreased from 1991 to 95.
Swift Cr	Hwy 118 nr Vanceboro, Cra. Co.	C Sw	27-97-(0.5)b	10.9			■	■			■	Sed	PS	Monitor	■	"	
Clayroot Swp	at SR-1941, Pitt Co.	C Sw	27-97-5	12.6				■			■		NS	Monitor	■	"	Impairment related to unspecified nonpoint sources
Creeping Swp	Amb. nr Vance., Hwy 43, Car. Co.	C Sw	27-97-5-3	6.6				■			■	DO, pH, Chl a	NS	◍		"	
Subbasin 11																	
Trent R	nr Trenton, Jones Co.	C Sw	27-101-(1)	71.8			■	■			■	DO	PS	○	■	Chapter 11	
Beaverdam Swp	US Hwy 258, Lnr. Co.	C Sw	27-101-3	4.7				■			■		PS	Monitor	■	"	
Ltl Chinquapin Br	at SR-1131, Jns. Co.	C Sw	27-101-11	4.4				■			■		PS	Monitor		"	
Beaver Cr	at SR-1316, Jns. Co.	C Sw	27-101-15	8.0				■			■		PS	Monitor	■	"	

Legend for Table 4.1

Class: Refers to official surface water classification for the subject stream. Information concerning Classifications and Water Quality Standards is set forth in the North Carolina Administrative Code Section 15A NCAC 2B .0100 and .0200.

- C = Class C. Freshwaters suitable for fishing and swimming.
- B = Class B. Freshwaters suitable for Class C uses and organized or frequent swimming.
- WS-I through IV = Water Supply Classifications. Waters suitable for Class C uses as well as for water supply. WS-I is most protective and WS-IV is least protective.
- CA = Critical area surrounding a WS water.
- SW = Swamp Water. This is a supplemental classification assigned to waters with naturally low dissolved oxygen and low pH.

Index #: A number used to designate specific stream segments in the Schedule of Classifications for the Neuse River Basin.

Miles: Length of the subject stream segment.

Probable Sources: Refers to probable sources of pollution that are contributing to the impairment of the stream.

- **Pt** = Point sources (includes impaired waters where wastewater treatment plant effluent may be a contributing factor to the impairment)
- **Urb** = Urban runoff (refers to waters that appear to be impaired, at least in part, from urban nonpoint source pollution. This can include urban runoff, runoff from industrial sites, illicit discharges from industrial and commercial sites, failing septic systems, leaking sewer mains (public), leaking house sewer laterals (private), sanitary sewer overflows, etc.)
- **Ag** = Agricultural runoff (includes impaired waters where agricultural appears to be a source of impairment)
- **Swp** = Swamp waters (includes waters classified as Swamp waters whose biological ratings may be Poor or Fair and use support ratings may partially or not supporting that appear to be resulting, at least in part, from natural swamp conditions. This results from applying a freshwater biological index that is not well-suited to assessing the biological health of a swamp system.
- **Dam Rel** = Dam release (refers to streams located downstream of reservoirs where water quality problems appear to be related, at least in part to, unnaturally low-flow releases and/or to waters being released with low dissolved oxygen.)
- **Oth** = Other sources (this would be checked if a source other than those listed in the table, were identified. It would then be included in the comments column)
- **Unk NPS** = Unknown NPS

Problem Parameters: Water quality measurements of concern

- Chl = Chorophyll *a*. High values can indicate excessive algal growth and nutrient overenrichment
- DO = Dissolved Oxygen. Problems occur when DO levels are too low for aquatic life. Low DO occurs naturally in swamp waters.
- Fecal = Fecal Coliform Bacteria. Bacteria commonly found in warm-blooded animals. Higher levels indicate increased human health risk associated with water contact.
- pH = Indicator or acid/alkaline conditions. Low pH is common in swamp systems.
- Sed = Sediment. High levels adversely affect aquatic life. Can result from poor erosion and sediment control in the watershed or streambank erosion.
- Turb = Turbidity.

Use Support Rating: FS - Fully Supporting, ST - Fully Supporting but Threatened, PS - Partially Supporting, NS - Not Supporting

303(d) List Priority: The ovals under 303(d) list priority mean the following (See Appendix II for additional explanation):

- Black oval = High priority
- Gray oval = Medium priority
- Open oval = Low priority
- Monitor - Additional monitoring needed.

BWRRP: This column refers to the priority watersheds identified in the Basinwide Wetlands and Riparian Plan for the Neuse River (a copy can be obtained from the Wetlands Restoration Program staff in DWQ). A black square indicates that a priority watershed has been identified within the watershed of the impaired water listed in Table 4.1

the next two basin cycles. Based on current EPA guidance, an implementation plan must be included with all TMDLs. For those waters on list that have a priority rating of *monitor*, DWQ has committed to develop a TMDL within two basin cycles after sufficient monitored data has been collected.

- **Implement the Neuse NSW Rules**

The Neuse NSW Rules are summarized in Chapter 5. They have been crafted to meet and maintain a 30 percent reduction in nitrogen levels in the basin. These rules have five components: wastewater discharges, urban stormwater, agriculture, nutrient management and riparian buffers. The state is committed to implementing each of these components of the rules and to achieving the 30 percent reduction.

- **Continue Funding for the Neuse River Modeling and Monitoring (MODMON) Project and Other Water Quality Research in the Neuse Estuary**

In addition to implementing the rules, continued monitoring, modeling and research will be needed to track changes in water quality resulting from implementation of the strategy, to understand how the estuary is responding to these changes, to provide a sound basis for improving the NSW strategy's nutrient reduction goals, and to improve implementation of nutrient reduction strategies.

- **Seek Additional Staff and Resources for DWQ Monitoring**

DWQ has and will continue to seek additional funding for staff and resources to improve its water quality monitoring capabilities. Improved monitoring capabilities are needed throughout the Neuse basin in order to better identify causes and sources of pollution for developing restoration plans, to track water quality trends, and to provide before and after monitoring for implementation of restoration projects. Current biological monitoring is conducted once every five years in the basin. Funding to allow annual monitoring would be a significant and needed improvement.

- **Seek Additional Staff and Resources for Coordinating Local Watershed Restoration Efforts and Implementing the NSW Buffer Rules**

No one group or agency will have the staff and resources to restore impaired waters on its own. However, DWQ can serve a key role of coordinating the formation of small-scale watershed teams or coalitions (made up of state and federal agencies, local governments, property owners, environmental groups, funding organizations and others) for the purposes of developing and implementing local watershed restoration projects. DWQ has proposed establishing such positions in its regional offices. If funded, there would be up to three positions to work on Neuse Basin issues (from the Washington, Wilmington and Raleigh Regional offices). Additional staff are also being sought to assist in implementation of the buffer requirements of the NSW rules.

- **Develop and Implement a Use Restoration Waters (URW) Approach**

DWQ has received approval from the NC Environmental Management Commission to pursue development of a Use Restoration Water Program. This program would include both an incentives component and a regulatory component for assuring implementation of appropriate best management practices for water quality restoration in the watersheds of impaired waters. This approach will be used to assist DWQ in meeting its EPA 303(d) commitments.

- **Restore Water Quality and Aquatic Habitat through Implementation of the Wetlands and Riparian Restoration Program**

The General Assembly passed legislation in 1996 creating the North Carolina Basinwide Wetlands Mitigation Program. This program, which is located in the Division of Water Quality, was provided with nine million dollars to be used for restoring wetlands and riparian zones in watersheds of impaired waters. Program staff have identified priority watershed areas and are now seeking suitable restoration sites in these watersheds.

- **Restore Water Quality Through Target Existing Funding Sources to Impaired Waters**

There are a number of sources of funding available for improving water quality in the Neuse Basin and elsewhere. These include the North Carolina Clean Water Management Trust Fund (CWMTF), the USDA Conservation Reserve Enhancement Program (CREP), Environmental Quality Incentives Program (EQIP), EPA's 319 nonpoint source implementation program, the North Carolina Agricultural Cost Share Program and others. To the extent possible, these funding sources should target expenditures to watersheds and riparian zones of impaired surface waters in the basin. DWQ has and will continue to work with the funding agencies to support this recommendation.

4-B. Goal 2: Protect the Quality of Surface Waters That Are Currently Supporting Their Uses

This goal is achieved by maintaining the quality of surface waters that currently support their uses. This goal would be a reasonably easy to achieve and maintain if conditions in the river basin remain unchanged. However, population and industrial growth and attendant changes in the landscape can increase both point and nonpoint source pollution as noted below.

4-B.1 Priority Growth Management Issues

- **Population Growth Impacts on Water Quality**

The population of the Neuse River Basin, which is currently about 1.2 million people, is estimated to increase by 35 percent to 1.6 million by 2020 (See Section 2-D, Chapter 2, Section A). This would represent an approximate 100 percent increase over the 50-year period from 1970. As the population increases, there are a number of secondary and cumulative environmental effects likely to occur that will adversely impact water quality if not adequately mitigated.

Urban land cover - As population increases, so does the amount of urban land area. Statistics presented in Section 2-C of Chapter 2 (Section A) showed a 76% increase in urban land area from 1982 to 1992. This change in land cover appears to be happening at the expense of forest and cultivated croplands. Urban land includes roads, parking lots, houses, shopping centers, schools, driveways and other impervious surfaces. Stormwater flows much more rapidly from impervious land than from agricultural or forestland and causes scouring, erosion and reduced aquatic habitat quality in receiving streams. In addition, there is less ground water recharge, and thus small streams in urban areas may have much reduced flows during dry summer periods than their counterparts with forested watersheds.

↑ **Urban stormwater runoff** - In addition to the increased flow of stormwater from urban lands, stormwater contains a wide array of pollutants that adversely affect aquatic life and can render water unsuitable for swimming and other recreation. Urban runoff can include automobile residues (oil, grease, abraded tire material, etc.), yard fertilizer and pesticides, animal wastes and other pollutants.

↓ **Forestland** - Forested land is an ideal natural land cover for the protection of surface water quality. Forests slow the flow of water, and their root systems absorb nutrients and hold the soil. Rainwater soaks into forest soils and recharges the groundwater which provides the baseflow for streams. According to land cover data presented in Chapter 2, the acreage of forestland decreased by almost seven percent from 1982 to 1992. Minimizing forest clearing and utilizing forested land as buffers along waterways to filter pollutants and absorb nutrients is strongly recommended and a key component of the nutrient sensitive waters strategy for the basin (See Section 5-1, Chapter 5, Section A).

↓ **Cultivated cropland runoff** - Significant acreages of cropland are being converted to roads and other urban uses. Reduced cropland acreages combined with improved erosion control techniques including no-till farming is reducing the pollution contribution from cropland in the Neuse basin.

↑ **Erosion and Sedimentation** - Erosion at construction sites is a significant source of sedimentation in streams and rivers. Even the best sediment control measures are only about seventy percent effective, and they could be much worse depending on how well the measures were designed, installed and maintained.

↑ **Water supply needs** - As the population increases, so will the need for water. As more water is used, more wastewater is generated. Also, as water is removed from a stream or river for water supply purposes, the reduced flow can result in the reduction of the assimilative capacity of the waterbody for accepting effluent from wastewater treatment plant. Water supplies in the upper basin come from a combination of surface water impoundments and wells in the upper and middle basin. The lower basin is served almost exclusively by wells. Major aquifer levels are currently dropping and further increases in use will cause continued reduction.

↑ **Wastewater Treatment and Disposal** - As more people live and work in the basin, more wastewater will continue to be generated. Treatment and disposal of this wastewater will be accomplished either by enlarging or creating more wastewater treatment plants or by constructing more on-site wastewater systems such as septic systems. Because the basin's surface waters have a limited capacity to assimilate wastewater, the level of treatment at wastewater treatments will need to continue to improve in order to hold the line on the amount of pollutants leaving the plants as the flow of wastewater to them increases. Also, while on-site wastewater systems can provide a very effective means of disposing and treating wastewater from individual homes or communities, they can also pose environmental risks if not properly installed and maintained. Wastewater treatment in the basin is split roughly in half between municipal wastewater systems and septic tanks.

- **Swine Industry Growth**

The swine population in the Neuse River Basin increased by almost 260 percent in the Neuse Basin from about 555,000 animals in 1990 to over 1.7 million in 1998. The General Assembly has imposed a moratorium on swine industry growth in the state until October 1999. While the effects of the swine operations on water quality in the basin are not well understood, there are concerns about the long-term cumulative effects of these operations on water quality.

Continued research is needed on nutrient loadings from spray field runoff, atmospheric deposition and groundwater (under lagoons and spray fields).

4-B.2 Recommendations for Protecting Water Quality

- **Reduce Urban Point and Nonpoint Source Pollution**

Several keys to reduce pollution and stream erosion from urban areas include minimizing impervious surfaces to slow runoff, promoting filtration and infiltration of the water before it reaches a creek or storm drain inlet, keeping pollutants out of the runoff, and encouraging local governments to consider water quality impacts during long-range planning. Local governments should have stormwater ordinances that serve to minimize the impacts of new development on water quality. The stormwater component of the NSW rules that requires local governments to reduce nitrogen loading by 30% should help to reduce pollutant loading from urban areas. To assist local governments in addressing stormwater pollution, the state should consider providing funds for planning and stormwater control technology. One approach would be to include a recommendation in the Governor's next biennial budget for a more significant funding mechanism for local governments to develop and implement already mandated stormwater programs.

- **Continue to Improve the Level of Wastewater Treatment and Address Inflow and Infiltration problems**

Wastewater treatment plants will be required to upgrade treatment in the future in order to assure that water quality standards are not violated as the amount of wastewater increases with a rising population (see Section 4-E. below). Continued improvements in technology should support this recommendation, but treatment costs will likely be higher. Customers should, therefore, expect to pay higher costs for waste treatment in the future. Also, old wastewater collection systems will need to be improved and/or replaced. Municipalities should embark on long-range operation and maintenance programs. This should include allocating funds to replace deteriorating collection systems and cross-connections with stormwater pipes.

- **Promote Water Reuse, Recycling and Conservation to Meet Long-Range Water Supply Needs**

With a growing population and a limited water supply, particularly in the lower portion of the basin, water supply needs are likely to become more acute. DWQ will be working more closely with the Division of Water Resources on coordinating water supply and water quality issues over the next basin cycle. This is being brought about in part by Senate Bill 1229, which requires that future basinwide plans consider the cumulative impacts of all water transfers into and out of a river basin. DWQ will also be pursuing water supply management options for addressing dropping aquifer levels in the lower portion of the basin. One of these options will need to be the reuse of highly treated wastewater effluent for irrigation and possible industrial water supply purposes.

- **Reduce Erosion and Sedimentation from Development and Support Strengthening of the Sedimentation Control Program**

Erosion and sedimentation are two major causes of stream impairment in the Neuse River basin, particularly in rapidly-developing areas. The Division of Land Resources (DLR) is the agency responsible for administration of the state's sedimentation control law. DLR needs support in its efforts to improve the program by adding more inspectors, strengthening its rules, and

improving enforcement. The program also includes training and education for contractors and others to ensure. (See Chapter 1, Section C for a more complete description of program improvements and activities in the Neuse Basin.). Control of sedimentation and erosion can be greatly enhanced if land owners, contractors and developers assume responsibility for keeping

- **Increase Public Awareness and Participation in Preserving Easements and Property under such Programs as the NC Conservation Tax Credit Program, CWMTF, CREP and Others**

There are now many more programs available for funding water quality protection and restoration efforts. It is important that local governments, state agencies and other qualifying entities put these dollars to good use.

4-C. Goal 3: Identify and Protect Highly Valued Resource Waters

Waters considered to be biologically sensitive or of high resource value may be afforded protection through reclassification to HQW (high quality waters), ORW (outstanding resource waters) or WS (water supply), or they may be protected through more stringent permit conditions. Waters eligible for reclassification to HQW or ORW (see Appendix I) may include those approved for commercial shellfish harvesting (SA), designated primary nursery areas, waters having excellent water quality, or those used for domestic water supply purposes (WS I and II). The HQW, ORW and WS classifications generally require more stringent point and nonpoint source pollution controls than do basic water quality classifications such as C or SC.

In addition, where waters are known to support state or federally listed endangered or threatened species or species of concern, but where water quality is not Excellent and where no critical habitat has been designated, consideration will be given during NPDES permitting to minimize impacts to these habitat areas consistent with the requirements of the federal Endangered Species Act and North Carolina's endangered species statutes. The federally endangered dwarf-wedge mussel (*Alasmidonta heterodon*) is known to occur in subbasins 02, 03, 06 and 07, and most subbasins provide habitat for threatened species or species of concern. Possible protection measures may include dechlorination or alternative disinfection, tertiary or advanced tertiary treatment, outfall relocation, backup power provisions to minimize accidental plant spills, and others. The need for special provisions will be determined on a case-by-case basis during review of individual permit applications and take into account the degree of impact and the costs of protection.

4-D. Other Priority Issues and Recommendations

4-D.1 Increase Public Stakeholder Involvement in Basinwide Planning

Currently there are three formal opportunities for public input into the basinwide planning process for each basin. This includes preplan development workshops, public meetings at the time the draft plan is circulated, and review and comment on the draft plan. These formal opportunities are limited to a large extent by staff limitations (currently there are two basinwide planners to handle all seventeen river basins in the state). However, DWQ is open to meeting with interested groups and individuals at any time during the five-year basin cycle to answer questions and receive recommendations on improving the plans and the process. Plans are underway to create a basinwide website, and DWQ is working with the NC Office of Environmental Education to prepare educational packets on the importance of watersheds.

Resources permitting, DWQ is also striving to prepare shorter summaries of each basin plan for easier, wider distribution and easier consumption of the major points of emphasis in the plans.

4-D.2 Address Secondary/Cumulative Impacts

It was stated earlier that nonpoint source pollution was the most widespread source of water quality impairment in the basin. By and large, nonpoint source pollution results from cumulative impacts of many relatively small actions. A prime example is the Neuse River estuary below New Bern. There is no one activity that is responsible for the water quality problems in this part of the river. It is the cumulative impacts of all of the houses, cities, roads, farms, wastewater discharges and industries within the ridgelines of the basin. So while each structure or alteration of the landscape seems inconsequential in and of itself, together, the impacts are significant.

Declaration of State Environmental Policy

The General Assembly of North Carolina, recognizing the profound influence of man's activity on the natural environment, and desiring in its role as the trustee for future generations, to assure that an environment of high quality be maintained for the health and well-being of all, declares that it shall be the continuing policy of the State of North Carolina to conserve and protect its natural resources and to create and maintain conditions under which man and nature can exist in productive harmony. Further, it shall be the policy of the State to seek for all it citizens, safe, healthful, productive, and aesthetically pleasing surroundings; to attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, and to preserve the important historic and cultural elements of our common inheritance. ***(North Carolina Environmental Policy Act, 1971)***

This phenomenon plays itself out on much smaller waterbodies as well. Almost all urban streams in the basin are impaired. As the development density and degree of imperviousness increases, excessive streamflow and pollution are predictable by-products. Pigeon House Branch in Raleigh is a prime example of an impaired urban stream. Others, like Swift and Middle Creeks that flow from Wake into Johnston County, are at risk of becoming impaired as growth radiates outward from Raleigh into surrounding towns.

The Declaration of State Environmental Policy, above, states that "it shall be the continuing policy of the State of North Carolina to conserve and protect its natural resources and to create and maintain conditions under which man and nature can exist in productive harmony." It is incumbent on state and local agencies in exercising their authorities to issue permits and zone land to consider the long-term and cumulative consequences of their actions such that the balance of human and natural productivity can be maintained.

4-E. NPDES Permitting Recommendations to Protect WQ Standards

Table 4.2 presents the NDPES Permitting strategies that were recommended in the 1993 Neuse Basinwide Plan and which are still applicable today with the following exceptions:

1. The NSW strategy that was in effect at the time of the original plan has been revised significantly. The table now refers to the NSW Wastewater Discharge Requirements set forth in Section 5-C. Chapter 5, below (Section A).

2. Another change to the table from the 1993 plan is that the first sentence of strategy number 4 at the bottom of the table has been revised. The words "of BOD" were inserted. The reason for this is that strategy number 4 applies to streams with little or no waste assimilative capacity for BOD. However, there may be some discharges that have no significant BOD component that may seek a discharge permit. This could include cooling water or water from a groundwater remediation site.

The 1993 Neuse River Basinwide Water Quality Management Plan recommended that a calibrated water quality model be developed for Contentnea Creek (subbasin 07).

Subsequently, the Division of Water Quality developed a study plan to collect data to calibrate a QUAL2E model of the system in consultation with the Environmental Protection Agency (EPA). EPA had provided information on new reaeration sampling methods that may be applicable to swamp systems. Their experience had indicated that QUAL2E reaeration rates are based on formulas driven, in part, by instream velocity, and they under-predict reaeration in swamp systems. In August 1995, EPA and DWQ staff performed the first sampling run on Contentnea Creek that included collecting velocity information and reaeration data.

Prior to collection of the second water quality data set, the Division began using its empirical water quality model to evaluate the effects of the City of Wilson on instream dissolved oxygen with plans to update the default velocity and reaeration rates with those collected during the August 1995 sampling run. The empirical model was initially run with the default modeling rates, and it predicted dissolved oxygen concentrations of 0 mg/l, but these concentrations are not reflected by instream data collected by the Division at its ambient stations or by NPDES dischargers. It was also noted that the default velocity and reaeration rates were higher, or less conservative, than those measured in the field, and inputting the lower rates would result in a longer stream reach with predicted dissolved oxygen concentrations of zero.

These modeling results indicate that the State's empirical desktop model is not an appropriate tool to predict instream dissolved oxygen concentrations in Contentnea Creek. Since QUAL2E is based on the same mathematical equations, it follows that it also is not an appropriate tool to model Contentnea Creek. Therefore, the second water quality study needed for model calibration was canceled since its completion would have wasted state resources.

It is likely that a dynamic model that can look at water quality changes over time is needed in many of our swamp systems. A study to further research swamp systems and develop an appropriate model for Contentnea Creek will be resource intensive, and at this time, developing a site specific water quality model for Contentnea Creek cannot be a Division priority due to a lack of resources. However, development of a model to predict assimilative capacity in Contentnea Creek is a tool that should be pursued as further research into swamp system processes is completed.

Table 4.2 Permit Wasteload Allocation Table for the Neuse River Basin

Below is a list of areas within the Neuse Basin where NPDES limits are governed by other than standard operating procedures, or that have been targeted for further study and management policies. If a stream is not included in this table, standard wasteload allocation procedures will be applied and permit limits will depend on dilution, stream characteristics, water quality characteristics, discharge interaction, waterbody classification, and NC and Federal water quality rules and regulations. NPDES permits in this case will likely be renewed with existing limits unless the facility is being expanded or if new standards must be applied. All NPDES permits in the Neuse Basin will be subject to NSW permitting requirements.

Subbasin	Stream Reach	BOD	Nutrients	Toxics	Nonpoint Mgmt	Comments
02,12,05, 09,10	Neuse Mainstem from Falls Dam to Streets Ferry	1	NSW	WLA	E, WS	Reduce permitted BOD loads to assimilative capacity
02 - 10, 12	Neuse tributaries	2	NSW	WLA	E	BOD allocation plan affects discharges close to mouth of the tributary
01	Flat River (Including North and South)		NSW	WLA	E, WS	
	Lake Michie and UTs	3	3	3	E, WS	Target pt. sources for removal or upgrade to adv. treatment
	Orange Reservoir and UTs	3	3	3	E, WS	
	Eno River from source to Falls Lake	4	5	WS	E, WS, U	Monitor impact of eliminating Durham WWTP
	Knap of Reeds Cr: source to Falls Lake	4	5	WS	E	Monitor impact of Butner WWTP upgrade
	Ellerbe Cr from Source to Falls Lake	4	5	WS	E, U	Monitor impact of Durham WWTP upgrade and expansion
	Lick Creek from source to Falls Lake	4	5	WLA	E	Removal of Durham WWTP should improve stream
	Falls Lake and UTs	3	3	3	E, WS	Eutrophication Model update scheduled for 1998
02	Crabtree Creek above Lassiter Mill Dam	4	NSW	WLA	E, U	BOD/DO Modeling analysis to be extended to the mouth
	Crabtree Creek below Lassiter Mill Dam		NSW	WLA	E, U	
	Swift Creek below Lake Benson Dam	4	NSW	WLA	E, U	Target restoration of DO below Lake Benson
	Perry Creek from source to mouth	1	NSW	WLA	E	Perry Creek Interceptor will remove most discharges
03	Middle Cr: source to Sunset Lake Dam	4	NSW-SP	WLA	E	Monitoring eutrophication in Sunset Lake
	Middle Cr: Sunset Lake Dam to mouth	4	NSW	WLA	E	Establish Cary S., Fuquay-Varina and Apex as regional plants
04	Black Creek	2	NSW	WLA	E	
	Mill Creek	2	NSW	WLA	E	
06	Buffalo Cr: source to Lake Wendell dan	1	5	WLA	E	Wendell WWTP will relocate discharge
	Little River	2	NSW	WLA	E, WS	Permit decisions depend on impact to endangered species
07	Contentnea Creek above Buckhorn Res.		NSW-SP	WLA	E	Additional monitoring needed to determine future BOD limits
	Wiggins Mill and Buckhorn Reservoirs	3	3	3	E	Targeting nonpoint source reductions
	Contentnea Cr below Buckhorn Reservoir		NSW	WLA	E	Proposed DO model did not work for swamp system
10	Slocum Creek	4	NSW	WLA	E	Targeting point source relocation to the Neuse River.
10,13,14	Neuse River Estuary below Streets Ferry		NSW	WLA	E	The DO model for the estuary was not done. Modeling resources resources were directed toward nutrient modeling.

Note: Tributaries are included with mainstems unless specifically mentioned.

Key to NPDES Permit Allocation Table

MLA — Wasteload allocations are established in accordance with Division standard operating procedures and NC water quality regulations. Specific NPDES limits are dependent on the amount and characteristics of the wastewater along with the stream classification and characteristics of the receiving water (e.g. flow, background loading, and assimilative capacity). Interaction with other sources, point and non-point, may affect limits.

1 — NPDES permits will reflect a minimum of advanced tertiary treatment levels (i.e., 5 mg/l BOD and 2 mg/l NH3-N). These requirements will apply to new and expanding facilities at permit issuance. Existing facilities will be handled on a case-by-case basis (Section 6.3)

2 — NPDES allocations established in tributaries to the Neuse will be set to minimize increases of BOD loading to the mainstem. However, in cases where a discharge is in close proximity to the mouth of a tributary to the Neuse, the permittee will not be given limits more stringent than 5 mg/l BOD5 and 2 mg/l NH3-N unless required to protect water quality standards downstream of the outfall.

3 — It is recommended that no new discharges will be permitted directly into the lake.

4 — No new discharges of BOD should be permitted. Existing discharges will be targeted for removal where feasible. Advanced tertiary treatment requirements will be phased in for those that cannot be eliminated (See subbasin descriptions in Section 6.3 of 1993 Neuse basinwide plan for more details).

5 — All major discharges in or above tributary arms and lakes can expect TP limits more stringent than those required by the NSW class.

E — Includes existing nonpoint source programs that apply to all areas of the state (See Section 5).

NSW — Nutrient Sensitive Water Classification requires phosphorus and nitrogen limitations. See NPDES NSW permitting strategies in Part A, Chapter 5.

WS — North Carolina's Water Supply Protection Program applies to these waterbodies (see Section 5.4.).

U — Federal Stormwater requirements for large and medium municipalities apply to at least a portion of these watersheds.

Chapter 5:
Nutrient Sensitive Waters Management Strategy

Reducing nutrient loading to the Neuse River estuary has been the top Neuse basin water quality priority for the Division of Water Quality over the past five years. Thousands of hours of staff time have been dedicated to holding workshops, public hearings, collecting and assessing water data, and crafting the new rules. This chapter provides a brief background on events leading to development of the current nutrient sensitive waters strategy (NSW); provides a brief summary of the rules including an update on the status of implementing them; summarizes the draft NPDES NSW permitting strategy (which is still being refined as of the time of this printing); and describes some of the modeling needed for developing the strategy and refining it in the future.

5-A. Background

In 1983, the North Carolina Environmental Management Commission (EMC) classified the Falls Lake watershed as Nutrient Sensitive Waters (NSW). This was followed, in 1987, by a statewide phosphate detergent ban that was enacted by the General Assembly to help address phosphorus water quality problems both in the Falls Lake watershed area and for other impoundments and estuaries in the state. Then in 1988, the EMC classified the entire Neuse River Basin as Nutrient Sensitive Waters (NSW). At that time, the EMC adopted a Nutrient Management Strategy to improve water quality in the basin. The strategy gave point source dischargers with flows greater than 0.5 MGD and all new facilities a total phosphorus (TP) limit of 2.0 mg/l. Facilities were notified that even more stringent controls may be required in the future. Some dischargers above Falls Lake had already been given TP limits as low as 0.5 mg/l. The Division of Water Quality (DWQ) also stated that nitrogen loading from nonpoint sources should be controlled through the Agricultural Cost Share Program administered by the NC Division of Soil and Water Conservation. At that time, most of the nutrient problems in the lower Neuse region were occurring in the lower freshwater portion of the river near Street's Ferry, and phosphorus was considered the most important nutrient.

In 1993, DWQ completed the first Basinwide Management Plan for the Neuse River Basin. The plan recognized the reductions in total phosphorus loading that had been achieved as a result of the phosphate detergent ban and improvements in wastewater treatment. However, the plan recommended that the NSW strategy for the Neuse Basin be reevaluated prior to being updated in 1998 for the purpose of revising the point and nonpoint nutrient management strategies. This recommendation was made, in part, to better address nitrogen in the Neuse Basin. Nitrogen was becoming a concern in the Neuse as monitoring and modeling in the Tar-Pamlico Basin were showing that nitrogen appeared to be the more important nutrient for brackish estuarine waters.

During July, September and October of 1995, extensive fish kills occurred in the Neuse River, primarily from New Bern to Minnesott Beach. DWQ collected water samples in the areas of the fish kills, which showed the water lacked oxygen as little as 1 to 2 meters below the surface. The monitoring results also showed a prevalence of algal blooms. Unusual meteorological conditions in 1995 were a major factor in the fish kills. During June, record rainfalls delivered a tremendous load of nonpoint source nutrients into the Neuse River. These rains were followed by a prolonged hot dry period. These conditions allowed the salt wedge at the bottom of the river to move further upstream and caused the water column to stratify due to both temperature and salinity differences in the water column. The fish kills were also a product of Pfiesteria, a toxic dinoflagellate that was stimulated to attack fish during this time period.

Over the past several years, increasing urban and suburban development (particularly in the Wake County area) and hog industry growth (in the middle and lower portions of the basin)

have occurred in the Neuse River Basin. These factors have put a strain on water quality, and these impacts will intensify if measures are not properly implemented to prevent or minimize water pollution.

Thus, because of continued water quality problems in the Neuse River, the EMC revised the Nutrient Management Strategy in December 1997 to further address point and nonpoint sources of pollution.

5-B. Update on the Neuse Nutrient Sensitive Waters (NSW) Rules

On December 11, 1997, the EMC approved an historic initiative -- the Neuse NSW rules. These rules are being held up across the country as an example of a comprehensive management strategy that includes mandatory measures for both point and nonpoint sources of nutrients. In January, the rules went before the state rules review commission and then on to the General Assembly. They became effective on August 1, 1998.

These Neuse NSW rules have been crafted to meet and maintain the 30 percent nitrogen reduction goal within 5 years. They have attempted to address the major known sources of nutrients in a flexible, fair and reasonable fashion. Scientists currently have inadequate information about some sources of nitrogen, such as atmospheric deposition of nitrogen from animal waste and septic systems, to enable the EMC to craft an appropriate reduction strategy for these sources. However, research on these sources is underway and additional requirements may be added to the Neuse NSW Strategy in the future.

In November 1996, DWQ conducted four public hearings on the original set of proposed rules. More than 600 people attended the hearings in Kinston, Goldsboro, New Bern and Raleigh. Based upon these public comments, the Hearing Officers made substantial changes to the plan. In June 1997, the EMC approved immediate protection of existing forested riparian areas and scheduled two public hearings on the revised rules in October 1997. More than 70 people spoke at these hearings in New Bern and Raleigh and about 300 written comments were submitted. The rules are much improved as a result of public comments.

- *Point Sources*: Currently, point sources are discharging 4.1 million pounds of nitrogen per year to the Neuse River. In order to achieve a 30 percent reduction, dischargers must reduce their nitrogen contribution to 2.8 million pounds per year. This rule equitably allocates the 2.8 million pounds per year between 3 different groups of dischargers within the Neuse basin. The nitrogen is to be allocated to the individual dischargers based upon the ratio of their permitted flow, with each facility's permitted flow established in the rule, to the sum total permitted flow of these discharges below the Falls Lake dam.

  Under the revised proposal, dischargers would still have the option to join a coalition of dischargers to allow implementation of point source controls in a more cost-effective manner throughout the basin. The second temporary rule specifies the "sign-up" period for wastewater dischargers to join a coalition so that DWQ can issue appropriate permits this spring. Draft NSW point source requirements are discussed in detail in Section 5-C., below.

- *Urban Stormwater*: This rule requires the basin's most heavily populated and fastest growing local governments to take responsibility for managing their stormwater. Under this program, the affected local governments would be required to work cooperatively with DWQ to develop and implement a local stormwater management program to reduce nitrogen by 30 percent.. The affected local governments include ten municipalities (Cary, Durham, Garner, Goldsboro, Havelock, Kinston, New Bern, Raleigh, Smithfield and Wilson) and five counties (Durham, Johnston, Orange, Wake and Wayne).

The program must include reviewing new development plans to ensure that they have adequate nitrogen controls, educating the public on how to reduce nitrogen loading from their homes and businesses, and identifying areas suitable for adding vegetated areas, wetlands and other measures for removing nitrogen from urban areas. DWQ is in the process of facilitating a series of meetings with the local governments to develop strategies and model ordinances which are to be adopted by each local government.

- *Protection and Maintenance of Existing Riparian Areas*: This rule requires that riparian (streamside) areas be protected and maintained on both sides of streams, rivers, lakes and estuaries. A total of 50 feet of riparian area would be required on each side of the waterbody. This 50-foot area would consist of 30 feet of virtually undisturbed forest vegetation and 20 feet of grass, vegetation or trees that could be harvested. The EMC adopted this as a temporary rule in June to provide immediate protection to riparian areas. On December 11, the EMC modified the temporary rule to clarify how the riparian areas should be managed. A bill passed by the 1998 General Assembly required DWQ to hold meetings with 23 stakeholder groups in the Fall of 1998 for the purpose of clarifying the buffer rules. DWQ is to present a revised buffer rule to the EMC by February 1999.

- *Agriculture*: The agricultural rule provides each farmer with two options:

  1. Become part of a collective local strategy for implementing best management practices on their land, or
  2. Implement standard best management practices as specified in a rule.

  Under the first option, the local strategy would be coordinated by a group of agency representatives and farmers who would target practices where cost-effective reductions could be achieved. The local strategies and the methods for accounting for nutrient reductions will be overseen by a multiagency basin oversight committee (BOC).

- *Nutrient Management*: This rule affects landowners, leasees and commercial applicators who apply nutrients to 50 acres or more of residential, agricultural, commercial, recreational or industrial land. Each person has two options for meeting the requirements of this rule:

  1. Successfully complete nutrient management training administered by the cooperative extension service or DWQ within five years, or
  2. Develop nutrient management plans for the lands where they apply fertilizer and maintain those plans kept on-site.

These rules are designed to meet and maintain the 30 percent nitrogen reduction goal within 5 years in a flexible, fair and reasonable fashion. As additional information about these and other sources of nitrogen such as septic systems becomes available, the EMC will consider additional control measures. Additional information on nutrient management in the Neuse River Basin can be found in the following documents available from DWQ:

Neuse River Nutrient Sensitive Waters Management Strategy (July 1996). This document describes the Neuse River's problems with nutrient overenrichment and describes a proposed strategy for addressing this problem through a combination of regulatory and voluntary approaches. The full document is over 250 pages; there is also a 44-page General Summary and a 14-page Executive Summary.

Fiscal Analysis: Neuse River Nutrient Sensitive Waters Management Strategy (July 1996). This document include a fiscal analysis of the proposed regulatory management strategies. The full document in over 280 pages; there is also a 36-page Executive Summary.

Accountability Issues: Neuse River Nutrient Sensitive Waters Management Strategy (July 1996). This document accounts for how the proposed management strategy will work toward meeting the nitrogen reduction goal in the Neuse River (44 pages).

Upcoming document: A companion document to the basinwide plan that will include general information about basinwide planning, water quality programs, pollutants, sources and effective management strategies.

5-C. Wastewater Discharge Requirements (15A NCAC 2B .0234)

5-C.1 Introduction

The greatest impacts of nutrient discharges in the Neuse basin are found in the upper Neuse estuary. The purpose of the Neuse NPDES permitting strategy is to control the levels of point source nutrient loadings to the estuary in order to help achieve the goals maintaining water quality and designated uses. On a case-by-case basis, additional controls may be necessary to prevent local water quality problems within the basin or to address existing problems.

This section of the plan briefly describes point source control strategies for NPDES discharges in the basin based on the NSW rules passed by the EMC. The rules will become effective in August 1998 pending approval by the General Assembly. A more complete description of the NPDES NSW permitting strategy can be obtained from DWQ's Point Source Permitting Branch (phone: (919) 733-5083 ext. 520).

5-C.2 Overview of the Nutrient Control Strategy

The nutrient control strategy of the December 1997 rules addresses phosphorus and nitrogen differently. It establishes technology-based concentration limits for phosphorus and water quality-based annual loadings for nitrogen. More stringent requirements are still allowed, where a given discharge would cause local water quality problems.

The new rule also allows alternative approaches for meeting the nitrogen targets. The following section presents the basic strategy first, followed by some of those alternatives.

- **Phosphorus**

Phosphorus limits for existing discharges will generally be held at the current 2.0 mg/l level, but they can differ depending upon the facility's location within the basin and the facility's discharge flow. Limits for existing dischargers (quarterly averages) are as follows:

Table 5.1 Phosphorus Effluent Limits

Location	Qp 0.5 MGD	0.5 MGD > Qp 0.05 MGD	Qp < 0.05 MGD
Above Falls Lake Dam	2.0 mg/l (a)	2.0 mg/l (a)	(a)
Below Falls Lake Dam	2.0 mg/l (a)	(a)	(a)

Qp: permitted flow as of December 31, 1995 (or flow specified in Table 2).

(a): More stringent limits may be required to protect local water quality.

New or expanding discharges, regardless of both the facility's location or flow, will be required to meet a phosphorus limit of 1.0 mg/l (monthly average).

- **Nitrogen**

The Neuse River Basin NSW Management Strategy states that the annual total nitrogen load for all individually permitted wastewater discharges in the Neuse River Basin shall not exceed 2.8 million pounds. Compliance with this requirement, collectively and/or individually, is to be achieved by January 1, 2003. These rules do not apply to facilities with general permits.

The new rules establish a combination of collective and individual allocations for nitrogen, depending upon both the facility's flow and its location in the basin. Thus, discharges in the Neuse River Basin are divided into three main categories:

- facilities with flows ≥ 0.5 MGD and upstream from Falls Lake Dam,
- facilities with flows ≥ 0.5 MGD and downstream from Falls Lake Dam, and
- facilities with flows < 0.5 MGD, regardless of location in the basin.

5-D. Nutrient Modeling in the Neuse River

The DWQ uses water quality models to help develop and analyze nutrient management strategies. Water quality models represent a conceptual design of the constituents and relationships that affect water quality. They are based on both physical measurements of a waterbody and an understanding of the processes taking place within it.

Models may be as simple as a linear relationship between pollutant concentration and its effect. Complex models may involve sets of equations that describe physics, chemistry and biology taking place within a waterbody.

Because no model can describe the entire complexity of a natural system, modeling involves selecting a subset of relevant processes to be included in the model. Which processes are modeled, and how they are described mathematically, are important assumptions that can affect the model results.

Once completed, a water quality model can provide estimates of specific water quality parameters for a range of input conditions. In this way, a water quality model may be used to identify the sensitivity of a system to changing conditions or used to evaluate the impact of various scenarios on water quality.

In order for a model to be a successful management tool, it is essential that management questions are clearly identified prior to model development. Good clear questions can result in good clear modeling answers.

A comprehensive nutrient model for the Neuse River Basin will involve many components that address the unique processes within the system. The exact form of such a model will depend on the exact management issues to be addressed. Broad management questions that require different methods of analysis are presented below.

Questions Which a Model Can Answer

Management Questions	Model
What is the effect of specific nutrient loads on estuary?	*Estuary Response Model* (see 5-D.1)
What are the sources of nutrients in the basin? How are the sources changing?	*Nutrient Watershed Models* (see 5D.2)
How much of these nutrients reach the estuary?	*Fate/Transport Model* (see 5-D.3)

5-D.1 Estuary Response Model

A tool is needed to help answer questions about estuary response to nutrient inputs. For example, if nitrogen loading at New Bern is reduced by 30 percent, the current target reduction, how much will water quality improve? The estuary response model describes water movement in the estuary, nutrient chemistry and biological response to nutrients.

Estuaries are difficult systems to model. The lunar and wind tides control the velocity and direction of flow. Due to rapidly changing conditions in the estuary, the estuary response model must be dynamic, that is, able to describe changing conditions over time. The model must accept input and provide output for short time periods of less than one hour. In addition, the model must describe different conditions at different locations within the estuary. At a minimum, a two-dimensional model is required, one that can describe environmental conditions at different locations up and downstream as well as at different depths. Depending on the kinds of management questions that are asked of the modeling analysis, it may be necessary to develop a three-dimensional model, one that can describe conditions at specific distances from the right and left bank as well as up/downstream position and depth.

An estuary response model requires the following integrated components:

- *Water Circulation Component* - This component describes how water moves and mixes in the estuary as a result of freshwater flow, winds, tides, salt concentration and other forces.

- *Nutrient Chemistry Component* - This component describes the rates at which nutrients are chemically altered in the estuary. Rates may vary by temperature, dissolved oxygen levels, biological action or other processes.

- *Biological Component* - This component uses hydrological and chemical data from the other components to describe biological growth and decay in the estuary. Biological activities influence algae and dissolved oxygen concentrations as well as feed back to the nutrient concentrations described in other components.

- *Sediment Component* - This component describes that rate at which nutrients enter and leave the estuary sediments.

The benefit of an estuary response model is that it provides estimates of the total nutrient reductions required in order to restore water quality in the Neuse River Estuary. It provides a way to assess the environmental benefit expected from various management options.

The Division of Water Quality was awarded a grant from the US Environmental Protection Agency to begin work on a model of the Neuse River estuary in 1995. DWQ contracted with the US Geological Survey (USGS) to begin developing a CE-QUAL-W2 model from Streets Ferry to a location near Oriental. CE-QUAL-W2 is a two dimensional, laterally averaged,

hydrodynamic water quality model which predicts water surface elevation, velocity, flow direction, temperature, dissolved oxygen, nitrogen and algae concentrations, among other parameters. Due to budget constraints, data to calibrate the model were not collected.

The 1996 General Assembly allocated funds to the Division of Water Quality to perform nutrient monitoring and modeling in the Neuse River Basin. A portion of these funds was used to collect daily water quality data at three sites on the lower Neuse River, and flow and water quality data at sites in the lower Neuse, Swift Creek, Contentnea Creek and the Trent River. In addition, a contract was awarded to the Water Resources Research Institute (WRRI) to monitor the estuary for one year, and use the data to improve the estuarine response model developed by USGS (MODMON project). WRRI has pulled together a team of scientists from the UNC Chapel Hill Institute of Marine Sciences in Morehead City, Duke University's Marine Laboratory, and East Carolina University and includes experts in water quality, hydrodynamic modeling, sediment chemistry and fisheries. In addition, Weyerhaeuser, Inc., USGS and DWQ are cooperating with the WRRI team to enhance one another's monitoring efforts. Work on the estuary model is ongoing, and a completed model is expected in December 1998.

5-D.2 Nutrient Loading Models

A nutrient loading model or watershed scale model is useful in providing better estimates of stream loadings arriving from surrounding watersheds for use in the fate and transport models described below. Currently, DWQ has worked with empirical approaches such as the export coefficient model to estimate loadings from certain land use/covers and FLUX which estimates the annual or seasonal load of nutrients at gauged sites within a basin. Other nonpoint source modeling activities being pursued in the Neuse River Basin include the Soil and Water Assessment Tool (SWAT) and the Nutrient Loss Evaluation Worksheet Program (NLEWP). Each of these modeling efforts is described in more detail below.

Export Coefficients

Nonpoint source loading for the Neuse Basin was originally estimated using export coefficients (EC) for different land cover types. The term, export coefficients, refers to the amount of a substance, such as nitrogen or some other nutrient or sediment, expected to be transported from the land by stormwater runoff to a nearby stream. Export coefficients, which are based on research studies, are expressed in terms of the amount of loading per unit area per year (e.g., kg/ha/yr or lbs/ac/yr). The export coefficients originally used in the 1993 Neuse Basin Plan were estimated for four major land covers: Agriculture, Forest/Wetland, Developed and Open Water (atmospheric) using published information gathered by Dodd and McMahon (1992). Land cover type classes were determined based on single scene, infrared LANDSAT imagery from 1987-88. Nonpoint source loading estimates have been updated based on more current land cover information and revised export coefficient estimates.

More current land cover type classifications for the Neuse Basin have become available. These classifications were interpreted from 30 meter resolution, two scenes (winter and summer), infrared LANDSAT imagery covering 1993-1995. The current land use/cover database distinguishes cultivated lands from pasture and/or open grass areas. In the original 1987-88 land cover database the "Agriculture" class included croplands and open grass areas such as fields, pasture lands and golf courses. Also, urban areas have been addressed differently from the 1987-88 land cover type data. Using the Dodd and McMahon (1992) literature review and database, export coefficients for additional land cover class delineations have been estimated. The following information briefly describes the steps used to redefine the export coefficients to account for more definition of the agricultural land class and the urban land class.

Associated with each export coefficient in the Dodd and McMahon (1992) database is a description of the type of land cover present when the study was conducted. First, the data were sorted by land cover based on five classes: crops, forests, residential (low and high density), industrial/commercial, and pasture/managed herbaceous. The median export coefficient value for each class was determined and used in load estimate calculations (Table 5.2).

Table 5.2 Land Use and Nutrient Export Coefficients

Land Use	Total P (kg/ha/yr) Median	Total P (kg/ha/yr) Range	Total N (kg/ha/yr) Median	Total N (kg/ha/yr) Range
Forest/Wetland	0.13	0.01 - 0.50	1.90	0.67 - 2.6
Mngd. Herb./Pas./Undev.	0.80	0.14 - 4.9	4.90	2.91 - 6.12
Cultivated (Crops)	2.41	0.26 - 18.6	15.2	9.65 - 21.30
Industrial/Commercial	1.57	1.46 - 1.79	14.60	12.55 - 14.79
Low Dens. Urban	0.62	0.28 - 1.01	6.39	4.0 - 7.74
Med/High Dens. Urb/Inst	1.12	1.01 - 1.91	9.63	6.95 - 9.86
Residential (general)	0.62	0.28 - 1.01	8.30	5.0 - 9.64
Open Water (atmospheric)	0.65		9.80	

The 1993-95 land cover type data does not have urban areas within the corporate boundaries fully classified. They have been blocked out as unclassified municipal areas. As an interim approach, these municipal areas were classified based on data available through city planning offices. Planners from sixteen municipalities in the Neuse and Tar-Pamlico basins with populations greater than 5000 were surveyed (by telephone) for land use information within their city's corporate boundaries. Nine municipalities were able to provide estimates of land use within their corporate boundaries. Using averages from the nine municipalities, the percent area covered by three broad land classes in municipalities: Industrial/Commercial, Residential and Undeveloped, was estimated (Table 5.3).

Table 5.3 Estimated Average Percent Land Cover within Municipal Corporate Boundaries Based on Three Cover Classes

Land Cover	Average %
Commercial/Industrial	29%
Residential	43%
Undeveloped	28%

The Commercial/Industrial class is based on commercial, light and heavy industrial, office/institutional, multifamily, and half of the transportation/utilities acreage. Residential is a combination of all forms of residential (except multifamily) and half of the transportation/utilities acreage. Undeveloped includes vacant land, forest/agricultural land, and parks/recreation land. Since the undeveloped area may represent a combination of several land types under a variety of land uses the pasture/managed herbaceous export coefficient was used.

Determination of the open water export coefficient was based on measured deposition data from the National Atmospheric Deposition Program (NADP). There are two NADP sites in eastern NC (Bertie and Sampson Counties) that have wet nitrate, nitrite and ammonium deposition data. DWQ calculated an average wet deposition estimate for four years of data from the two sites. To estimate dry deposition it was assumed that dry is equal to wet (i.e.,

double wet deposition estimate). In addition, a factor of 20% of the combined wet/dry deposition number to account for dissolved organic N (DON) was added. The phosphorus open water export coefficient used in the 1993 report was used in this analysis.

Initial estimates of nitrogen loading were calculated based on the new land cover types for the 14 major subbasins that comprise the Neuse Basin. Tables 5.4 and 5.5 summarize the export coefficient loading estimates for nitrogen and phosphorus by subbasin. Also,

Table 5.4 Nonpoint Source Nitrogen Loading to the Neuse River Basin by Land Type and Subbasin

Subbasin	Cultivated (kg/year)	Forest /Wetland (kg/year)	Urban (kg/year)	Mngd Herb. /Pasture (kg/year)	Water (kg/year)	Totals (kg/year)	Totals Percent
03 04 01	104,239	285,810	100,156	137,470	60,231	687,906	6.7%
03 04 02	362,365	201,934	354,036	29,277	19,673	967,285	9.5%
03 04 03	179,146	38,492	11,604	3,262	4,322	236,826	2.3%
03 04 04	531,838	74,981	10,063	981	8,944	626,807	6.1%
03 04 05	723,575	130,990	78,192	18,676	10,882	962,315	9.4%
03 04 06	412,000	94,367	16,469	14,916	6,499	544,251	5.3%
03 04 07	1,590,624	269,275	75,908	33,269	15,895	1,984,971	19.4%
03 04 08	243,007	79,634	11,706	3,562	7,806	345,715	3.4%
03 04 09	300,004	120,263	15,877	9,251	2,217	447,612	4.4%
03 04 10	295,684	204,560	81,059	10,922	475,572	1,067,797	10.4%
03 04 11	432,855	159,269	10,445	15,421	3,653	621,643	6.1%
03 04 12	350,784	56,327	18,511	5,902	5,870	437,394	4.3%
03 04 13	131,617	48,258	19,144	2,574	344,237	545,830	5.3%
03 04 14	17,934	32,456	581	1,038	700,388	752,397	7.4%
Totals	5,675,672	1,796,616	803,751	286,521	1,666,189	10,228,749	
	55.5%	17.6%	7.9%	2.8%	16.3%		100.0%

Table 5.5 Nonpoint Source Phosphorus Loading to the Neuse River Basin by Land Type and Subbasin

Subbasin	Cultivated (kg/year)	Forest /Wetland (kg/year)	Urban (kg/year)	Mngd Herb. /Pasture (kg/year)	Water (kg/year)	Totals (kg/year)	Totals Percent
03 04 01	16,527	19,352	10,591	22,444	3,995	72,909	5.7%
03 04 02	57,454	13,646	36,685	4,780	1,305	113,870	9.0%
03 04 03	28,404	2,597	1,226	533	4,322	37,082	2.9%
03 04 04	84,324	5,066	1,065	160	593	91,208	7.2%
03 04 05	114,725	8,833	8,083	3,049	722	135,412	10.6%
03 04 06	65,324	6,358	1,711	2,435	431	76,259	6.0%
03 04 07	252,198	18,156	7,843	5,432	1,054	284,683	22.4%
03 04 08	38,529	5,368	1,291	581	518	46,287	3.6%
03 04 09	47,566	8,102	1,634	1,510	147	58,959	4.6%
03 04 10	46,881	15,482	8,452	1,783	31,543	104,141	8.2%
03 04 11	68,630	10,915	1,123	2,517	242	83,427	6.6%
03 04 12	55,618	3,807	1,916	964	389	62,694	4.9%
03 04 13	20,868	4,480	1,991	420	22,832	50,591	4.0%
03 04 14	2,843	4,677	67	169	46,454	54,210	4.3%
Totals	899,891	126,839	83,678	46,777	114,547	1,271,732	
%	70.8%	10.0%	6.6%	3.7%	9.0%		100.0%

nonpoint source loads estimates were calculated for each of the 14-digit Hydrologic Units (HU, based on NRCS delineation) in the Neuse Basin. The 14-digit HU basins are nested within the larger subbasins. The 14-digit HU data are used in the Fate and Transport modeling efforts described later in this document. The Fate and Transport Model will provide estimates of the actual contribution of the nonpoint source loads to the outlet of the Neuse River at New Bern.

FLUX - Nutrient Loads to the Neuse River Estuary from the Trent River

The Trent River drains 520 square miles into the Neuse River estuary. This represents approximately fifty percent of the total drainage area discharging directly into the estuary from sources other than the Neuse River at New Bern. Agriculture and animal operations, significant sources of nitrogen, are a predominant component of the economy in the Trent River watershed. Due to the nitrogen enrichment of the Neuse River estuary, the relative nitrogen contribution from the Trent to the Neuse was evaluated. In addition, nitrogen contributions from drainage areas along the Trent were estimated. This information is being used by DWQ to prioritize nonpoint source pollution controls in the Trent River watershed.

In the last few years, extensive macrophyte infestations (i.e., horntorn, elodea, southern naiad, slender pondweed, red-headed grass, widgeon grass, watermeal and duckweed) have been documented in the upper portion of the Trent River estuary, near Trent Woods. It has been previously determined that an overabundance of nitrogen in these surface waters triggers phytoplankton proliferation. However, the effect of this nitrogen overabundance on stimulating macrophyte growth has not been determined in these surface waters. It appears that the grass growth is cyclical, and that a combination of recent warm winters and nutrient inputs from the Trent River watershed may have contributed to the macrophyte infestation. However, control of macrophytes through nutrient management strategies is not fully understood.

Water quality data and flow data collected from June 1995 to August 1996 were applied to a FLUX model. The FLUX model is an empirical method developed by the US Army Corps of Engineers to estimate nutrient loads. This model interprets intermittent water quality and flow data to estimate total loading over the complete flow record between two dates.

The results of the FLUX application indicated that approximately 661,400 lbs/year of total nitrogen pass through the Trent River at SR 1121 near Oak Grove, approximately 5 miles upstream of Pollocksville. This site is a good estimator of the nutrient load contribution of the Trent River to the estuary.

The estimated total nitrogen load near Oak Grove compares to approximately 8,700,00 lbs/year previously estimated by DWQ near New Bern. Thus, excluding other total nitrogen inputs below New Bern, the Trent River contributes approximately eight percent of the total nitrogen load going into the Neuse River estuary. Although this percentage will be reduced as other total nitrogen loading sources are added to the system, the additional contribution of these sources is not expected to be large.

Nitrogen fluxes were also estimated in a downstream direction along the Trent at these additional sites: SR 1130 near Pleasant Hill, SR 1129 near Phillips Crossroads and NC 42 near Trenton. The estimated total nitrogen loads were approximately 132,270 lbs/year at SR 1130, 400,000 lbs/year at SR 1129, and 573,000 lbs/year at NC 42. The largest increase in total nitrogen per square mile (2,200 lbs/year/square mile) was estimated to occur in the drainage area upstream of SR 1129 near Phillips Crossroads.

The estimated ammonia load at SR 1121 near Oak Grove was approximately 46,300 lbs/year. This is a good estimator of the ammonia load discharged to the estuary. The largest increase of ammonia per square mile (265 lbs /year/square mile) was detected in the drainage area accrued between SR 1129 near Phillips Crossroads and NC 42 near Trenton.

The load of nitrates at SR 1121 near Oak Grove was estimated to be approximately 308,600 lbs/year. Again, this is a good estimator of the nitrate load coming into the estuary. Additional nitrate loads along the Trent River were approximately the following: 55,100 lbs/year at SR 1130 near Pleasant Hill, 161,000 lbs/year at SR 1129 near Phillips Crossroads, and 280,000 lbs/year at NC 42 near Trenton. No significant increases of nitrates per square mile were observed among the different drainage areas.

The Trent River watershed is extensively cropland. In addition, approximately 90 hog farms are located along the Trent River and its tributaries in Jones and Lenoir Counties. DWQ has targeted the entire Trent River Basin for nonpoint source pollution controls, and permitting and compliance for animal operations.

Additional NPS Watershed Modeling Activities

DENR obtained funds from EPA to develop a shell that will facilitate developing a modeling system that links the estuary model to a watershed model, groundwater model and atmospheric model. DENR contracted with Research Triangle Institute (RTI) to develop this tool which is called the River Management Decision Support System (RIMDESS). RIMDESS is intended to provide DENR with the ability to review various nitrogen management options in the basin and assess the cost-effectiveness of these options. However, the shell needs to be filled with the different model components and updated information.

Funding to expand the MODMON effort into the Neuse River watershed is being pursued. If the General Assembly funds this effort, the MODMON team will be expanded to include scientists with expertise on nonpoint source modeling. This team will work on gathering the data and developing the modeling tools to be included in the RIMDESS.

If this expanded MODMON work is not funded, other nonpoint source modeling activities will be pursued as resources are available. Other efforts that may be pursued include the Soil and Water Assessment Tool (SWAT) and the Nutrient Loss Evaluation Worksheet Program (NLEWP).

Two additional nonpoint source modeling activities are being pursued in the Neuse Basin. SWAT is a continuous-time, basin-scale model (Arnold et al., 1996). It is capable of long-term simulations of hydrology, pesticide and nutrient cycling, and erosion and sediment transport. SWAT operates on a daily time-step. The objective of the model application is to evaluate implications of management decisions over time. Efforts have begun to develop the necessary input data to apply SWAT to the Neuse.

The second nonpoint source modeling effort involves the Nutrient Loss Evaluation Worksheet Program (NLEWP) being developed by the Natural Resource Conservation Service (NRCS), with assistance from DWQ. NLEWP is a spreadsheet application that provides an estimate of edge of field and bottom of root zone nitrogen loads. The model utilizes inputs on crop type, fertilization practices, conservation trapping practices, and relative soil erosion and soil type. It can be applied on a per farm basis or it can be used to evaluate agricultural activities on a larger scale such as a watershed level. Work is underway to refine the application of this model to agricultural land in the Neuse Basin.

5-D.3 Fate and Transport Model

Nutrient fate and transport models are used to understand how nutrients in the basin are transported to the estuary. A certain percentage of the nutrients deposited in the upper portion of the basin are lost to various processes such as conversion to nitrogen gas, an inert form of the nutrient, and subsequently released to the atmosphere. Fate and transport models are therefore

used to estimate nutrient delivery to the estuary, and they can be used to help target where BMP implementation should be a priority.

The DWQ has developed a GIS-based nutrient fate and transport model for the Neuse River Basin. For modeling purposes, the estuary is defined as beginning at New Bern. Within the model, the delivered load is assumed to be a function of the location of a source within the basin, the stream velocities between the source and the estuary, and the rate at which the pollutant load decays along the route.

The nitrogen transport model is a refinement of the modeling framework previously provided by the Research Triangle Institute, and relies on the Reach File 3.0 (RF3) hydrography database developed by the USEPA. Reach File 3.0 breaks the basin down into over 6000 stream reaches, each having key attributes within the database that allow for the establishment of a connected stream network. A first order decay equation is used to simulate the loss of nutrient down the network. The model is linked to a Geographic Information System (GIS) for purposes of calculating and displaying the results.

Nonpoint source nutrient inputs are estimated for each 14 digit hydrologic unit (HU) by aggregating the 1993-1995 LandSat land cover data into appropriate land use categories and applying total nitrogen (TN) export coefficients to those categories (i.e., agriculture, urban, forestry, etc.). A more detailed discussion of the export coefficient application is provided above. The nonpoint source TN load for each hydrologic unit is input to the stream reach identified as the outlet for that particular watershed. Point sources can also be included in the model at the specific discharge locations.

Mathematics

The TN delivery calculated by the model relies upon distance and stream velocity to calculate a time of travel. Once the time of travel down individual reaches is known, the time of travel from any point to the estuary is calculated by summing the times of travel for all reaches that lead to the point of interest. The model performs the time of travel summation for all stream reaches. Total nitrogen delivery is calculated using a first order decay equation for the entire river basin. Thus, we assume that the percentage of TN delivered from a particular stream reach is equal to

Percent TN delivered = $e^{(-k*t)}$ *100
where:

k = "decay" coefficient that represents the loss of total nitrogen from the system in a day

t = time of travel from a stream reach to the estuary in days.

Velocity

Velocity is entered into the model by grouping the streams in the Neuse River basin into four velocity zones:

1. Neuse River mainstem, piedmont (above geologic "fall line")
2. Tributaries to the mainstem, piedmont
3. Neuse River mainstem, coastal plain (below geologic "fall line")
4. Tributaries to the mainstem, coastal plain

Velocity data was selected from USGS stream gauging stations distributed throughout the four zones for a 25-year period of record. Log normal regression was used to establish a power function that relates discharge to velocity. Stations with the best regression fitting were selected to calculate representative velocities for various flow conditions in the four zones.

Decay Coefficient

The current model framework allows for the assignment of a single, global decay coefficient to each reach in the basin. Literature decay rates vary across a substantial range, and currently, the DWQ is unaware of any existing research to define decay rates specific to the Neuse River

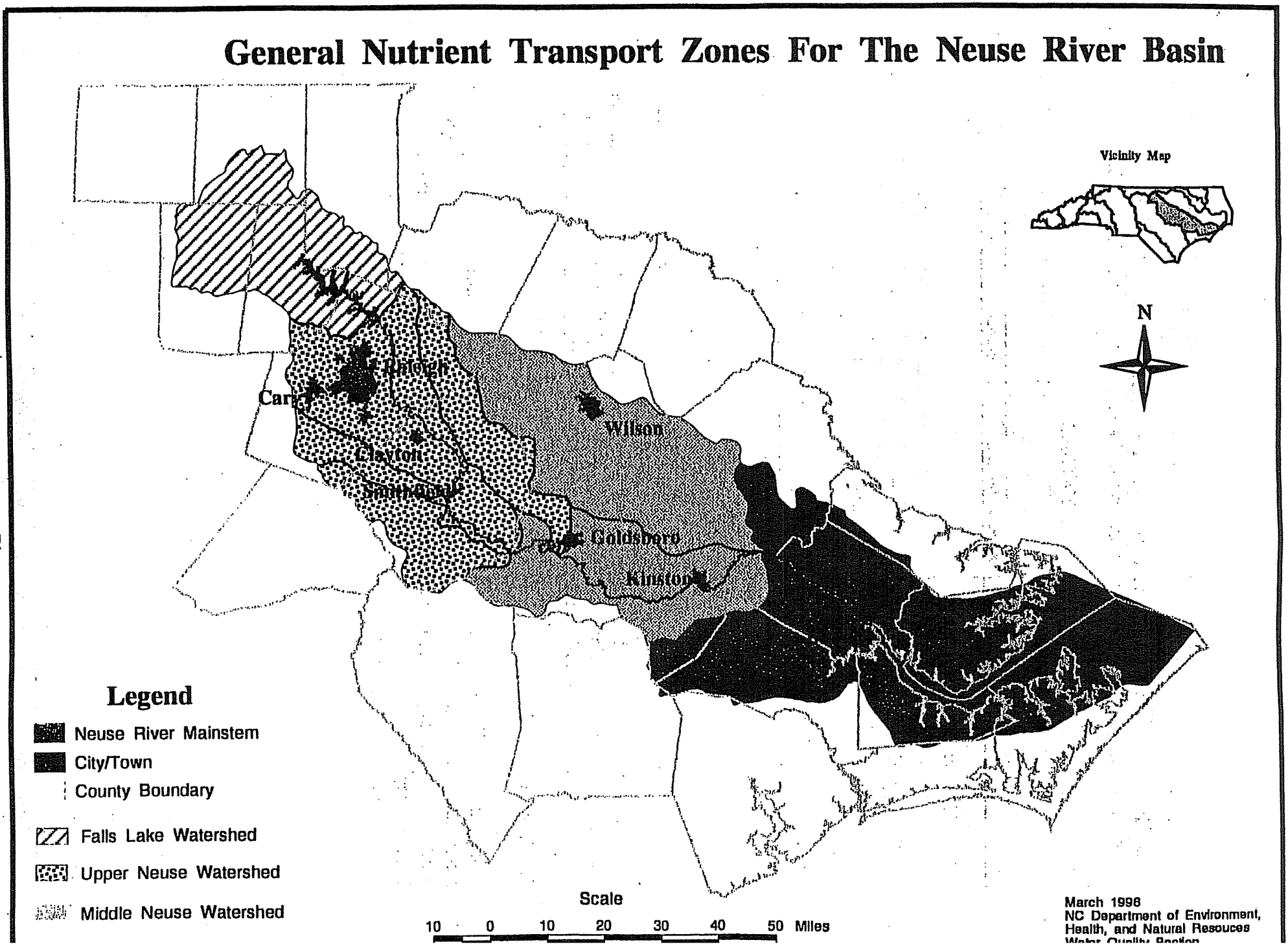
basin. The results presented here are based on model runs using a decay coefficient equal to 0.1/day, which is within the range of scientific literature values. The DWQ plans to perform field studies to quantify decay rates in the basin. The studies will be used to verify that the range of decay rates reported in the literature are appropriate for simulating TN loss in the Neuse River basin.

Model Results and Applications

For each of the 6000 plus reaches in the RF3 database the model estimates a percentage of TN load that would be delivered from that reach to the beginning of the estuary, defined for modeling purposes as New Bern, NC. Figure 5.1 illustrates the estimated nutrient delivery zones for the basin in 20% brackets based on a decay coefficient of k = 0.1/day and stream velocities corresponding to median flows.

By utilizing the percent delivery estimates from each reach the model can also be used to generate comparisons of the delivered loads from different locations and/or sources throughout the basin. The results illustrate where the most concentrated areas of loading to the estuary per unit of land area may originate.

Figure 5.1 General Nutrient Transport Zones for the Neuse River



Section B

Subbasin Descriptions

Chapter 1:
Neuse Subbasin 01
(Falls Lake Watershed including Hillsborough and Durham and portions of Person, Granville, Orange, Durham and Wake Counties)

1-A. Subbasin Description

This subbasin contains the Falls Lake watershed. The urban areas of Durham and Hillsborough have been rapidly expanding since the 1993 basinwide plan. The eastern part of Subbasin 01 also includes some of Raleigh's newest residential developments.

Subbasin 01 at a Glance

Land and Water Acre (sq. mi.)

Total area:	**772**
Land area:	**739**
Water area:	**32**

Population/Growth

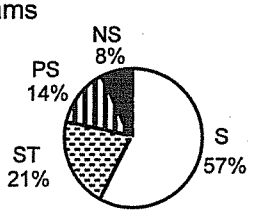
1996 Est. Pop.:	**179,551**
Pop. Density:	**243 pers/sq. mi.**
Proj. 2017 Pop.:	**224,439**
% increase (1996-2017):	**25%**

Land Cover (%)

Forest/Wetlands:	**72.6%**
Cultivated:	**3.42%**
Urban:	**7.29%**
Water:	**2.66**

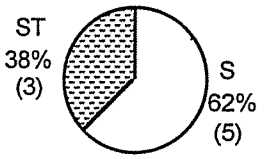
Use Support Ratings

*Streams



*Based on *monitored* data

Lakes (8 Total)



There are three major impoundments in this subbasin (Falls Lake on the Neuse River, Orange Reservoir on the Little River, and Lake Michie on the Flat River) and several smaller but important ones that serve as water supply reservoirs and recreational facilities to area residents. A map of this subbasin including water quality monitoring sampling is presented in Figure 1.1.

1-B. Water Quality Overview

Most of the streams in this subbasin are classified as Water Supplies. The highest quality water supplies in the subbasin are WS-II and include the Eno River and its tributaries above Hillsborough as well as the Little River and its tributaries above Orange Reservoir.

Many of the subbasin 01 streams have interesting and unusual geology. Most of the western portion of the subbasin is part of the *Slate Belt*. Unlike most of the streams in the Piedmont region that have sandy streambeds, the Slate Belt streams have streambeds composed of boulders and large rocks. The smaller streams in the Slate Belt are often greatly impacted during drought conditions. However, larger Slate Belt streams usually have good to excellent water quality and abundant wildlife habitat. Some of the Slate Belt streams in this subbasin include the Flat, Eno, and Little Rivers and their tributaries.

In addition to the Slate Belt, there is a narrow band through the middle of the subbasin contains *Triassic basin* rocks. Like the Slate Belt streams, the larger streams with Triassic basin rocks have rocky streambeds and high water quality. Wastewater treatment plants had little affect on stream biota in Slate Belt streams.

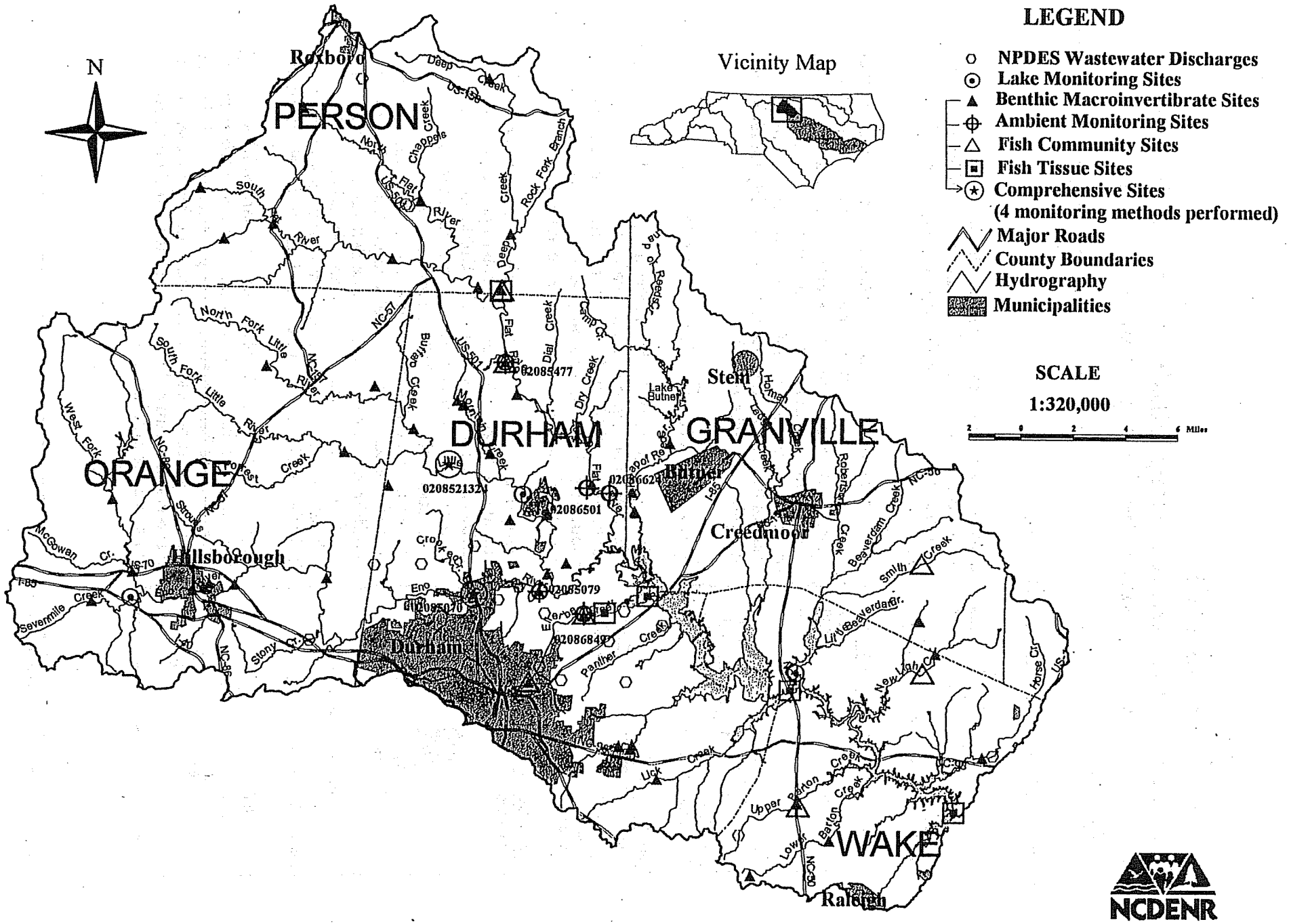


Figure 1.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 01)

These Falls Lake tributaries received a Good or Good-Fair rating, with all streams affected to some degree by nonpoint source runoff. This area was sampled during the spring of 1995, although two sites were resampled during summer months. Smith Creek did not show any seasonal change in rating, but Upper Barton Creek changed from Excellent in February to Good-Fair in July. More reliance is placed on the spring data because of the low flow problems that occur in this drainage during summer months. Land use in this area is slowly changing from agricultural to residential. Many of these streams have become very sandy because of erosion, especially Lower Barton Creek and Horse Creek.

All of the lakes in subbasin 01 are supporting their designated uses.

Although a few sites changed bioclassifications between 1991 and 1995, these changes were usually due to the high flow and scour that preceded the 1995 collections.

Those Durham area tributaries sampled in Spring 1985 were characterized by poor habitat: severe bank erosion and a high proportion of sand and silt.

1-C. Priority Issues and Recommendations

Controlling urban stormwater, restoring eroded stream channels and streams impacted by improper dam releases, protecting Falls Lake and other reservoirs, and planning for long-range sustainable growth are priority issues in this subbasin. Durham has made progress on its NPDES stormwater permit. The NPDES stormwater program is focused on monitoring waste loading from urban nonpoint source pollution, determining its impacts, and developing appropriate management strategies. The program is intended to reduce pollution and flow impacts associated with stormwater flow from both new and developing urban areas. However, restoration of impaired urban streams will require funding and resources beyond the scope of the NPDES stormwater program. Restoration of Ellerbe Creek could be a good candidate for a Clean Water Management Trust Fund grant.

Nutrient Sensitive Waters

Durham and other discharges have already begun addressing nutrient reductions at their wastewater treatment plants. The new NSW rules will also require some municipalities and counties to reduce nitrogen loading in stormwater runoff.

Stream Wastewater Assimilative Capacity

DWQ had established a policy of limiting and/or disallowing new discharges to several streams in this subbasin. This is because streams in this subbasin tend to experience summer low flow conditions that limits their ability to assimilate oxygen-consuming wastes from wastewater treatment plants. Streams where no additional discharges are recommended include Eno River, Little Lick Creek, Ellerbe Creek and Knap of Reeds Creek. Additional information is provided in the 1993 Neuse Basinwide Plan. It should be noted that Durham has taken major strides in reducing pollution loading to local streams through improvements in its wastewater treatment systems. It has removed plants on Little Lick Creek and the Eno River and diverted the wastewater to its upgraded North Durham Water Reclamation Facility. Durham spent $35,000,000 on upgrading this facility and approximately $14,000,000 for pumping stations and force mains to eliminate the discharges at Eno River and Little Lick Creek.

1-D. Current or Previously Impaired Waters: Update, Status and Recommendations

- **Ellerbe Creek**

Ellerbe Creek drains an urban watershed in Durham. This creek is rated as not supporting (NS) its uses, and it appears that stormwater runoff from urbanized lands in this watershed is the primary source of impairment. Raleigh Regional Office staff have indicated that single family septic discharges may also be affecting water quality. While benthic macroinvertebrate data continue to indicate poor conditions, some improvement has been seen in the fish and chemical ratings that could be attributed to improvements in Durham's wastewater treatment plant. The instream waste concentration below the plant is 99.5 during low flow (7Q10) conditions.

All of the 1995 benthic macroinvertebrate samples from Ellerbe Creek indicate Poor water quality both above and below the Durham WWTP. Urban nonpoint source pollution appears to be responsible for the problems in the upstream area. It is difficult to evaluate the impact of the WWTP in light of this Poor upstream water quality. Similar results were obtained in a 1979 survey of Ellerbe Creek, indicating no significant change in water quality based on benthos sampling between 1979 and 1995.

Benthic organisms associated with organic loading and low dissolved oxygen have decreased in abundance, probably due to improvements at the Durham wastewater treatment plant. This group of species was abundant at the downstream site only in the first collection (June 1985). The dominant taxa in 1991 and 1995 were chironomids associated with toxic.

Chemical monitoring at the downstream site (see ambient data) has shown some improvements including a large decline in nutrient concentrations over a ten-year period, and dissolved oxygen concentration increased slightly. Dissolved copper and zinc, however, are still consistently above state standards.

Fish community assessments were conducted at two locations on Ellerbe: one upstream (Fair at SR 1709) and one downstream (Poor-Fair at SR 1636) from the City of Durham's wastewater treatment plant. Both ratings were improvements over the Poor ratings received in 1988. However, Ellerbe Creek at SR 1636 was one of the four lowest rated streams which were sampled in 1995 in the Neuse River basin.

Despite the plant improvements, Ellerbe Creek downstream of the Durham wastewater treatment plant was still one of the four lowest rated streams that DWQ sampled during 1995 in the Neuse basin. It appears that the main source of pollution in Ellerbe Creek stream is nonpoint source pollution from urban and suburban areas.

One initiative that is occurring in the Ellerbe Creek watershed to address these problems is the Goose Creek Section 319 Project. Goose Creek is a tributary to Ellerbe Creek. The project objective is to demonstrate ecosystem protection practices (EPPs) that reduce sediment, water temperature, and flow fluctuation and increase dissolved oxygen levels. Some examples of EPPs are tree planting, low head dams, filter/buffer inlets, and pollution prevention education.

Waterbody / Location	Ellerbe Creek (above and below Durham's WWTP)
Classification	C NSW
1992 Use Support Rating	NS
Reason(s) for Impairment	Nutrients, DO, low flow, urban nonpoint source pollution. Difficult to evaluate the impact of Durham Northside WWTP because of poor upstream water quality.
1993 Planned Strategy	1. NPDES Municipal Stormwater Program. 2. Durham-Northside WWTP will get state-of-the-art nutrient removal. 3. No new discharges should be permitted to protect water quality. 4. Utilize existing programs.
1993-1997 Actions	1. Upgrade of Durham-Northside WWTP completed with total phosphorus removal of 0.5 mg/l during the summer months and 2.0 mg/l during the winter months. 2. At least one proposed discharge denied due to availability of sewer. 3. Three other discharges in area are permitted at advanced tertiary treatment limits. 4. Goose Creek Section 319 Project is underway.
1998 Use Support Rating	NS
1995 WQ Observations	1. Poor water quality both above and below Durham - Northside WWTP although nutrient concentrations at a downstream site indicated substantial decrease, and dissolved oxygen levels slightly increased as a result of improvements at the WWTP. 2. Urban nonpoint source pollution appears to be the major pollution source.
1998 Planned Strategy	Restoration will require a more detailed evaluation of the watershed to better assess the types and locations of BMPs and other restorative measures that will be needed. Cost estimates for correcting the problems will also be needed so that the magnitude of restoration efforts can be fully understood and planned for.

- **Eno River and Seven Mile Creek**

Eno River upstream of Hillsborough
The Eno River upstream of Hwy 70 near Hillsborough is rated fully supporting but threatened (ST). The watershed contains a mixture of agricultural and residential areas. The stream's substrate is evenly mixed between boulder/rubble and sand. There was no between-year change in benthic bioclassification. The abundance of some intolerant macroinvertebrates was lower in 1995, but this was probably due to high flow and scour that preceded the 1995 collection.

Eno River downstream of Hillsborough at Cabes Ford
The Eno River within the Eno River State Park (downstream of Hillsborough) showed improvement in benthic bioclassification between 1988 (Good) and 1991 (Excellent). This change is probably due to improvements made at the Hillsborough WWTP. Small positive changes also were observed during this time period at two other upstream sites: Eno River at NC 86 and Eno River at NC 70 Bypass. The Eno River at Cabes Ford retained its Excellent bioclassification in 1995, in spite of the high flows that preceded our collections. The Eno River in Durham has been consistently assigned a Good bioclassification since collections began in 1984. High flows resulted in lower EPT taxa richness in 1995, but this was offset by the lower Biotic Index value.

Eno River, US 501, Durham
The Eno River in Durham has been consistently assigned a Good bioclassification since collections began in 1984. High flows resulted in lower EPT taxa richness in 1995, but this was offset by the lower Biotic Index value.

Data from the ambient site on the Eno River near Durham shows an increase in median dissolved oxygen concentration (1987-1991: 7.9 mg/l; 1990-1994: 9.3 mg/l). However,

conductivity also increased over this time period from a medium value of 1/2 to a medium value of 163. This pattern suggests improved waste treatment, but a greater amount of wastes. It should be noted that these data reflect conditions prior to removal of Durham's Eno River wastewater treatment plant, just downstream of US 501, in 1995. Future monitoring should reveal water quality improvements.

Sevenmile Creek
Seven Mile Creek, a tributary of the Eno River, is a rocky Slate Belt stream near Hillsborough that is of interest because of improvement in its use support rating from fully supporting but threatened (ST) in 1991 to fully supporting (FS) in 1995. Flow was very low during the 1991 survey, contrasting with the high flow and turbid water during the 1995 survey. The bioclass changed from Good-Fair in 1991 to Good in 1995, due to a small (+1) change in the EPT taxa richness. Considering the large between-year difference in flow, this probably did not reflect a significant change in water quality. Future monitoring will be needed to ascertain the significance of this change.

- **Flat River**

Flat River near Quail Roost
This portion of the Flat River is of interest because of its good water quality and the presence of many rare mussel species (NC Scientific Council, 1990), including one state-listed endangered species (***Lasmigona subviridis***) and 4 state-listed threatened species. ***Corbicula fluminea*** (the introduced "Asiatic clam") invaded this area in 1990 and may compete with these native mollusks.

In 1995, this portion of the Flat River was assigned a benthic bioclassification of good. One reason the bioclassification was not excellent was because of extreme variations in flow, with high flows in 1984 and 1995 and very low flows in 1986-1990.

In 1993, a detailed survey in the Flat River catchment was conducted to determine if any portion of this catchment might qualify for an HQW classification. Although this study confirmed the Excellent rating for the Flat River near Quail Roost, most upstream sites received only Good-Fair or Good ratings. Studies by USGS biologists in February 1995, however, produced an Excellent rating for a downstream site on the Flat River near Bahama (unpublished results).

This portion of the Flat River may be subject to future development. It will be important to implement sound land use planning and preventive measures to ensure that this remains a clean and ecologically valuable river.

South Flat River near SR 1009
This site is located near the headwaters of the river, and the impaired rating may be a function of the extreme flow variations at the site.

Waterbody / Location	South Flat River, SR 1009, Person County
Classification	WS-III
1992 Use Support Rating	PS
1992 Source of Impairment	BOD, solids, fecal coliform and some point source problems. Nonpoint sources (particularly in the headwaters) include septic systems and agriculture.
1993 Planned Strategy	1. Implement Water Supply Program. 2. Point sources discharging to zero 7Q10 streams are targeted for removal. 3. Utilize existing programs.
1993-1997 Actions	Continuation of existing programs.
1998 Use Support Rating	PS (based on 1990 benthic sampling).
1995 WQ Observations	1. Extreme flow variations over 11-year period of study - both high and low flow species abundant during the accompanying flow periods. 2. This site last sampled 1990. 3. Downstream sites sampled in 1990 and 1995 vacillate between Good and Excellent.
1998 Planned Strategy	1. Need to determine whether the low rating is a function of man-induced impacts or natural low flow conditions. DWQ will likely not have the resources to do this in the next basin cycle and will need to rely on local government or agency assistance such as the County government, USDA NRCS and/or NC Cooperative Extension Serv. 2. Resampling by DWQ is recommended.

Flat River downstream of Lake Michie

While most of the Flat River and tributaries have unusually good water quality due to a general lack of disturbance and the Slate Belt geology, the Flat River downstream of Lake Michie is rated as partially supporting (PS). This impaired use support rating is based on the Fair benthic macroinvertebrate ratings in the Flat River resulting from low flow releases from the dam. In both 1985 and 1995, this reach received a Fair bioclassification in spite of large between-year differences in flow. Water chemistry indicates that this site has minimum dissolved oxygen concentrations of less than 0.3 mg/l. The dissolved oxygen standard for these waters is 4.0 mg/l for instantaneous measurements and 5.0 mg/l for a daily average. Based solely on water chemistry data in 1992, this stream reach was rated as not supporting (NS) its uses.

Waterbody / Location	Flat Creek below Lake Michie at SR 1004 near Williardsville, Durham Co
Classification	WS-IV
1992 Use Support Rating	NS (based on ambient WQ data - no benthos collected in 86 to 91)
Reason(s) for Impairment	1. Low flow from Lake Michie Dam. 2. Low dissolved oxygen.
1993 Planned Strategy	1. Implement Water Supply Program. 2. Lake Michie discharges will look at non-discharge options. Remaining discharges may have more stringent limits. No new discharges to Lake Michie will be allowed. 3. Utilize existing programs.
1993-1997 Actions	Continuation of existing programs.
1998 Use Support Rating	PS (improved since 1992).
1995 WQ Observations	1. Aquatic fauna is dominated by tolerant filter-feeders with rating of Fair for both 1985 and 1995. 2. Documentation of < 0.3 mg/l Dissolved Oxygen. 3. Lake supported all of its uses in 1995, but was borderline eutrophic.
1998 Planned Strategy	The City of Durham will need to evaluate and probably revise its flow release policy from the lake, if this portion of the river, below the dam, is to be restored. This evaluation should also consider where in the water column the water is being drawn from the lake to determine whether the quality of release is suitable for aquatic life downstream.

- **Knap of Reeds Creek**

Knap of Reeds Creek is a small tributary to the northern end Falls Lake. It is impounded at about its mid-point by Lake Butner. That portion of the creek downstream of lake Butner is impaired and rated as partially supporting (PS) its uses. This impairment appears to be related to low flow conditions below the dam and to effluent from the Umstead Hospital/Butner wastewater treatment plant (although the degree of impact from the plant appears to have lessened as a result of upgrades).

Surveys in 1982, 1985 and 1987 indicated Poor water quality at a downstream site below the WWTP, with the worst conditions observed during 1985 when there was little upstream flow to provide dilution. The bioclassification changed to Fair in 1991 and 1994, after improvements at the Butner WWTP. Most samples from the downstream site have been dominated by benthic macroinvertebrates that can tolerate low-dissolved oxygen conditions. Macroinvertebrate data indicated low dissolved oxygen and toxic conditions.

Water chemistry data from the ambient site (below discharge) also suggested some improvement. Comparisons of medium values from 1987-91 with more recent data shows slightly higher DO and lower nutrients. Conductivity values, however, have increased sharply, increasing from a medium value of 245 in 1987-1991 to 427 in 1994. Dissolved copper decreased slightly, but still exceeds the standard 17 mg/l 48% of the time.

Waterbody / Location	Knap of Reeds Creek above and below Umstead Hosp/Butner WWTP
Classification	WS-IV NSW
1992 Use Support Rating	PS
Reason(s) for Impairment	Nutrients, DO, low flow, copper - Impacts from the Umstead Hospital/ Butner discharge, including severe impacts on fauna.
1993 Planned Strategy	1. Umstead Hospital/Butner WWTP has had recent upgrades including adding phosphorus removal facilities. 2. No new discharges should be permitted to the creek. 3. Utilize existing NPS programs.
1993-1997 Actions	Umstead Hospital/Butner WWTP has been expanded and upgraded, including tertiary treatment filters, carbon filters and dechlorination.
1998 Use Support Rating	PS (rating unchanged, but some WQ improvements noted below WWTP).
1995 WQ Observations	1. Bioclassifications have been consistently Fair upstream from the WWTP. Downstream of WWTP, Poor ratings in 1980s improved to Fair in 1991 and 1994. 2. Ambient data have suggested some improvement since plant upgrade with slightly higher dissolved oxygen and slightly lower nutrient levels in the creek below the WWTP. 3. Conductivity has increased, and copper, while down from past measurements, would still exceed Action Levels.
1998 Planned Strategy	1. Continue to monitor effects of WWTP plant improvements on downstream water quality, and use results to determine whether additional improvements at plant are deemed necessary. 2. Raleigh Regional Office is to examine the high copper levels. 3. Inflow and infiltration should be addressed. 4. Better data is needed on why the creek upstream of the WWTP is impaired. Check on dam releases and possible contributions from the NC Department of Agriculture dairy farm. Also check on leaking pump station.

- **Little Lick and Lick Creeks**

Little Lick and Lick Creeks are two small streams that drain urbanizing watersheds in Durham and flow into Falls Lake. Until 1995, Little Lick Creek received effluent from Durham's Little Lick Creek WWTP. Both streams are impaired.

Little Lick Creek, SR 1815 and SR 1814
Paired sites were established above and below the Durham Little Lick Creek WWTP, but assessment of this discharge was complicated by a Poor bioclassification upstream. This small and sandy stream is severely affected by urban nonpoint source pollution, especially after periods of high flow.

The wastewater discharge was removed about one month prior to DWQ's 1995 sampling. Little improvement was observed, but this probably reflected a residual effect of the discharge as we would not expect the benthos to recover in one month. The dominant taxa at the downstream site in 1995 was the midge *Chironomus*, a genus usually associated with organic loading and low dissolved oxygen conditions.

Waterbody / Location	Little Lick Creek (above and below the WWTP)
Classification	WS-IV NSW
1992 Use Support Rating	NS above plant and PS below plant
Reason(s) for Impairment	1. Nutrients, DO, low flow 2. In upstream area, low flow contributes stress to the area and biological data indicated organic loading above the Durham discharge. 3. Difficult to evaluate WWTP impact because of upstream poor water quality.
1993 Planned Strategy	1, Durham is under a Consent Order to eliminate the Little Lick WWTP. 2. No new discharges should be permitted to protect water quality. 3. Continue existing NPS programs.
1993-1997 Actions	1. Durham Little Lick Creek WWTP permit rescinded February 1995. 2. Two other permits also rescinded - one oxygen consuming discharge remains which treats waste to advanced tertiary levels.
1998 Use Support Rating	NS
1995 WQ Observations	1. Up and downstream sites were established to determine impacts of WWTP. Upstream site had a poor bioclassification, thus making assessment difficult. 2. Further studies should reflect improvements in the system below the old WWTP site due to the elimination of the discharge.
1998 Planned Strategy	1. Continue to monitor creek to determine the full extent of the effects of removing the WWTP. 2. In light of the poor condition of the creek upstream of the WWTP, it appears that substantial work will be needed in Durham County (and a small portion of the City of Durham) to address the impacts of urban stormwater if the stream is to be restored. 3. This watershed has been targeted by the NC Wetlands Restoration Program for riparian zone and wetlands restoration (NCDWQ, 1998).

Lick Creek
The benthic macroinvertebrates in Lick Creek received a Fair rating -- partly because of poor habitat. Lick Creek has a deeply entrenched channel, uniform sand runs and no riffles. It has little or no flow during the summer months, so samples were collected during the winter (February). Mainly because of its sparse macroinvertebrate population, this stream received a Fair rating in both 1985 and 1995.

Waterbody / Location	Lick Creek
Classification	WS-IV NSW
1992 Use Support Rating	PS
Reason(s) for Impairment	Sediment, low flow, low DO
1993 Planned Strategy	1. Support development of Durham's NPDES urban stormwater program. 2. Continue existing NPS programs.
1993-1997 Actions	
1998 Use Support Rating	PS
1995 WQ Observations	1. Poor habitat, deeply entrenched, with no riffles and low summer flow.
1998 Planned Strategy	1. Substantial work will be needed in Durham County to address the impacts of urban stormwater if the stream is to be restored. 2. Instream restoration may also be required in light of the entrenched condition and poor habit quality of the stream. 3 This watershed has been targeted by the NC Wetlands Restoration Program for riparian zone and wetlands restoration (NCDWQ, 1998).

- **New Light Creek**

New Light Creek is a small impaired tributary to Falls Lake located in Wake County. It is rated as partially supporting (PS) its uses. Based on fish community data, New Light Creek has been consistently evaluated as Fair since 1986. It was given a Good-Fair biological rating in 1995 based on benthic macroinvertebrate sampling.

Waterbody / Location	New Light Creek
Classification	WS-IV NSW
1992 Use Support Rating	PS
Reason(s) for Impairment	Causes and sources of pollution not well understood. The watershed is relatively undeveloped, and there are no known wastewater treatment plants. The small size and possible low flow of the stream may be a contributor to its impaired rating.
1993 Planned Strategy	Investigate sources and continue existing programs.
1993-1997 Actions	1. Follow-up monitoring conducted in 1995. 2. No investigations were done.
1998 Use Support Rating	PS (unchanged)
1995 WQ Observations	Received Good-Fair benthos rating and Fair fish community rating.
1998 Planned Strategy	A more detailed investigation of the watershed is needed to determine the causes and sources of impairment sufficient to develop a restoration plan. DWQ will likely not have the resources to do this in the next basin cycle and will need to rely on local government or agency assistance such as the County government, USDA NRCS and/or NC Cooperative Extension Service.

- **Lake Rogers**

Lake Rogers is a small water supply reservoir built in 1939 for the Town of Creedmoor. It is located on Ledge Creek, a small tributary to the upper end of Falls Lake. It was rated as not supporting (NS) its uses in 1993, but is now rated as fully supporting (FS). The approximate size of the lake is as follows: surface area of 210 acres, maximum depth of 9 feet (3 meters) and mean depth of 3.3 feet (one meter). Tributaries to Lake Rogers include Ledge Creek and Holman Creek. The main water quality problems in Lake Rogers have been eutrophication and associated aquatic weeds, such as *hydrilla*.

Based on data and observations collected on August 17, 1995, the uses of Lake Rogers were supported. On the sampling day, the water was mostly cloudy and the data indicated eutrophic conditions. Lake Rogers was previously sampled by DWQ on August 8, 1991 and August 26, 1992. In both of these samplings, the lake was not supporting its designated use as

a water supply because of the algal blooms, aquatic weeds and water quality standards violations.

In 1992, DWQ surveyed the potential causes of the lake's eutrophication problems. The survey determined the approximate distribution of land cover types in the watershed:

- 15 to 20% was under cultivation (primarily tobacco);
- 7 to 10% was residential (including the Town of Stem);
- 7 to 10% was wetlands;
- 60 to 70% was forested; and
- no permitted discharges or sludge land applications.

Two suspected nutrient sources were a logging operation and an unbuffered tobacco field. This tobacco field was located within 50 feet of a beaver impoundment on the creek, and runoff from the field into the impoundment was indicated by trough cut into the soil of the field to the surface water. It was recommended that agricultural agencies provide necessary information concerning BMPs and land use to farmers in the lake's watershed.

To control the *hydrilla* in Lake Rogers, 1400 grass carp were released into the lake in 1991 (DWQ, 1992). In 1991, DWQ staff did not observe any changes in the *hydrilla* infestation; however, the Town of Creedmoor believed that some improvements had taken place in the least affected area adjacent to the boat ramp.

Waterbody / Location	Lake Rogers
Classification	WS C
1992 Use Support Rating	NS
Reason(s) for Impairment	Nutrients, DO, salinity, total dissolved solids, chlorides Lake Rogers has Hydrilla infestation associated with nutrient enrichment.
1993 Planned Strategy	1. Land use controls. 2. Identify and control of nonpoint sources of nutrients. 3. Continue existing programs.
1993-1997 Actions	1. Monitor effects of grass carp. 2. Address logging operation and tobacco field situations.
1997 Use Support Rating	FS
1995 WQ Observations	While the uses of Lake Rogers were considered to be supported, the potentially eutrophic conditions still exist.
1998 Planned Strategy	1. Continue to monitor lake and grass carp activity. 2. Encourage local government to develop and implement a protection strategy for the lake.

1-E. Other Waters of Special Interest

- **Falls of Neuse Reservoir**

Falls of the Neuse Reservoir (Falls Lake) is located near the headwaters of the Neuse River in Durham, Granville and Wake Counties in the piedmont section of North Carolina. The lake, which was filled in 1983, was created by the US Army Corps of Engineers for multiple purposes including water supply, flood control, wildlife propagation and recreation. The City of Raleigh uses the lake as its primary supply of drinking water.

The drainage area of the lake is 770 square miles. Forested areas as well as agricultural and urban areas are present in the rapidly developing watershed. Major tributaries to the lake include the Eno, Flat and Little Rivers, and Knap of Reeds, Ellerbe, Ledge, Lick, Little Lick and Beaverdam Creeks. The surface area of the lake is 12,490 acres, and the length of the lake is 56 miles at normal pool elevation. The morphology of the lake is wide and shallow upstream of Highway 50 and narrow and deep downstream of Highway 50. Falls of the Neuse Reservoir

has a mean depth of 16 feet and a maximum depth of 33. This reservoir is classified WS-IV B NSW.

Surface dissolved oxygen values at three stations downstream of Highway 50 were below the state dissolved oxygen standard of 5.0 mg/l (3.2, 1.6 and 2.1 mg/l from the Highway 50 bridge downstream to the dam). These surface dissolved oxygen values may have been due to a turnover of the lake's water and the mixing of anoxic hypolimnetic waters. Stratification was not observed at any stations in September due to the fall overturn. Based on data collected in 1995, the uses of the reservoir were fully supporting but threatened.

Extensive historical water quality monitoring has been performed by DWQ on Falls of the Neuse Reservoir since 1983. The lake has consistently been eutrophic with high nutrient and chlorophyll *a* concentrations. After the reservoir began filling in 1983, algal blooms have occurred nearly annually in the first ten years during summer months. The shallow stations in the upper reaches of this reservoir typically experience the highest algal growth as demonstrated by elevated chlorophyll *a* values and visual observations reported by samplers. Lower chlorophyll *a* values and less frequent algal blooms are reported from downstream portion of the reservoir due to settling and assimilation. For the purposes of this report, only data collected since 1991 is summarized. From 1991 to 1994, chlorophyll *a* concentrations ranged from 2 to 140 µg/l (compared with a state standard of 40µg/l).
No violations of organic contaminants were found in fish species sampled (carp and bass).

Chapter 2:
Neuse Subbasin 02
(Neuse River and tributaries from Falls Lake Dam to Mill Creek including Raleigh, Cary, Wake Forest, Garner, Clayton, Selma, and Smithfield and portions of Wake and Johnston Counties)

2-A. Subbasin Description

Neuse subbasin 02 includes the Neuse River and its tributaries (except Middle and Black Creeks) from Falls Lake Dam to its confluence with Mill Creek downstream of Smithfield. This subbasin contains the most urban development in the Neuse basin including the cities of Raleigh, Cary, Wake Forest, Garner, Clayton, Selma and Smithfield. Many streams in this subbasin are impaired by urban stormwater runoff. A map of this subbasin showing water quality monitoring locations is presented in Figure 2.1.

Subbasin 02 at a Glance

Land and Water Area (sq. mi.)

Total area:	**726**
Land area:	**724**
Water area:	**1**

Population/Growth

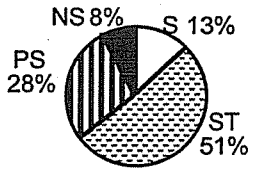
1996 Est. Pop.:	**488,505**
Pop. Density:	**675 pers/sq. mi.**
Proj. 2017 Pop.:	**757,183**
% increase (1996-2017):	**55%**

Land Cover (%)

Forest/Wetlands:	**53.5%**
Cultivated:	**13.06%**
Developed:	**29.54%**
Water:	**0.7%**

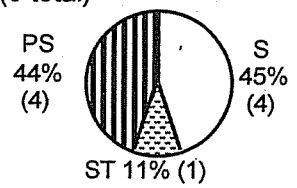
Use Support Ratings

*Streams



* based on *monitored* data

Lakes (9 total)



The western portion of the subbasin (generally west of Smithfield and I-95) lies within the piedmont physiographic region. The piedmont streams are underlain by rock formations that cause smaller streams to have a tendency to dry up under low flow conditions. This reduces their ability to assimilate wastewater and places stress on aquatic life. The eastern portion of the subbasin is located in the coastal plain physiographic region. The two regions are divided by the *fall line*, which runs roughly parallel to I-95.

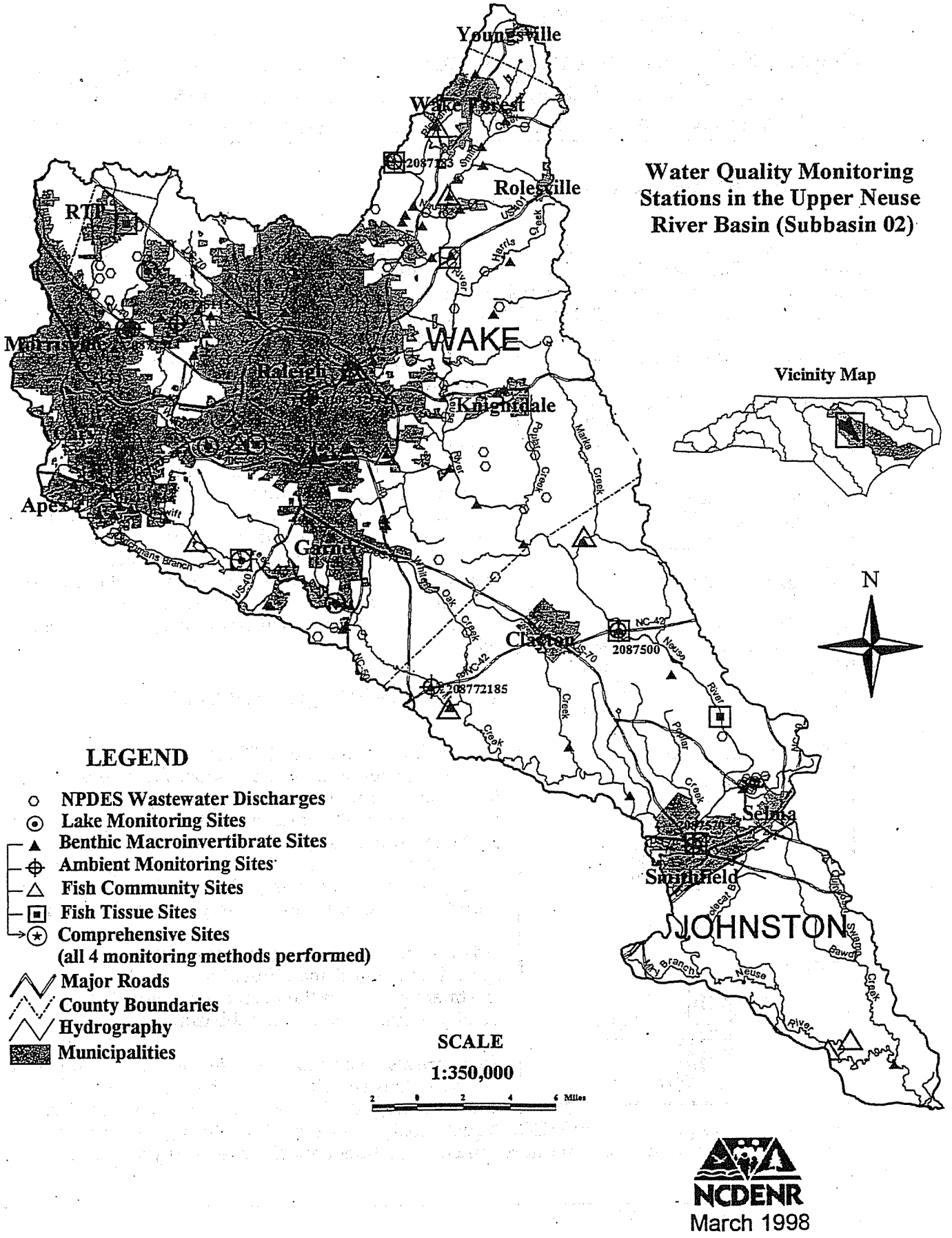
2-B. Water Quality Overview

Data collected from the 63 DWQ benthic macroinvertebrate sites in this subbasin suggested that this subbasin has severe water quality problems. Fisheries information also suggested some water quality problems in this subbasin, with 6 out of the 9 sites sampled in 1995 were assigned a Fair rating. Fish tissue data from two sites (Lake Wheeler, Neuse River) found no elevated levels of heavy metals or pesticides.

Urban stormwater runoff, and to a lesser extent, agricultural runoff and effluent from wastewater treatment plants are the main contributors to water quality degradation in this subbasin.

There are also many small dischargers in this subbasin, and 5 dischargers with greater than 1.5 MGD design flow. The largest of these is the Raleigh Neuse River WWTP, with a design flow of 60 MGD. Aquatic toxicity data (self-monitoring) at wastewater treatment plants show substantial improvements in effluent toxicity over a 10-year period.

Figure 2.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 02)



Most facilities showed some test failures during 1988-1992, but most major discharges have passed toxicity tests during 1995 and 1996. The Clayton WWTP failed numerous tests, but greatly increased their dilution by relocating the discharge from Little Creek to the Neuse River in April 1996. They are now passing all toxicity tests.

The entire Neuse River was declared Nutrient Sensitive Waters in 1988 at about the time a statewide phosphate detergent ban went into effect. Water chemistry data from the 1993 Neuse Basin Plan revealed major reductions in instream phosphorus concentrations below Raleigh's wastewater treatment plant and lesser, but measurable, reductions in phosphorus downstream (although nitrogen loading was unaffected by the phosphorus reduction efforts and has been the subject of recent revisions to the NSW strategy for the basin).

Macroinvertebrate data from one site (Neuse River near Clayton) suggest that new restrictions and other management strategies have improved water quality for aquatic life up to 1991. Improvements also were observed for the Neuse River at US 64 (Raleigh) from 1986-1995. The Neuse River from NC 64 (Raleigh) to SR 1201 (western Johnson County above Goldsboro) was assigned a Good bioclassification in 1995 based on macroinvertebrate collections. Water chemistry data for the last five years suggest few water quality problems in the larger streams and the Neuse River, although urban streams (like Pigeon House Branch) may have low dissolved oxygen and elevated concentrations of copper and zinc.

2-C. Priority Issues

Urban Stormwater Runoff

Water quality impacts from population growth and development are major water issues in this subbasin. These impacts occur both locally, as borne out by the following benthic macroinvertebrate data, and all the way to Neuse estuary through nutrient contributions from runoff and wastewater treatment plants.

Monitored streams which drain urban or residential areas include Perry Creek, Mine Creek, Pigeon House Creek, Marsh Creek, Walnut Creek, and the upper portions of Swift Creek and Crabtree Creek. Pigeon House Creek is within the most highly developed catchment of Raleigh and received a Poor rating. Ambient monitoring has demonstrated elevated levels of copper and zinc in this stream, and conductivity has doubled (to >200) over a 10-year period. This site has poor habitat, and a high incidence of midge deformities also indicated toxicity problems.

Poor ratings also were assigned to upper Crabtree Creek, Mine Creek and upper Swift Creek. These latter streams appear to be affected by poor water quality, poor habitat and highly variable flow. Increasing development is associated with an increase in the amount of impervious surface, leading to extremely high flows after rain events, and very low flows during low rainfall periods. Many of these small urban streams cease flowing during droughts. Most other urban streams (Perry Creek, Walnut Creek, Marsh Creek) received a Fair rating. Of this group of sites, the incidence of midge deformities at Walnut Creek also indicated instream toxicity.

Swift Creek had Poor to Fair water quality in the developed headwaters near Cary and Raleigh, but showed gradual downstream recovery. Stonefly larvae, the most pollution-intolerant of the benthic macroinvertebrate indicator species, did not appear until the most downstream site, and were not abundant at any of the Swift Creek sites. Crabtree Creek showed some improvement in habitat, especially at the site in Umstead Park. The invertebrates, however, did not indicate any further improvement in water quality at the most downstream.

Raleigh has made progress on its NPDES stormwater permit. The NPDES stormwater program is focused on monitoring waste loading from urban nonpoint source pollution, determining its impacts, and developing appropriate management strategies. The program is intended to reduce pollution and flow impacts associated with stormwater flow from both new and developing urban areas. There is little indication, however, that water quality has improved as a result of this program, so far, and development continues at a rapid pace throughout this subbasin.

If impaired urban streams are to be restored within this subbasin, major investments will be needed by the municipalities in stormwater controls. Because of the need for retrofitting controls in developed areas, costs will be high - probably in the range of several hundred million dollars. In addition, unless preventive measures are taken in the watersheds of currently unimpaired streams, they too will be degraded as development spreads outward from existing urban centers.

Raleigh, Cary and other discharges have already begun addressing nutrient reductions at their wastewater treatment plants. The new NSW rules will also require some municipalities and counties to reduce nitrogen loading in stormwater runoff.

Nutrient Loading to Lakes

Nine lakes were evaluated in Subbasin 02 for nutrient enrichment (trophic state) and the presence of a nuisance aquatic weed, *hydrilla*. Earlier samples in Subbasin 02 had shown a mixture of mesotrophic and eutrophic lakes, but all nine lakes were classified as eutrophic in 1995. There seems to be a tendency for eutrophication in some of these lakes, especially Lake Johnson and Lake Raleigh, although we would normally expect some between-year variation in trophic state. For both Lake Johnson and Lake Raleigh, the amount of developed area in their catchments has increased in recent years. Lake Raleigh was recently drained when the dam broke during Hurricane Fran. The designated uses of Lake Crabtree are considered to be Threatened due to high turbidity, elevated nutrients and algal blooms.

Infestations of *hydrilla* have been recorded in most of these lakes, and it was present at nuisance levels in Reedy Creek Lake, Big Lake, Sycamore Lake and Lake Raleigh. Because of these nuisance growth, these four lakes were evaluated as only Partially Supporting their designated uses. Spraying with herbicides and/or lake drawdown achieved only temporary control in some areas, but stocking with grass carp has been effective in controlling *hydrilla* in Lake Wheeler and Lake Benson.

Stream Wastewater Assimilative Capacity

DWQ had established a policy of limiting and/or disallowing new discharges to several streams in this subbasin. This is because streams in this subbasin tend to experience summer low flow conditions that limit their ability to assimilate oxygen-consuming wastes from wastewater treatment plants. Streams where no additional discharges are recommended include Crabtree Creek upstream from Lassiter Mill Pond and Swift Creek. In Perry Creek, it is recommended that new and expanding discharges meet advanced tertiary waste limits or better. Additional information is provided in the 1993 Neuse Basinwide Plan.

2-D. Current or Previously Impaired Waters: Update, Status and Recommendations

- **Crabtree Creek**

Crabtree Creek is a tributary to the Neuse River that originates in Cary and flows through Umstead State Park and Raleigh before reaching the Neuse. Use support ratings range from not supporting (NS) at the upper end of the creek in Cary to supporting but threatened at the downstream end below Raleigh.

Crabtree Creek above Umstead State Park in Cary
Two stations upstream of Cary's wastewater treatment plant were rated as Poor based on benthic macroinvertebrate sampling (site numbers B-20 and 22). This is a decline from the Fair rating in the 1993 Neuse Basinwide Plan. Due to continuing development in the Lake Crabtree catchment, most of the tributaries have become temporary streams, which may stop flowing for extended periods of time. Crabtree Creek was rated as Fair at three locations below the WWTP discharge.

Crabtree Creek in Umstead Park
Crabtree Creek in Umstead State Park has had a long-term decline in water quality due to a combination of factors: upstream development, impoundment of Lake Crabtree and discharge from the Cary WWTP. A partial recovery was observed in 1995 associated with improvements at the Cary WWTP. Limited improvement also was observed for a downstream site on Crabtree Creek.

Data are available from this site going back to 1980, although the July 1980 collection did not use the standard qualitative sampling method. These early samples were comprised of two kick-net samples and would be expected to have lower taxa richness values, but this collection can be used to help evaluate changes in the dominant riffle organisms. The abundant organisms in this 1980 sample included several intolerant taxa, including *Chimarra, Micrasema watauga, Acroneuria abnormis, Isonychia* and *Optioservus*. This site received a Good rating using 1980 criteria for kick-net samples.

Since that time, there have many changes in the catchment above Umstead Park:

- Early 1980s: continuing development, including airport construction
- Fall 1984: Cary WWTP on-line (0.7-1.0 MGD)
- June 1987: Spill event (sludge and hydrogen peroxide)
- Cary WWTP discharge increased (2.5-3 MGD)
- Lake Crabtree impounded

In comparison with the 1980 collections, there was a decline to Good-Fair in 1984-1986. This change coincided with both upstream development and the startup of the Cary WWTP. A further decline to Fair was observed in 1987-1994, but a limited recovery (to Good-Fair) was recorded in the 1995 sample.

Waterbody / Location	Crabtree Creek from Cary to Lassiter Mill Pond
Classification	C and B NSW
1992 Use Support Rating	PS at all stations
Reason(s) for Impairment	Fecal coliform, sediment, DO, copper, zinc Point source impacts from multiple dischargers. Urban nonpoint source pollution and siltation from land development. Nonpoint source impacts from the construction of Lake Crabtree. Reduced summer flows.
1993 Planned Strategy	1. Continue existing NPS programs (& NPDES Stormwater Program). 2. Recommend no new wastewater dischargers above Lassiter Mill Pond except for Cary Northside (w/ adv. tertiary limits). Below Lassiter Mill, wasteload allocations should be done on a case-by-case basis. 3. A comprehensive water quality model will be developed to determine effects of the 36 point sources. 4. Recommend non-discharge options when feasible WWTPs.
1993 - 1997 Actions	1. Cary upgraded its WWTP. 2. Raleigh has continued to work on its NPDES permit. 3. The WQ model for Crabtree Creek was not done as modeling resources were put into developing the Neuse Basin NSW strategy.
1997 Use Support Rating	NS above Cary's WWTP and PS below to US 401 in Raleigh
1995 WQ Observations	1. Water quality above the Cary WWTP declined apparently from increased development.
1998 Planned Strategy	1. Substantial work will need to be done by Cary, Raleigh and others to address the impacts of urban stormwater if the stream is to be restored and if further impacts from growth are to be minimized. 2. Instream riparian and wetlands restoration may be required to address poor habit quality. 3. This watershed has been targeted by the NC Wetlands Restoration Program for riparian zone and wetlands restoration (NCDWQ, 1998).

Crabtree Creek, US 1 near old Farmer's Market
Crabtree Creek has been sampled four times during summer months since 1983; additional samples were collected in 1989 to help in the evaluation of seasonal variation. Fair ratings were assigned to this site in 1984 and 1986, but the bioclassification improved to Good-Fair in 1995.

Crabtree Creek at Hwy 70/401
The fish samples gave a much higher rating at a station on the lower segment of Crabtree Creek at Hwy 70/401 (Good-Excellent) than the benthos samples (Good-Fair).

- **Hare Snipe and Mine Creeks**

Hare Snipe Creek and Mine Creek, located in north Raleigh and tributaries to Crabtree Creek, were found to be impacted by runoff from residential areas. These streams appear to be affected by poor water quality, poor habitat and highly variable flow. Increasing development is associated with an increase in the amount of impervious surface, leading to extremely high flows after rain events, and very low flows during low rainfall periods. Mine Creek flows through a small impoundment called Shelley Lake.

Waterbody / Location	Hare Snipe and Mine Creeks
Classification	C
1992 Use Support Rating	Not rated in 1992
Reason(s) for Impairment	Sediment, urban nonpoint source pollution
1993 Planned Strategy	Not applicable
1993-1997 Actions	Not applicable
1997 Use Support Rating	PS (NS for Mine Creek below Shelley Lake).
1995 WQ Observations	1. Received fair benthic ratings. 2. Streams have low water quality, poor habitat and highly variable flow.
1998 Planned Strategy	1. Substantial work will need to be done by Raleigh and others to address the impacts of urban stormwater if the streams are to be restored and if further impacts from growth are to be minimized. 2. This watershed has been targeted by the NC Wetlands Restoration Program for riparian zone and wetlands restoration (NCDWQ, 1998).

- **Little Creek**

This stream is a tributary to Swift Creek near its confluence with the Neuse River. It flows near the edge of downtown Clayton and is the site of Clayton's wastewater treatment plant.

Waterbody / Location	Little Creek at SR 1562 in Johnston County
Classification	C
1992 Use Support Rating	PS
Reason(s) for Impairment	Sediment, urban nonpoint source pollution
1993 Planned Strategy	1. Evaluate impacts of Clayton WWTP. 2. Continue existing NPS programs.
1993-1997 Actions	
1997 Use Support Rating	PS
1995 WQ Observations	Benthos rating declined from Good-Fair in 1991 to Fair in 1995.
1998 Planned Strategy	1. A more detailed investigation of the watershed is needed to determine the causes and sources of impairment sufficient to develop a restoration plan. DWQ will likely not have the resources to do this in the next basin cycle and will need to rely on local government or agency assistance such as the city and county governments, USDA NRCS and/or NC Cooperative Extension Serv. 2. This watershed has been targeted by the NC Wetlands Restoration Program for riparian zone and wetlands restoration (NCDWQ, 1998).

- **Marsh Creek**

This is a small urban stream that flows south into Crabtree Creek near the Beltline and Capital Boulevard. Four previous benthic samples in 1983 and 1984 were rated Poor. The 1995 benthic rating improved to Fair.

Waterbody / Location	Marsh Creek from source to Crabtree Creek
Classification	C
1992 Use Support Rating	NS
Reason(s) for Impairment	Sediment, urban nonpoint source pollution
1993 Planned Strategy	1. Implement Raleigh's urban NPDES Stormwater Program 2. Continue existing programs.
1993-1997 Actions	
1997 Use Support Rating	PS
1995 WQ Observations	Benthos ratings improved from Poor in the mid 80s to Fair in 1995.
1998 Planned Strategy	1. Continue implementation of Raleigh's urban NPDES Stormwater Prog. 2. This watershed has been targeted by the NC Wetlands Restoration Program for riparian zone and wetlands restoration (NCDWQ, 1998).

• Pigeon House Branch

Pigeon House Branch is probably the most degraded stream in this subbasin. It lies within the most highly developed catchment of Raleigh and received a Poor rating. Ambient monitoring has demonstrated elevated levels of copper and zinc in this stream, and conductivity over a 10-year period. This site has poor habitat, and water quality data indicated toxicity problems.

Classification	C
1992 Use Support Rating	NS
Reason(s) for Impairment	Sediment, Copper, Zinc from Urban nonpoint source pollution.
1993 Planned Strategy	1. Development of Raleigh's urban NPDES Municipal Stormwater Prog. 2. Continue existing NPS programs.
1993-1997 Actions	Monitoring and evaluation by City of Raleigh
1997 Use Support Rating	NS
1995 WQ observations	Received a Poor benthic rating in 1995
1998 Planned Strategy	Implementation of Raleigh's urban NPDES Stormwater Program

• Richland Creek / Richlands Creek

Richland and Richlands Creeks are two different streams in this subbasin. Richland Creek is a very sandy stream that drains a portion of Wake Forest. The first sample collected from this site (August 1991) was unusual because of the abundance of a pollution- intolerant stonefly: *Pteronarcys*. This taxon was also collected in 1994 and 1995, but had become rare. Although there has been a steady decline in EPT abundance from 1991 to 1995, EPT taxa richness and the bioclassification have not changed. Richland Creek receives large amounts of sediment from upstream developments, but has kept a Good-Fair benthic rating and a supporting but threatened (ST) use support rating.

Richlands Creek is a tributary to Crabtree Creek located west of Raleigh near Umstead State Park. It received a Fair biological rating in 1991 at a sampling site on Ebenezer Church Road. A follow-up sampling in 1996 also had a Fair rating.

• Swift Creek

Swift Creek is a moderate-sized stream that flows from Cary into the Neuse River near Clayton. The creek is impounded at two locations in its upper third to form Lake Benson and Lake Wheeler. Swift Creek is under pressure from growth and yet it still supports populations of rare, threatened and endangered mussels downstream of Lake Benson.

Swift Creeks headwaters near Cary and Raleigh were rated Poor to Fair based on benthic macroinvertebrates, but showed gradual recovery downstream. The most pollution-intolerant benthic macroinvertebrates did not appear until the most downstream site and were not abundant at any of the Swift Creek sites. Fish sampling in the middle reach of the creek (at SR 1525) showed a decline from Good-Excellent in 1991 to Fair in 1995.

Upper Swift Creek, SR 1152 (Holly Springs Road)
Swift Creek at Holly Springs Road (above Lake Wheeler, but downstream of Cary) carries a heavy sediment load from residential and urban areas and tends to have high flow variability which stresses aquatic life. This site was rated as Fair based on benthos sampling in both 1989 and 1995, with no indication of any long-term change in water quality.

Middle Swift Creek
Two fish community sites were sampled at SR 1152 in Wake County and SR 1525 in Johnston County within this developing portion of Swift Creek watershed in 1995. Both received a Fair

rating. The Fair rating at the SR 1525 site represents a significant decline from its Good-Excellent rating in 1991. Declines in the ecological health of this fish community were noted in the number of individuals, species, sunfish species and intolerant species metrics in 1995.

A benthic sample at the SR 1525 site received a Fair-Good rating.

Lower Swift Creek, SR 1501
This site is in the most downstream portion of Swift Creek, in an area intermediate between the piedmont and coastal plain ecoregions. Some downstream recovery has occurred, with a Good benthic rating in both 1991 and 1995. However, water quality in this portion of the stream is threatened by a variety of ongoing or planned activities.

Downstream of Lake Benson, the Town of Garner is proposing to discharge wastewater into the creek at the site of its present wastewater spray field near the creek. The Neuse River Foundation Creek Keeper for Swift Creek has identified the Eastside Septic Company sludge site the and Town of Garner's wastewater treatment plan spray site as two significant sources of nonpoint source pollution in the lower Swift Creek. In addition, there are numerous activities being planned that will likely increase growth, development and nonpoint source pollution loading to the creek. For example, the proposed path of the outer loop (I-540) runs through the lower Swift Creek watershed, and there is a proposed interchange with I-40 just east of the creek. There is also a proposed Clayton Bypass and proposed widening of NC 42. New water districts will be providing another growth incentive by making public water available to properties in the area.

The NC Wildlife Resources Commission and the US Fish and Wildlife Service have met with the NC Department of Transportation and local county and municipal representatives to discuss the cumulative effects of these proposed activities on future water quality. It was hoped that by calling attention to these actions and meeting with key government agencies in advance of construction, that steps could be taken to plan for and mitigate impacts to natural resources and water quality in this area. This initiative is commendable, but there needs to be follow-through by those governments entities that are permitting or sponsoring these activities if the impacts of their impacts are to be effectively mitigated.

Waterbody/location	Swift Creek, Wake and Johnston Counties
Classification	WS-III
1992 Use Support Rating	NS/PS
Reason(s) for Impairment	Sediment, Nutrients, DO, Aquatic Weeds (also, some impoundments have aquatic weed problems.) from WWTPs, runoff from urban areas, land development, and agricultural lands.
1993 Planned Strategy	1. NPDES Municipal Stormwater Program. 2. Recommend that no new dischargers be allowed based on limited waste assimilative capacity and presence of rare, threatened and endangered species. 3. Existing dischargers are being required to meet advanced tertiary treatment limits. 4. Water Supply Watershed Program. 5. Utilize existing programs.
1993-1997 Actions	1. The Town of Garner has been actively pursuing an NPDES permit for a new WWTP discharge into the creek despite recommendations against a plant presented in the 1993 basinwide plan. 2. A draft EIS has been prepared and is under review. 3. The NC Wildlife Resources Commission and US Fish & Wildlife Service have expressed concerns over the cumulative impacts of growth and development on Swift Creek and have attempted to work with local governments to address the issue.
1998 Use Support Rating	NS (headwaters) / PS (between and above lakes) / ST (below lakes)
1995 WQ Observations	1. Use support ratings between and above the lakes were unchanged from 1992. 2. A reach from Lake Wheeler to NC 42 that was PS in 1992 is ST now. However, no improvement has been documented, and a previous Good-Excellent fish rating at this site in 1991 declined to Fair in 1995.
1998 Planned Strategy	1. DWQ continues to recommend against new wastewater discharges into the creek in light of the presence of the rare, threatened and endangered species and lack of adequate waste assimilative capacity. 2. It is recommended that the creek be targeted for funding by the NC Wetlands Restoration Program

- **Walnut Creek**

Walnut Creek drains a highly urban section of Raleigh, and DWQ investigations have demonstrated Poor water quality at upstream sites. The incidence of midge deformities at Walnut Creek also indicated instream toxicity. There is some limited downstream recovery at this site, with a Fair rating assigned for all collections. The heavy rains that preceded the 1995 collections would be expected to cause severe scour in this very sandy stream. There did not appear to be any long-term change in water quality at this site.

Fish community sites sampled in 1995 in this increasingly urbanized watershed had ecological health ratings of Fair. The drainage area of Walnut Creek from below Lake Johnson at SR 1348 to SR 2544 was rated as Fair with the lowest scores received in the number of individuals, intolerant species, and number of sucker species metrics. Walnut Creek at SR 1348 had been rated as Good in 1991.

Waterbody/location	Walnut Creek, Wake County
Classification	C
1992 Use Support Rating	PS
Reason(s) for Impairment	Nutrients, Sediment WWTPs, urban nonpoint source pollution, land development
1993 Planned Strategy	1. NPDES Municipal Stormwater Program. 2. Utilize existing programs.
1993-1997 Actions	
1997 Use Support Rating	PS at most sites, NS at SR 1700
1998 Planned Strategy	1. Implementation of Raleigh's urban NPDES Stormwater Program with an emphasis of identifying and removing any illegal discharges in light of toxicity problems being seen in the creek. 2. Need to prevent pump station sewage spills.

- **Williams Creek**

Williams Creek is tributary to Swift Creek that was rated as not supporting its uses (NS) in the 1993 Basinwide Plan based on a Poor benthic macroinvertebrate sample. It has not been resampled since then and is not included in the impaired streams list in this plan, however, it has been included on the 1998 303(d) list of impaired streams provided to and approved by the US EPA.

Waterbody / location	Williams Creek from source to Swift Creek (4.8 miles)
Classification	WS-III
1992 Use Support Rating	NS (based on 1989 benthic sample at Old Raleigh Road)
Reason(s) for Impairment	Possible pollutants include sediment and habitat destruction from upstream construction and urban nonpoint source pollution
1993 Planned Strategy	1. NPDES Municipal Stormwater Program. 2. Water Supply Watershed Program. 3. Utilize existing programs.
1993-1997 Actions	
1997 Use Support Rating	Not rated
1998 Planned Strategy	1. Included on 1998 303(d) list to US EPA 2. Needs to be resampled.

- **Big Lake**

Big Lake is located in Umstead State Park in northwestern Wake County, adjacent to the Raleigh-Durham International Airport. Sycamore Creek is impounded twice within the park, first forming Big Lake and then Sycamore Lake. Big Lake has a drainage basin of seven square miles. Land use in the watershed is primarily forest and agriculture; however, development has increased considerably over the past years. Big Lake has a maximum depth of 16 feet (5 meters), a mean depth of 6.5 feet (2 meters).

Big Lake was most recently sampled on August 10, 1995. At the time of sampling, the lake was stratified. The mean surface dissolved oxygen was 5.1 mg/l and dropped to a mean of 1.1 mg/l on the lake's bottom. The Secchi depth at both sampling sites was less than one meter, however, values for chlorophyll *a*, turbidity and both total dissolved and suspended solids did not violate state water quality standards (Appendix L2). The lakewide mean ammonia concentration was 0.01 mg/l and mean total phosphorus value was 0.03 mg/l. Fecal coliform bacteria density was less than 10/100 ml. The NCTSI score was 0.7, indicating that the trophic status was eutrophic on the day the lake was sampled. Big Lake had a nuisance level growth of *hydrilla verticillata* which was observed on the day the lake was sampled. The current use status of the lake is Partially Supported due to the excessive growth of *hydrilla verticillata.*

Big Lake was previously sampled in 1991 and 1981. In 1981, the sampling stations at the upper, shallow end of the lake and near the center of the lake were stratified. Mean surface

dissolved oxygen was 5.2 mg/l and dropped to a mean of 0.5 mg/l at the lake bottom (depth = three meters). Secchi depth was 1.6 meters. Mean ammonia was less than 0.01 mg/l and mean total phosphorus was 0.03 mg/l. In 1991, the lake was stratified for dissolved oxygen. Hypoxic conditions were observed on the lake bottom at the sampling station near the center of the lake (three meters deep). At the more shallow upstream sampling station, (two meters) the bottom dissolved oxygen value was 4.6 mg/l. At this same site, ammonia was 0.13 mg/l and total phosphorus was 0.05 mg/l.

Hydrilla was first documented in Big Lake in 1983, and applications of herbicides were applied throughout the 1980's. In addition, the EPA Clean Lakes funds were used to drain and dredge the lake in 1991 in an effort to combat the hydrilla verticillata However, according to Alan Jeffreys (Division of Parks and Recreation, personal communication), the lake is presently 30% to 35% infested with hydrilla verticillata, and in the shallow areas (four feet and less), the infestation is 50% or more.

2-E. Other Waters of Special Interest: Update, Status and Recommendations

- **Neuse River (Falls Lake Dam to Smithfield)**

Scouring during high flow appears to have reduced total taxa richness values in 1989 and 1995, but variety and abundance of pollution-intolerant aquatic insect larvae has remained fairly stable. A slight improvement in water quality was indicated by the lower biotic index in 1991 and 1995 (5.8-5.9), plus the abundance of an intolerant mayfly (*Isonychia*) during 1995. The fauna continued to be dominated by heptageniid mayflies (*Ephemeroptera*) and hydropsychid caddisflies (*Trichoptera*). Stoneflies (*Plecoptera*) remained sparse, usually absent, at this site. Burlington Industries was a discharger to the river upstream of this site at the time of sampling. This facility failed 2 out of 21 self-monitoring tests from January 1991 to June 1995. In 1995, Burlington terminated its former textile operations at its Wake County plant. Burlington is currently evaluating potential future uses of the plant, including manufacturing uses by third parties, which may involve the discharge of treated wastewater from the Burlington wastewater treatment plant. Future monitoring will determine what effect any permanent reduction and/or modification of the Burlington discharge may have.

This site is upstream of the Raleigh WWTP. The first collection (December 1986) followed a fish kill that was caused by a spill of dairy wastes into a tributary stream. The Fair rating, therefore, may have not represented normal conditions in this part of the Neuse River. This site was upgraded to Good-Fair in 1991, and further upgraded to Good in 1995. There was no difference in EPT taxa richness between 1991 and 1995, but the abundance of several intolerant species (*Macrostemum*, and *Isonychia*) resulted in a decrease in the Biotic Index.

The Neuse River near Clayton has been sampled during the summer eight times since 1983. Consistent Good-Fair ratings were obtained from 1983 to 1990, although EPT taxa richness was much lower in the first sample (1983). The bioclassification improved to Good in 1991 and 1995.

The most distinct indication of improvement has been an increase in EPT abundance, almost doubling over the period of study (1983-1995). One intolerant mayfly (*Isonychia*) became abundant in 1990 and was one of the dominant invertebrates in 1995.

The potential impact of upstream sources also has changed during this time period. Several small waste water treatment plants on Perry Creek have ceased discharge since 1988 and connected into Raleigh's WWTP system. Also, a ban on phosphate detergent was instituted in

1988. The Raleigh WWTP (a 60 MGD plant located upstream of this station) observed a 55% reduction in effluent phosphorus concentration after the ban was put into effect (EHNR, 1991). Additionally, according to personnel from the DWQ Raleigh Regional Office, the plant is using an odor controller that also precipitates phosphorous, reducing their phosphorus levels in the effluent to an average of less than 1 mg/l. Water chemistry data taken from this site suggest a lowering of total phosphorus from yearly averages of 0.46-0.91 mg/l between 1980 and 1987 to yearly averages of 0.16-0.29 mg/l between 1988 and 1991.

Neuse River at SR 1201
This portion of the Neuse River is characterized by a sandy substrate and frequently turbid water. In spite of such habitat problems, the invertebrate community suggested that the river at SR 1201 is the highest quality site on the Neuse River. Most of the macroinvertebrates collected were associated with snag habitats.

Fish tissue samples were collected at two sites in this subbasin. Metals contaminants remained below levels of concern at both stations except for mercury which was detected at levels above EPA and/or FDA criteria in longnose gar collected from the Neuse River near Smithfield and in one largemouth bass sample from Lake Wheeler. Organics analyses were performed on channel catfish, bluegill, and carp samples collected from the Neuse River near Smithfield in 1992. Results show eleven contaminants were detected and except for PCB's remained below levels of concern. PCB's were detected in all three species at levels above the EPA screening value of 0.01 ppm.

- **Lake Benson**

Lake Benson is a man-made impoundment located in southern Wake County. The first impoundment on the site, called Rand's Pond, was built in 1844. In 1927, the City of Raleigh purchased the land and the lake for use as a water supply. The reservoir was expanded in 1953. The lake has a surface area of 440 acres, maximum depth of 19 feet (6 meters) and a watershed area of 65 square miles. The primary tributary is Swift Creek.

Presently, the lake is used as a secondary water supply and for recreation. The topography of the drainage area is characterized by rolling hills with approximately half being forested. Urban land use will undoubtedly play a major role in the development of the watershed as future urban sprawl is inevitable.

Lake Benson was most recently sampled by DWQ on September 1, 1995. The more downstream of the two lake stations had a dissolved oxygen violation at the lake bottom. At both sampling sites, values for nutrients, suspended solids, chlorophyll *a* and metals were below the state water quality action levels. Aquatic macrophytes, primarily ***hydrilla***, was reported along the shoreline of the lake and at the boat launch area. ***Hydrilla*** in the lake is currently being controlled with grass carp. Lake Benson was determined to be eutrophic in 1995 and the lake's designated uses were supported.

Lake Benson was previously sampled in 1981, 1983, 1987, 1988 and 1991. In 1981, the lake had dissolved oxygen violations on the bottom. At both sampling sites, values for nutrients, suspended solids, chlorophyll *a* and metals were below the state water quality action levels. In 1987, heavy ***hydrilla*** growth was observed at the dam and hypoxic conditions were observed on the bottom at the mid-lake sampling station. ***Hydrilla*** growth in the lake was observed at nuisance levels in 1991, particularly at the more upstream lake sampling station.

- **Lake Crabtree**

Lake Crabtree was built in 1989 by the Natural Resources Conservation Service (formerly the Soil Conservation Service) as one of eleven lakes constructed for flood control in the Crabtree Creek watershed. Wake County owns a park around the lake which is used extensively for recreation. Average depth in Lake Crabtree is six and a half feet (two meters) with a maximum depth of approximately 13 feet (4 meters). The primarily urban and residential drainage area is 51 square miles. Three tributaries, Crabtree Creek, Haleys Branch, and Stirrup Iron Creek drain portions of Cary, Morrisville, and the Raleigh-Durham International Airport. Several point source discharges and numerous construction sites in the watershed contribute to the drainage area of the lake.

Lake Crabtree was most recently sampled by DWQ on August 17, 1995. The sampling site located near the dam (depth = 8 feet or 2.5 meters), exhibited stratification. The surface dissolved oxygen was 6.8 mg/l and the bottom dissolved oxygen was 0.2 mg/l. The other two lake sampling stations with depths of 2.5 feet (0.8 meter) and 5 feet (1.5 meters) did not exhibit stratification. Water quality standards for turbidity (25 NTU) were violated at all three stations. The lakewide mean turbidity value was 52 NTU (range = 36 to 65 NTU). Total suspended solids values were 55 mg/l at the upstream station on Crabtree Creek (NEUCL1) 70 mg/l at the station located just upstream of SR 3015 (NEUCL2), and 25 mg/l at the station located at the dam (NEUCL3). Secchi disk readings of 0.2 meters at all three stations further indicate that Lake Crabtree is experiencing effects from sediments and turbidity. At the time of sampling, the lake had a distinctly muddy appearance. The geometric mean fecal coliform density was less than 10/100 ml. Lakewide mean ammonia was 0.06 mg/l and mean total phosphorus was 0.12 mg/l. The chlorophyll *a* values ranged from 8 to 13 µg/l. Lake Crabtree had a NCTSI score of 4.8, indicating the presence of eutrophic in August 1995. The uses of Lake Crabtree were considered Threatened due to elevated nutrients, low Secchi reading, and turbidity violations at all three lake stations.

Lake Crabtree was previously sampled in 1990 and 1991. The turbidity value near Crabtree Creek was greater than the state water quality standard. Total suspended residue was elevated at all three stations.

In 1990, DWQ sampled six sites at Lake Crabtree for ambient chemical data and fecal coliform bacteria. At the sampling station located near the park at the boat ramp, iron was detected at levels greater than the state water action level. The remaining data collected for nutrients, metals, organics and fecal coliform indicated that they met state water quality standards.

In 1991, the sampling site near the Lake Crabtree dam exhibited stratification for dissolved oxygen and hypoxic conditions were found at the lake bottom. As in 1995, the stations near Crabtree Creek and the SR 3015 had turbidity values (38 NTU and 28 NTU, respectively) which were greater than the state water quality standard for turbidity of 25 NTU. This elevated turbidity observed in the Crabtree Creek arm of the lake may be due, in part, to land clearing and construction activities within the drainage area of the creek. Secchi readings were less than 1.0 meter (0.3 meter at the two upstream stations and 0.5 meter at the sampling site located near the dam). Total suspended solids values were 64 mg/l near the dam, 38 mg/l at near Crabtree Creek, and 16 mg/l near SR 3015. Fecal coliform bacteria was less than 10/100 ml and the lakewide mean chlorophyll *a* was 24 µg/l.

In the 1992-1993 305(b) Report, Lake Crabtree's use support was listed as Partially Supporting due to elevated nutrients, algae blooms, violations of the chlorophyll *a* standard and turbidity violations (less than 25 NTU). According to Water Resources (Dave Demont, Division of Water Resources, personal communication), a small hydrilla verticillata infestation in Lake Crabtree is considered to be under control. Grass carp were stocked in upstream lakes (Fred

Bond Lake, Sorrells Grove Lake, Page Lake, and Briar Creek Reservoir), and this along with Aquathol Granular treatments of Lake Crabtree appear to have brought the ***hydrilla*** under control. The uses of Lake Crabtree were considered Threatened in the 1994-1995 due to elevated nutrients and turbidity violations at all three lake stations.

- **Lake Raleigh**

Lake Raleigh is a man-made impoundment that was once used as a water supply for the City of Raleigh. The original earthen dam was constructed in 1914 and was raised two feet in 1919. The water from the lake primarily served the downtown Raleigh area. In 1986, North Carolina State University gained control of Lake Raleigh and the surrounding land to build the Centennial Campus. The lake has a drainage area of 12 square miles and a surface area of 89 acres (36 hectares). Walnut Creek is the main tributary of Lake Raleigh. The lake has a maximum depth of 10 feet (3 meters) and a mean depth of 7 feet (2 meters). Land use in the drainage area is urban and residential with some forest and agriculture.

Lake Raleigh was most recently sampled on September 6, 1995. From the appearance of the silt fences and the disturbed areas surrounding the lake, it was obvious that sediment was washing into the lake from construction of the Centennial Campus during rainstorm events. Lake Raleigh was determined to be eutrophic in 1995. The uses of Lake Raleigh were considered to be Partially Supported due to the nuisance growth of ***hydrilla***.

Lake Raleigh was previously sampled by DWQ in 1987, 1988 and 1991. During 1987, ***hydrilla*** was observed along the shoreline and the western arm of the lake. In 1988, ***hydrilla*** was present along all shorelines, and in the western arm of the lake, it was present in waters up to two meters. In 1991, the lake was not stratified for dissolved oxygen or water temperature. Secchi depth was less than one meter at both sampling stations. Concentrations of total phosphorus at 0.11 mg/l and ammonia at 0.11 mg/l were observed at the sampling station near the dam. There were no violations for chlorophyll *a*, metals or nutrients.

According to the Division of Water Resources (Dave Demont, personal communication), no treatment has been implemented to combat the ***hydrilla*** infestation. Lake Raleigh is considered to be Partially Supporting due to sedimentation and ***hydrilla*** infestation.

- **Lake Wheeler**

Lake Wheeler is located in southwestern Wake County upstream of Lake Benson on Swift Creek. The lake has a drainage area of 38 square miles and a surface area of 12,450 acres (5039 hectares). The lake is relatively shallow with a maximum depth of 30 feet (nine meters) and an average depth of 13 feet (four meters). About half of the watershed is forested, but urban and agricultural areas are also significant.

In addition to serving as an auxiliary water supply for the City of Raleigh, Lake Wheeler is used extensively for recreational purposes including sail and motor boat racing, triathlon competitions, and canoe and kayak racing.

Lake Wheeler was most recently sampled in August 1995. The data indicated that the lake was eutrophic at the time of sampling and no violations of state water quality standards were observed. Water lilies and ***hydrilla*** were observed in the more shallow areas of the lake. Lake Wheeler's uses were supported in 1995.

Lake Wheeler was previously sampled by DWQ in 1981, 1982, 1983, 1985 and 1991. In 1981, the lake was mesotrophic. In 1982, metals were below DWQ laboratory detection levels. In

1985, metals were below DWQ laboratory detection levels except for copper and zinc; however, the concentrations of these metals did not violate state water quality action levels.

In 1985, approximately 50% of lake was infested with ***hydrilla***. Efforts to control to control the ***hydrilla*** previously had included both chemical and biological treatments. In September 1985, the NC Division of Water Resources and the NC Wildlife Resources Commission introduced 2,000 sterile grass carp into the lake to serve as a biological control. Visual observations through 1986 indicated little or no control. Therefore, in the spring of 1987, an additional 2,000 carp were introduced into the lake. According to the Division of Water Resources (Dave Demont, Division of Water resources, personal communication), the ***hydrilla*** problem in the main part of Lake Wheeler has been under control due to the grass carp stocking.

- **Lake Johnson**

Lake Johnson is owned by the City of Raleigh and is located in Wake County. The original use of the lake was as an auxiliary water supply for the City of Raleigh, but the lake is now used solely for recreation. Lake Johnson is essentially subdivided into two basins by a road crossing at mid-lake. The lake has a watershed measuring seven square miles. Walnut Creek is the major lake tributary. In recent years, the predominantly forested and agricultural watershed has become increasingly more residential.

Lake Johnson was most recently sampled on August 8, 1995. There are two stations, one located in the upstream portion of the lake and one located at the downstream section. Both stations exhibited stratification with hypoxic conditions at the lake bottom (approximately 0.2 mg/l). Lakewide mean ammonia concentration was 0.04 mg/l and mean total phosphorus was 0.03 mg/l. Fecal coliform bacteria density was less than 10 /100 ml, and Secchi depth was less than one meter at the two lake sampling sites (mean Secchi depth = 0.6 meter). Lake Johnson was eutrophic based on 1995 NCTSI score of 1.2. The uses of this lake were supported.

Lake Johnson was previously sampled in 1981, 1983, 1987 and 1991. Sampling conducted in 1983 and 1981 demonstrated stratification for dissolved oxygen. In both sampling years, ammonia and nitrite plus nitrate were at or less than 0.01 mg/l. Metals samples were collected in 1983 and were below DWQ laboratory detection levels. In 1987, profiles of water temperature indicated that the lake was not thermally stratified. Dissolved oxygen at the downstream lake sampling site was not stratified and at the upstream sampling site, dissolved oxygen ranged from 7.0 mg/l at the surface to 2.3 mg/l near the bottom (depth to bottom = 2.5 meters). The two lake sampling sites were similar for nutrient concentrations. Hydrilla verticillata was observed in the upstream portion of the lake in 1987, but was not considered to be at nuisance levels.

In 1991, Secchi depth at both sampling sites was less than one meter. Turbidity values were below the state water quality standard and chlorophyll *a* concentrations were also below the state water quality standard of 40 µg/l. The highest ammonia concentration recorded at Lake Johnson from 1987 through 1995 was observed in 1991 at the downstream lake sampling station (0.24 mg/l). Metals were below DWQ laboratory detection levels except for aluminum (82 µg/l), iron (94 µg/l) and manganese (21 µg/l). The values for iron and manganese were not greater than the applicable state water quality standards. Hydrilla verticillata was again observed in the lake in 1991, but locations and estimated lake coverage was not noted in the field data.

Chapter 3:
Neuse Subbasin 03
(Middle Creek Watershed including portions of Wake and Johnston Counties)

3-A. Subbasin Description

This subbasin is located in southern Wake and central Johnston counties and is experiencing rapid growth in residential development. The greatest development is in the upper reaches of the Middle Creek watershed, which contains the municipalities of Cary, Fuquay-Varina and Apex. Middle Creek is the largest stream in this subbasin. It is a tributary to Swift Creek with the confluence occurring less than a mile from the Neuse River. It generally has moderate flow and biological ratings assigned to the stream are based on Piedmont criteria. However, many tributaries to Middle Creek are very slow moving and exhibit Coastal Plain ecoregion characteristics. Many tributaries to Middle Creek drain agricultural areas. A map of the subbasin showing water quality monitoring sites is presented in Figure 3.1 (also includes subbasin 04).

Subbasin 03 at a Glance

Land and Water Area (sq. mi.)

Total area:	**131**
Land area:	**131**
Water area:	**0**

Population/Growth

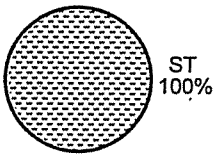
1996 Est. Pop.:	**29,326**
Pop. Density:	**224 pers/sq. mi.**
Proj. 2017 Pop.:	**45,456**
% increase (1996-2017):	**55%**

Land Cover (%)

Forest/Wetlands:	**57.26%**
Cultivated:	**17.6%**
Developed:	**22%**
Water:	**1.1%**

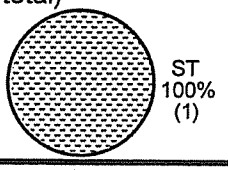
Use Support Ratings

*Streams



* based on *monitored* data

Lakes (1 total)



3-B. Water Quality Overview

Middle Creek is the only stream in this subbasin with enough flow to assess using current biological criteria. Middle Creek was sampled at several locations between 1986 and 1995, during both special studies and basin assessment. Middle Creek was rated as Fair at two sites using benthos data in 1986 (SR 1375) and in 1987 (NC 50). Since that time, macroinvertebrate samples have consistently rated the Creek as Good-Fair at both of these sites. The higher ratings came after improvements at the Cary WWTP. Middle Creek at NC 50 is an ambient site and water chemistry data did not indicate any water quality problems.

Fisheries information consistently gave a higher rating to Middle Creek sites compared to ratings from benthos data. One site in the upper part of the catchment (Middle Creek at SR 1404) was given an Excellent rating in 1995, and two other sites on Middle Creek received Good-Excellent ratings. The site at SR 1404 had received a rating of Fair-Good in 1991, suggesting some improvement in water quality for this portion of the stream. Some reaches of Middle Creek showed stream habitat problems (unstable banks and breaks in the riparian zone), resulting in the sandy substrate of this stream.

There are two permitted dischargers (Cary South WWTP and Star Enterprise) to Middle Creek and two facilities (Apex WWTP and Colonial Pipeline-Apex) which discharge to unnamed

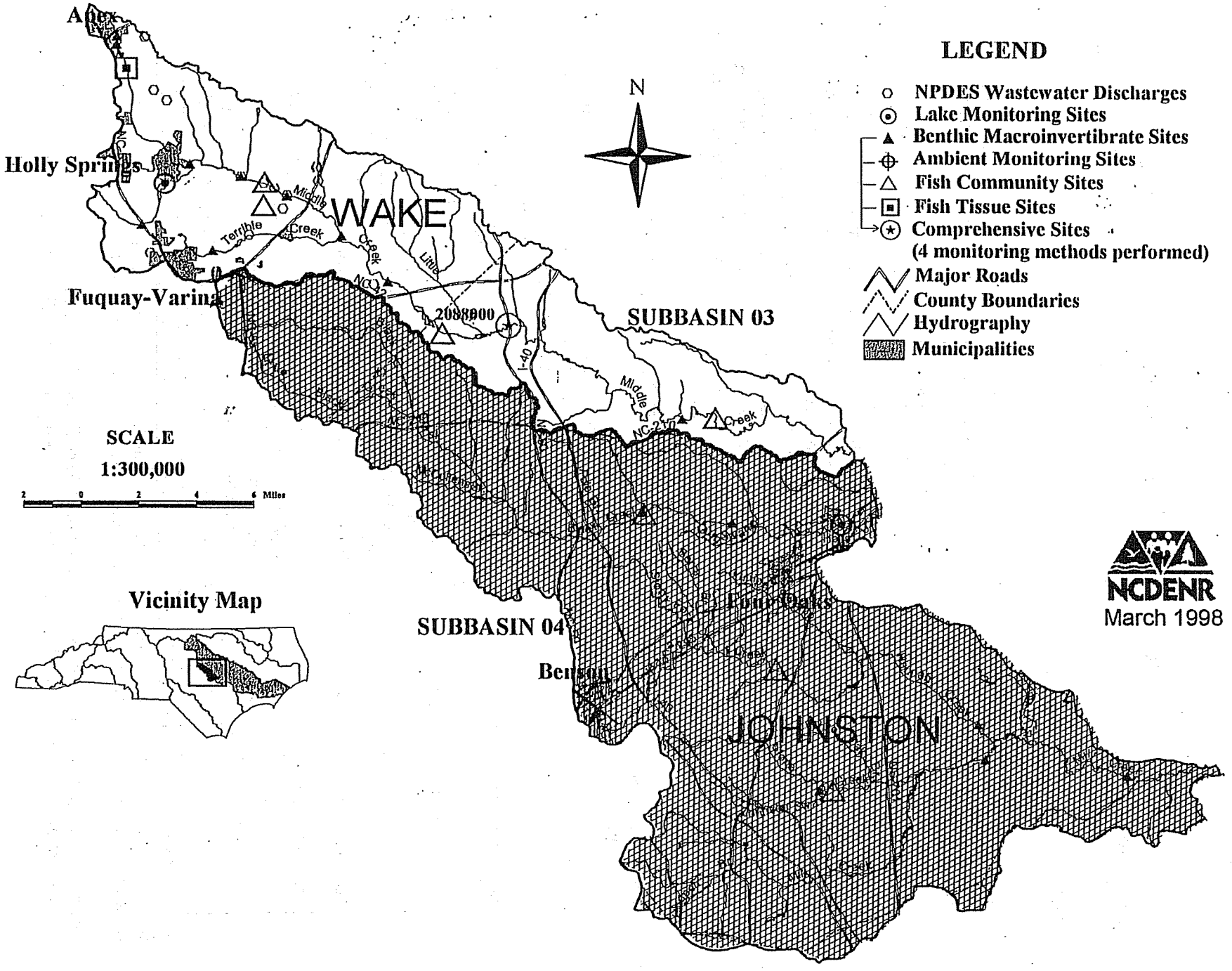


Figure 3.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasins 03 and 04)

tributaries of Middle Creek. While Cary South WWTP and Apex WWTP have each failed 3/20 toxicity tests since 1992, the biological sampling suggested that neither of these facilities affect Middle Creek.

Bass Lake was the only lake assessed in this subbasin. It was evaluated as eutrophic, but was found to fully support it uses. However, the subbasin is becoming more residential in nature, and further nutrient loading may result in unfavorable growths of algae or macrophytes.

3-C. Priority Issues

Limited water quality sampling in this small, but rapidly urbanizing, subbasin found waters impacted by urban nonpoint source pollution, though none were rated as impaired. Streambanks were observed by biologists to be unstable and noted as a possible source of sedimentation. Maintaining water quality and a healthy aquatic habitat in the face of rapid urban growth and increased stormwater runoff is a major water quality issue in this subbasin. According to census data presented in Chapter 2 of Section A, this subbasin experienced over a 100 percent population increase from 1970 to 1990. Population projections for the subbasin, based on Wake and Johnston County projections by the Office of State Planning, conservatively estimate a 55 percent increase in population by 2017.

Cary has done a good job of upgrading its wastewater treatment, and improvements were noted in the past. The town will be challenged in the future, however, to maintain a high quality effluent as its population increases and demands for wastewater treatment increase.

3-D. Current or Previously Impaired Waters Update, Status and Recommendations

- **Middle Creek**

This site was first sampled in 1986 as part of a special study to assess water quality in the Middle Creek watershed prior to a new WWTP discharge from Cary (B-870515). In 1991, it became part of the basinwide assessment to monitor water quality in the upper section of the Middle Creek watershed.

Improvements were made in 1987 in the treatment of Cary's wastewater, and in 1991, the bioclassification improved from Fair to Good-Fair. Although total taxa and EPT abundance were considerably lower in 1995 than previous years, the BI did not show much change. Middle Creek has unstable banks and several breaks in the riparian zone. These factors may lead to greater erosion, allowing nonpoint source input. Middle Creek also had a very sandy substrate (estimated >50% sand). At the time of sampling in 1995, flows were slightly high from rains which had fallen a few days prior to sampling. This may have led to scour of several organisms (especially *Diptera*) and account for the low total taxa and higher BI.

Middle Creek near Clayton
Middle Creek near Clayton at NC 50 has an ambient station that has been sampled four times since 1987. The station is located just before Middle Creek joins the Neuse River. It was sampled to integrate water quality over the entire Middle Creek watershed.

Water quality ratings improved at NC 50 after improvements were made to waste treatment facilities higher in the watershed. Overall physical conditions of the stream appeared generally healthy: the banks were stable, the riparian zone had few breaks, and there was cover for fish and other organisms. However, there is a very high percentage of sand in the substrate

(approximately 75%) and riffles are poorly defined. The sediment load in this stream was most likely from development and agriculture practices throughout this watershed. High flows during the sampling, coupled with the sandy substrate and scour, may account for the low total taxa count in 1995.

Three sites along Middle Creek, all below the city of Cary's southeastern wastewater treatment plant, were sampled in 1995. In 1991, Middle Creek at SR 1404 had been evaluated as Fair-Good. But in 1995, improvements were noted in 6 of the 12 metrics--number of individuals, species of darters, suckers, and intolerants, and in the percentages of omnivores and insectivores collected. As a result, Middle Creek at SR 1404 was one of only three sites rated as Excellent of all the sites sampled in 1995 in the Neuse River basin. Middle Creek at SR 1504 was also rated as Good-Excellent when last evaluated in 1991.

Middle Creek / Wake County - Hwy 401
A Sediment Oxygen Demand study was performed on Middle Creek at Hwy 401 in Wake County on April 2, 1992. The creek is approximately 20 feet wide at the site, and the chambers were set at a depth of 5 to 6 feet. Bottom sediment consisted of fine silty sand and bottom topography was typically flat. Water temperature averaged 12.03°C and the average SOD rate was -0.9965 $gr/m^2/day$. Average SOD is -1.6712 $gr/m^2/day$ when corrected to 20°C.

Middle Creek / Wake County - Hwy 42
On April 9, 1992, a SOD study was conducted on Middle Creek at Hwy 42, (5.5 miles downstream from the Hwy 401 site). The creek is approximately 25 feet wide and chambers were set at a depth of 5 feet. The creek bottom consisted of silty sand with patches of detritus. The average SOD rate for the site was -1.2185 $gr/m^2/day$ at the average ambient water temperature of 14.98 °C. The average SOD rate is -1.6461 $gr/m^2/day$ when corrected to 20°C. A faint smell of chlorine was detected at the Hwy 42 site, and floating solids were observed. Large numbers of midge larva (*chironomidea*) were found to be attached to the chambers at the end of the test. This is generally indicative of high nutrient and organic loading at a site.

- **Bass Lake**

Bass Lake is a privately-owned lake located in southern Wake County. The lake's watershed is approximately 9 square miles, consisting mostly of agriculture and residential uses. However, with recent development the watershed is becoming more residential in nature. The lake is primarily fed by Basal Creek and two small unnamed, intermittent tributaries. The lake has a maximum depth of 11 feet (3.5 meters), a mean depth of 9 feet (2.8 meters) and a surface area of 94 acres (38 hectares). The primary use of the lake is recreation with access restricted to the fishing club members (Bass Lake Fishing Association). Only boats with electric outboard motors are permitted for use on this lake by the fishing club. A section of the lake has also been donated to the Nature Conservancy and is used as a waterfowl refuge.

DWQ sampled Bass Lake in July 1995. Fecal coliform bacteria densities and chlorophyll *a* values were well below the state water quality standards. The data indicated that the lake was eutrophic. The uses of Bass Lake were supported in 1995.

In 1986 through 1987, Bass Lake was monitored as part of a study to assess water quality impacts of shoreline housing development on the lake (DWQ, 1987). Bass Lake was sampled six times between April 1986 and February 1987. Bass Lake had anoxic conditions developing below a depth of six feet and elevated nutrient levels in July 1986. Low pH was observed with some values below the state water quality standard. Theses low values were attributed to swampy conditions upstream of the lake which may have contributed low pH organic materials to the lake.

These studies suggested that the increased nutrient loading and the increased retention time of the lake during periods of low rainfall may result in unfavorable algae growth. From physical, chemical and phytoplankton data collected during this study, it was determined that water quality of Bass Lake could be negatively impacted if retention time and nutrient loading increased in the future.

Chapter 4:
Neuse Subbasin 04
(Black Creek and Hannah Creek Watersheds including part of Benson and portions of Johnston, Wake and Wayne Counties)

4-A. Subbasin Description

This subbasin is located in the inner Coastal Plain ecoregion. The topography is very flat with many slow-moving streams. Agriculture is the major land use. Benson is the largest town, and its WWTP (1.5 MGD) discharges into Hannah Creek. A map of the subbasin (and subbasin 03) showing water quality monitoring stations is presented in Figure 4.1.

Subbasin 04 at a Glance

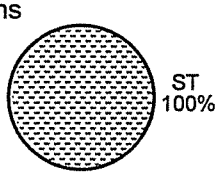
Land and Water Area (sq. mi.)	
Total area:	278
Land area:	277
Water area:	0

Population/Growth	
1996 Est. Pop.:	25,588
Pop. Density:	92 pers/sq. mi.
Proj. 2017 Pop.:	36,514
% increase (1996-2017):	42.7%

Land Cover (%)	
Forest/Wetlands:	50.87%
Cultivated:	45.88%
Developed:	1.9%
Water:	1.1%

Use Support Ratings

*Streams



* based on *monitored* data

4-B. Water Quality Overview

Four streams have been sampled for benthic macro-invertebrates in this subbasin: Black Creek received a Fair rating, while Mill Creek, Stone Creek and Hannah Creek received Good-Fair ratings. Fish collections assigned higher ratings with Black, Stone and Hannah Creeks receiving a Good classification. There is only one permitted discharger (Benson WWTP) in this subbasin. It discharges into Hannah Creek, and has failed one out of four toxicity tests in both 1995 and 1996. The biological collections, however, suggested that the Benson WWTP did not negatively affect the stream fauna.

The streams in this subbasin are mostly small, and seem to incur some natural stress due to low flows during drought periods. Additionally, the substrates were sandy and instream habitat offered little refuge for benthos during periods of high flow. These factors may account for some of the differences between fish and benthos ratings.

4-C. Priority Issues and Recommendations

All waters sampled in this subbasin were rated as supporting but threatened, an improvement from 1993, but still showing signs of stress. The subbasin is primarily agricultural, and its population density is about half that of the basin as a whole, but it appears to be primed for growth. Johnston County, which encompasses nearly this entire subbasin, is projected to increase its population by over 40 percent by the year 2017. Maintaining the quality of these already stressed waters in this subbasin in the face of increased population growth, urbanization and increased stormwater will be a major challenge. As these waters are not presently impaired, it will be largely up to the local community to determine the value these waters hold for them, and the priority they will place on protecting them waters through land use management, local ordinances, education and volunteer efforts.

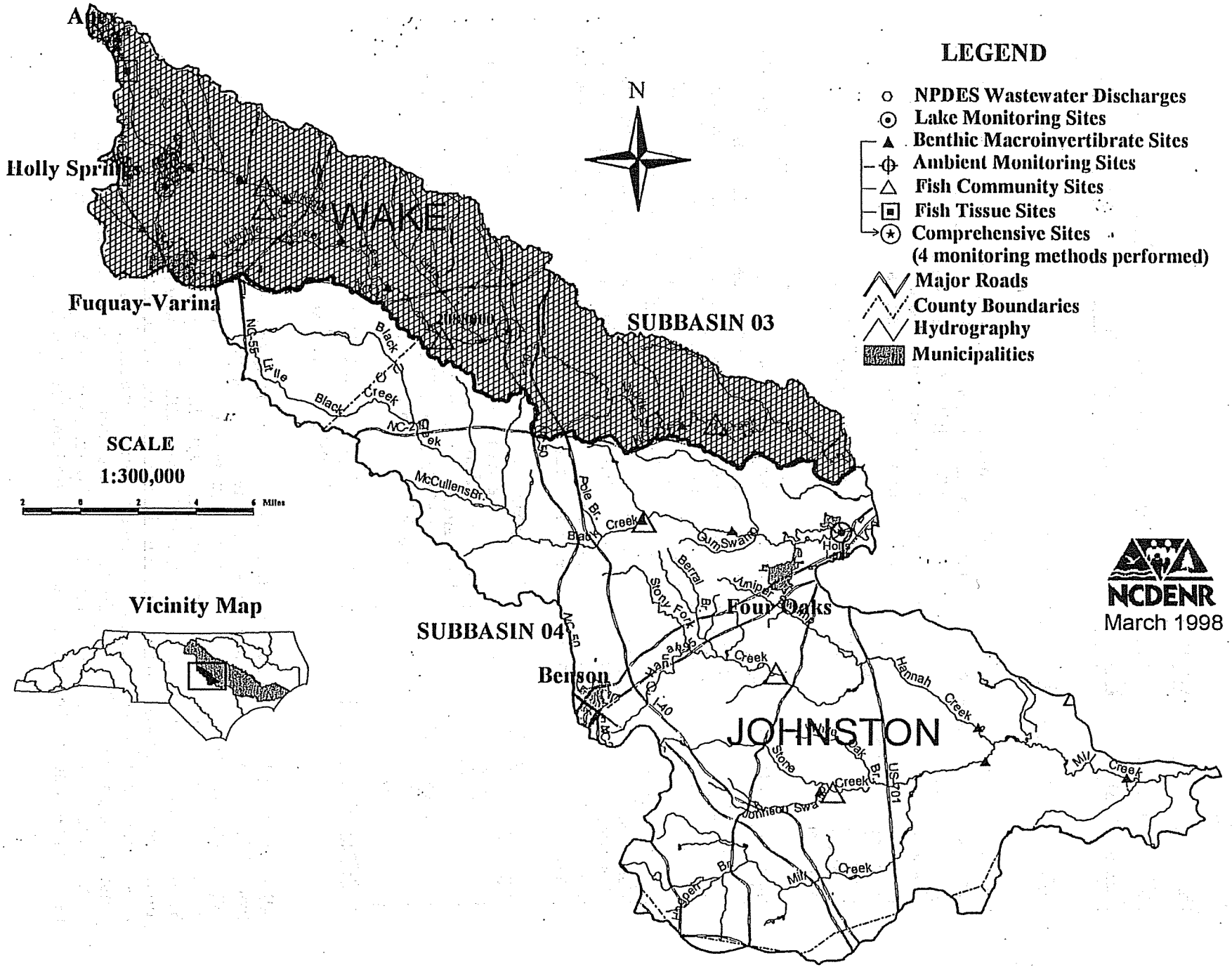


Figure 4.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasins 03 and 04)

4-D. Current or Previously Impaired Waters Updates, Status and Recommendations

All three of the following streams were rated as impaired (partially supporting (PS) their uses) in the 1993 basin plan, but all three have been upgraded to supporting but threatened in this plan. Despite being stressed, all three received Good ecological health rating from the fish sampling.

- **Black Creek**

Black Creek is the largest stream in subbasin 04, with a drainage area of 73.3 square miles. Black Creek at SR 1330 site was rated Fair in both 1991 and 1995 based on benthos data. The 1995 sample collected fewer organisms which may have been a result of high flow and scour during the sampling period. The substrate was predominately sand with some gravel and silt, which does not provide good refuge for macroinvertebrates during high flow. Despite the Fair rating based on benthos data, site received a Good ecological health rating based on a fish community sample. The overall use support rating assigned the site was supporting but threatened.

- **Hannah Creek**

Hannah Creek below the town of Benson's wastewater treatment plant, received a Fair bioclassification in 1991 that improved to Good-Fair in 1995. However, the data suggest that the change in bioclassification may be related to changes in flow. During a year of low flow, such as 1991, the stream may completely stop flowing for a period of time and naturally not support as many macroinvertebrates.

The fish community assessment on Hannah Creek was rated as Good in both 1991 and 1995.

- **Stone Creek**

Stone Creek is a small stream with a braided channel. It had very low flow at the time it was sampled in 1995.

The fish community in Stone Creek was rated as Fair in 1991, but improved to a Good rating in 1995. The 1995 sampling had a greater number of individuals, total species, species of sunfish and percentage of piscivores collected as well as a decrease in the percentage of tolerant individuals collected.

In 1995, a Stone Creek benthic macroinvertebrate site was added to complement the fisheries data. It received a bioclassification of Good-Fair.

Chapter 5:
Neuse Subbasin 05
(Neuse River from Goldsboro to Contentnea Creek including Kinston and portions of Wayne, Lenoir, Greene and Jones Counties)

5-A. Subbasin Description

Neuse subbasin 05 is located in the inner Coastal Plain region. The primary land use is agriculture; however, there are also urban areas around Kinston and Goldsboro. Streams in this area include both slow-flowing creeks with sandy substrates to swamp-like streams with mixed sediment-detritus substrates. Roughly one third of the monitored streams were found to be impaired. The remaining two thirds were supporting their uses but threatened. A map of the subbasin showing water quality monitoring stations is presented in Figure 5.1.

Subbasin 05 at a Glance

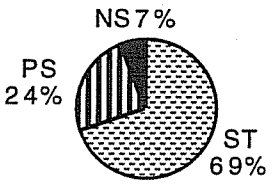
Land and Water Area (sq. mi.)	
Total area:	499
Land area:	496
Water area:	3

Population/Growth	
1996 Est. Pop.:	107,503
Pop. Density:	217 pers/sq. mi.
Proj. 2017 Pop.:	113,953
% increase (1996-2017):	6%

Land Cover (%)	
Forest/Wetlands:	51.6%
Cultivated:	36.5%
Developed:	8.2%
Water:	0.8%

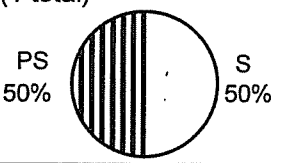
Use Support Ratings

*Streams



* based on *monitored* data

Lakes (1 total)



Nonpoint source impacts, mainly from agriculture, were evident in most smaller streams. The Neuse River in this area receives both nonpoint and point source input, but has maintained moderate to good water quality since 1983.

This portion of the Neuse River has moderate to slow flow throughout the year, but many tributaries become stagnant during periods of low rainfall. Subbasin 05 contains the cities of Kinston and LaGrange which discharge to the Neuse River (4.5 MGD) and to UT Moseley Creek (0.75 MGD), respectively. The Goldsboro WWTP discharges to the Neuse River in this subbasin.

For NPDES wastewater discharges in subbasin 05, oxygen-consuming TMDLs for this subbasin will reflect advanced tertiary treatment for discharges to the mainstem and to minimize BOD loading from the tributaries.

5-B. Water Quality Overview

The Neuse River at NC 58 (Kinston) received a Good rating from 1988 to 1995. Water chemistry data from a nearby site (NC 11 bypass) also did not indicate any water quality problems. The Neuse River receives effluent from seven permitted dischargers in subbasin 05. Kinston Northside WWTP has failed one toxicity test since January, 1992. More recently, waste bypasses and other improper wastewater treatment problems have been discovered and addressed through enforcement actions. Other facilities, with the exception of Celotex Corporation, have passed all toxicity tests since January 1992. Celotex discharges to an

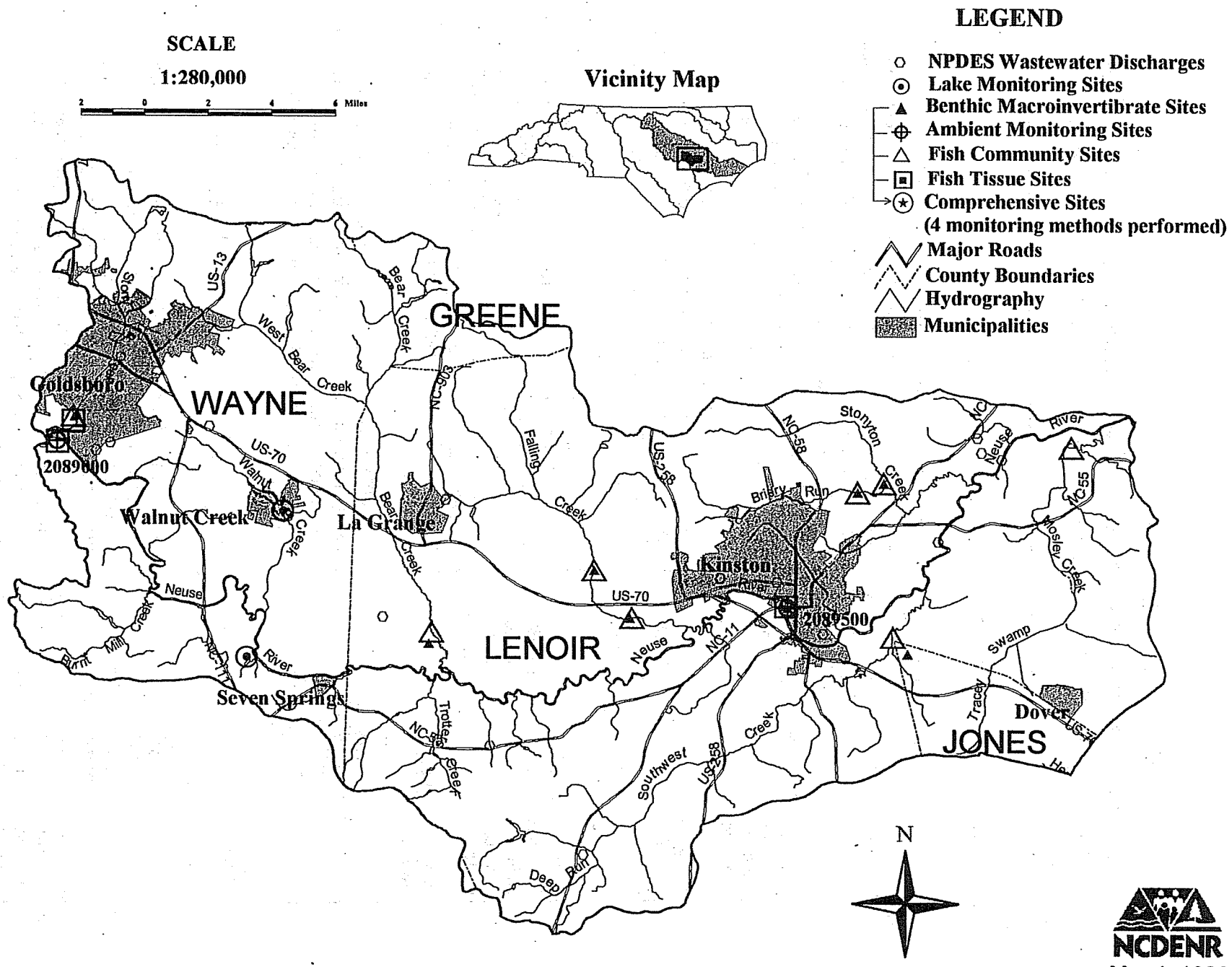


Figure 5.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 05)

NCDENR
March 1998

unnamed tributary of the Neuse River, and has had numerous failures on chronic toxicity test at 90%. Their current permit requires only monitoring for toxicity; it does not contain a limit for toxicity. However, in October, 1996, Celotex indicated they will begin a toxicity reduction evaluation (TRE).

Five tributaries of the Neuse River received ratings ranging from Poor to Excellent based on biological criteria. Stoney Creek receives runoff from Goldsboro and Seymour Johnson Air Force Base, and this stream was shown to have water quality problems by both invertebrate sampling (Poor) and fish collections (Fair). Bear Creek and Falling Creek received Excellent ratings using fisheries data, although these streams received ratings of Fair and Good-Fair, respectively, using benthos data.

Lake Wakena and Cliffs of the Neuse Lake were sampled in 1995. Lake Wakena is a privately-owned lake with a residential development and golf course on its shoreline. The watershed is mostly forested and agricultural. Lake Wakena was found to be eutrophic and has its designated uses Partially Supported due to prolific algal growth in the lake. Cliffs of the Neuse Lake is located in Cliffs of the Neuse State Park. It was found to be oligotrophic and supported all of its designated uses.

5-C. Priority Issues and Recommendations

A recent report by the Natural Resources Conservation Service (1995) shows that most of this subbasin has a high nonpoint source pollution potential, including NPS runoff from cropland, forageland and animals operations. There will also be challenges to Goldsboro and Kinston in meeting water quality standards in the Neuse River while trying to accommodate the increased wastewater demands of industry and a growing population.

5-D. Current or Previously Impaired Waters Updates, Status and Recommendations

- **Bear Creek**

Bear Creek is a tributary to the Neuse River that runs just west of LaGrange. Its watershed is mostly forested, although there are agricultural activities in the upper portion. Bear Creek is one of the three sites within the entire Neuse River basin which were sampled in 1995 that received an Excellent rating for fish. However, its benthic macroinvertebrate rating dropped from Good-Fair in 1991 to Fair in 1995. The reduced benthos rating may be related to increased runoff from agricultural lands.

Waterbody / Location	Bear Creek west of LaGrange
1992 Use Support Rating	ST
Reason(s) for Impairment	Sediment
1993 Planned Strategy	Utilize existing programs.
1993-1997 Actions	Conducted monitoring in 1995.
1998 Use Support Rating	PS
1995 WQ Observations	1. Excellent rating based on fish community assessment. 2. Fair rating based on benthic macroinvertebrates.
1998 Planned Strategy	1. A closer examination of the watershed is needed to better identify and characterize potential sources of impact (which appear to be related to increased runoff) and to work with property owners, as needed, to ensure that appropriate BMPs are being utilized. 2. DWQ will likely not have the resources to do this in the next basin cycle and will need to rely on local government or agency assistance such as the County government, USDA NRCS, SWCD and/or NC Cooperative Extension Service.

- **Neuse River**

Neuse River near Kinston
The Neuse River at Kinston is very wide with a sandy substrate and little instream habitat for benthos and fish. It receives the discharge from Kinston's WWTP, as well as urban nonpoint source pollution and agricultural runoff above Kinston. Even with these apparent stresses, it is able to support a moderately intolerant macroinvertebrate community and has been assigned a bioclassification of Good since 1988.

From 1990 through 1995, the upper Neuse River at Kinston contained very little algal growth. Although this area contained very high levels of nitrogen and phosphorus, the speed of the water flow limits algae growth. During the summer of 1987, an algal bloom occurred at Kinston and at downstream Neuse River stations. Phytoplankton sampling at Kinston was discontinued in 1990 because of the infrequent occurrence of blooms. DWQ continues to collect data on nutrients and flow at this site to provide important information for assessing nutrient loading from the upper Neuse River to the estuary.

Neuse River near Goldsboro
The Neuse River had been sampled at SR 1915 near Goldsboro four times during 1984-1990. This site was above the Goldsboro WWTP outfall and received Good ratings from 1986-1990. In 1988, the WWTP outfall for Goldsboro was moved to a new location on the Neuse River. After the discharge location was changed, the monitoring site was moved to NC 117 to stay above the discharge point. The differing number of total taxa and EPT taxa is probably reflecting more of a flow change than a water quality change, although additional urban and agricultural runoff can not be discounted. There were many areas of erosion along the banks and bank vegetation was sparse.

Fish tissue samples were collected at one site within the Neuse 12 subbasin. Metals analyses performed on samples from the Neuse River at Goldsboro show only mercury exceeding FDA and EPA criteria in three of twenty-three samples collected from 1992 to 1994. A composite sample of channel catfish was collected at the station and analyzed for metals in 1992. Results indicated eleven detectable compounds; however, levels remained below FDA and EPA criteria.

- **Stone Creek**

All sites have prior benthos data except Stone Creek which was added in 1995 to compare with fisheries data. It runs through much of Goldsboro and adjacent to Seymour Johnson Air Force Base. While the stream habitat appeared to be in good condition, very few macroinvertebrates were collected.

Five sites were sampled in this subbasin in 1995 with ecological health ratings ranging from Fair (Stone Creek) to Excellent (Bear Creek and Falling Creek). Stone Creek was rated Fair because of metrics scores of 1 for the number of individuals (112 fish), number of species of suckers (0 species), and number of intolerant species (0) species) collected. Moseley Creek had also been sampled in 1991 when it had been rated as Good. The slight decrease in the NCIBI score was a result of the collection of four fewer species of sunfish in 1995 in contrast to 1991. Bear Creek and Falling Creek were two of the three sites within the entire Neuse River basin which were sampled in 1995 that were rated as Excellent.

- **Southwest Creek**

Southwest Creek is a tannic stream which drains the area southeast of Kinston. Although the same bioclassification was assigned in 1991 and 1995, fewer EPT were found in 1995.

Particularly noticeable was the absence of edge-dwelling Trichoptera (*Nectopsyche, Oecetis* and *Triaenodes*) which were common in 1991.

Classification	C Sw
1992 Use Support Rating	PS
Reason(s) for Impairment	?? Nonpoint sources.
1993 Planned Strategy	Utilize existing programs.
1993-1997 Actions	
1997 Use Support Rating	PS
1995 WQ Observations	Same bioclass assigned, but fewer of the pollution-intolerant species were found.
1998 Planned Strategy	1. A closer examination of the watershed is needed to better identify and characterize potential sources of impact (which appear to be related to increased runoff) and to work with property owners, as needed, to ensure that appropriate BMPs are being utilized. 2. DWQ will likely not have the resources to do this in the next basin cycle and will need to rely on local government or agency assistance such as the County government, USDA NRCS, SWCD and/or NC Cooperative Extension Service.

- **Cliffs of the Neuse Lake**

Cliffs of the Neuse Lake is located in a state-owned park of the same name in Wayne County. The 10-acre lake has a maximum depth of 20 feet (59 meters) and a mean depth of 30 feet (9 meters). Mill Creek, the only significant tributary, was impounded to form the lake in 1953. The small, 0.5 square mile watershed is completely forested and contained entirely in the park. The lake is primarily used for recreation and education.

DWQ last sampled Cliffs of the Neuse Lake in July 1995. Low pH values were attributed to springs at the bottom of the lake which contribute acidic water from the Black Creek Formation (aquifer) (personal communication with Bill Hoffman, state geologist). The lake also had anoxic conditions at the bottom. Data indicated that the lake is oligotrophic. With few human influences, the trophic state of this lake is likely to remain stable for some time. In 1995, Cliffs of the Neuse Lake supported all of its designated uses.

DWQ previously sampled Cliffs of the Neuse Lake in 1981, 1988 and 1991. In 1981 and 1988, the lake was determined to be mesotrophic. In 1988, the water column was clear and well mixed with acidic pH. In 1991, Cliffs of the Neuse Lake was again well mixed, and the lake was oligotrophic.

Special Study

These streams were sampled to assess water quality before the development of an airport in the Global Transpark area. The streams were not given final bioclassification ratings because of their swamp-like nature. However, low taxa richness (especially EPT taxa) were recorded at both sites.

Site #	Creek	Date	Study	County	Road	S:Rating
B-6	Stonyton Creek	931102	Global Transpark	Lenoir	SR 1742	25:Swp
B-7	Briery Run	931102	Global Transpark	Lenoir	SR 1732	23:Swp

Chapter 6:
Neuse Subbasin 06
(Little River Watershed including Wendell and parts of Wake, Wayne and Johnston Counties)

6-A. Subbasin Description

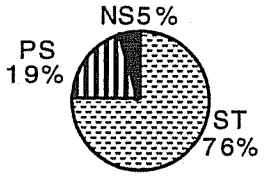
Neuse subbasin 06 includes the entire Little River catchment form its headwaters at Moore's Millpond in Franklin County to its confluence with the Neuse River near Goldsboro. The lower part of the watershed in Johnston and Wayne Counties is characterized by larger farms with smaller buffer zones. Land use throughout the subbasin is primarily a combination of agriculture and forestry, with scattered, but growing, small towns. The river is home to a number of rare, threatened and endangered species including the federally endangered dwarf wedge mussel. A map of the subbasin showing water quality monitoring stations is shown in Figure 6.1.

Subbasin 06 at a Glance

Land and Water Area (sq. mi.)	
Total area:	**317**
Land area:	**317**
Water area:	**<1**
Population/Growth	
1996 Est. Pop.:	**51,133**
Pop. Density:	**161 pers/sq. mi.**
Proj. 2017 Pop.:	**79,255**
% increase (1996-2017):	**55%**
Land Cover (%)	
Forest/Wetlands:	59.4%
Cultivated:	**33%**
Developed:	**3.2%**
Water:	**0.8%**

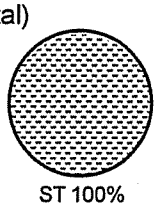
Use Support Ratings

*Streams



* based on *monitored* data

Lakes (2 total)



The Little River has two distinct reaches in this subbasin. The first reach flows quickly as it drops out of the piedmont (an average slope of 27 feet per mile in the first 1.5 miles and 6 feet per mile in the next 9.5 miles). The second reach moves more slowly as it meanders through the Coastal Plain (an average slope of 2.6 feet per mile for the downstream 61 miles).

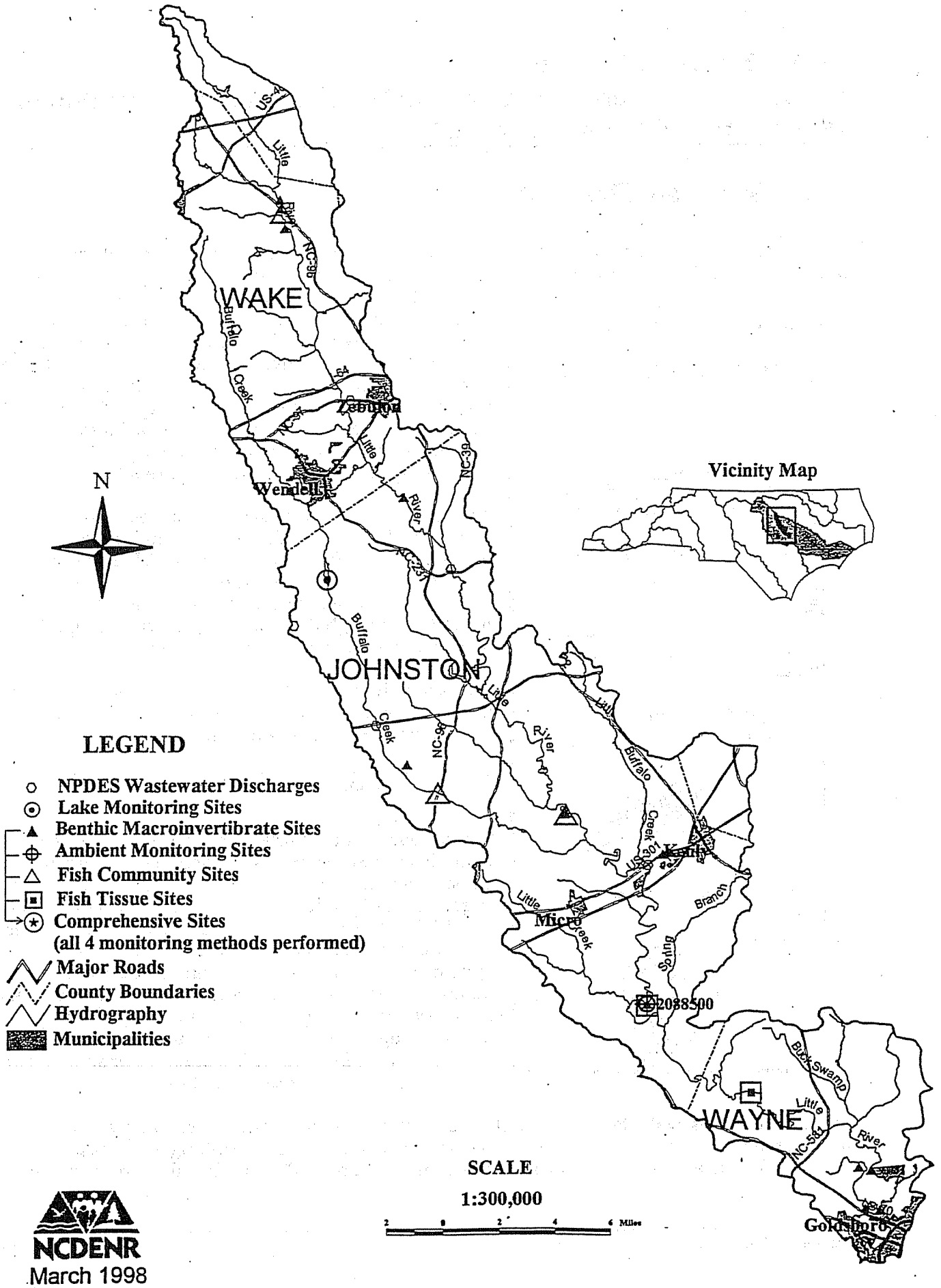
The Kenly Regional WWTP is the only major (permitted flow 0.52 MGD) NPDES discharger in subbasin 06. The facility discharges to the Little River.

6-B. Water Quality Overview

Water quality of the Little River in 1995 was generally Good-Fair based on macroinvertebrate samples, but Good based on fish data. The macroinvertebrate data suggested a slight decline in water quality between 1991 and 1995 in the middle and lower portions of the river. Nonpoint runoff associated with rapid development appears to have the greatest potential to affect water quality in this area, but agricultural water withdrawals also may affect the aquatic community by reducing flows during drought periods. While not classified as swamp waters, Little River is a blackwater stream that has some swamp-like characteristics.

This subbasin was evaluated for the first time in 1995 when three sites were sampled. Two sites on the Little River were sampled above and below a proposed drinking water supply reservoir for eastern Wake County and were rated as Good and Good-Excellent, respectively.

Figure 6.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 06)



Buffalo Creek, a tributary to the Little River, was sampled above the proposed drinking water supply reservoir. It also was rated as Good.

The lake is classified C NSW but continued to experience algae blooms in 1995. The designated uses of Lake Wendell were determined to be threatened due to elevated percent oxygen saturation in surface waters, low dissolved oxygen in bottom waters, a documented nuisance bloom of blue-green algae, and hypereutrophic conditions. The other lake monitored in this subbasin was Holts Lake. Holts Lake is eutrophic, but was found to be supporting its designated uses.

6-C. Priority Issues and Recommendations

The water quality in Little River is fully supporting but threatened. Population is projected to increase by 55% from 1996 to 2017. Sedimentation and urban nonpoint runoff have the potential to significantly impact water quality unless mitigating measures are undertaken by local governments and developers to protect the river. Endangered species habitat is threatened by a proposed reservoir downstream from Mitchells Mill State Natural Area.

6-D. Current or Previously Impaired Waters Updates, Status and Recommendations

- **Buffalo Creek**

Fisheries data for 1995 produced a Good rating for Buffalo Creek, although prior macroinvertebrate samples had assigned Poor or Fair ratings for this stream. No additional benthic sampling was done in 1995. Buffalo Creek is the main tributary to Lake Wendell.

Classification	B/C
1992 Use Support Rating	PS/NS
Reason(s) for Impairment	Sediment, DO, Nutrients (especially P) Wendell WWTP, urban nonpoint source pollution.
1993 Planned Strategy	1. Utilize existing programs. 2. NPDES permits will reflect advanced tertiary treatment (5 mg/l BOD and 2 mg/l ammonia) for new and expanding dischargers. 3. The Town of Wendell is considering relocating its discharge and may tie to the Raleigh WWTP. 4. Existing facilities will be handled on a case-by-case basis.
1993-1997 Actions	
1997 Use Support Rating	PS
1998 Planned Strategy	1. Follow-up benthic macroinvertebrate sampling needs to be performed to update the 1991 data. 2. A closer examination of the watershed is needed to better identify and characterize potential sources of impact (which appear to be related to increased runoff) and to work with property owners, as needed, to ensure that appropriate BMPs are being utilized. 3. DWQ will likely not have the resources to do this in the next basin cycle and will need to rely on local government or agency assistance such as the County government, USDA NRCS, SWCD and/or NC Cooperative Extension Service.

- **Little River**

Little River contains twelve rare animals: three fishes, one amphibian and eight mussels, including several populations of the federally endangered dwarf wedgemussel. The only

protected site along the river is Mitchells Mill State Natural Area in Wake County. A reservoir, which will impact some of these rare species, is being planned on the river downstream from Mitchells Mill State Natural Area. Aquatic species would benefit from protection efforts along the River.

Little River at NC 96
The Little River at the sampling location flows primarily over areas of exposed bedrock with only small amounts of rubble and gravel substrate. Stream width at the site is variable with alternating pools and constrictions, but averages approximately eight meters.
This site has received a Good-Fair bioclassification during each of the four summers it has been sampled. The bioclassification has remained constant in spite of between-year ranges in flow for the 30 days prior to the time of sampling. The site has also been sampled a number of times during nonsummer months as part of seasonal and multiple reach studies.

Little River at SR 2130
The physical characteristics at this site are quite different than those found at the NC 96 location. Sand composes the highest percentage (40%) of the substrate at this site, with the rest of the substrate being a fairly even mix of boulder, rubble and gravel. The stream is approximately 10 meters wide at this point.

Although total taxa richness was the same for 1991 and 1995, EPT taxa richness and EPT abundance decreased and the BI value increased. These changes caused the bioclassification to decrease from Good in 1991 to Good-Fair in 1995. Although both sampling events occurred during years when river flow rates were highly variable during the late spring and early summer, the large decrease in EPT taxa richness and increase in the BI value suggests a change in water quality has occurred at this site.

Little River at NC 581
This site is located downstream of the SR 2130 site and has a higher percentage of sand as substrate than the SR 2130 site. The Little River in this area is a slow-flowing inner coastal plain and is approximately 15 meters wide.

The Little River at this site experienced a drop in bioclassification from Good in 1991 to Good-Fair in 1995. Total taxa richness, EPT taxa richness and EPT abundance all decreased between 1991 and 1995, coincident with an increase in the BI between the two sampling years. Similar to the SR 2130 site, the Little River at NC 581 had variable flows before the sampling events, but the degree of change in the macroinvertebrate metrics suggests a change in water quality for this site also. Three sites on the Little River were sampled within two weeks after 6,800 gallons of a solution of 50% sodium hydroxide (NaOH) spilled on the Goldsboro water treatment plant property. At least a portion of NaOH reached the Little River and caused a fish kill. However, based on the data collected during this survey, there did not appear to be an impact on the river's macroinvertebrate community (B-940805).

- **Wendell Lake**

Constructed in 1927, Wendell Lake was originally used to provide power for a grist mill operation. Today, the lake is used for recreational fishing and access is limited to members of the Wendell Lake Fishing Club. Over the years, the lake has lost much of its storage capacity and presently has a surface area of 100 acres and a mean depth of 5 feet (1.5 meters). Land use in the 25-square mile watershed includes agricultural, residential, forested and wetland areas.

Buffalo Creek, the main tributary of the lake, is a slow-moving blackwater creek whose flow is restricted by numerous beaver dams upstream of Wendell Lake. Nutrient enrichment has also

been a major problem with this lake. Much of the nutrient inputs appear to originate from upstream wastewater discharges into Buffalo Creek by the Town of Wendell and Vaiden Whitley High School. In 1994, wastewater from the Town of Wendell was directed to Raleigh for treatment and the Wendell WWTP was taken off-line.

DWQ most recently sampled Wendell Lake in July 1995. The lake was turbid at both lake sampling sites and the lake violated water quality standards for dissolved oxygen and pH. The elevated pH, low dissolved oxygen, and high chlorophyll *a* levels at the upstream sampling site confirmed the presence of algal blooms. The data indicated that the lake was hypereutrophic. The designated uses of Wendell Lake were rated Support Threatened.

This lake was sampled previously by DWQ in 1988 and 1991. In 1988, the data showed oxygen depletion and chlorophyll *a* values at both sampling sites to be approximately three times greater than the state water quality standard. A large population of aquatic macrophytes, along with nuisance amounts of algae and duckweed were observed in Wendell Lake. Overall, the data in 1988 indicated that Lake Wendell was hypereutrophic and not supporting its designated uses. When Wendell Lake was sampled again in August 1991, chlorophyll *a* concentrations showed a major decrease from the 1988 concentrations and data indicated an improvement to eutrophic conditions.

In 1986, DWQ conducted a special study of nutrient loading that involved both the lake and Buffalo Creek upstream and downstream of the lake. Agricultural activities and developed areas were identified as potential sources of nutrient loading. Point sources were identified as Vaiden Whitley High School wastewater treatment operation (discharged into Buffalo Creek upstream of the Highway 64 bridge) and the Town of Wendell's wastewater treatment plant (discharged into Buffalo Creek at SR 2358 at the Wake County - Johnston County line). Because Wendell Lake is quite shallow and nutrient inputs were high, internal recycling of nutrients was another problem for the lake.

Chapter 7:
Neuse Subbasin 07
(Includes: Contentnea Creek, Cities of Wilson, Farmville and Fremont and portions of Nash, Wayne, Wilson, Greene, Wake, Johnston and Lenoir Counties)

7-A. Subbasin Description

This subbasin contains the entire Contentnea Creek watershed which is the largest tributary of the Neuse River containing approximately 849 square miles. Agriculture is the primary land. Most of the streams have sandy substrates, primarily due to erosion of riparian zones. Figure 7.1 shows a map of the subbasin with water quality sampling stations.

Subbasin 07 at a Glance

Land and Water Acre (sq. mi.)

Total area:	**1,007**
Land area:	**1,004**
Water area:	**3**

Population/Growth

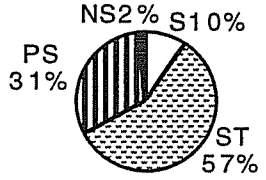
1996 Est. Pop.:	**124,629**
Pop. Density:	**124 pers/sq. mi.**
Proj. 2017 Pop.:	**137,092**
% increase (1996-2017):	**10%**

Land Cover (%)

Forest/Wetlands:	**52.9%**
Cultivated:	**39.82%**
Developed:	**4.1%**
Water:	**0.6%**

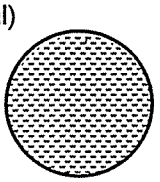
Use Support Ratings

*Streams



* based on *monitored* data

Lakes (5 total)



Streams in the western section of this subbasin are typically piedmont streams. In the eastern portion, the streams have more swamp and pocosin-like characteristics and are classified using coastal 'A' criteria. Wetlands, including bottomland hardwoods, account for about 3 percent of the total acreage of the watershed.

7-B. Water Quality Overview

According to 1992 estimates, Contentnea Creek accounts for 20 percent of the nitrogen load delivered to the Neuse Estuary. This basin will likely receive DWQ's highest priority for cooperative efforts between government agencies. Cooperation will be necessary to identify and prioritize where nonpoint source controls will be most efficiently implemented. Also, wasteload allocations will be done on a case-by-case basis.

This subbasin contains all of the Contentnea Creek catchment. The streams in the western part of the subbasin (approximately from US 301 west) were evaluated using piedmont criteria, while streams east of US 301 were generally considered to be coastal plain. Many of the streams in the coastal plain portion of this subbasin are slow-flowing and swamp-like. Agriculture is the primary land use in this subbasin with scattered forested areas and some small towns.

Moccasin Creek and Turkey Creek are the two major tributaries that flow into Buckhorn Reservoir and form the headwaters of Contentnea Creek. Water quality in these streams was shown to be Good-Fair (benthos) or Good (fish) in 1995. Limited populations of the federally endangered dwarf

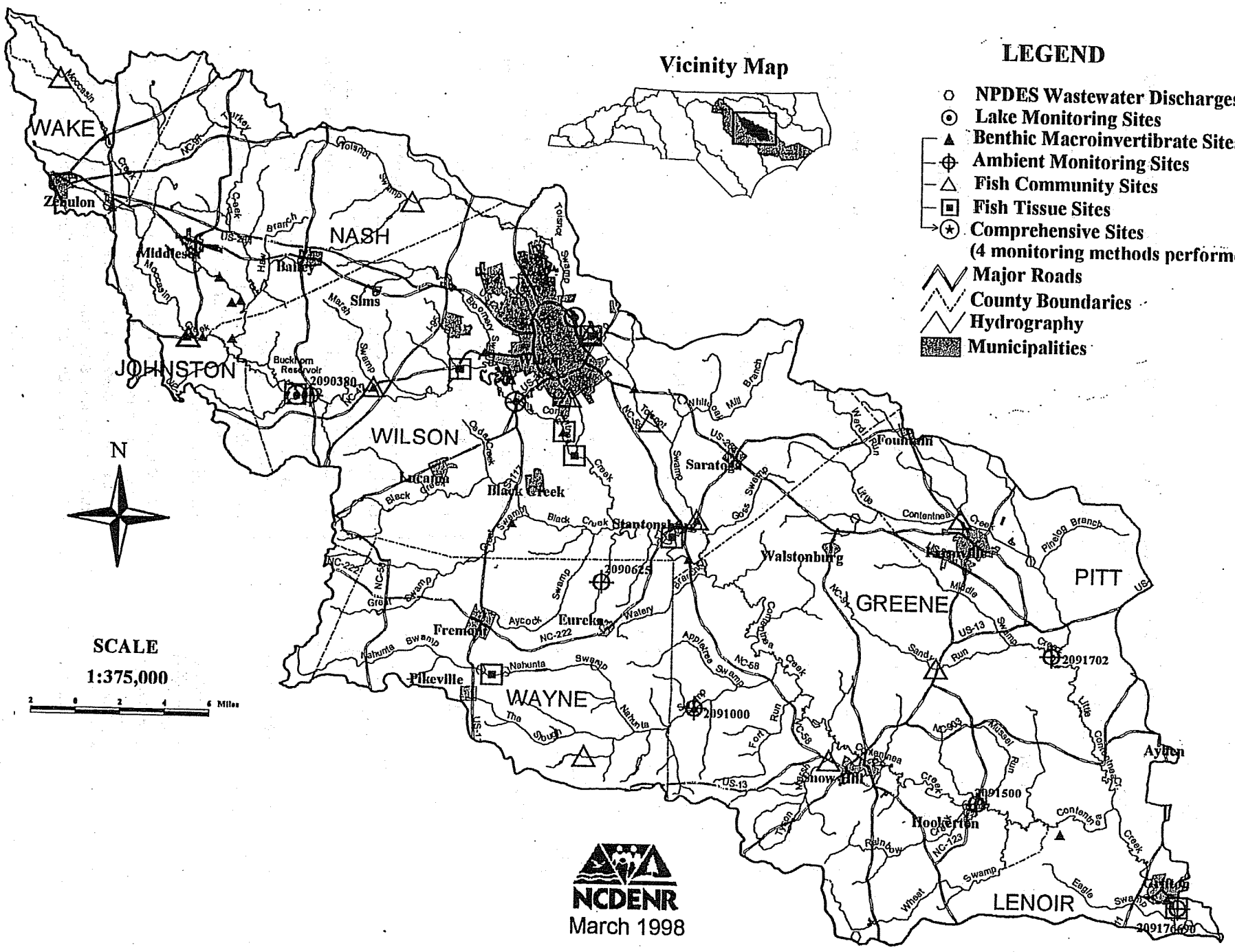


Figure 7.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 07)

wedge mussel have been found in both creeks. Water quality for Contentnea Creek varied from Good at NC 42 below Buckhorn Reservoir to Fair near Stantonsburg to Good-Fair near Grifton. Fifty-three percent of fish tissue samples collected between 1992 and 1995 from Contentnea Creek near Grifton were determined to have mercury levels above EPA and FDA criteria.

Good or better water quality was indicated in three smaller streams based on fish samples: Toisnot Swamp, Exum Mill Branch and Tyson Marsh. Tributaries that were shown to have Fair or Poor water quality included Nahunta Swamp, Hominy Swamp, Little Contentnea Creek and Sandy Run. Rating water quality of many streams in the lower areas of this subbasin with biological parameters is difficult due to the lack of flowing water during the summers.

Surveys were conducted on five lakes and reservoirs in this subbasin. Buckhorn Reservoir and Wiggins Mill Reservoir are classified WS-V NSW, and serve as water supply for Wilson. Both lakes support their designated uses, but were found to be eutrophic. Toisnot Reservoir, Silver Lake and Lake Wilson are classified WS-III NSW. These reservoirs also were shown to be eutrophic, but still supported designated uses.

Chemical monitoring data from all three Contentnea Creek sites (1991 to 1995) showed violations of the dissolved oxygen (DO) criterion for 13-19% of the samples. Samples collected from Little Contentnea Creek indicated the most severe DO problems in this subbasin with 52% of the samples collected being less than 5.0 mg/l.

Water quality in this subbasin is potentially affected by a combination of nonpoint source runoff and NPDES permitted dischargers. The runoff in this subbasin is primarily from agricultural areas, including a rapidly growing number of hog farms. The four major dischargers are: Zebulon (1.85 MGD to UT Moccasin Creek), Wilson WWTP (12.0 MGD to Contentnea Creek), Farmville WWTP (3.5 MGD to Little Contentnea Creek), and Contentnea District WWTP (2.85 MGD to Contentnea Creek).

A recent report by the Natural Resources Conservation Service (1995) shows that most of this subbasin has a high nonpoint source pollution potential, including NPS runoff from cropland, forageland and animals operations.

7-C. Current or Previously Impaired Waters: Status, Updates and Recommendations

Approximately one third of the monitored streams in this watershed are considered impaired. This is based largely on biological sampling results although chemical sampling has revealed low dissolved oxygen levels in some streams. Unfortunately, little information is provided, in the following stream-by-stream discussions, on pollution sources. Agriculture could be a contributing factor as roughly 40 percent of the land area in the watershed is in cultivated cropland. There are also several dischargers and small pockets of development that could be contributing. It is also recognized that waters in this watershed tend to be naturally stressed during the summer by low flows and the swampy nature of the streams. Swamp waters are naturally low in dissolved oxygen. As a general recommendation, additional monitoring and a more thorough examination of the watersheds draining to the impaired waters within this subbasin are needed in order to identify the causes and sources of pollution and to develop strategies to correct these problems (to the extent the problems are man-induced and correctable.).

At present, the Division of Water Quality has insufficient resources to do more than periodic routine monitoring in this subbasin. It is noted, however, that the Contentnea Creek watershed has been designated as one of five high priority watersheds in North Carolina for receiving special federal restoration funds under a new federal program called Unified Watershed

Assessment (UWA). It is hoped that through this program, or perhaps through focusing additional attention on the needs of this subbasin for additional study, that more resources can directed to Contentnea Creek for monitoring, watershed evaluation and restoration work.

- **Contentnea Creek**

Contentnea Creek near Stantonsburg
Contentnea Creek is a coastal plain stream that flows through largely agricultural areas near this site, with some semi-urban areas around the town. The stream at this location is approximately 25 meters wide and has a substrate composed almost entirely of sand.

This site has been assigned either a Fair or Good-Fair bioclassification for each of the five years it has been sampled. The metric that showed the largest contrast between the two bioclassification groups was EPT abundance. For years with a Fair bioclassification, the EPT abundance values were all in the 40s, while the values for the Good-Fair bioclassifications were 89 and 112. The macroinvertebrate community had shown steady improvement in terms of an increase in EPT taxa richness and a decrease in BI values from 1988 to 1991. However, a large drop in EPT taxa richness and a substantial increase in the BI were recorded in 1995. The size of these changes indicates a decrease in water quality at the sites from 1991 to 1995.

Contentnea Creek in Grifton
The site is located near a public boat ramp in the town, and land use in the immediate area is urban or residential. Contentnea Creek at this location is approximately 25 meters wide and nearly all the substrate is sand.

The bioclassification at this site improved from Good-Fair in 1983 and 1985 to Good in 1987 and 1991. EPT taxa richness and abundance also improved during this time span, and the 1991 BI value was the lowest recorded at this sampling location. In 1995, the bioclassification dropped back to Good-Fair, accompanied by sharp decreases in EPT taxa richness and abundance and a large increase in the BI. The degree of change in the macroinvertebrate community suggests a drop in water quality at the site between 1991 and 1995.

Fish tissue samples were collected at two sites within the Neuse 07 subbasin. Metals contaminants remained below levels of concern at both stations except for mercury which was detected at levels above EPA and FDA criteria in 30 of 57 samples collected from Contentnea Creek near Grifton from 1992 to 1995. Organics analyses were performed on largemouth bass and redhorse sucker composite samples collected from Contentnea Creek near Grifton in 1992. Results show eight contaminants were detected at levels below FDA and EPA criteria.

Composite samples of redhorse suckers and largemouth bass were collected and analyzed for organic contaminants in 1992. No organic contaminants exceeded water quality criteria.

A low flow water quality study was conducted on a 53 mile reach of Contentnea Creek from Hwy. 58 south of Stantonsburg (3.3 mile distance). Problems found by the study were low dissolved oxygen values and elevated nutrient values.

- **Little Contentnea Creek**

Eight fish community assessment sites were sampled in this subbasin in 1995 with ecological health ratings ranging as low as Poor-Fair. Little Contentnea Creek at SR 1228, rated as Poor-Fair, was one of the four lowest rated streams which were sampled in 1995 in the Neuse River basin. The low rating was attributed to the metric scores of 1 for the few number of individual fish collected (n = 34) and the absence of darters, suckers and intolerant species.

The Town of Farmville WWTP had been under a Special Order by Consent (SOC) which specifies chronic toxicity monitoring without a limit on a quarterly basis. The SOC required compliance with the permit limit by 12/31/96. The Town of Middlesex WWTP has also been under a Special Order by Consent (SOC) which specifies chronic toxicity monitoring without a limit on a quarterly basis. The SOC required compliance with the permit limit by 4/1/97.

- **Little Creek (West Side)**

Little Creek was last sampled in July 1991 at Hwy 97 in Nash County. It received a Poor biological rating and is included on the state's 303(d) list of impaired waters. Additional monitoring is needed in order to confirm the impaired status of the stream and to help identify potential causes and sources of the impairment.

- **Beaverdam Creek**

Beaverdam Creek was last sampled in May 1991 at SR 1112 in Nash County. At that time, it received a Fair biological rating and is now included on the state's 303(d) list of impaired waters. Additional monitoring is needed in order to confirm the impaired status of the stream and to help identify potential causes and sources of the impairment.

- **Nahunta Swamp**

Nahunta Swamp at SR 1058, near Shine
The bioclassification for this location was Good-Fair for the years prior to 1995, when it dropped to Fair. The stream is now included on the state's 303(d) list of impaired waters. The stream has been channelized in the past and is bordered by forested and agricultural areas.

The decrease in the bioclassification was due to a decrease in EPT taxa richness to its lowest value recorded at the site. Total taxa richness and EPT abundance values in 1995 also were record lows for the site. While these changes in the macroinvertebrate metrics suggest a possible decrease in water quality at the site, the 1995 BI value was a slight improvement over the BI recorded during other sampling events.

Date	Total S	EPT S	EPT N	BI(BIEPT)	Bioclass	Flow
22 Aug 95	57	6	17	6.40(5.76)	Fair	Low
09 July 90	68	16	62	6.54(5.24)	Good-Fair	Low
02 May 90	66	13	61	6.34(5.14)	Good-Fair	Normal
11 July 88	66	11	39	6.65(4.78)	Good-Fair	Low

Additional monitoring and examination of the watershed is needed in order to confirm the impaired status of the stream and to help identify potential causes and sources of the impairment.

7-D. Other Waters of Interest

Hominy Swamp and Sandy Run

While these streams received a Fully Supporting but Threatened use support rating, both Hominy Swamp and Sandy Run were rated only as Fair based on a fish community assessment. Both received metric scores of 1 due to the absence of darters and intolerant species and/or due to the large percentage of tolerant individuals collected. At Hominy Swamp, 52% of all fish collected were *Gambusia holbrooki*, the Eastern mosquitofish, a tolerant species.

Future monitoring will be needed to determine whether there is a significant downtrend in water quality occurring in these streams.

Chapter 8:
Neuse Subbasin 08
(Includes: Neuse River from Contentnea Creek to New Bern and portions of Pitt, Craven and Jones Counties)

8-A. Subbasin Description

Neuse subbasin 08 is primarily within the Outer Coastal Plain region. The primary land use is agriculture, with some urban areas in Vanceboro and on the outskirts of New Bern. Most streams in this area are slow-flowing, brown-water streams with very sandy substrates.

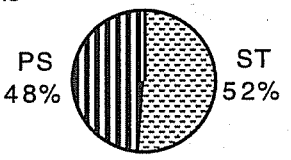
Subbasin 08 at a Glance

Land and Water Area (sq. mi.)	
Total area:	231
Land area:	229
Water area:	3

Population/Growth	
1996 Est. Pop.:	12,410
Pop. Density:	54 pers/sq. mi.
Proj. 2017 Pop.:	14,594
% increase (1996-2017):	17.6%

Land Cover (%)	
Forest/Wetlands:	67.3%
Cultivated:	26.3%
Developed:	3.9%
Water:	1.2%

Use Support Ratings
*Streams



* based on *monitored* data

Subbasin 8 contains approximately 25 river miles of the Neuse River downstream to New Bern and several small tributary catchments including Core and Bachelor Creeks. The tributaries drain swamp and pocosin wetlands and are therefore blackwater (or tannin) streams typically having low dissolved oxygen and pH concentrations. A map of the subbasin with water quality sampling stations is shown in Figure 8.1

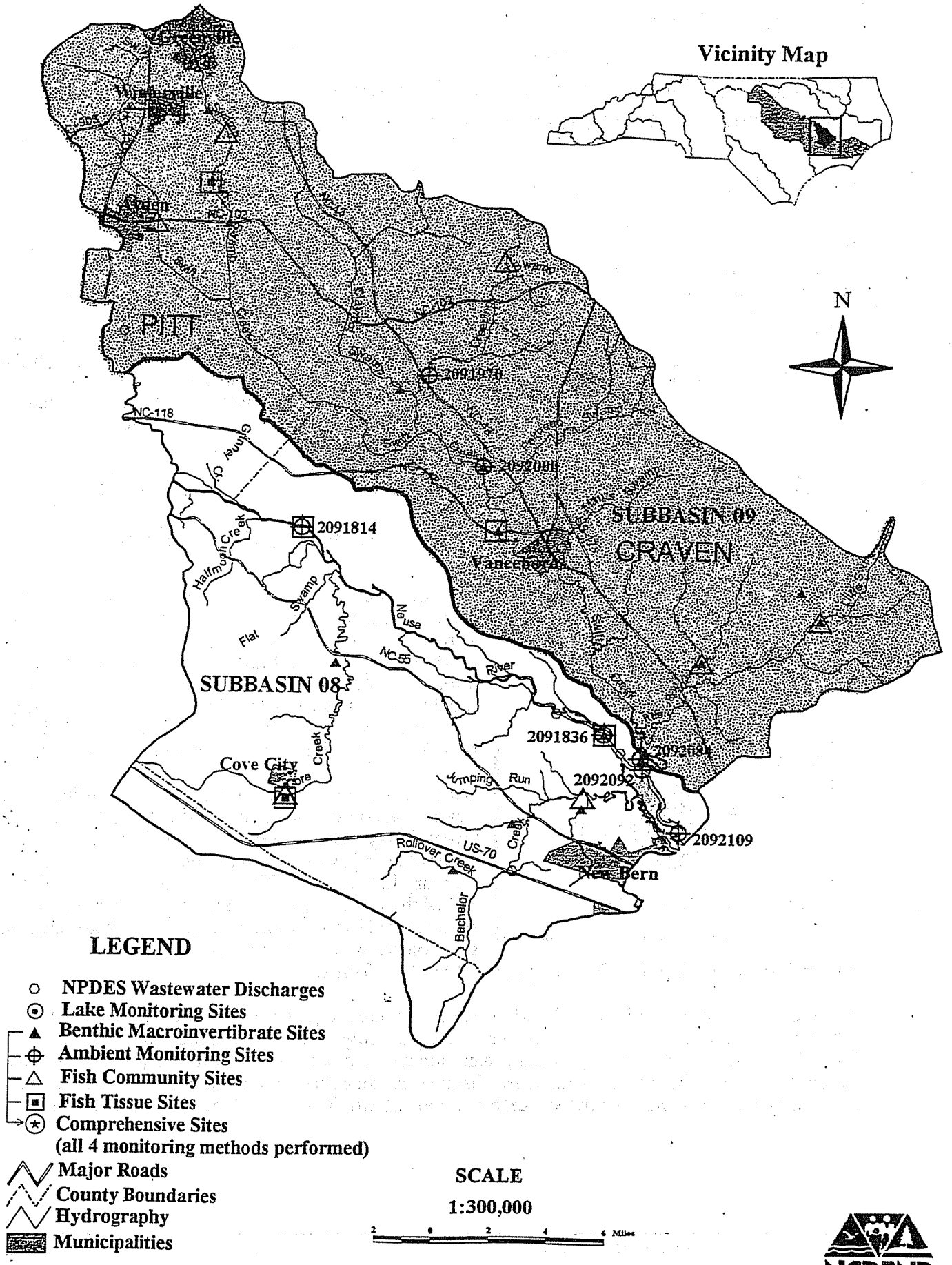
8-B. Water Quality Overview

Core Creek is the only tributary given a water quality rating based on biological parameters. An 18.5-mile segment of the creek has been rated as impaired (partially supporting it uses). Nonpoint source runoff appears to have the biggest potential to affect water quality in the subbasin. The only major discharger in this subbasin is Weyerhaeuser, with a permitted flow of 32 MGD into the Neuse River above New Bern.

The Neuse River in this subbasin has Good-Fair water quality based on macroinvertebrate samples near Streets Ferry. Fish tissue collections from the Neuse River at Fort Barnwell and Streets Ferry indicated mercury levels above FDA and EPA criteria in about 1/3 of the fish samples. Chemical monitoring data from several locations on the Neuse River documented sporadic violations of state standards for some parameters, including dissolved oxygen and fecal coliforms.

The Neuse River at Fort Barnwell and Streets Ferry had frequent algal blooms in the 1970s and 1980s, with the worst blue-green bloom occurring in August 1983. Since the impoundment of Falls Reservoir in 1984, no major blue-green blooms have been reported in this part of the Neuse River. Slightly higher algal counts were observed further downstream at the Narrows. Elevated chlorophyll *a* levels were recorded during periods of low flow in September 1990 and August 1993.

Figure 8.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasins 08 and 09)



8-C. Current or Previously Impaired Waters: Update, Status and Recommendations

Core Creek

Core Creek is a slow-flowing, slightly tannic, stream at the sampling location. It is approximately 40 feet wide, with a substrate composed primarily of sand, but also including a significant component of silt and detritus.

Fisheries data indicated Good water quality in the upper sections of the stream at SR 1001. Macroinvertebrate data assigned only a Fair rating to Core Creek at NC 55, and comparisons of samples from 1991 and 1995 suggested a decline in water quality over this time period. Other streams where macroinvertebrates were collected were not assigned water quality ratings due to the nonflowing, swampy nature of these streams.

The sampling protocol at this site was changed between 1991 and 1995 to provide a more thorough evaluation of this slow-moving stream. In spite of the more intensive sampling in 1995, benthic macroinvertebrate diversity and abundance dropped between 1991 and 1995; however, the change was not enough to change the bioclassification of Fair.

The fish assessment produced an ecological health rating of Good-Excellent, although there was an absence of intolerant species and one fewer species of darter than expected.

As noted above, impairment of the creek appears to be resulting from nonpoint source pollution although the actual sources are not identified. In order to identify the causes and sources of this impairment, more intensive sampling and a thorough evaluation of the watershed will be needed.

8-D. Other Waters of Special Interest

Neuse River

In the Neuse River, eutrophication was a major concern during the 1970s as demonstrated by blue-green algal blooms in the freshwater portion of the river from Streets Ferry to New Bern while diatom blooms fouled nets from New Bern downstream. A special investigation conducted from 1979 through 1981 revealed that algal blooms were a frequent occurrence each summer. High chlorophyll *a* concentrations (up to 250 µg/l) were found during the warmer months while the surface blooming blue-green alga, *Anacystis cyanea* (*Microcystis aeruginosa*) comprised 60% of the algal population at Fort Barnwell in September 1980.

Work by Division of Environmental Management and university researchers in the early 1980s was done to determine the extent of the algal problem including the frequency and duration of the blooms. The worst blue-green algal bloom in the Neuse River occurred in August 1983. Surface blooms of *Anacystis cyanea* were present in the area of Fort Barnwell and Streets Ferry in August with chlorophyll *a* values near the surface as high as 1700 µg/l. Flow and temperature appeared to be the controlling factors in determining phytoplankton composition and abundance. Although there were high concentrations of algae present, they were not limited by nutrients. A predictive model for the occurrence of these blue-green blooms was developed by Christian et al. (1986). This model incorporates flow and water temperatures as its variables. Interestingly, since the impoundment of Falls Reservoir in 1984, no major blooms of cyanophytes have been recorded in this upper section of the Neuse River.

From 1990 through 1995, the upper Neuse River (above New Bern) contained very little algal growth. Three sampling stations between Fort Barnwell and the mouth of Swift Creek, 02091814, 02091836 and 02092092 averaged 2 µg/l of chlorophyll *a*. Freshwater algae including bacillariophytes (diatoms), cryptomonads (cryptophytes) and chlorophytes (green algae) dominate this portion of the river. As with the Kinston station, phytoplankton sampling at Fort Barnwell was dropped in 1990 because of the absence of problematic algal growth. The next downstream phytoplankton station, 02092109, at Narrows averaged 5 µg/l of chlorophyll *a*. Two elevated chlorophyll *a* values were found at Narrows in September 1990 (21 µg/l) and in August 1993 (68 µg/l). Although no algal samples were collected, the chlorophyll *a* concentrations were indicative of increased algal growth and both coincided with periods of low flow. The river widens and slows at New Bern and algal growth is greatly increased downstream of US Highway 17.

Neuse River at SR 1423, near Streets Ferry

The Neuse River at this point during the summer is a very slow-flowing outer coastal plain stream. It is approximately 75 feet wide and has a sand substrate. When evaluated with Coastal B criteria, this site has been assigned a Good-Fair bioclassification the last three years it has been sampled, compared to a Fair bioclassification for the first two years. Total and EPT taxa richness and EPT abundance all declined in 1995 when compared to 1989. Although the BI rose slightly from 1989 to 1995, the 1995 value was the second lowest score recorded at the site, with the 1989 value being the lowest. While these changes in the macroinvertebrate metrics indicate a slight drop in water quality, they were not large enough to cause a decrease in the bioclassification.

Chapter 9:
Neuse Subbasin 09
(Includes: Swift Creek, Vanceboro and portions of Pitt, Craven and Greene Counties)

9-A. Subbasin Overview

This coastal plain subbasin contains Swift Creek and its tributaries. Most of the disturbed streams in the area are slow-moving, blackwater swamp streams. Primary land use for the subbasin is agriculture with patchy forested areas. There are only a few small towns in this subbasin and little concentrated development. Development radiating from the Greenville area is beginning to occur in the upper watershed and could influence water quality. A map of the subbasin (and subbasin 08) is presented in Figure 9.1.

Subbasin 09 at a Glance

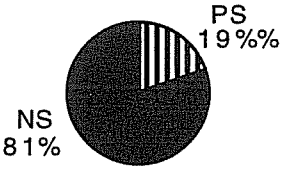
Land and Water Area (sq. mi.)	
Total area:	**333**
Land area:	**332**
Water area:	**1**

Population/Growth	
1996 Est. Pop.:	**31,050**
Pop. Density:	**93 pers/sq. mi.**
Proj. 2017 Pop.:	**36,515**
% increase (1996-2017):	**17.6%**

Land Cover (%)	
Forest/Wetlands:	72.9%
Cultivated:	22.7%
Developed:	3.1%
Water:	0.3%

Use Support

*Streams



Monitored streams

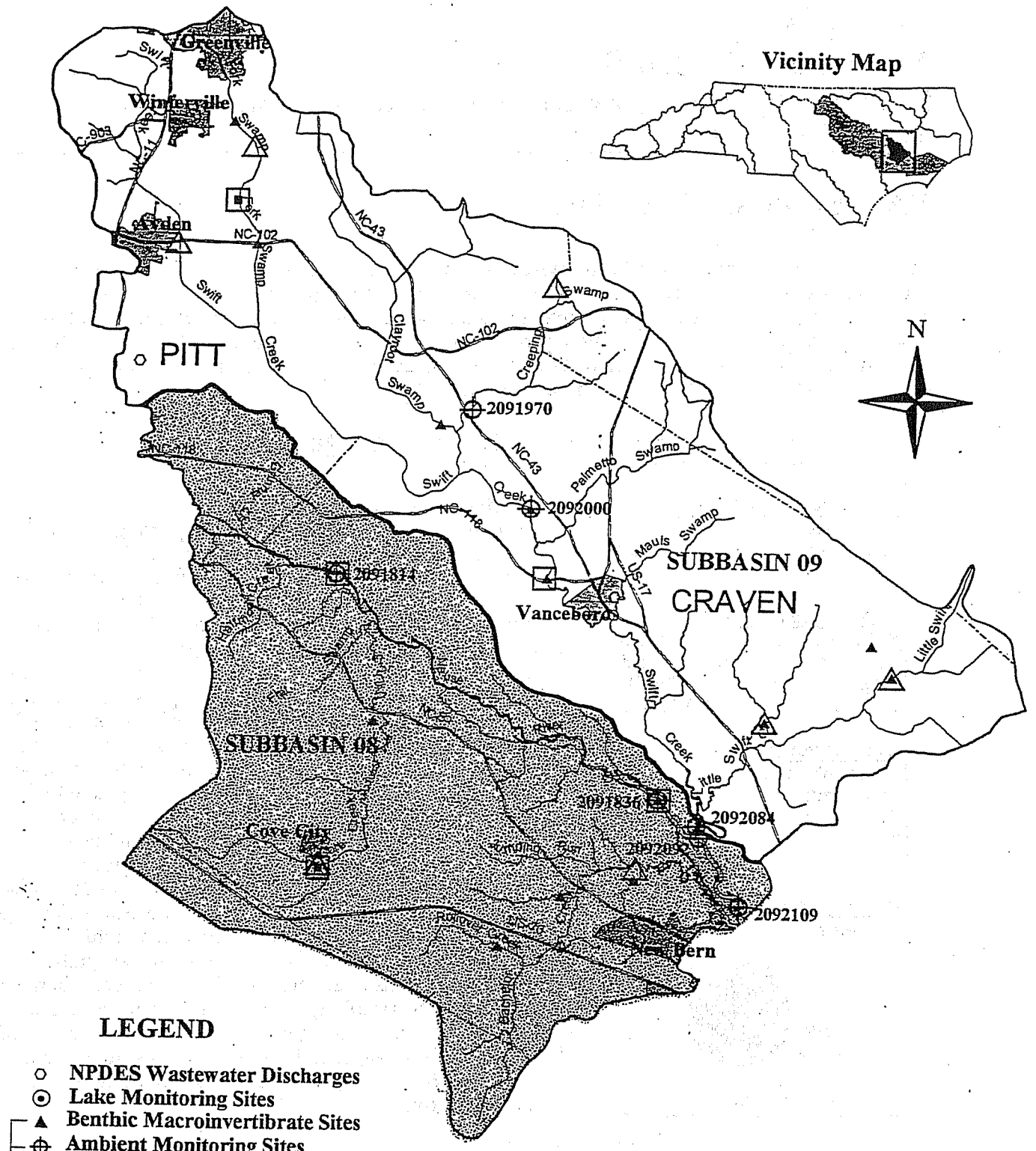
9-B. Water Quality Overview

All streams sampled in this subbasin are rated as impaired (either partially or not supporting their uses). Summer benthic macroinvertebrate collections resulted in ratings ranging from Poor for Swift Creek near Ayden to Fair for Swift Creek near Vanceboro. Poor water quality was also indicated in Clayroot Swamp. The bioclassifications at both locations on Swift Creek and the site on Clayroot were lower in 1995 than they were during the 1991 basinwide survey, suggesting a decline in water quality. Creeping Swamp received a Fair fish rating in 1991 but was not resampled in 1995. Spring fish collections found Poor-Fair water quality in Little Swift Creek, but resulted higher ratings (relative to the macroinvertebrate data) in Clayroot Swamp (Good-Excellent) and Swift Creek (Good). The difference between fish and benthos ratings may be due to marginal water quality being compounded by low flow and high stress during the summer. The lack of flowing water during the summer for many areas in this subbasin makes it difficult to assign a water quality rating to streams using biological parameters. Chemical water quality sampling in Creeping Swamp revealed very low dissolved oxygen concentrations and elevated chlorophyll *a* concentrations. Nonpoint source impacts appear to have the greatest potential to influence water quality in this subbasin.

9-C. Priority Issues and Recommendations

The relatively low overall water quality in the subbasin and the apparent decline in water quality in Swift Creek and Clayroot Swamps from 1991 to 1995 are of concern. While there are some questions regarding the actual degree of natural versus man-induced impairment-based,

Figure 9.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasins 08 and 09)



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in part, on uncertainty in the biological assessment techniques for swamp waters, there do appear to be sufficient nonpoint source-related impacts to warrant pursuit of restoration actions.

Additional follow-up monitoring and a closer examination of land use and land cover changes in the subbasin are recommended in order to better define the degree of impact and to help measure the effects of any restoration actions. DWQ is in the process of refining its biological assessment techniques for swamp waters throughout eastern North Carolina and will employ any advancements in these techniques in the next round of sampling. In regard to restoration, a closer examination of the watershed is needed to better identify and characterize specific pollution sources and to work with property owners, local governments and developers, as needed, to ensure that appropriate BMPs are being utilized. DWQ will likely not have the resources to do this in the next basin cycle and will need to rely on local government or agency assistance such as the Pitt and Craven County governments, USDA NRCS, SWCD and/or NC Cooperative Extension Service to help out. Efforts by local governments to seek funding to address restoration would be supported by DWQ.

9-D. Waters of Special Interest

- **Clayroot Swamp**

The stream at the sampling location is essentially a channelized, sand bottom canal, approximately four meters wide surrounded by fields of active row crops.

The benthic macroinvertebrate diversity and abundance decreased sharply at this site between 1991 and 1995, and the bioclassification dropped from Fair in 1991 to Poor in 1995. In addition to the change in the macroinvertebrate community, field observations also indicated heavy growths of filamentous algae and flocculent material covering almost all available instream habitat in 1995. This decrease in water quality appears to be due to nonpoint runoff.

Spring fish collections in Clayroot Swamp resulted in a Good-Excellent fish assessment. The difference between fish and benthos ratings may be due to low flow and high stress conditions during the summer macroinvertebrate sampling.

- **Little Swift Creek**

Little Swift Creek at SR 1623, rated as Poor-Fair, received one of the four lowest rated fish assessment scores of the streams sampled in the basin during 1995. The fish community indicated problems from nutrient enrichment.

- **Swift Creek**

Swift Creek at NC 102
Swift Creek at this location is a small, (approximately 15 feet wide) channelized stream. The substrate is mostly sand and thick growths of submerged macrophytes are present throughout the sampling area.

DWQ sampled the benthic macroinvertebrates at this site in 1991 and 1995 and found that the bioclassification decreased from Fair in 1991 to Poor in 1995. Low flow conditions at this site appear to compound effects from nonpoint source runoff to the stream.

Swift Creek at NC 118, near Vanceboro
Swift Creek downstream at this sampling location is approximately 18 feet wide and has slow to moderate flow. The substrate is largely silt mixed with sand and detritus. The sampling protocol at this site was changed between 1991 and 1995 to provide a more complete evaluation of the macroinvertebrate community.

Even with the use of the more intensive sampling method in 1995, the bioclassification decreased from Good-Fair in 1991 to Fair in 1995. The macroinvertebrate data suggests a decrease in water quality at this site.

Chapter 10:
Neuse Subbasin 10
(Includes: Lower Neuse River, New Bern, Havelock and portions of Craven, Pamlico and Carteret Counties)

10-A. Subbasin Description

This subbasin consists of the Neuse River and its tributaries from below Streets Ferry to Pamlico Sound in Craven, Pamlico and Carteret counties. Land use in the area is mostly agriculture, including a portion of the Open Grounds Farm, a 44,000-acre crop and cattle production operation, though all cattle operations are to be phased out by the end of 1996. Areas of development in this subbasin include New Bern, Havelock and, to a lesser extent, Oriental. A portion of Croatan National Forest is also in this subbasin.

Subbasin 10 at a Glance

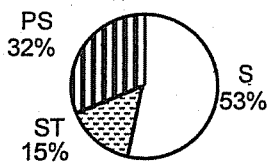
Land and Water Area (sq. mi.)	
Total area:	**702**
Land area:	**519**
Water area:	**183**

Population/Growth	
1996 Est. Pop.:	**71,770**
Pop. Density:	**138 pers/sq. mi.**
Proj. 2017 Pop.:	**89,713**
% increase (1996-2017):	**25%**

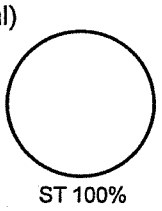
Land Cover (%)	
Forest/Wetlands:	56.2%
Cultivated:	10.5%
Developed:	6.3%
Water:	26.1%

Use Support Ratings

Estuarine waters



Lakes (2 total)



Most of the waters in this subbasin are estuarine. Freshwater in this subbasin is confined to the upper reaches of the many tributary streams, which are mostly swampy in nature. A map of the subbasin showing water quality monitoring stations is shown in Figure 10.1.

There are four major dischargers in this subbasin:

- New Bern (4.7 MGD) (Neuse River),
- NE Craven Utilities (1.0 MGD) (Neuse River),
- USMC Cherry Point (3.5 MGD) (Neuse River), and
- Havelock WWTP (1.9 MGD) (East Prong Slocum Creek).

10-B. Water Quality Overview

Water chemistry information suggested that many of the problems in the Neuse estuary come from upstream sources. Phosphorus levels were highest near New Bern and gradually declined as the Neuse flows toward Oriental. Nitrate/Nitrite concentrations are highest at the head of the estuary near New Bern (median concentration of 0.35 mg/l) and decline sharply between Light 22 (0.28 mg/l) and Broad Creek (0.04 mg/l). The number of algae blooms has increased over time in this part of the Neuse River, often accompanied by extreme swings in dissolved oxygen concentrations and pH values greater than 9.0. Mean pH values ≥ 8.0 are found in the middle portion of Neuse River from Broad Creek to the mouth, but lowest dissolved oxygen concentration were recorded from the upper part of the river from New Bern to Riverdale. Back Creek, a tributary to Adams

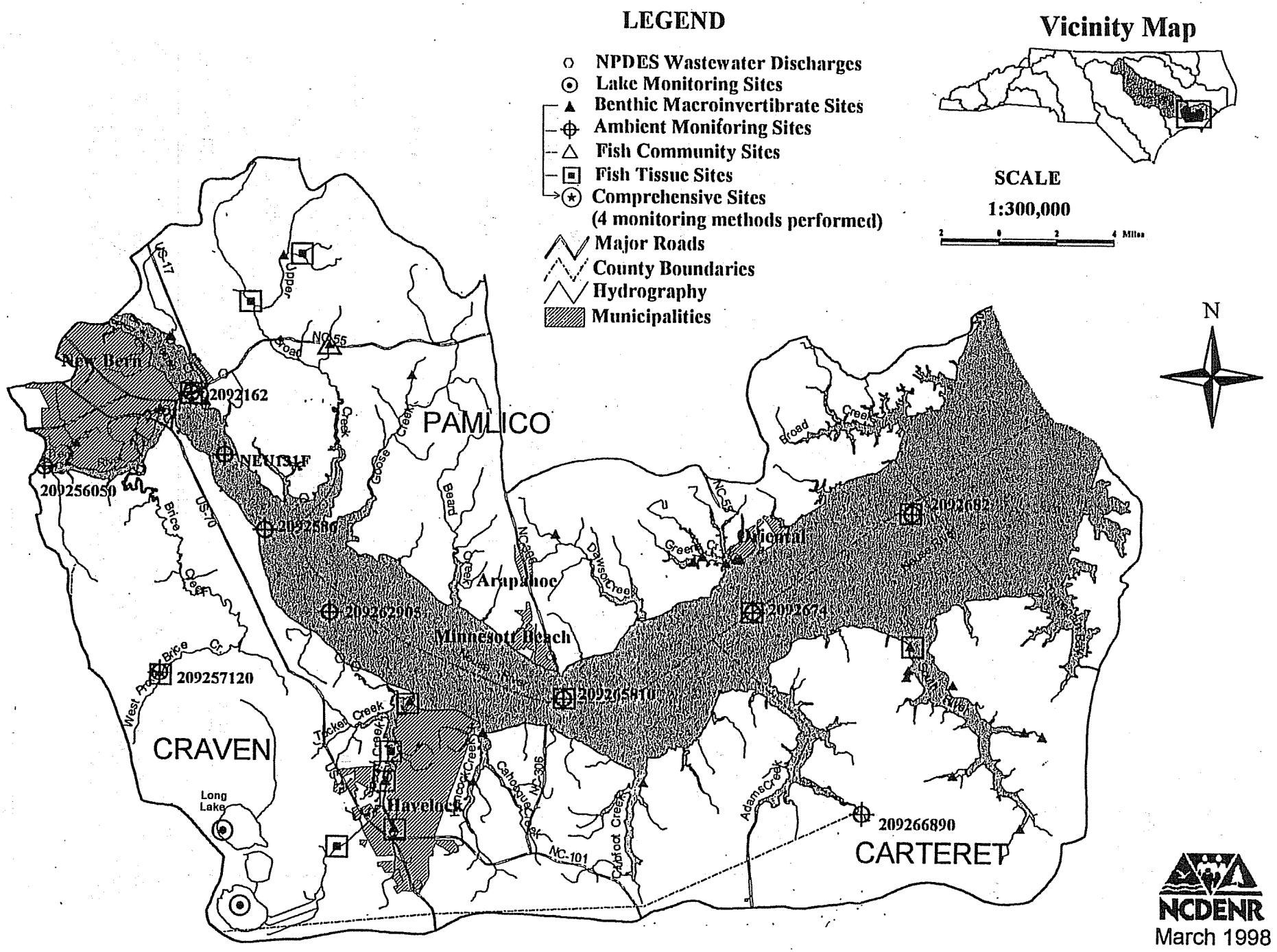


Figure 10.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 10)

Creek that drains a portion of Open Grounds Farm, has higher median nutrient concentrations (phosphorus = 0.13 mg/l, nitrate/nitrite = 0.20 mg/l) and occasional DO values < 5.0 mg/l.

Phytoplankton blooms occur throughout the year, but the greatest problems are associated with summer blooms. At this time of year, the mesohaline section of the river becomes strongly stratified, leading to oxygen depletion of bottom waters. Summer algae blooms (primarily of dinoflagellates, diatoms and cryptomonads) have been a common and chronic problem in this subbasin for many years. Over the last six years, the most severe algal blooms occurred during 1990 and 1995. Both years were periods of high flow in spring and early summer, followed by a period of prolonged summer low flow.

Most blooms occur between New Bern and Minnesott Beach, with fewer blooms from Minnesott Beach to the mouth of the river. This decline is due to better water exchange with the sound. At Minnesott Beach and Oriental, severe algal blooms still occur, but they are less frequent and the associated declines in DO are not as dramatic. Nutrients, chlorophyll *a* and turbidity all decline to levels indicative of generally good water quality near the mouth of the Neuse River.

Winter blooms generally occur slightly downstream of the area affected by summer blooms. The algae responsible for winter blooms are cool-weather dinoflagellates, and such blooms result in orange or reddish-tinted water. Other than the color change, such blooms cause no immediate problems.

Fish kills have been reported from the Neuse River at New Bern east to Broad Creek. The area of most frequent problems extends from Flanner Beach/Carolina Pines to Minnesott Beach. Overall, nine fish kills were reported in subbasin 10 during 1995. Menhaden were the primary fish involved in these kills, and most exhibited sores. The toxic dinoflagellate (*Pfiesteria*) was often present and bottom waters were frequently anoxic. Several researchers are investigating the effects of *Pfiesteria*, both on aquatic communities and on humans in frequent contact with river water.

Biological information was collected primarily from tributaries to the Neuse River, with only two samples collected from the Neuse proper. Bioclassifications could not be assigned to any of the six freshwater macroinvertebrate swamp sites, the seven macroinvertebrate estuarine sites or the single fish site. It was possible, however, to make comparisons between apparent reference sites and possible degraded sites. Degraded sites included Mill Branch (below a former chemical processor), Fork Run (in an agricultural catchment), and the marina area at Oriental. Broad Creek may have slight impacts from local agriculture, while Deep Run could not be assessed consistently because of its tendency to dry up. Among the six freshwater sites, Goose Creek had the best water quality. Biological monitoring suggested that water quality in the Neuse River at New Bern was generally stable.

Greens Creek from Kershaw Creek to the Neuse River and all of its tributaries, except lower Smith Creek, have been classified as High Quality Waters based on their designation as Primary Nursery Areas.

The Division of Environmental Health's Shellfish Sanitation Branch has reported DMF closure to shellfishing of all waters upstream of Minnesott Beach because Shellfish Sanitation does not monitor the area due to the absence of commercially important shellfish. Of the 63,700 acres remaining in this subbasin with a potential shellfish resource, 3526 acres (all within tributaries of the Neuse) are closed to shellfishing. Both Whittaker Creek and Greens Creek are closed due to development and marinas. Most of the other closed areas in this subbasin receive unacceptable levels of coliform bacteria from freshwater runoff: Clubfoot Creek, Dawson Creek, Pierce Creek, upper Adams Creek, Back Creek and tributaries to the South River. The mainstem of South River (1100 acres) has recently been provisionally opened to shellfishing. Oysters are the only commercial species in this subbasin.

Fish tissue was collected from Dawson Creek and Slocum Creek and analyzed for metals. No metals were found in concentrations above either FDA or EPA criteria.

Four dischargers conduct toxicity tests in this subbasin: Cherry Point USMC, New Bern WWTP, Havelock WWTP and Phillips Plating Company. Cherry Point moved their discharge from Slocum Creek to the Neuse River after Slocum Creek was shown to have consistently eutrophic conditions. Self-monitoring reports show that Cherry Point has been in compliance with their toxicity limits since 1993. Follow-up studies on the impacts of moving the discharge to the Neuse River are being conducted by Dr. Joanne Burkholder. This is discussed under Slocum Creek. New Bern WWTP has failed one test in 1995 and one in 1994 while Havelock WWTP has failed two tests in 1994 and one in 1993.

There are two lakes in this subbasin: Long Lake and Lake Ellis. Both are typical dystrophic Carolina Bay lakes with shallow depth, tannic waters and low nutrients. Both lakes are generally unimpaired and support designated uses.

Twelve sites were sampled for benthic macroinvertebrates in the summer of 1995 (Table B-10.1). The Neuse River at New Bern has been sampled on two previous occasions and will be discussed in the Long-Term Benthos section.

Currently no biological criteria have been developed for estuarine areas. Developmental and validation work underway has found that an Estuarine Biotic Index (EBI) can separate sites of different water quality. Additionally, other metrics have been found to be useful depending on the sampling method used and the salinity of the sample. For a sweep in waters from 10-35 ppt salinity, total taxa richness, and the number of amphipods and caridian shrimp taxa also serve to separate sites. For an epibenthic trawl, % Oligochaeta and Pelecypoda is an additional metric that helps rank sites of different water quality.

Neuse subbasins 10, 13 and 14 are primarily estuarine in nature. Tides in subbasins 10, 13 and 14 tend to be more wind-dominated than lunar. Freshwater streams in this subbasin are limited to the Croatan National Forest and are, for the most part, minimally impacted. The primary land use is agriculture, with urban areas around New Bern and the Cherry Point Naval Air Station.

However, monitoring regimes are being developed and a calibrated multidimensional water quality model is planned to be available by the next permit cycle to serve as a link between the river loadings and the estuarine response. The estuary modeling will be a cooperative effort between Weyerhaeuser, the US Geological Survey (USGS) and NCDWQ. Standard WLA procedures will apply to these subbasins until the modeling effort and subsequent management plans are completed. New and expanding discharges in the estuary area will likely receive NPDES limits reflecting advanced wastewater treatment.

10-C. Current or Previously Impaired Waters: Updates, Status and Recommendations

- **Neuse River at Hancock Creek**

The Neuse River at Hancock Creek was sampled for the first time in 1995. This site was a high energy area, and samples were collected from coarse sand and *Spartina*. Four of the five most abundant taxa were moderately intolerant (tolerance values 2 or 2.5) crustaceans; however, half of the total taxa were very tolerant (tolerance values <1.5). This suggested that low oxygen levels could be a problem in deeper and calmer areas of the river. Subtidal sand collected at this site was coated green, indicating a probable bloom of benthic diatoms. DO (9.5 mg/l) and

pH (8.9) were elevated at this site, also suggesting high algal activity. Water chemistry samples were not collected, so it is unclear whether nutrients were elevated, or if a bloom was also occurring in the water column.

- **Neuse River Estuary**

Neuse River at New Bern, US 17
Neuse River at New Bern has been sampled three times since 1983. Total taxa richness and percent (%) freshwater taxa were very similar in 1983 and 1995, suggesting similar salinity regimes and thus comparable conditions. The increased taxa richness and decreased % freshwater taxa suggest a higher salinity in 1984, and thus, the data was less comparable. The increase in the EBI of 0.4 from 1983 (1.8) to 1995 (2.2) appeared to be primarily related to a change in sampling method which has caused an increase in the EBI of 0.3 at two other oligohaline sites. There appeared to be a shift in dominant taxa from the worms *Limnodrilus hoffmeisteri* and *Laeonereis culveri* and the clam *Rangia cuneata*, all very tolerant taxa, to the mysid shrimp *Mysidopsis almyra* and the amphipods *Corophium lacustre* and *Melita nitida*, which are more intolerant. This shift, like the increase in EBI, was primarily indicative of a more epibenthic sampling method.

Want more information on water quality, fish kills, Pfiesteria, algal blooms and Neuse estuary research? Check out the following web sites....

Current Neuse River Conditions (Hwy 17 at New and Channel Lights 9 and 11)
> sgi1dncrlg.er.usgs.gov/qw/NeuseRiver.html

Neuse River Research Projects at the Univ. of North Carolina
> www.ehnr.state.nc.us/EHNR/neuse/

WRRI's Neuse River Homepage
> www2.ncsu.edu/ncsu/CIL/WRRI/

Fish kill Updates
> 207.4.102.3/fishkill.htm

NCSU Aquatic Botany Laboratory *Pfiesteria piscicida* Page
> www2.ncsu.edu/unity/lockers/project/aquatic_botany/pfiest

Neuse River Modeling and Monitoring (ModMon) Project
> www.marine.unc.edu/neuse/modmon

The majority of research and management actions for the Neuse River through 1988 were directed at resolving problems in the freshwater segments of the river. Eutrophication effects were also apparent in the lower mesohaline sections of the river. To improve coverage of the lower section of the Neuse, sampling sites were added from New Bern to the Pamlico Sound.

In the lower Neuse River subbasin, Lebo (1995) reports that internal cycling of nutrients from sediments are the primary source of nutrient inputs to the estuary except during periods of extreme flow (>10,000 cfs). The nutrients most important for algal growth are delivered during varying flow regimes. For example, nitrate/nitrite reaches the river during high flows (nonpoint runoff) while values for orthophosphate are highest in the Neuse River during low river flow.

Algal growth and resultant chlorophyll *a* values are typically greatest from New Bern through Minnesott Beach, and these values decrease downstream to Oriental and at the mouth of the Neuse River. Likewise, nutrient concentrations decrease in a downstream progression as algal assimilation, settling and dilution occur.

Dinoflagellates, cryptomonads and diatoms typically dominate the algal community in the Neuse River estuary. Cryptomonads are ubiquitous and are prevalent throughout the year in the Neuse River system. Green algae (chlorophytes) are present in diverse numbers, although they rarely comprise a large portion of the biovolume or density in the Neuse River. Chlorophytes are more common in the upper estuary but occur in higher numbers further downstream during winter and spring when increased flows dilute the estuary. Small

cyanophytes including filamentous types, *Phormidium angustissimum* and *Lyngbya* spp. and colonial forms, *Merismopedia tenuissima, Chroococcus* spp. and *Synechococcus* spp. are common in Neuse River waters during warm weather, but typically comprise little of the algal biovolume or density.

Seasonally, spring and fall blooms in the Neuse River generally occur several miles downstream of New Bern and are comprised of common dinoflagellates (*Gymnodinium* spp., *Gyrodinium* spp., *Peridinium* spp.), small centric (*Cyclotella* spp.) and chain forming diatoms (*Skeletonema potamos*). The diatoms, *Skeletonema costatum, Leptocylindrus danicans, L. minimus* and *Nitzschia closterium* tend to be more common during spring and fall in the middle to lower Neuse, while *Cyclotella* is found commonly throughout the growing season. While there is generally sufficient oxygen throughout the water column during winter and spring, summer blooms are of concern in the Neuse River estuary, since this is the mesohaline area where freshwater meets saltwater and density gradients prevent the mixing of oxygen throughout the water column. Under stratified conditions, increased productivity during summer months can exacerbate problems associated with oxygen depletion. Poorly oxygenated waters are trapped on the river bottom until mixing occurs. This often results in low levels of oxygen throughout the water column.

Winter blooms occur nearly annually from near Fairfield Harbor (NEU131F) down to Oriental or near the mouth of the Neuse River. In general, winter algal growth occurs slightly downstream of the summer maximum growth area. Mean chlorophyll *a* values are illustrated on Figure P1 for the Neuse River. This graph differentiates between winter blooms which persist further downstream and summer blooms which originate further upstream. The algae responsible for these winter blooms are the cool weather dinoflagellates, *Prorocentrum minimum* and *Heterocapsa triquetra*. Prolonged blooms of these species occur when nutrient (nitrogen) inputs carried by rainfall, are significant. The winter of 1993-94 was perhaps the most extensive record for winter dinoflagellate blooms in the mid-lower Neuse. The cool season dinoflagellate blooms cause no immediate problem and are a preferred food sources for zoo plankton. They often result in visible blooms of reddish water. These winter dinoflagellates are photosynthetic and are typically golden brown because of the presence of xanthophyll pigments. Under high light conditions, these dinoflagellates produce carotenoid (orange-red) pigments which protect the cells from ultraviolet radiation, resulting in orange or reddish tinted water.

Both brackish water algal species and freshwater algal species occur at New Bern (as well as downstream) depending on the salinity content of the river. Dinoflagellates (*Gyrodinium aureolum*) which occur during higher salinities, diatoms (*Cyclotella* spp.) and a diversity of green algae are typically dominant at New Bern. Throughout the years, at the New Bern station, high chlorophyll *a* values corresponded to blooms of diatoms (*Cyclotella* species 3), dinoflagellates (*Gyrodinium aureolum, Gymnodinium* species) and xanthophytes (*Olisthodiscuscus* spp.). In general, at the New Bern station, the highest values of chlorophyll *a* occurred during the summer. A review of mean summer chlorophyll *a* values showed that New Bern contained annual summer mean values of >20 µg/l or exceedences of the state standard during dry (low flow) years. In contrast, chlorophyll *a* values were moderately low at New Bern in 1984, 1989 and 1995 (high flow years).

The next two downstream stations, NEU131F near Fairfield Harbor and 02092586 near Thurman, contained similar species composition. Large to medium dinoflagellates (*Gyrodinium uncatenum, Gymnodinium nelsoni, Gyrodinium aureolum* and *Peridinium trochoideum*) often dominate algal biovolume estimates. The toxic dinoflagellate, *Pfiesteria piscicida*, is frequently found at Thurman as well as at stations further downstream. Small centric diatoms (*Cyclotetella* species 2 and 3) are common dominants by density. *Olisthodiscus*, an xanthophyte, which results in high chlorophyll *a* concentrations during blooms sometimes occurs during summer months near Thurman and Fairfield Harbor. Overall, highest algal growth in the Neuse occurred at NEU131F, approximately five miles downstream where brackish water blooms are fairly

constant. A review of chlorophyll *a* data (1990-1995) reveals that this station has consistently had spring blooms (May) except for during 1993 when April flows were high. Summer blooms are a frequent occurrence as indicated by high chlorophyll *a* concentrations, algal bloom reports and ambient data. Station NEU131F often represents the uppermost boundary for winter blooms. Chlorophyll *a* data indicate that winter blooms occur annually at this station except during the winter of 1994 -95. During this winter, the bloom was pushed further downstream where reports of red water were associated with high levels of winter dinoflagellates. The Neuse River at Thurman (02092586) contained similarly high values for chlorophyll *a* as station, NEU131F.

The ambient stations near Riverdale (NEU131X) and Minnesott Beach (NEU139) contained similar species composition as the Thurman station. During low flow conditions, when salinities are increased, a large dinoflagellate, *Polykrikos* spp., occurs as far upstream as Minnesott Beach. This dinoflagellate usually does not occur in high numbers, although it easily dominates biovolume estimates because of its large size. Just downstream of the mouth of Thurman, NEU131X exhibited slightly lower levels of chlorophyll *a* likely due to distance from the mouths of tributaries which deliver nutrients. The Minnesott Beach station (NEU139) typically marks the easternmost boundary for seasonal summer blooms. The river is constricted near Minnesott Beach which decreases flushing, increases retention time, and enhances growth west of the Minnesott Beach transect.

Downstream near Oriental (02092674) and near the mouth of the Neuse (02092682), typical dinoflagellates and diatoms occur, with the addition of the dinoflagellate, *Polykrikos* spp. and the silicoflagellate, *Dictyocha fibula*. Algal growth in the lower Neuse is usually negligible except for winter blooms that may discolor waters when present in sufficient numbers.

The algal bloom reporting program was implemented to document suspected blooms and to aid in fish kill investigations. Algal bloom samples provide extra information and help identify problem areas. Bloom samples collected from 1990 indicate that this was one of the most severe years for blooms. During the years, 1991 through 1994, a few summer blooms occurred, some in conjunction with fish kills. Sometimes the toxic dinoflagellate, *Pfiesteria piscicida* was present, and bottom waters were frequently anoxic with the presence of a salt wedge. In 1995, numerous fish kills occurred generally from New Bern to Minnesott Beach in July and September through October. Menhaden were the primary fish involved in the kills, and most exhibited sores. Record rainfalls in June 1995 indicated delivery of a large load of nonpoint nutrients into the Neuse River which occurred later in the season than normal. The freshwater in June led to defined density gradients (salt wedges) throughout several miles of the river. When salt wedges occur, resistance to mixing is high, leaving poorly oxygenated waters on the river bottom. Temperatures in July 1995 were excessively hot with 24 consecutive days of greater than 90°F recorded at the RDU airport.

Numerous water quality samples were collected in the areas of the fish kills. Dissolved oxygen was hypoxic (contained low levels of oxygen) in much of the water column in July and September but appeared to be sufficient in October during sample collection. Likewise, algal growth and chlorophyll *a* was generally low in July and September, but at the end of October, high chlorophyll *a* concentrations and blooms of dinoflagellates (*Peridinium trochoideum*), cryptophytes and diatoms (*Skeletonema costatum*) occurred. Low concentrations of *Pfiesteria piscicida* were found in the vicinity of the fish kills; however, the combination of low dissolved oxygen and toxic activity from *P. piscicida*, may have caused the fish kills.

- **Slocum Creek**

The mouth of Slocum Creek, after channel dredging and spoil disposal, was a constricted, deep, fast-flowing, coarse substrate (large sand grains and marine mollusk shells) environment. This was very different from the slow-moving, salt marsh lined, mud bottomed creeks that

characterized the rest of the watershed. The EBI at this site was high (2.4) because two relatively intolerant shrimp, *Palaemontes pugio* and *Mysidopsis almyra*, dominated the sample with over six times the abundance than all the other taxa at this site. Like nearby Hancock Creek, the large number (6 of 14 total taxa) of tolerant taxa (EBI ≤1.5) in a high flow area suggest DO problems in the slow-flowing portions of the creek.

This survey was conducted to evaluate the potential impacts of elevated metals in sediments. Impacts were documented in Slocum Creek and moderate impacts were found at the Oriental Harbor docks although the impacts could not be attributed solely to the sediments. Sediment toxicity testing showed toxic sediments only in Slocum Creek.

Slocum Creek has exhibited eutrophic conditions which warranted the removal of the USMC Cherry Point Marine Base and City of Havelock discharges. During low flow conditions, little flushing occurs in Slocum Creek because of the constricted configuration of the river mouth. Westerly winds also cause water from the Neuse to back further into the creek. To alleviate problems in Slocum Creek, the USMC discharge was moved to the Neuse River mainstem and is discharged by way of a diffuser pipe. Monitoring and analyses of this discharge are being conducted by Dr. JoAnn Burkholder at NCSU. Monitoring was conducted predischarge and is scheduled for the first, second and fifth years post discharge. The monitoring schedule is staggered by weekly, biweekly and monthly sites during the growing season. Outside of the growing season, monthly monitoring is also being conducted. Water quality samples and data are being collected in a radial pattern centered around the diffuser pipe and from transects above and below the discharge. Preliminary data suggest that nutrient concentrations have decreased in Slocum Creek and that nitrate concentrations are higher immediately around the diffuser site, although nutrient levels are diluted during periods of high flow.

- **Oriental Harbor**

Greens Creek was sampled as a reference site to evaluate the extent of impacts in Oriental Harbor. A similar survey of Oriental Harbor in 1992, which is discussed further in the special studies section, documented a moderate impact. Sampling in 1992 was conducted using a petite ponar, while these samples were collected using an epibenthic trawl. The decline in EBI by 0.6 between Greens Creek and Oriental Harbor trawl samples more clearly documented the degradation in Oriental Harbor than did the ponar dredge samples which only showed a decline in EBI of 0.1. Based on this, efforts will continue to refine trawl sampling methods and criteria in preference to the dredge.

This survey was conducted to evaluate the potential impacts of elevated metals in sediments. Moderate impacts were found at the Oriental Harbor docks.

- **Long Lake**

Long Lake is a blackwater Carolina Bay Lake located in the Croatan National Forest. Previously owned by the United States Forest Service and now under private ownership, Long Lake is a large but shallow body with an average depth of one meter and a maximum depth of two meters. The lake is surrounded by and undisturbed pocosin swamp and managed forestland. Long Lake is classified C SW NSW.

This lake was most recently monitored by DWQ on August 8, 1995. Mean pH was 3.5 su and Secchi depth was 0.3 meters. Mean ammonia was 0.02 mg/l and mean total phosphorus was 0.02 mg/l. Chlorophyll *a* ranged from 2 to 4 µg/l, as would be expected for a dystrophic lake with low nutrient concentrations in the water column. The NCTSI score was -0.2. Long Lake supported all of its designated uses in 1995.

Long Lake was previously sampled in 1988. Lakewide pH was 4.2 su and Secchi depth was 0.5 meter. Mean ammonia was 0.02 mg/l and mean total phosphorus was 0.02 mg/l. Long Lake contained low amounts of phytoplankton (chlorophyll *a* concentration was 0.2 µg/l) which is common in an acidic Carolina Bay Lake. Algal samples were dominated by bacillariophytes (diatoms) and chlorophytes (green algae). Long Lake had a NCTSI score of -1.4 and supported all of its designated uses.

Chapter 11:
Neuse Subbasin 11
(Includes: Trent River and portions of Jones, Lenoir and Craven County)

11-A. Subbasin Description

Subbasin 11 is composed entirely of the Trent River watershed and is located in the outer Coastal Plain region of the state. A portion of the Croatan National Forest lies within this subbasin, east of US 17 and south of the Trent River. A map of the subbasin showing water quality monitoring stations is shown in Figure 11.1.

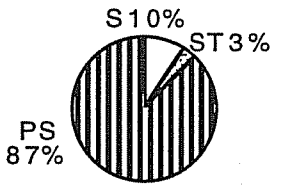
Subbasin 11 at a Glance

Land and Water Area (sq. mi.)	
Total area:	**443**
Land area:	**443**
Water area:	**1**

Population/Growth	
1996 Est. Pop.:	**14,466**
Pop. Density:	**33 pers/sq. mi.**
Proj. 2017 Pop.:	**14,466**
% increase (1996-2017):	**0%**

Land Cover (%)	
Forest/Wetlands:	71.1%
Cultivated:	24.7%
Developed:	1.45%
Water:	0.3%

Use Support Ratings
*Streams



*based on *monitored* data

The primary land use is agriculture, with a small urban area around Trenton. Streams within this subbasin are usually humic-colored "blackwater" streams, with a substrate composed of sand, silt and organic debris. Because of the limestone bedrock throughout this area, few streams have the low pH values that are usually associated with swamp waters.

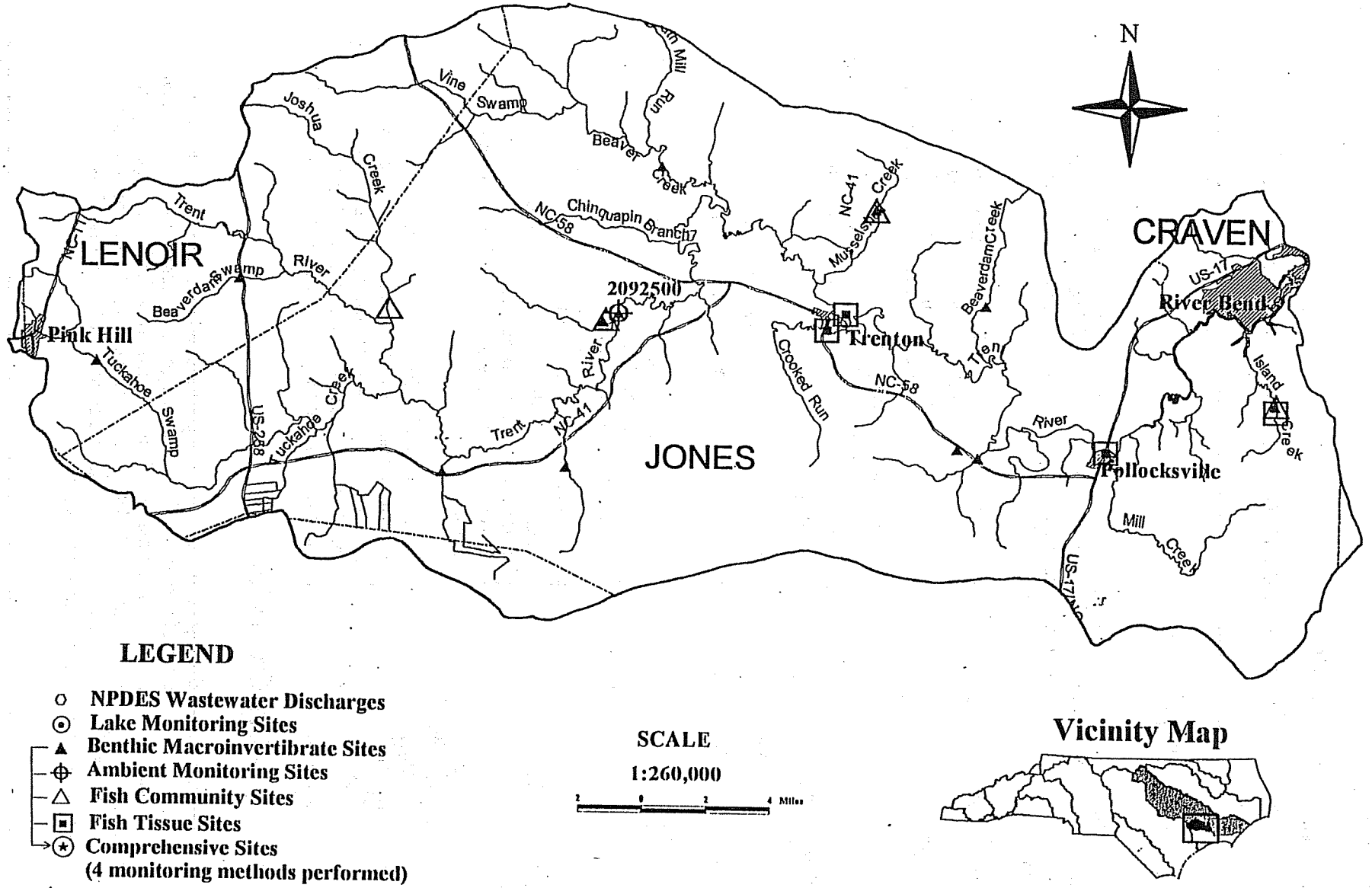
11-B. Priority Issues and Recommendations

Most of the waters in this subbasin (87%) are rated as partially supporting their uses. Greatly reduced summer flows in recent years which result in depressed dissolved oxygen levels, and nonpoint source impacts are notable causes of water quality degradation in this subbasin. Phytoplankton blooms and an overabundance of aquatic plants (macrophytes) have also contributed to this impairment.

Further investigation is needed on determining the extent of impacts of summer irrigation activities on streamflow and water quality in this subbasin. Further investigations are also needed to determine the cause of the overabundance of aquatic plants.

11-C. Water Quality Overview

Natural stresses are intensified during summer low flow periods, when many streams in this subbasin stop flowing. At this time of the year, dissolved oxygen concentrations may be low even in the least-impacted streams. Some of the smallest streams may dry up completely or become a series of pools separated by dry land. Water withdrawals for irrigation also may affect summer low flows. There is some evidence that the severity of low flows has been increasing in recent years for the Trent River at NC 58.



Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 11)

Figure 11.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 11)

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Nonpoint source impacts were evident in many of the streams in this subbasin. Agricultural land use can lead to inputs of sediment, nutrients and pesticides, and removal of riparian buffer areas increases these inputs. There are no major permitted discharges in this subbasin. Streams flowing through the Croatan National Forest were found to have the best water quality in this subbasin.

The lower Trent River has recently experienced dense growth of submerged aquatic vegetation. This is discussed further, below, under Section 11-C.

Fish tissue samples were collected at one site within the Neuse 11 subbasin. Metals results indicate that only mercury was detected above levels of concern with six of twenty samples from the Trent River at Pollocksville containing mercury above FDA and EPA criteria. No organics analyses were performed in the subbasin between 1992 and 1995.

11-C. Current or Previously Impaired Waters: Updates, Status and Recommendations

• Trent River

The Trent River has been sampled nine times for benthic macroinvertebrates since 1983, allowing an assessment of long-term changes in water quality. Streamflows were very low during August of 1995, precluding sampling of most small streams in this subbasin. Even at the largest site, Trent River at NC 58, discernible flow was found only at infrequent riffles. A few sites were sampled in spring (March 1995) to avoid the problems of summer low flows.

Trent River, NC 58 near Trenton
This station has been sampled in the summer six times since 1983. This river often suffers from low dissolved oxygen (DO) levels, especially during prolonged hot, low flow periods. Monthly chemistry samples during 1990 yielded DO levels below 5.0 mg/l from June through September (3.6 mg/l in June). At the 1990 sampling, collectors noted that the river was very low, with little visible current and abundant filamentous algae. Similar conditions also were observed during summer collections in 1995. Bioclassifications have varied from Fair to Good, depending (in part) on antecedent flows.

The higher EPT taxa richness values (1982, 1986-1990) usually occurred in spring or early summer (May-June), or during a period of higher flow. Lower EPT values have been recorded since that time, including two samples in 1990 and a single collection in 1995. The heavy periphyton growths often observed at this site suggest nutrient inputs, and organic indicator species were abundant from 1986 to 1990. Earlier collections usually included some intolerant taxa, but these have disappeared in recent years. In particular, *Brachycentrus numerosus* was abundant from 1985-1989, but was rare or absent in the last two samples.

It is difficult to determine trends in water quality at this site because of low flows for two of the last three collections. There is some indication that the extent of low flow periods have been increasing in recent years. Given below are mean monthly flows (in cfs) for three periods: 1) 1978-1986; 2) 1987-1994; and 3) the long-term mean for the period of record (1954-1994).

	Means by Month											
	10	11	12	1	2	3	4	5	6	7	8	9
1954-94	90	90	168	305	320	348	221	124	119	148	184	122
1978-86	**48**	94	150	299	379	391	258	148	113	**83**	138	**96**
1987-94	**35**	**62**	209	362	191	333	270	121	**63**	**50**	178	**45**

There has been no significant decline in flows during winter and spring months (December-May), but summer and fall flows (June-November) seem to be showing a steady decline. This may be due to increasing agricultural water use in the Trent River catchment. This question needs to be further addressed by examining the relationship between rainfall and water yield to the river. Fish tissue samples were collected at one site within the Neuse 11 subbasin. Metals results indicate that only mercury was detected above levels of concern with six of twenty samples from the Trent River at Pollocksville containing mercury above FDA and EPA criteria. No organics analyses were performed in the subbasin between 1992 and 1995.

Aquatic macrophytes
During recent summers, the Trent River and its tributaries have contained expansive growths of aquatic vegetation. The vegetation covers shallower areas where water depth is less than 5.5 feet. In addition, plants which are not rooted are floating in deeper waters. Most residential docks affected are in shallow (less than five feet) waters and are, therefore, surrounded by vegetation. This situation can be problematic for riparian land owners, boaters or swimmers. Additional problems with odor have been reported during senescence in the late summer and early fall. All of the plant species found in the Trent River are native to North America and are commonly found in the coastal plain of North Carolina. None of the species occur on the Division of Water Resources' Noxious Weed list. The most common plants encountered in the Trent River and tributaries include:

Potamogeton pusillis - slender pondweed
Ceratophyllum demersum - hornwort, coontail
Najas guadalupensis - southern naiad
Ruppia maritima - widgeon grass
Potamogeton perfoliatus - red-headed grass (few plants)
Elodea canadensis - American elodea (few plants)

Water quality data from the Ambient Monitoring System were examined to determine if there were any trends in water quality that might explain this resurgence in aquatic vegetation. These data suggested only one temporal trend in water quality. Water temperatures were higher in recent years and dropped only slightly below 10°C in the past five years. It is not known if the lack of cold winters has a direct effect on the die-back of the vegetation found, although generally aquatic plants tend to proliferate during warmer weather. While there was considerable variability in other parameters measured including major nutrients, there was no long-term increase or decrease over the period measured.

- **Musselshell Creek**

Musselshell Creek is a small stream located in an area of cotton farming. This stream has been channelized, and has little buffer between the stream and adjacent agricultural fields. Stream modification has confined the stream to a very narrow (1 meter) channel. Good flow was observed during all periods of 1995; however, observations in June 1996 indicated that this stream may have no flow during some drought periods. Benthic macroinvertebrate sampling indicated severe water quality problems, as both the abundance and diversity of indicators were very low in March and August. Since the fish community did not show the same degree of impact, it is possible that pesticides in agricultural runoff are responsible for the low invertebrate taxa richness values. For purposes of comparison, we also sampled a nearby stream (Beaverdam Creek) that had a more intact riparian zone. This stream had much better diversity and abundance of indicator species, including some intolerant species.

Chapter 12:
Neuse Subbasin 12
(Includes: Goldsboro, Mount Olive and portions of Wayne, Lenoir, Greene, Jones and Craven Counties)

12-A. Subbasin Description

This subbasin is located in the coastal plain. The primary land use is agriculture, but includes urban areas west of Goldsboro. The WWTP for Goldsboro (6.7 MGD) discharges just downstream of this subbasin, in Neuse 05. Goldsboro is seeking permission to upgrade and increase the capacity of its wastewater treatment plant. Tributaries to the Neuse include both sandy-substrate streams with continuous flow and swamp streams which may stop flowing for an extended time during the year. A map of the subbasin showing water quality monitoring stations is shown in Figure 12.1.

Subbasin 12 at a Glance

Land and Water Area (sq. mi.)

Total area:	**183**
Land area:	**181**
Water area:	**2**

Population/Growth

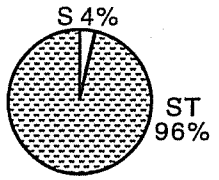
1996 Est. Pop.:	**33,429**
Pop. Density:	**183 pers/sq. mi.**
Proj. 2017 Pop.:	**37,140**
% increase (1996-2017):	**11.1%**

Land Cover (%)

Forest/Wetlands:	51.7%
Cultivated:	41%
Developed:	4.1%
Water:	1.1%

Use Support Ratings

*Streams



*based on *monitored* data

12-B. Water Quality Overview

There are no impaired waters in this subbasin based on 1995 sampling. Benthos samples have resulted in ratings of Good-Fair to Good for the Neuse River at NC 117 near Goldsboro. Water chemistry data from an ambient site near Goldsboro did not indicate any water quality problems.

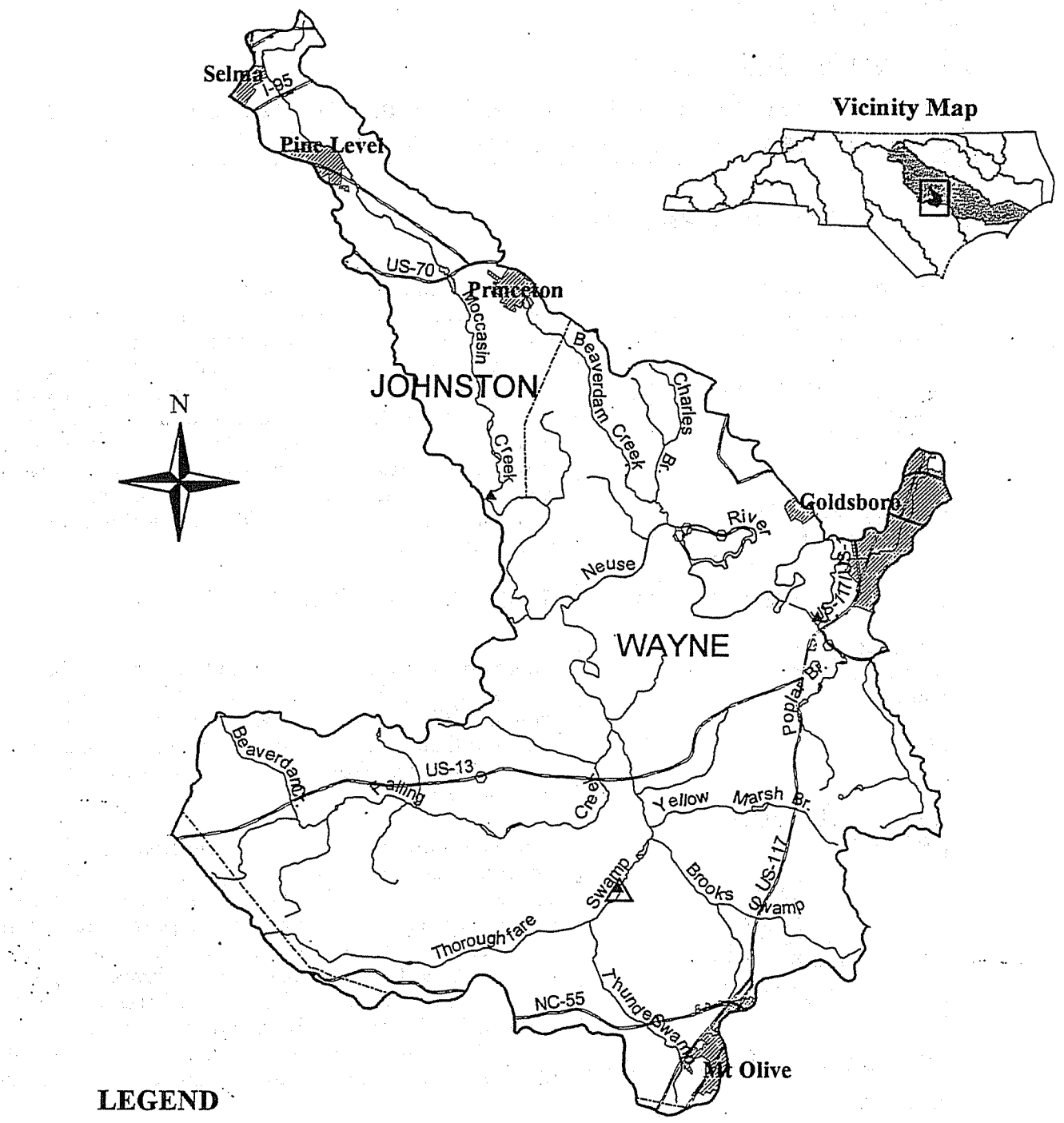
A fish community sample was collected from Thoroughfare Swamp and assigned a rating of Good-Fair to this system. No other streams in subbasin 12 had enough continuous flow to sample and rate with current biological criteria during the 1995 sampling period. A 1991 benthic macroinvertebrate sample on Thoroughfare Swamp at SR 1120 (referred to in the 1993 basinwide plan as Buck Swamp) had a Poor rating, but it was considered invalid as it was based on older biological criteria that did not accurately assess swamp conditions.

12-C. Current or Previously Impaired Waters: Updates, Status and Recommendations

- **Neuse River near Goldsboro**

The Neuse River was sampled at SR 1915 near Goldsboro four times between 1994 and 1990. The site above the Goldsboro WWTP received Good ratings from 1986 to 1990. In 1988, the WWTP outfall for Goldsboro was moved to a new location on the Neuse River. After the

Figure 12.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 12)



LEGEND

- NPDES Wastewater Discharges
- Lake Monitoring Sites
- Benthic Macroinvertibrate Sites
- Ambient Monitoring Sites
- Fish Community Sites
- Fish Tissue Sites
- Comprehensive Sites (all 4 monitoring methods performed)
- Major Roads
- County Boundaries
- Hydrography
- Municipalities

Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasin 12)

SCALE

1:240,000

2 0 2 4 Miles

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discharge location was changed, the monitoring site was moved to NC 117 to stay above the discharge point.

The benthic macroinvertebrates at the new site received a Good rating in July 1991 and a Good-Fair rating in August 1995. Although this difference may reflect the differing flows on the two sampling dates, nonpoint source pollution may also be a culprit. The Goldsboro portion of the Neuse River drainage includes both urban and agricultural activities. This portion of the Neuse River also has many eroded areas and sparse streamside vegetation.

Fish tissue analysis was also performed on the Neuse River near Goldsboro. DWQ performed metals analyses on 23 samples collected from 1992 to 1994. These analyses showed only 3 samples in which mercury exceeded FDA and EPA standards. In 1992, DWQ performed an organic contaminants analysis. Results indicated eleven detectable compounds; however, levels remained below FDA and EPA standards.

- **Buck Swamp (Brooks Swamp) at SR 1120**

The 1993 Neuse Basinwide Plan included a small swamp stream called Buck Swamp as an impaired stream that is not in this year's plan. Buck Swamp is actually called Brooks Swamp, a small tributary to Thoroughfare Swamp that originates near the Mt. Olive airport. The 1993 Neuse Basinwide Plan reported a Not Supporting use rating for the stream based on a Poor benthic macroinvertebrate sample at SR 1120 in 1991. However, the sampling site was actually at a nearby location on Thoroughfare Swamp, also at a crossing of SR 1120. Therefore, Buck Swamp (Brooks Swamp) is not included in this plan or the accompanying assessment report. Also, as noted above, the poor rating was based on out-of-date biological criteria that are no longer considered to be valid for a swamp stream such as this one.

Chapter 13:
Neuse Subbasin 13
(Includes: Bay River, Bayboro and portions of Pamlico County)

13-A. Subbasin Description

Subbasin 13 consists of a portion of Pamlico Sound and its tributaries Broad Creek, Bay River and Jones Bay in Pamlico County. Land use in the subbasin is mostly agriculture and most of the waters are estuarine. Freshwater is confined to the upper reaches of the many tributary streams, which are swamp-like in nature with ephemeral flow. There is one discharger in this subbasin (Bay River MSD WWTP, 0.3 MGD), and it is under a Special Order by Consent to go to a land application system. A map of the subbasin showing water quality monitoring stations is shown in Figure 13.1.

Subbasin 13 at a Glance

Land and Water Acre (sq. mi.)

Total area:	**277**
Land area:	**145**
Water area:	**132**

Population/Growth

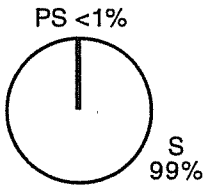
1996 Est. Pop.:	**4,774**
Pop. Density:	**33 pers/sq. mi.**
Proj. 2017 Pop.:	**6,402**
% increase (1996-2017):	**34.1%**

Land Cover (%)

Forest/Wetlands:	33.6%
Cultivated:	12.2%
Developed:	4.0%
Water:	49.8%

Use Support Ratings

Estuarine Waters



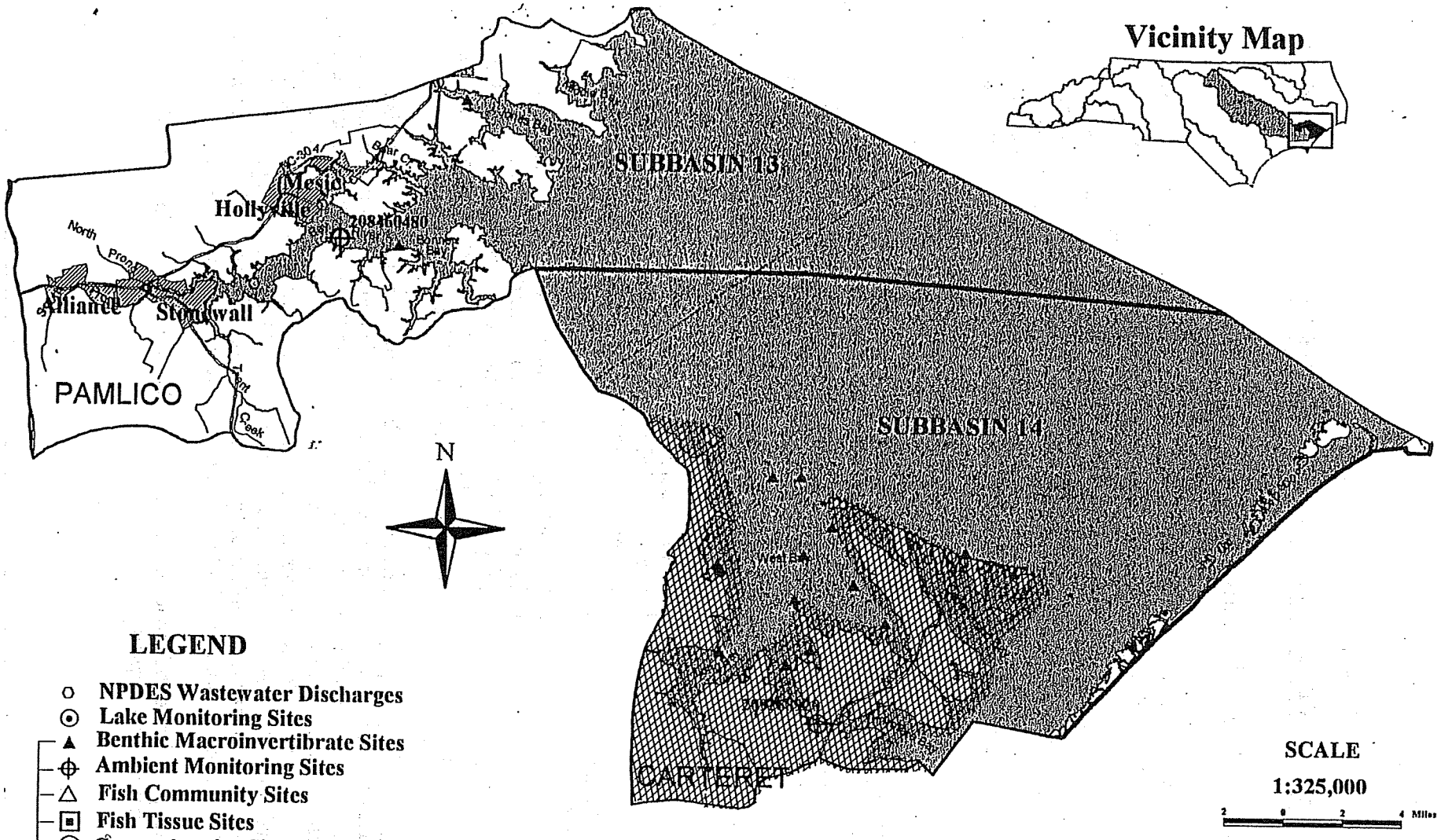
13-B. Water Quality Overview

Water chemistry from the Bay River near Vandemere indicated generally good water quality, but with periodic pulses of elevated coliforms, nutrients and chlorophyll *a*. These pulses are associated with high rainfall, suggesting the effects of nonpoint source runoff. Macroinvertebrate samples from Bay River and Jones Bay also reflect the generally good water quality in this subbasin. Algae blooms are uncommon in this subbasin. Only one bloom of dinoflagellates has been documented, located in the upper portions of Bay River during 1990.

Upper Chapel Creek and its tributaries, upper Swindell Creek and its tributaries, Smith Creek and the tributaries to Vandemere Creek have been classified High Quality Waters in this subbasin because of their designation as Primary Nursery Areas.

The Division of Environmental Health's Shellfish Sanitation Branch has reported DMF closure to shellfishing of 337 acres out of the 28,000 acres of waters in this subbasin. With the exception of Point Marina on Broad Creek, all closed areas are due to elevated levels of coliform bacteria in freshwater runoff. These areas include Bay River above Flea Point, Smith Creek, Vandemere Creek, upper Bear Creek, Gale Creek to the ICWW, the ICWW north of Gales Creek and upper Jones Creek. Oysters are the primary shellfish resource in this subbasin and this area is rated Fair to Poor for shellfish over most of the subbasin, but with Fair to Good production at cultch plantings in Broad Creek.

Two sites were sampled for benthic macroinvertebrates in the summer of 1995 (Table B-13.1). Neither has been previously sampled.



Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasins 13 & 14)

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March 1998

Figure 13:1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasins 13 and 14)

Bay River and Jones Bay were both sampled in sandy to muddy erosional areas within *Spartina* salt marshes. Salinities were moderate (15-17 ppt) at both sites. The high EBI values and moderate to high number of taxa collected at these sites indicated that both sites had high water quality with few signs of impacts. This contrasts sharply with samples collected from Jones Bay for the EMAP program (Jeffery Hyland, personal communication). Those benthic grab samples only collected three taxa, all of which were very tolerant, opportunistic species which would be more reflective of a highly stressed situation. It is not clear whether this difference was due to different sampling methods or different site locations.

13-C. Priority Issues and Recommendations

Water quality in this subbasin is generally very good, although as noted above, water has been observed to decline after rainfall in Bay River indicating the susceptibility of these waters to nonpoint source pollution. The only waters rated as impaired are ones closed to shellfish harvesting. Challenges for the future will be to reopen the closed waters, as discussed below in 13-D and to take steps to protect the quality of the unimpaired waters.

13-D. Waters of Special Interest

- **Bay River Area**

Waterbody / Location	Bay River (DEH area F6)
Classification	SA
1992 Use Support Rating	PS (204 acres closed out of 19,663 acres)
Reason(s) for Impairment	Fecal coliform from urban, WWTP, septic tanks, marina, wildlife and Ag (animals)
1993 Planned Strategy	Continue existing NPS programs.
1993-1997 Actions	WQ and shellfish monitoring
1997 Use Support Rating	PS (337 acres closed out of 19,663 acres)
1998 Planned Strategy	1. Continued monitoring by the DEH Shellfish Sanitation Program to update the status and more clearly pinpoint the sources of fecal coliform bacteria. 2. Recommend that Pamlico Company address potential sources of fecal coliform bacteria in future CAMA land use plans. Consultation with the DEH Shellfish Sanitation Branch is recommended in order to determine the potential success of and possible strategies for reopening closed waters and in preventing other waters from being closed. 3. Eliminate the Bay River WWTP discharge.

Chapter 14:
Neuse Subbasin 14
(Includes: Cedar Island, West Bay and portions of Pamlico and Core Sounds in Carteret County)

14-A. Subbasin Description

Subbasin 14 consists of Pamlico Sound, upper Core Sound, West Bay, and their embayments and tributaries in Carteret County. Land use in the area is mostly agriculture (including a portion of Open Grounds Farm) or undeveloped. These undeveloped areas include a military bombing range and the Cedar Island National Wildlife Refuge. All of the waters in this subbasin are estuarine. There are no large dischargers in this subbasin. A map of the subbasin showing water quality monitoring stations is shown in Figure 14.1.

Subbasin 14 at a Glance

Land and Water Acre (sq. mi.)

Total area:	**336**
Land area:	**59**
Water area:	**277**

Population/Growth

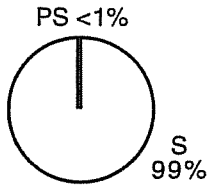
1996 Est. Pop.:	**898**
Pop. Density:	**15 pers/sq. mi.**
Proj. 2017 Pop.:	**1,171**
% increase (1996-2017):	**30.4%**

Land Cover (%)

Forest/Wetlands:	16.6%
Cultivated:	1.4%
Developed:	0.1%
Water:	80.5%

Use Support Ratings

Estuarine Waters



14-B. Water Quality Overview

Water chemistry in West Thorofare Bay and The Thorofare showed an area of very good water quality, with no algae blooms and low nutrients. Coliform, nutrient and turbidity values were slightly higher in The Thorofare than West Thorofare Bay, probably due to runoff from the bridge and the docked boats at the site. Macroinvertebrate samples collected in West Bay also reflect consistently high water quality in Thorofare Bay.

Core Sound, Pamlico Sound, Thorofare Bay, Barry Bay, Rumley Bay, Lewis Creek, SW Prong Lewis Creek, Cedar Island Bay, Back Bay and Goose Bay have been classified as Outstanding Resource Waters because of their high fisheries value.

The Division of Environmental Health's Shellfish sanitation branch has reported DMF closure to shellfishing of The Thorofare, Salters Creek Canal and Cedar Island Harbor; an area of 25 acres in the 85,000 acres of waters in this subbasin. The source of the closure in the West Bay area (DEH Area F6) is said to be wildlife. The source in the Cedar Island area (DEH Area F4) is said to be the ferry and marina. In the 1993 Neuse Basinwide Plan, 500 acres were closed to shellfish harvesting due to elevated fecal coliform levels, so there has been a marked improvement over the past five years. Oyster and clam production are rated Good in this subbasin with Fair commercial value.

14-C. Priority Issues and Recommendations

Water quality in this subbasin is generally very good. The only waters rated as impaired are the 25 acres closed to shellfish harvesting. The biggest challenge in the future will be to protect the quality of the unimpaired waters from any future development or marinas.

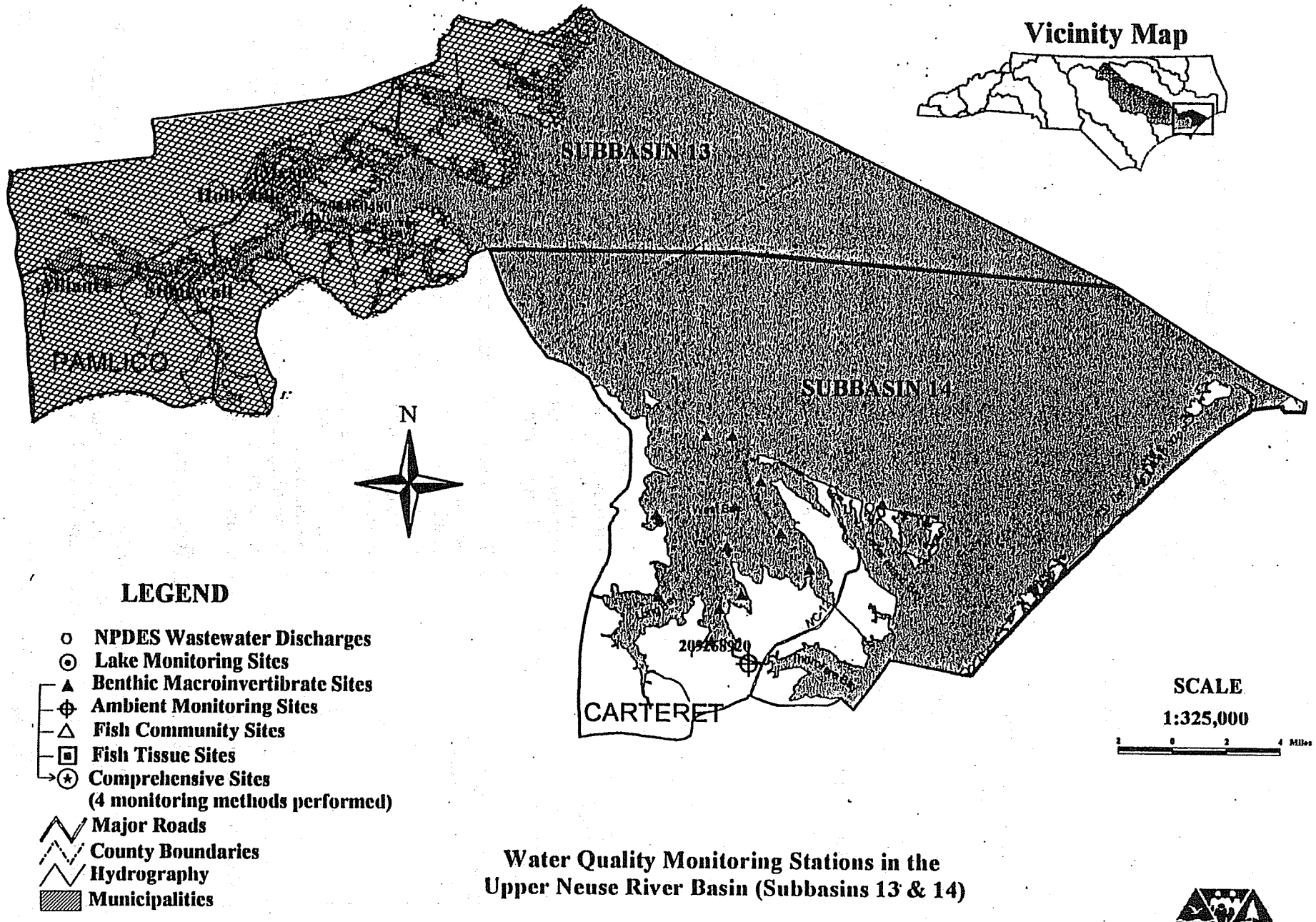


Figure 14.1 Water Quality Monitoring Stations in the Upper Neuse River Basin (Subbasins 13 and 14)

14-D. Waters of Special Interest

- **West Bay**

One site in West Bay near Tump Island has been sampled once in 1993 and once in 1995. High EBI, Total taxa, Amphipods and caridian shrimp are indicative of a pollution- intolerant community and high water quality. Macroinvertebrates from this site in 1993 were comparable to ORW areas of similar salinity. These sites were all dominated by the mysid shrimp *Mysidopsis bahia* with the clams *Gemma gemma* and *Mulinia lateralis,* the snail *Acteocina canaliculata,* the shrimp *Palaemonetes vulgaris* and the amphipod *Gammarus palustris* usually abundant. The continued high number of taxa and generally intolerant community in 1995 demonstrates that water quality has not declined since the original study.

These sites were sampled as part of an evaluation of West Bay for designation as ORW. Water quality in West Bay appears to be high, especially on the eastern side near the Cedar Island Wildlife Refuge.

Section C

Major Neuse Basin Initiatives and Accomplishments Since 1993

Chapter 1:
Major Neuse Basin Initiatives and Accomplishments: 1993-98

Listed below are important pieces of legislation, rule-making activities, organizational developments, educational outreach efforts and regulatory reforms that have been undertaken to address the water quality problems in the Neuse River since the original basinwide plan was completed in 1993. While a clear victory in restoring the waters of the Neuse is many years away, it is still worthwhile acknowledging the positive accomplishments over the past five years.

1-A. Lower Neuse River Basin Association

The Lower Neuse River Basin Association is a unique voluntary association of industrial and municipal point source dischargers in the lower Neuse River Basin. The Association, formally established three years ago, has worked with DWQ to design and implement a water quality monitoring program in the Neuse. It is the first association of its kind in North Carolina. The Lower Neuse River Basin Association has initiated a cost-effective monitoring system that complements the monitoring efforts of the DWQ. In effect, the Association provides a vehicle for better decision making, allowing for municipalities and industries to work together with State environmental agencies to evaluate and solve environmental problems.

1-B. Neuse River Foundation / Neuse River Keeper

In April 1993, the Neuse River Foundation hired Rick Dove to be the 'Neuse River Keeper'. His duties are to monitor the lower 50 miles of river for problems or violations and to make reports or collect samples for other agencies to analyze. Mr. Dove is also heavily involved in environmental education and public awareness activities concerning protection and restoration of the Neuse River. His tireless efforts over the past several years have significantly influenced the passage of laws and the development of regulations to protect the river. He also started a stream keeper program to extend citizen water quality monitoring efforts further upstream. Mr. Dove and the Neuse River Foundation are strong advocates for restoring water quality in the Neuse River.

1-C. Senate Select Committee on Water Quality and Fish Kills

Chaired by Senator Beverly Perdue, the Senate Select Committee on River Water Quality and Fish Kills was formed in the Fall of 1995 after major fish kills occurred in the Neuse River. The purpose of the committee was to investigate river water quality problems and make recommendations for corrective actions. The committee heard expert testimony from seven technical focus groups regarding the history and causes of pollution in the Neuse. Based on the information given in these and future presentations, the committee formulated specific courses of actions to address the problem.

The Committee presented a number of recommendations including allocating additional funding for monitoring and modeling, initiating a public education campaign, obtaining conservation easements to provide buffers, and creating an interagency task force. The Committee is also interested in improving management of animal waste. The committee later acted on these

recommendations through passage of the Clean Water Responsibility Act and funding was provided through the General Assembly.

1-D. Clean Water Responsibility Act

The Clean Water Responsibility Act (House Bill 515) was passed by the General Assembly in 1997. It was a comprehensive piece of environmental legislation that included, but was not limited to, a moratorium on construction or expansion of swine farms, control of emissions from animal operations, agricultural zoning, nutrient technology limits for facilities discharging to nutrient sensitive waters (including the Neuse River Basin), statewide stormwater management, and a requirement to prepare basinwide plans.

1-E. Neuse River Nutrient Sensitive Waters Rules

In December 1997, the North Carolina Environmental Management Commission approved a comprehensive set of new rules for controlling nutrients in the Neuse River Basin. The rules, which are briefly summarized in Chapter 5 of Section A, included provisions for controlling nutrients from agriculture, urban areas and wastewater treatment plants. The rules also include a provision for preserving forested riparian buffer zones and put additional requirements on large fertilizer applicators. The riparian buffer rules went into effect right away as temporary rules. The remaining rules are considered permanent rules, but they do not go into effect until after the 1998 session of the General Assembly (provided there are no bills passed by the GA that would negate them).

1-F. Clean Water Management Trust Fund

The Clean Water Management Trust was created pursuant to House Bill 53 by the 1996 session of the General Assembly. The fund was established to finance projects to clean up or prevent surface water pollution across the state. It is governed by a Board of Trustees and has an Executive Director and support staff. Organizationally it is located in the NC Department of Environment and Natural Resources; however, it is based in Greenville. The fund receives six and one-half percent of any unreserved credit balance remaining in the General Fund at the end of each fiscal year. It received $41 million dollars the first year, with $9 million of this amount being set aside for creation of a basinwide wetland restoration program in the NC Division of Water Quality.

1-G. Basinwide Wetlands Restoration Program

The North Carolina Wetlands Restoration Program (NCWRP) is responsible for implementing wetland and stream restoration projects to increase wetlands acreage, functions and values on a basinwide scale throughout the State to enhance water quality, flood prevention, fisheries, wildlife habitat, and recreational opportunities. The NCWRP's restoration efforts are a principle tool for achieving the water quality and aquatic habitat protection and enhancement goals set forth in the Basinwide Water Quality Management Plans.

The NCWRP is not a grant program. However, it can complement grant programs like the 319 program by taking on actual restoration projects that are identified through 319 grant applications. Alternatively, studies funded by the 319 program to identify suitable stream or wetland restoration sites can then be implemented by the NCWRP. The NCWRP can also directly fund other stream or wetland restoration sites identified by Nonpoint Source Teams or other means, provided those sites are located within a priority subbasin, as determined by the

NCWRP. Finally, the NCWRP can perform restoration projects cooperatively with other state or federal programs, or with environmental groups.

The NCWRP is focusing its stream and wetlands restoration work in sixty designated priority subbasins throughout North Carolina and is in the process of identifying prior converted wetlands, stream frontage and riparian buffers that, when restored, can provide significant functions and values on a watershed scale. Landowners who are willing to consider selling either property title or a permanent conservation easement (i.e., a legally binding agreement to allow restoration work and not to prohibit development) on suitable land are encouraged to contact the NCWRP. In turn, the NCWRP will determine the restoration potential of the land, whether it is located in a designated priority subbasin, and the basinwide ecological benefits of siting a restoration project there. If mutually acceptable to the NCWRP and the landowner, the latter may receive cash payments for land sales or tax breaks for conservation easements. The NCWRP will be responsible for the costs of wetlands or stream restoration and maintenance.

An interim plan has been prepared for the Neuse River basin. It highlights priority subbasins and watershed areas within the Neuse basin for restoration and mitigation. Most of the priority watersheds are indicated in a the freshwater impaired waters table in Chapter 4 of Section A.

1-H. Neuse River Regional Council

In March 1995, Governor James Hunt issued an Executive Order calling for the creation of Regional Councils. Regional Councils were originally recommended as part of the Albemarle-Pamlico Estuary Comprehensive Conservation and Management Plan (APES CCMP) to foster public input from each of the five river basins in the Albemarle-Pamlico region. The Neuse River Basin Regional Council (NRBRC) was formed ahead of regional councils for the other basins in order to help address water quality and fish kill concerns in the Neuse River Basin. The NRBRC, consisting of 52 members, held its inaugural meeting in New Bern on November 27, 1995.

Over the long-term, the NRBRC is providing input to the DENR, EMC and others in implementing the goals of the APES CCMP. Over the past two years, the NRBRC has identified issues in the Neuse River basin which members feel have been overlooked or deserve greater attention. In pursuit of discharging its duties as an advisory body, the NRBRC drafted resolutions addressing specific (or potential) problem areas. Several of these resolutions are listed below.

1. A resolution concerning the NRBRC's role in protecting and improving water quality in the Neuse River Basin.
2. Expressed support for improvements in the funding process for studies and supporting services for water quality improvement in the Neuse River Basin..
3. Requested that the State of North Carolina address its responsibilities for the cleanup of its navigable waterways by contracting with fisherman to pick up large fish kills for disposal in a safe and environmentally sound manner.
4. Expressed concern for required a study on the rate of withdrawal of aquifer waters in North Carolina.

1-I. NC State - Cooperative Extension Service: Neuse Education Team (NET Team)

This is a team of five extension agents with the NC Cooperative Extension Service that have been created to enhance education efforts in the Neuse basin. Their positions resulted from funding by the NC General Assembly in 1996. The team is working with other local and state

agencies, county governments and citizens to prioritize, identify and focus educational programs to improve the Neuse. All are experienced in water quality and environmental education. The team has been putting out a quarterly newsletter called *Neuse Letter* since June 1, 1997. They are headquartered in Raleigh at the Wake County Extension Center, 4001 (E) Carya Drive, Raleigh, NC 27610. Their e-mail address is mwoodwrd@wake.ces.state.nc.us, and their web page address is *ces.soil.ncsu.edu/net.*

1-J. Neuse Rapid Response Team

The Neuse Rapid Response Team was formed in 1997 and is comprised of four team members. Their positions were funded by the 1996 NC General Assembly. Their purpose is to respond to and investigate fish kills in the Neuse River. They are located in New Bern and are a part of the NC Division of Water Quality. Funding has been continued through 1998. More information on the Neuse RRT including recent fish kill information can be found at their page: *www.ehnr.state.nc.us/EHNR/neuse.*

1-K. Upper Neuse River Basin Association

The Upper Neuse River Basin Association is a voluntary association local governments. Unlike the Lower Neuse River Association, the Upper Neuse River Association is not a formal organization of dischargers. The Upper Neuse River Association consists of elected officials and representatives of local government, consulting firms and other interested groups. The Association has met monthly since January 1996. Various current events and issues are being addressed by the Upper Neuse River Association, they include: agricultural nonpoint source pollution, point source dischargers and urban stormwater. They have recently hired a full-time Executive Director and are in the process of developing a local watershed plan for the Falls Lake watershed pursuant to Senate Bill 114 which was passed by the 1997 of the General Assembly.

1-L. Neuse Stormwater Team and Nonpoint Source Teams

1-L.1 The Neuse Stormwater Team

The Neuse Stormwater Team includes participants from the 15 local governments that are subject to the Neuse Stormwater Rule (Cary, Durham, Garner, Goldsboro, Havelock, Kinston, New Bern, Raleigh, Smithfield, Wilson, Durham County, Johnston County, Orange County, Wake County, Wayne County) as well as other pertinent agencies and organizations, such as the Councils of Governments, the Office of Environmental Education and DWQ.

The Neuse Stormwater Team is playing a key role in developing the model plan for controlling nitrogen from urban stormwater in the Neuse basin. The Neuse stormwater rule (15A NCAC 2B .0234) requires that the local governments listed above develop and implement stormwater plans that include the following elements:

1. A model educational program to reduce nitrogen in urban stormwater.
2. A model program for evaluating new developments to determine if they meet nitrogen control standards.
3. Model criteria for identifying appropriate retrofit sites.
4. Guidance for implementing an illegal discharges program.

The Neuse Stormwater Team is meeting once a month between March 1998 and August 1999. During that time, the team will develop the model stormwater plan and present it to the Water Quality Committee (May 1999) and the Environmental Management Commission (July 1999).

After the model plan is developed and approved by the Environmental Management Commission, the team will meet once a year, at a minimum, in September (right before the annual reports for the local stormwater programs are due). The team may meet more often if it so chooses.

1-L.2 The Upper Neuse NPS Team

The Upper Neuse NPS Team has been meeting since March 1997. This group includes representatives of local governments, agencies and organizations as well as local citizens from the headwaters of the Neuse River to the Wake-Johnston county line. The purpose of this group is to identify NPS needs within the Upper Neuse basin and to develop and implement projects to address the highest-priority needs. This team of about 20 regular participants has received preliminary approval for a project proposal ($45,000 from EPA, $90,000 from the NC Division of Water Resources and $90,000 from the Clean Water Management Trust Fund). The project has these objectives:

1. Habitat assessments and hydrologic model calibrations of 12 small watersheds. One purpose of this study is to determine the types of restoration needs under different land use scenarios. The information gained from this study will assist state and local governments in making decisions about appropriate land uses in small watersheds targeted for future development and will provide a basis for restoration objectives in small watershed that have already been developed.
2. Implementing three small watershed restoration projects. The team will choose three high-priority small watersheds that have well-documented water quality needs and a high chance of successful restoration. Team members will oversee these projects and contribute their technical expertise.
3. Educating local stakeholders about watershed restoration. The team will link educational programs to the small watershed project so that the community may be made aware of the importance of protecting water quality and how their actions contribute to water quality health and/or degradation.

The team is working on choosing three high-priority restoration sites (objective 2) and beginning to develop the educational component (objective 3). Monitoring and modeling of the small watersheds are already underway (objective 1).

1-L.3 Middle Neuse NPS Team

The Middle Neuse NPS Team has been meeting since March 1997. Team participants, which include representatives of agencies, local governments and interest groups, have described existing NPS control programs in the basin and identified a list of potential priority NPS waterbodies in the region. Based on the discussion of the potential priority waterbodies, the NPS Team developed a 319 grant proposal focus on the Stoney Creek watershed. The Stoney Creek watershed was selected because:

1. It needs restoration and is valuable to the community.
2. There is a diversity of activities within the watershed.
3. Local stakeholders are interested in this watershed and believe its restoration will have a positive impact in the community.

The proposal received the primary approval from the State NPS Workgroup.

1-L.4 Lower Neuse NPS Team

The Lower Neuse NPS Team has been meeting since March 1997. This team has organized a number of presentations for its members on water quality monitoring, the impacts of NPS pollution, best management practices (BMP) and water quality activities in the Lower Neuse area. The Lower Neuse NPS Team has developed a project proposal to address Clubfoot Creek watershed. The objective of the project is to educate the public on NPS pollution concerns relative to septic systems, increase watershed awareness and to reduce pollutant impacts on identified critical areas. This project has received the primary approval from the State NPS Workgroup.

1-M. Water Quality Models

DWQ uses water quality models to help develop and analyze management strategies. These models are a conceptual design of the conditions that affect water quality. Water quality models are generally based on both physical measurements (e.g., flow, pollutant concentration, width, etc.) and an understanding of physical, chemical and biological processes. See Section A Chapter 5 for a detailed discussion of nutrient modeling in the Neuse.

Multimedia Integrated Modeling System

EPA's Office of Research and Development is developing a state-of-the-art multimedia modeling framework for a portion of the Albemarle-Pamlico Estuarine area including the Neuse River Basin. The focus of this modeling effort will be to bring together atmospheric, surface water and groundwater interaction into a single multimedia system to simulate nutrient cycling. $600,000 was funded to this effort in FY98, and EPA expects to fund approximately 1 to 1.5 million dollars per year for the duration of the project. At this time, it is anticipated that a beta version of the model will be available in 2004, and a final model will be completed by 2006.

1-N. Section 319 Projects

Section 319 of the Clean Water Act authorizes states to develop statewide Nonpoint Source Pollution (NPS) Management Programs. North Carolina's program was initially approved by EPA in 1989. Congress appropriates funds annually for states to implement Section 319 programs, with the focus on establishing demonstration projects for best management practices (BMPs). The Neuse NPS Team has the opportunity to develop and submit project proposals DWQ for consideration for Section 319 funding.

Several Section 319 projects are currently funded in the Neuse River Basin. These include the following:

- *Farm*A*Syst Project*, a statewide effort targeting the farming community, consists of a series of fact sheets and work sheets that will allow the user to assess contamination risk due to a particular pollutant source, such as pesticide storage or livestock waste. The program is a modification of the Wisconsin Farm*A*Syst program. Farm*A*Syst will be modified further into Home*A*Syst in order to reach the nonfarm community. Both Farm*A*Syst and Home*A*Syst will be tested in Johnston County.

- *Open Grounds Farm Project* is located in eastern Carteret County on a flat Coastal Plain landscape which drains into South River. On this area of historically poor drainage, several water control structures, rock dams, vegetative buffer areas, filter strips, and restored wetlands have been installed. The 44,000-acre farm, in existence since the early 1970s, is the supplier of three percent of the state's corn crop.

- *Little Chinquapin Creek Irrigation BMP Project* aims to establish and demonstrate several on-site BMPs that can be used to increase irrigation efficiency/performance and reduce the likelihood of wastewater nutrients reaching nearby surface waters. An irrigation scheduling service will be provided to all wastewater irrigators for one year of the project. Tours and irrigator training will also be offered in the watershed.

- *Wetland Restoration Project* near Vanceboro (Craven County) seeks to demonstrate and evaluate two field-scale wetlands restorations on prior-converted wetlands in order to restore hydroperiod and steam water quality degraded by sediment and/or nutrients. Wetland hydrology will be restored on the site by installing flashboard riser type control structures in the outlet ditches. Restoration treatment will consist of planting three native species; target species include yellow poplar, swamp white oak, willow oak, cherrybark oak, black gum, cypress and Atlantic white cedar.

- *Trenched Level Spreaders Project* coordinators (Wayne County near Goldsboro) propose to demonstrate the use of trenched level spreaders to enhance the effectiveness of forested filter zones (FFZ) in cleaning agricultural runoff. The objective of the spreaders is to produce sheetflow. A fact sheet will be produced to describe level spreaders, their function, implementation, construction and water quality benefits.

- *Vermicomposting Project* is a pilot-scale demonstration at NCSU Unit 2 Swine Facility. The objective of the project is to demonstrate the effectiveness of biologically recycling (using earthworms) swine waste from a 500-hog finishing house. Waste solids will be analyzed for inorganic nutrients, solids, volatile solids and bacterial pathogens like *Salmonella*.

- *Goose Creek Project*, east-central Durham drainage area, aims to install and demonstrate ecosystem protection practices (EPPs) to reduce sediment, water temperature and flow fluctuation while increasing dissolved oxygen as well. EPPs consist of tree planting, low head dams, filter/buffer inlets and pollution prevention education. Goose Creek is a tributary of Ellerbe Creek which has a Class C nutrient sensitive waters designation. Class C water is suitable for fish and other aquatic life, agriculture and any use except primary recreation and water supply.

- *Storm Drain Stenciling and Project HERO* (Help the Environment by Recycling Oil) involves volunteers painting messages on storm drains and catch basins to alert the public that pollution washed or dumped into the drains end up in rivers, creeks, lakes and coastal waters. The objective of the project is to reduce sediment, nutrients, pesticides and toxic materials like motor oil inputs to water resources. This storm drain stenciling component of the project is an extension of the successful 1994 piedmont pilot. Project HERO will be piloted in 19 counties as an educational program. Two of the counties will have a used oil filter collection component.

- *Urban Biofiltration BMP Demonstration Project* will be implemented in the Greensboro Watershed. The biofiltration system consists of a vegetated well-drained trench to provide positive flow of runoff from built-upon area.

- *Basinwide NPS Planning and Management* includes two components related to the Neuse River Basin: 1) analysis of current and needed nutrient reduction BMPs on farms; and 2) analysis of current fertilizer use on nonagricultural lands and potential water quality impacts. Project results will support basinwide estimation of resource allocations to meet nutrient reduction goals.

  Component #1 is further subdivided into two parts. Section A will identify on selected farms in the Neuse River Basin the current BMPs in operation and those that are needed to

protect water quality. BMPs to be evaluated include nutrient management, water table control and riparian buffers. The initial focus will be on farms located in the Contentnea Creek watershed. Results will be entered into the USDA NRCS FOCS reporting system.

Section B of the first component will evaluate the effectiveness of the Agriculture Cost Share Program (ACSP) as a whole and specific BMPs in reducing nutrient loading to the Contentnea Creek watershed. The approach will require entering ACSP BMP information implemented in Contentnea Creek from program year 1992 through program year 1996 into FOCS and then apply a newly developed nutrient effects evaluation calculation software program for the BMPs. This process will help develop and refine a method to account for and track nutrient reduction resulting from BMP implementation.

NPS Water Quality Modeling. The overall objective of this activity is to develop and apply watershed scale models to evaluate the effects of land use and management practices on the nitrogen loading of watersheds in the lower coastal plain. Watershed scale models will be developed and extensively tested using data collected from a heavily instrumented site located near Washington County, NC. The tested models will then be applied to evaluate the effect of various land use and management scenarios on nitrogen loading in the lower coastal plain of the Neuse River Basin. Although a variety of models show promise for achieving these objectives and need to be studied, the project proposed herein will develop and test a linkage between the field scale nitrogen model DRAINMOD-N and the Dutch in-stream model DUFLOW. The model will be applied for conditions and management scenarios on a watershed in the lower coastal plain.

Table 1-F Section 319 Projects Which Apply to the Neuse River Basin

Project	Federal	Match	Total
Farm*A*Syst	$34,971	$23,555	$58,526
Open Grounds Farm	$80,000	$64,000	$144,000
Little Chinquapin Creek Irrigation BMPs	$134,670	$91,642	$226,312
Wetland Restoration	$126,790	$85,282	$212,072
Trenched Level Spreaders	$172,665	$115,111	$287,776
Vermicomposting	$40,000	$26,667	$66,667
Goose Creek	$42,000	$28,000	$70,000
Storm Drain Stenciling and Project HERO	$61,730	$41,153	$102,883
Urban Biofiltration BMP Demonstration	$92,460	$61,640	$154,100
Basinwide NPS Planning and Management	$55,000	$36,667	$91,667
NPS Water Quality Modeling	$60,000	$40,000	$100,000
Total	$900,286	$613,717	$1,514,003

1-O. Animal Waste Management Initiatives

Starting with adoption of stricter animal waste management rules (15A NCAC 2H .0217) in December 1992 by the NC Environmental Management Commission, many improvements have been made in the regulation and management of large-scale swine and other animal operations. Listed below are some of the requirements of animal operations regulations and statutes adopted and implemented in the last five years:

- Establishment of regulatory standards for waste lagoon construction

- Prohibition of waste discharges to public surface waters
- Requiring that all farms have a Certified Waste Management Plan approved by the Division of Water Quality
- Requiring all farms to have a Certified Waste Water Operator
- Prevention of swine and other animal nutrients from being applied to crops in excess of the crop's yearly nutrient uptake
- Conducting twice-yearly inspections of all operations for compliance for all rules and regulations
- Placement of a moratorium on the expansion and construction of new farms until September 1999
- Placement all farms under a General Permit Program supervised by the NC Division of Water Quality
- Passing of zoning laws by the General Assembly that empower counties to specify the location of any farm over 600,000 pounds steady state live weight

1-P. NC Office of Environmental Education: "Know Your Ecological Address" Campaign

In 1995, the Senate Select Committee on River Water Quality and Fish Kills invited the Office of Environmental Education to develop an environmental education strategy to help the 1.5 million people living within the Neuse River Basin become better aware of their connection to the watershed.
In response to the committee's request, the Office of Environmental Education began coordinating existing resources and networks into an effective environmental education strategy. Under the banner "Know Your Ecological Address," the goal of the strategy is to strengthen citizens' understanding of natural systems so that they can make well-informed environmental decisions. Some of the partners involved with the "Know Your Ecological Address" strategy include government agencies, universities and colleges, nonprofit organizations, businesses and industry.

The Environmental Education Strategy includes components to reach both the general public as well as all ages of students. Some of the many achievements of the "Know Your Ecological Address" campaign are:

- DOT 's installation of river basin boundary signs and basin signs at stream crossings.
- The Big Sweep program added river basin designations to their data collection cards to enable approximately 12,000 volunteers at over 500 sites identify their river basin and to allow data to be compared between river basin.
- The NC Association of Soil and Water Conservation Districts recently passed a resolution encouraging the districts to add river basin information to their district signs.
- Duke Power Company, NC Power and CP&L distributed "Know Your Ecological Address" and "Know Your River Basin" educational material to over 2 million households as utility bill inserts.
- ElectriCities sponsored a "Know Your Ecological Address" poster that was distributed to classrooms.
- The Agency for Public Telecommunications and the North Carolina Wildlife Federation collaborated to produce television public service announcements highlighting children talking about their ecological address.
- The State Library Director, local libraries and DEHNR worked together to expand environmental education information at the state's 378 public libraries, 2,500 school media centers and 124 environmental education centers. Institutions received pamphlets, state river basin maps and data, and the *Citizen's Guide to Neuse River Basin Environmental Education Programs and Resources*, which describes educational resources available through numerous agencies, organizations, businesses and industries.

- A $200,000 Environmental Education Grant Fund was included in Governor Hunt's proposed budget and has been introduced as bills in both the NC Senate and House. If approved, this fund would provide the award of grants to K-12 school media centers, public libraries and environmental education centers to improve their environmental education library resources and materials collections, ensuring that schools as well as the public have access to high-quality environmental education resources.

The Neuse River Basin Environmental Education Strategy recognizes that teachers need access to appropriate environmental education resources. The *Neuse River Basin Supplement to the Teachers' Guide to Environmental Education Programs and Resources* helps teachers integrate environmental education into other instructional areas. Available free of charge to teachers, the *Supplement* catalogues environmental education programs for students, educational opportunities for teachers, and environmental education classroom materials. In addition, environmental geographic data specific to the Neuse River basin were placed on CD-ROM in geographic information systems (GIS) format and a partnership of educators developed related classroom activities at a week-long workshop in June 1996. The CD, which requires GIS software, is available to educators from the Office of Environmental Education.

Thus far, the actions of the Neuse River Basin Environmental Education Strategy have primarily targeted the Neuse River Basin. In the future, the program will be expanded statewide, reminding all North Carolinians that they are closely connected to their local watershed and providing them with the knowledge, awareness and skills necessary to make well-informed environmental decisions. In doing this, the Neuse River Basin Environmental Education Strategy will help prevent environmental episodes similar to the one that inspired its inception.

To learn more about river basin environmental education, visit the DENR Office of Environmental Education web site at http://www.whnr.state.nc.us/ENR/ee or contact the office at Post Office Box 27687, Raleigh, North Carolina 27611-7687, phone: (919) 733-0711.

1-Q. NC Division of Soil and Water Conservation

Listed below are a number of agricultural-related initiatives that have been undertaken by this division to improve water quality in the Neuse.

Basin Coordinator Position
A position created and filled in DENR Division Soil and Water Conservation to coordinate state and local level agency efforts to assure that agriculture achieves nitrogen reduction goals in the basin, and to attain landowner compliance, under the Environmental Management Commission (EMC) rule 15A NCAC 2B.0238. The position will target technical and financial assistance for installation of best management practices on cropland.

Technical Assistance
Funding from USDA and the state legislature has expanded technical assistance by creating 12 new technical positions in the basin. These positions are located in Soil and Water Conservation Districts throughout the basin, with administrative supervision provided by the Basin Coordinator. These positions will enhance existing efforts in the targeting, planning, installing and tracking of nutrient reduction BMPs implemented in the basin.

Neuse Rule Implementation
EMC rules to implement nitrogen reduction strategies in the basin went into effect August 1, 1998. Since May, 1998, the Neuse Agriculture Interagency Workgroup has been working on the tasks that face the Basin Oversight Committee (BOC), created under rule .0238. The BOC must develop a draft accounting and tracking method for the EMC by February, 1999. The BOC must also allocate reduction goals to the Local Advisory Committees (LAC) for development of

their reduction strategies. Local stakeholder agencies have already begun meeting to begin farmer sign-up for participation in the local options under rule .0238.

Agriculture Cost-Share Program (ACSP)
While continuing to fund best management practices (BMPs) for water quality protection, the program has removed the 100-acre cap on nutrient management incentive payments, due partly to the NSW status of the Neuse River. Payments are allowed on unlimited acreage of $6 per acre, and are not allowed on land receiving animal waste.

Animal Operations
Legislature approved, for FY 96-97, non-recurring ACSP funding of $1.75 million in the basin above the regular allocations to be used only for assisting existing (those established prior to May, 1992) animal operations in compliance with .0200 non-discharge rules.

Conservation Reserve Enhancement Program (CREP)
A Federal, State, and Local initiative to address NPS in the Chowan, Neuse, and Tar-Pamlico basins, as well as the Jordan Lake Watershed. Funding for the $274 million initiative will be provided by the US Department of Agriculture, Clean Water Management Trust Fund, NC Agricultural Cost Share Program, and NC Wetlands Restoration Program. CREP will include a five-year effort to enroll 100,000 acres of agricultural land next to rivers, streams, field ditches, estuarine waters, and wetlands in conservation agreements and install BMPs. Enrollment in the program ends production on the enrolled parcels for 10, 15 and 30 years, or permanently. Agricultural lands that meet the criteria can voluntarily be enrolled at any time. Payments will be used to encourage farmers to enroll their environmentally sensitive farmland. USDA will pay annual payments for up to 15 years and 50 percent of the farmer costs of installing BMPs. The state will pay a bonus at the time the land is enrolled to farmers willing to enroll in either 30-year or permanent conservation agreements, and will pay from 10 to 50 percent of the cost of installing BMPs on all enrolled land according to the water quality effectiveness of the BMP and the length of the conservation agreement.

Environmental Quality Incentives Program (EQIP)
USDA Natural Resources Conservation Service has allocated approximately $1.4 million in the Neuse basin for FY 1998 and 1999 to implement BMPs for environmental protection.

1-R. NC Division of Land Resources Activities in the Neuse Basin

Below is a brief overview of the nonpoint programs within the Land Quality Section governing erosion and sedimentation from construction and mining sites in NC and the Neuse Basin.

The Land Quality Section enforces the *Sedimentation Pollution Control Act of 1973* (SPCA), the *Mining Act of 1971* (Mining Act) and the *Dam Safety Law of 1967* (the Dam Safety Law). The SPCA and the Mining Act address nonpoint pollution for sedimentation from construction and mine sites. Erosion and sedimentation control measures, or BMPs, are installed to protect water quality. The SPCA has mandatory standards that must be met by all land-disturbing activities under the jurisdiction of the SPCA. Agriculture is exempt from the SPCA and Mining Act, while timbering activities must comply with Forest Practice Guidelines.

1-R.1 Construction

Mandatory standards for the SPCA
- keep visible siltation within the 25% of the buffer zone closest to the land disturbance
- stabilize all slopes within 30 working days of completion of any phase of grading

- retain sediment generated by land disturbances of any size
- provide a permanent groundcover within 30 working days or 120 calendar days after completion
- file and have approved an erosion control plan for construction activities disturbing 1 acre or more before the activity begins

Research Partially or Fully Supported by the Sedimentation Control Commission
The Sedimentation Control Commission (SCC) supports research to strengthen erosion and sediment control in NC. Some of the research supported by the SCC follows:

- Ongoing research on improving sediment basin settling efficiencies with flocculants and by design
- Research to quantify the economic benefits of sediment and erosion control on construction sites
- Research to examine the effects paving secondary roads has on water quality
- Future research needs: Research the efficiencies of erosion and sediment control measures as they are installed in the field; research sediment loading rates from construction sites and corresponding nutrient loading

Education
The Education Program within the Erosion and Sedimentation Control Program is made up of one full-time position and one part-time intern. Educational needs of the public are met through school programs and lectures. Technical assistance needs are met through workshops, a newsletter and technical materials, such as manuals and videos. A more detailed outline of our Section's education program follows:

- 4 annual Erosion and Sediment Control Design Workshops for consultants and designers
- Annual training workshop for local erosion and sediment control programs
- *Erosion Patrol 3rd Grade Curriculum Supplement* - distributed as requested to teachers
- *Muddy Water Essay Contest* for high school students, held annually
- Technical manuals and videos distributed to the public and design communities for design, installation and inspection of erosion and sedimentation control measures
- *Sediments* newsletter - 4 issues/year covering erosion and sediment control issues, distributed to the design, regulatory and construction communities
- Enviroscape/Erosion and sedimentation control lectures given to classes and other groups
- College scholarship - 2 annual awards of $2500 to students enrolled in curricula supporting erosion and sedimentation control principles
- Contractor's/Developer's awards program - new initiative to begin fall of 1997, recognizing contractors and/or developers who have excelled in erosion and sedimentation control on a North Carolina site
- Local Sedimentation Control Program awards program - new initiative to begin in fall 1997, recognizing local programs that have developed innovative approaches to erosion and sediment control, excelled in public education, begun new initiatives within their program, etc.
- Various other education projects: EELE project in Umstead Park for 5th graders; development of a college-level course on erosion and sedimentation control; public service announcements; display in the Museum of Life and Sciences

1-R.2 Mining

Program Requirements
An approved mining permit and reclamation plan are required for mining activities disturbing 1 or more acres of land. The *Mining Act* and corresponding administrative code address sediment and erosion control generally by requiring mine operators to minimize siltation of streams and other waterbodies. The standards and policies set in the Sediment Program are

applied in the Mining Program for temporary BMPs. However, permanent measures must be designed for larger storm events. The Mining Act also requires a detailed reclamation plan for each mine site to permanently stabilize all affected areas.

Education
The Mining Commission also supports education. The following programs have been supported and partially funded by the Mining Commission:

- Forest geology trail at Clemmons Educational Forest
- Rock kits to be assembled and distributed to public schools in NC
- Annual Earth Science Teachers' Workshops and Outstanding Earth Science Teacher Awards
- *Surface Mining Manual* for consultants and mine operators, outlining the permit process and program requirements
- Mine Reclamation Awards Program, recognizing outstanding reclamation efforts
- Outreach projects coordinated by the Minerals Research Lab for western NC teachers

1-R.3 Land Quality Section Activities in the Neuse Basin

The Neuse River Basin crosses the Raleigh, Washington and the Wilmington Regional Offices. A breakdown of the construction sites permitted in FY96-97 and the active mine sites for FY96-97 is provided by county in the table below. This information does **not** include local program information.

County	Construction - Total No. of Sites Approved in FY96-97	Construction - Acres Approved to be Disturbed	Mining - Active sites for FY96-97	Mining - Acres Disturbed
Carteret	3	19.8	17	47
Pamlico	12	115.9	2	4
Craven	35	482.7	22	964.5
Jones	1	1.8	3	7.5
Lenoir	25	121.9	15	59.5
Greene	4	17.3	4	4.3
Wayne	30	352.6	16	227.2
Wilson	30	163.2	11	295.8
Johnston	53	607.5	10	290.3
Wake	39	455.3	7	773.7
Franklin	4	39.9	1	7.2
Nash	8	46.2	1	35.76
Granville	9	55.6	1	48.2
Person	5	29	0	0
Orange	6	148.2	3	72.4
Durham	9	88.5	4	276.2
Beaufort	1	15.1	1	16.6
Pitt	9	62.6	10	146.8
TOTALS	**283**	**2823.1**	**128**	**3276.96**

1-R.4 Local Programs

There are eight local sedimentation control programs within the Neuse River Basin. The local programs have jurisdiction over construction sites within their areas (all mine sites are within the jurisdiction of the Land Quality Section). The following programs are either completely or partially within the Neuse River Basin:

° Apex
° Cary
° Chapel Hill
° Durham/Durham County
° Orange County
° Pitt County
° Raleigh
° Wake County

Until better maps are provided to these local programs, accurate reporting of their projects will not be possible. NCDOT, DWQ and the Land Quality Section are currently working on producing these maps to provide to the local programs.

1-S. City of Durham Water Quality Improvements

Since 1993, Durham, and many other local governments within the Neuse River Basin, have invested significant local dollars in major capital improvements for wastewater treatment. The City of Durham alone has spent in excess of $35,000,000 on upgrading and expanding the North Durham Water Reclamation Facility, plus approximately $14,000,000 in additional costs for pumping stations and force mains to eliminate the discharges at Eno River and Little Lick Creek.

1-T. Richland Creek Initiatives (Wake County

In April 1997, a Conservation Plan for the Richland Creek Corridor by NCSU's Schenck Forest and Umstead State Park was published. This effort was funded through a grant awarded in 1993 to Triangle Land Conservancy, Triangle Greenways Council, and The Umstead Coalition by the World Wildlife Fund and with additional funding support from the Woodson Family Foundation, Junior League of Raleigh, Pi Alpha Xi National Honor Fraternity (NCSU Chapter) and REI. The report summarizes the natural resources, recreational uses, existing land use patterns and regulation, development constraints and conservation recommendations for land use along the Richland Creek Corridor that connects Schenk Forest and Umstead State Park. A Steering Committee developed conservation recommendations for the Richland Creek Corridor between Wade Avenue/I-40 and the confluence of Crabtree Creek.

Richland Lake and Shelly Lake are the subjects of a Wake County study that is assessing the actual rate of sedimentation that has occurred in these lakes and estimating the remaining life span in these two flood control facilities. The assessment is expected to be completed by December 1998.

Chapter 2:
The South River Success Story

2-A. Reopening the South River Shellfish Waters

Closure of shellfishing waters in the South River, located near the mouth of the Neuse River, began in 1981 when approximately half of its area was closed to shellfish harvesting. The closure area remained the same until 1988 when it was reduced to approximately a third of the river. In 1992, the closure line was extended to include the majority of the river, totaling 1375 acres. In April 1992, DWQ initiated an intensive sampling program to investigate all of the land uses in the South River watershed and their impacts on fecal coliform bacteria concentrations in adjacent waters. The results of that investigation along with management recommendations were described in *An Examination of Fecal Coliform Bacteria Levels in the South River, Carteret County, North Carolina* (DEM, 1994).

Since the publication of the report in 1994, DWQ, other agencies and private landowners have been engaged in an effort to implement voluntary Best Management Practices (BMPs) on specific sites in the South River watershed. Based on bacteriological sampling conducted between April 1992 and September 1995 by the Shellfish Sanitation Branch of DEHNR, approximately 1100 acres in the South River have been reclassified to conditionally approved status for shellfishing, with provisions for immediate temporary closure in the event of heavy rainfall.

Establishing clear links with contamination sources is extremely complex since the cumulative effects of agricultural operations, timber harvesting, construction activities, septic systems and other human activities interact with weather, estuarine flow dynamics and background sources of contamination to influence fecal coliform levels in the river. Some probable links can, however, be suggested by examining watershed attributes and impacts which have been modified since the 1992 closure.

2-B. South River Initiatives for Improving Water Quality

The following were key components of the South River Initiative:

- Residential Development Survey
- Better Compliance for Forestry Operations
- Open Grounds Farm Project

Many resource managers are cautiously optimistic that the voluntary measures implemented in the watershed to date are contributing to the gradual improvement of water quality in the South River. The voluntary relocation and reduction of the Open Grounds Farm cattle population, implementation of controlled drainage and conservation tillage BMPs, and increased protection of stream buffers during timber harvests in the watershed may have directly contributed to the reopening of 1100 acres of shellfish waters in November 1995.

Results of ongoing monitoring and the research efforts at Open Grounds Farms by Dr. Kirby-Smith of Duke Marine Lab, funded by the Section 319 NPS Grant progress, are presented below in 2-B.3.

2-B.1 Residential Development Survey

A *Residential Development Survey* in November 1995, indicated that the only existing residential development within the South River watershed was the Martin Creek subdivision on Hardy Creek, containing eleven lots with none developed. The survey determined that no new development was apparent on the immediate shoreline of the South River.

2-B.2 Better Compliance with the Forest Practices Guidelines

Better Compliance with the Forest Practices Guidelines (15 NCAC 1J .0201-.0203) has occurred since a 1992 Notice of Violation. The NOV was served for failing to leave stream buffers of sufficient width, improper skidding and stream crossings, and violation of the State Water Quality Standard for turbidity and fecal coliform. Since 1992, several hundred acres of forestland have been harvested, and there have been no reported violations of 15 NCAC 1J .0201-.0203. DFR personnel report that subsequent harvesting operations have voluntarily left an undisturbed buffer measuring at least twice the recommended 50-foot streamside buffer zone.

2-B.3 Open Grounds Farm Project

The *Open Grounds Farm Project* (OGF) is a 44,000-acre crop and cattle production operation with almost 13,000 acres of cropland and pastureland draining to the South River. In 1992, there were 3000 head of cattle utilizing approximately 11,500 acres of pastures. Nearly 5000 acres of these pastures were located at the head of the river. Since 1992, the farm has changed ownership and is in the process of phasing out all cattle operations by the end of 1996. One of the first management modifications occurred when pastures located in the headwater areas of the river were relocated to other sections of the farm. Currently, there are approximately 760 head (600 are calves) in the South River watershed, and no animals are located within 1.5 miles of the river.

OGF has also begun an intensive effort to place all cropland under drainage control through the use of water control structures. These structures are managed year-round and enhance crop production while simultaneously decreasing nutrient exports and fecal coliform levels through increasing the detention time of drainage waters. More than twenty water control structures affecting over 6000 acres of cropland have been voluntarily financed and installed in the last two years by the owners and operators. In addition, OGF has implemented the BMP of conservation tillage on approximately 96 percent of their cropland in the South River watershed. Conservation tillage reduces soil disturbance and erosion.

A CWA Section 319(h) funding contract was established with Carteret Soil and Water Conservation District for the period of July 1994 through March 1997 for a demonstration project involving the installation and monitoring of several BMPs designed to reduce sediment, pesticides, fertilizers and fecal coliform bacteria emanating from OGF. Four types of BMPs were proposed:

1) constructed wetlands,
2) rock dam/filter,
3) flashboard risers, and
4) vegetated buffer strips.

Flashboard risers were intended to raise water tables during the growing season and winter, conserving water and providing detention time to allow pollutant reduction, including fecal coliform die-off. In winter, risers were to be operated to provide slow bleed-down of detained

drainage to make storage volume available for succeeding storm events. Four such risers were funded in the contract, but construction was delayed until 1996. Monitoring of the four funded risers was conducted under the direction of Dr. Kirby-Smith of Duke Marine Lab. A summary of conclusions from the monitoring study are presented below.

The constructed wetland is approximately 10 acres of prior converted cropland, adjacent to Southwest Creek, on which cropping has ceased. Blocked inflow ditches were to be reopened, and an outfall structure put in place to reestablish wetland hydroperiod and to raise water tables under approximately 300 acres of upgradient cropland. Fecal coliform improvements are not anticipated from the wetland itself since it is expected to draw wildlife usage. The wetland has not been installed at this time. The third practice, a rock dam/filter, was to detain erosive flows occurring in a major drainage canal feeding West Fork. The dam was to provide temporary detention and sedimentation of storm flows with passive bleed-down, as well as a high water level bypass through an adjacent *Juncus* marsh. Detention time afforded by this structure was not expected to be sufficient to provide substantial fecal coliform reductions. The dam was installed in December 1994. The fourth practice involved vegetated buffer strips of 10 to 20 feet width, totaling approximately 116 acres, bordering Southwest Creek, West Fork and the South River itself. These strips were an existing BMP to be sampled for pollutant reduction effectiveness, including fecal coliform. At this time, sampling of the buffer strips has not begun.

Summary of Conclusions from Monitoring Study

Restored Wetland

1. The restored wetland created a habitat that reduced fecal coliform bacteria to below detection.
2. The restored wetland removed more than 90% of the ammonia nitrogen and 97% of the nitrate nitrogen from the inflow from fields.
3. The restored wetland increased phosphate phosphorus by 30% to 70% in the outflow probably by reducing the pH of the water.
4. The restored wetland absorbed essentially all of the inflow water in the summer 1997, so that there was no outflow observed.
5. Turbidity and solids were very low in most inflow and outflow waters.

Rock Dam

1. During large runoff events, the rock dam reduced the rate of flow of water into the estuary and forced some of the runoff to flow through an adjacent marsh.
2. Although not measured, the rock dam probably eliminated the bedload transport of fine sands from the canal into the estuary.
3. During slow flows, the dam significantly reduced the delivery of suspended solids to the estuary.
4. Fecal coliform bacteria concentrations were unaffected by the rock dam.
5. During high flows, the dam offered no water quality improvements; the rate of flow was apparently too great for any reduction in nutrients or suspended sediments to occur.

Flashboard Riser

1. The flashboard riser caused a reduction in suspended solids.
2. In one set of measurements, the flashboard riser had no impact on the nitrate and ammonia nitrogen entering the canal from field ditches. In a second set of measurements, the riser had significantly less nitrogen than a free flowing canal. The data suggest a careful evaluation of riser management if they are to be used to reduce nitrogen loading.
3. The flashboard riser had no effect on concentrations of fecal coliform bacteria.

Grass Buffer Strips

1. Grass buffers significantly reduced the concentration of sediments (48%), turbidity (20%), phosphate (54%), ammonia (48%) and nitrate+nitrite (53%).
2. Grass buffers had no effect on pH, conductivity or fecal coliform bacteria.

APPENDIX I

Comments from Public Workshops

***

Responses to Question #11 of the Questionnaire

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Worshop Questionnaire

Workshop Comments

A-1.1 Workshop Summary

Five workshops were held in March 1997 in advance of preparing this plan.

New Bern (2): Monday, March 3, 1997, 2 PM and 7 PM

Goldsboro (1): Thursday, March 6, 1997, 7 PM

Raleigh (2): Tuesday, March 11, 1997, 9 AM and 7 PM

Each workshop, which ran from two to three hours, was divided into two sessions. The first session included a series of speakers from DWQ that discussed modeling, monitoring and other aspects of updating the Neuse Basinwide Plan. The second session was set aside for comments by the workshop participants. Depending on the size of the audience, comments were solicited either from the plenary group, or they were taken through smaller breakout groups. A questionnaire was also handed out and there were 65 respondents.

A summary of the comments provided at each session is provided in the following section (I-2.). The results of the questionnaires are summarized in the Table A-1.1.

The comments and questionnaire results were used to help shape the plan and provide some guidance on its contents.

Some of the revisions made in response to comments include:

- Elimination of general information - Most of the general information found in previous plans has been eliminated and replace with more stream-specific information. In the months to come, DWQ is planning on producing a companion document for the plans that describes causes and sources of pollution, point and nonpoint source programs, and so on.
- Revised format - The bulk of the water quality information and recommendations are now combined and presented by subbasin in Part B. Before, the water quality information was in Chapter 4 and the recommendations were in Chapter 6.
- More attention to impaired streams - Individual tables have been prepared for most of the impaired streams in the basin in order to help generate some restoration actions.
- Summary document(s) - Upon completion of the final report, and provided adequate resources are available, DWQ will plan on putting out a 10-20 page summary document and/or a brochure which highlights the major findings and recommendations of the plan. These documents should be less expensive to produce, be easier to read and have broader distribution.

Table A.1 Summary of Neuse Basinwide Workshop Results

		New Bern		Goldsboro	Raleigh		
Question No.	Workshop	2:00 PM	7:00 PM	7:00 PM	9:00 AM	7:00 PM	Total
	# of surveys	25	4	12	19	5	65
1	**Do you live in the Neuse River Basin?**						
	Live in basin	18	3	11	17	2	51
	Don't live in basin	7	1	0	2	3	13
2	**How did you hear about the workshop?**						
	Announcement	17	4	6	14	4	45
	Someone else	8	1	4	5	1	19
3	**How would you characterize your interest in the workshop?**						
	Professional	18	4	9	16	3	50
	Personal	19	4	8	14	5	50
4	**Which of the following best represents your group affiliation?**						
	Homeowner	2	0	2	2	1	7
	Farmer	0	0	3	0	0	3
	Ag. Org.	1	0	2	0	1	4
	Business	5	0	1	4	1	11
	Env. Org.	6	0	1	1	3	11
	Local Govt.	8	3	3	5	1	20
	State Govt.	5	1	3	6	2	17
	Fed. Govt.	2	0	0	0	0	2
5	**How do you or your group value the Neuse River?**						
	Recreation	19	3	11	9	4	46
	Water Supply	6	0	6	11	4	27
	Eco. Dev.	11	2	3	5	2	23
	Com. Fishing	6	1	4	3	2	16
	Wastewater	15	2	2	9	0	28
6	**How would you characterize the condition of the river?**						
	Critical	6	0	2	5	3	16
	Serious	11	3	6	6	1	27
	Not as bad	9	0	4	6	1	20
	Not aware	0	0	0	1	0	1
*7	**Rate WQ issues in the basin (rank in order, 1 the worst)**						
	Algal Blooms	46	14	29	59	13	161
	Toxic Dino.	61	12	23	56	16	168
	Cl. Shellfishing	80	11	29	68	16	204
	Erosion/Sed.	95	14	51	59	19	238
	Toxic Substances	100	15	48	73	21	257

8	**Rate the most serious pollution sources (rank in order, 1 the worst)**						
	Ag. - Animals	68	11	45	43	13	180
	Urban	82	11	36	54	12	195
	Ag. - Crops	87	14	56	46	16	219
	WWTPs	94	17	45	84	17	257
	Construction	117	21	55	77	26	296
	Atmospheric	147	28	75	119	23	392
	Mining	158	25	67	117	33	400
9	**What is the adequacy of the existing WQ protection regulations?**						
	Grossly inadequate	4	1	0	4	2	11
	Inadequate	13	1	3	7	2	26
	Better enf.	9	3	8	7	1	28
	Too much reg.	0	0	0	0	0	0
10	**What role should be basinwide plan play in addressing WQ problems?**						
	Make people aware	17	4	9	15	5	50
	Recommend improve.	19	4	12	18	4	57
	Rec. stricter laws	14	3	3	8	4	32
	None	0	0	0	0	0	0
12	**Which of the following formats would be of most use to your group?**						
	Brochure	10	2	2	8	2	24
	10-20 page summ.	15	2	5	13	4	39
	200+ page plan	11	1	7	11	4	34

***Note: for questions 7 and 8, the lower the number, the higher the priority**

A-I.2 Comments Received During Break-Out Sessions in the Neuse Basinwide Public Workshops

New Bern, 2:00 pm on 3/3/97

Water Quality Issues:

1. Homeowner fertilizer use
   The Neuse NSW Stormwater rule requires that 15 of the largest local governments implement a public education program on reducing nutrients. One of the topics that this education program will cover is homeowner fertilizer use. The DENR Office of Environmental Education has made contacts with fertilizer wholesalers for the purpose of providing homeowers with information on the proper application of fertilizers.
2. DOT fertilizer use
   All nutrient applicators that apply nutrients to 50 acres or more of land in the Neuse basin (this includes DOT) are covered by the Neuse NSW Nutrient Management rule. This rule requires the affected nutrient applicators to either attend nutrient management training or to prepare nutrient management plans for the lands on which they apply nutrients.

3. Golf course management
   See 2., above (includes golf courses).
4. Nitrogen from WWTPs
   The Neuse NSW Wastewater rule requires that wastewater dischargers attain a 30% reduction in their nitrogen loading to the Neuse River estuary. Each discharger has the choice of participating in a collective nitrogen reduction plan or individually achieving the nitrogen reduction at the plant. (For more information, see Part A, Chapter 5.)
5. Land clearing
   - sediment, stormwater
   - programmatic controls
   - enforcement
   - not enough monitoring

   The effects of land clearing are being partially addressed by the Neuse NSW Riparian Area Protection and Maintenance rule. This rule prohibits clearing within 30 feet of all perennial and intermittent streams, rivers, ponds, lakes and estuaries in the basin that are bordered by forest vegetation (with certain exemptions). This rule will help to address the additional loads of sediment and other pollutants resulting from land clearing activities (For more information, see Part A, Chapter 5). The Sedimentation Control Commission is also seeking ways of addressing
6. Stormwater
   - streets, industrial sites
   - distribution houses for fertilizer
   - oil & grease
   - Are current stormwater controls getting to all contaminants?
7. Agriculture
   - where practices (cost-effective) for it?
   - who will pay?
   - monitoring streams from farmland. (headwaters)

   There are currently numerous programs to assist farmers in attaining the resources needed to implement BMPs. Most of these programs are cost-share, meaning that public funds pay for part of the BMP and farmers pay part.
8. Clogged-up streams in NC
   - cleaned out
   - beavers
10. Atmospheric
    - local industries
    - vehicles
    - animals
    - long-range
    - fertilizers

    The NC Division of Air Quality, in cooperation with the University of North Carolina and NC State University, is studying ammonia emissions and their deposition on land and water, with emphasis on their ultimate reactions in the atmosphere and contributions to nitrogen in rivers and estuaries, particularly the Neuse.
11. Catastrophic Events
    - hurricanes and wastewater treatment
    - animal lagoon spills
    - define the event
12. Development in the Floodplain
    Development in the floodplain will be limited by the Neuse NSW Riparian Area rule, which requires that new development be located at least 50 feet away from all perennial and intermittent streams, rivers, ponds, lakes and estuaries in the basin that are bordered by forest vegetation (For more information, see Part A, Chapter 5)
13. Development density
14. Marinas - toilets, oil, paint
15. Cherry Point

See Slocum Creek in Chapter 10, Part B for a discusion of movement of the discharge outfall from Slocum Creek to the Neuse River

16. Septic systems
    - how bad are they?
    - surveys for existing systems that may be failing
17. Septage management
18. Mining operations - turbidity drop in water table
19. Macrophytes on Trent R - problem is clearly from populated areas according to fishermen
    See Trent River in Chapter 11 of Part B for a discussion on this topic.
20. Overall - need to take time to study the problem
    New Bern is doing some innovative things that require permits
    - "Test but don't guess"
    - Need to see facts
    - increased monitoring data
    - farmers are willing to implement BMPs if problems are proven

21. Nutrients - Algal blooms
    Obviously this has been the major water quality issues in the basin over the past three years. The Neuse NSW strategy
22. Aquatic weeds - River bend
    See Part B, Chapter 11, Trent River
23. Point source spills - Need better controls
    Agreed.
24. WWTPs and Hog farms and industrial plants and stronger penalties
25. Nonpoint source agencies need to coordinate enforcement between agencies.
26. Citizens need a clearing house for water quality information (web sites?)
27. Need to address BMP implementation
    - How can we assure they're being installed?
    - What data available on BMP implementation for various NPS activities
28. We need growth management for residential and other types of development.
29. Trash/abuse of river (old fishing nets)
30. Need better education of children on environment
    The NC Office of Environmental Education has just acquired two basinwide educators that are working on improving basinwide education through schools, libraries and environmental education centers. In addition, the Neuse NSW Stormwater rule requires that 15 of the largest local governments implement a public education program. This effort will probably include educational efforts targeted toward children. (For more information, see Part A, Chapter 5)
31. Global Transpark - How will basin plan address?
    - Affects similar PCS on groundwater
    - Need to review EIS.
32. Need consensus on modeling - arguments lead to inaction - involve stakeholders in model development
    This issue was addressed in the Clean Water Responsibility Act which requires that a calibrated nutrient model for the Neuse (or other NSW basins) include stakeholder involvement in its development. WRRI and DWQ are in the process of developing a model for the Neuse River that does emphasize and include stakeholder input.
33. Closed shellfish waters - Existing non-urban residential septic tanks
    Septic tanks are often cited as a probable cause of shellfish water closures, but there is little documented evidence of them having a significant widespread effect. Of greater import are land disturing activities and artificial drainage systems that allow more rapid and increased delivery of stormwater that contains fecal coliforms. This plan reports a 1700-acrea reduction in the acreage of shellfish water closed to harvesting. Most of the improvement occurred in South River.
34. Coordinate central sewer plant approvals with WQ protection goals (secondary growth issues)
35. Pfiesteria (impacts of phosphorus from WWTP and animal operations)

Recommendations to Improve Plan:

1. Don't think a lot of changes were made as a result of the plans
   True to an extent, but the plan sets the stage for addressing issues at the basin level. Need to build on that progress.
2. Set ground rules in the plan.
   See Chapter 4
3. The plans are too general -- people need to know what the problems are and what to do about it
   Agreed. An attempt has been made in this plan to provide more detailed information on the problems so as to help others in developing solutins.
4. Make the plans easier to read
   The format of the plan has been significantly revised. Much of the stream specific information is now presented by subbasins (watersheds) instead of by water quality parameters. Also, much of the generic, or information not related directly to the Neuse basin, has been eliminated.
5. Lawyer's didn't write it
   Thank you.
6. Good at setting up data gathering phase

New Bern, 7:00 on 3/3/97

Water Quality Issues:

1. WWTP (municipal)
   - New Bern area
   - Whole basin
2. Highway runoff and parking lots
   - Extensive ditching
   - Implement BMPs

   DWQ has recently issued an NPDES Stormwater permit to DOT. This permit requires DOT to implement 14 BMPs across the state each year to address the impacts to sensitive areas from existing highways. In addition, DOT has to control pollutants coming from their vehicle maintenance areas.
3. Urban stormwater controls -- retrofitting-fitting BMPs in existing urban areas.
   The Neuse NSW Stormwater rule requires that 15 of the largest local governments implement a stormwater program. One of the components of the stormwater program is to identify urban sites where retrofits could be possible and beneficial. There are currently many avenues available for implementing urban retrofits to improve water quality, including the Clean Water Management Trust Fund and the Wetland Restoration Program.
4. Use support rating (swimmability of lower Neuse (below. New Bern)
   See 6, below.
5. Data acquisition (closer examination of nitrogen fertilizer purchase and application agriculture vs. non-agriculture)
6. Check class B reclass in lower Neuse
   The Class B reclassification is still alive although processing has been put on hold based on awaiting the implementation of the new NSW rules and on getting better information on the human health effects of Pfiesteria.

Recommendations to improve plan:

1. Improve pie chart-better science/better description
   The pie chart has not been included in this plan in light of the degree of uncertainty of the sources of nitrogen and phosphorus from the atmosphere and groundwaters.

2. Use-support ratings - estuarine waters-difficult to understand how ratings defined. Need to clarify how ratings devised.
   A description of the methodology is included in section 3-C of Chapter 3, Part A.
4. Better recognition of well operating WWTPs and successful BMP implementation.
   This has not been included in this draft but needs to be a part of the final document.
5. Closer examination of fertilizer purchases/application and runoff. Stanley's numbers versus export coefficient method.

6. Watershed level nutrient pie charts.
   This information has not been generated for this version of the plan.

Goldsboro, 7:00 pm on 3/6/97

Water Quality Issues:

1. Contentnea Creek - Effects of Fran - Slower Flow
   The impacts of Hurricane Fran are briefly described in Chapter 3 of Part A. References to other information sources are provided.
2. Look at effects Basinwide
   - Include update on Isotope study
   - Development in upper basin

3. Urban stormwater
   - Effects of Piedmont Development on downstream development. (Regs. on downstream development)
   - Effects of coastal stormwater regs on growth.

4. Regulation of urban and agricultural runoff

5. Source of dry litter operation information.

Raleigh, 9:00 am on 3/11/97

Water Quality Issues

1. Will monitoring be increased?
   - Discuss differences in monitoring between first plan and second
   - USGS real time sites
   - Weekly and daily nutrient sites
   - Lower Neuse? approach

   The plan includes some brief summaries of present monitoring efforts. Monitoring inthe estuary has been increased substantially over what was being done for the previous basin plan. It is unknown how long this elevelated level of monitoring can be continued as it is very costly and the General Assembly has only to committed to short-term monitoring. The basin plan provides a comparison of monitored data between the 1993 plan and this one.
2. Lots of talk, not much money
   Actually, since the workshops were held, there has been a lot of money made available to the Neuse River for protecting and restoring water quality. Over $200 million has been made available from the USDA NRCS through the Conservation Restoration Enhancement Program (CREP) for nutrient management in the Neuse, Tar-Pamlico, and Chowan River Basin. Tens of millions of other dollars are available through the NC Clean Water Management Trust Fund, the NC Agricultural Cost Share Program, the NC Basinwide Wetlands Restoration Program, federal 319

nonpoint source program, and through a recently-passed state referendum allowing the sale of revenue bonds to provide $800 million for wastewater plant and system improvements.

3. Why do citizens have to find problems with wastewater treatment plants and act on them? Shouldn't the state be doing that?
   The state does identify and correct many wastewater treatment plant problems through periodic wastewater treatment plant inspections and evaluation of monitoring reports. However, the number of inspectors is limited by the limited availability of tax revenues and permit fees. The assistance of citizens in identifying problems is valuable and welcomed as supplement to the state's enforcement and compliance program.
4. Need to assess overall PS and NPS assimilitative capacity
   This is a goal of basinwide management, and modeling is being done to determine assimilative capacity for certain pollutants in targeted waterbodies. Nutrients and biochemical oxygen demand are the two primary pollutants for which assimilative capacity has been determined for many waters in the basin. However, the assimilative capacity for each water body differs depending on such factors as stream flow, temperature, tidal influence, pH and time of year. Determing assimilitive capacity for nonpoint source pollutants such as sediment and fecal coliform bacteria is extremely difficult.

5. To what extent are we looking at long term population growth? We should look at the PS and NPS impacts of the growth.
   The plan has highlighted population growth as an important issue and has added information on population projections. This is a major concern, but one which will require local government involvement if it is to be effectively addressed.

Improvements to the basinwide plan:

1. Show discharger locations, (DWQ & others), monitoring locations, and water uses.
   Done
2. SC is producing a CD-ROM for local governments -- could NC do that?
   NC would like to eventually produce it's basinwide plans on CD-ROMs but it is not presently equipped and funded to do so.
3. Should include an assessment of improvements since last plan.
   Done
4. Need better map of evaluated streams.
   Done
5. More information about impairments.
   While more information is needed to correct problems on some of the impaired waters, this plan include much more information on impaired waters than the previous one.
6. Include descriptions of permitting plan.
   This plan adopts the NPDES permitting strategies for biochemical oxygen demand (BOD) from the 1993 plan and includes a description of the most recent nutrient permitting plan.
7. Maybe include county land use regulations.
   This has not been included in this draft but it is still a goal to have it in the final plan.
8. Put information into GIS whenever possible - may reduce size
   Many more GIS maps have been included but the plan size has not been reduced.
9. Make maps less busy
   An effort has been made to do so
10. Do a lot of brochures and 10-20 pages
    This is DWQ's goal once the final plan has been approved.
11. Local governments need full document.
    They will be notified of the plan availability and will be provided with plans upon request.

Raleigh, 7:00 pm on 3/11/97

Water Quality Issues

1. Basins should have a basin conservation plan with priorities on riparian restoration
   Done. A basinwide wetlands and riparian restoration plan has been prepared. It is a separate document from this basinwide plan.
2. CWMTF should act as an integrating force.
   The Clean Water Management Trust Fund is an important funding source for water quality protection and restoration and has been featured in this plan.
3. Models are only on estuary.
   Not true. Modeling was done for the 1993 plan on many streams and the mainstem of the river for impacts on dissolved oxygen by wastewater treatment plant discharges. These recommendations are included in Chapter 4 of Part A. Chapter 5 of Part A describes nutrient-related models that address not only the estuary but where the nutrients are coming from and how much is being transported downstream.
4. What about algacides -- what are appropriate chemicals that will not destroy creeks?
   DWQ has not considered the use of algacides in surface waters but has instead focused on reducing the nutrients loadings that stimulate algal growth.

Improvements to the basinwide plan:

1. Plan should facilitate local cooperation and involvement.
   Local cooperation and involvement is extremely important and is emphasized, especially in strategies to restore impaired waters, in Part B of the plan.
2. Present the big picture and show what people can do.
   The plan shows the big picture (and many little pictures as well). It is hoped that this can be taken forward to folks such as the nonpoint source team members, the CWMTF, the Neuse Basin Cooperative Extension Team to their constituents for further implementation.
3. Will the relationships between agencies be described?
   This has not been done in this plan. A separate supporting document is being prepared that will provide more information on this topic.
4. GIS - How will the methods be described?
5. Will the maps be referenced in discussion of water bodies?
   Yes.
6. Would like to see how we restore rivers in the long term?
   - Include successes.
     A separate chapter in Part C has been included to highlight the South River success story however, there are other success stories that could be highlighted. We hope to hear of some during the draft review of this plan.
   - Should work with Office of Environmental Education to get appropriate education materials.
     See Education in Part C. Also, DWQ is working with OEE to produce a series of educational packet on watershed management that will include brochures in individual basins.

I-2. Workshop Participant Responses to Question #11 of the Questionnaire

11) If you are familiar with the 1993 basinwide plan, what would consider its strengths and weaknesses for use in updating the plan this year?

a. Positive features to build on in updating the plan

- Continue to collect data and provide factual scientific data unbiased by politics or special interest groups
- Good data collection plan
- Nitrogen Reduction
- Buffer Zones
- Storm Water Regulations
- A needed stang however (20) years behind schedule
- Targeting of management actions by problem subbasins.
- Encourage GIS based approach to watershed modeling but with appropriate spatial variations in parameters such as "roughness"
- It was a reasonable plan which was only marginally implemented.
- More public concern
- Plan was very comprehensive and covered the subject well
- Overall basin strategy
- Closer regulation of chemical fertilizer on agricultural lands and turf area (golf courses)should be more closely regulated to elemenate runoff
- Improve nutrient mass balance & source allocation estimates by including better estimates of atmospheric deposit and background N loads
- Strengthen justifications for adequate or more that adequate, eg. excellent, reparion buffers.
- Concentrate on big picture

b. Negative features to avoid

- Passing the problem to the existing regulated entities for implementing solution (i.e., NPDES permitted facilities had major impacts placed on them. Phosphorus was cited as a major problem - now nitrogen is being cited.
- Focusing on one group of dischargers and drawing conclusions without supporting data.
- Models are susceptible to attach as being inadequate
- Enforcement for soil erosion, logging, animal operations, and stream pollution
- Plan should include all tributaries that also connect to the Neuse River
- All runoff = polution, ignoring past record of improvements for different sectors and condeming all who contribute.
- Relying on voluntary proposals
- Domination by industry groups
- Unproven models which have co efficients that are pure - SWAG models assign nutrient loads to various land uses that appear to have no basis in fact only some one's bios.
- More maps, less text. If in doubt use a map or graph.
- Break down by themes -ex.4 "less busy" maps on a page vs. 1 very busy map
- The status quo
- Should avoid segregating animal eg. complexes
- Out of date landuse estimates
- Lumping animal Ops. into Ag. landuse export
- Too much detailed data in brochure & summary

c. Areas that need improvement or strengthening

- Problem is a basinwide problem - cost should be equally shared to implement a solution - action should not be politically motivated as in the past but on completed scientific studies that provide a solution and the best practices to use for both PS and NPS.

- Need to look at the big picture and produce the most cost-effective solutions. In the 1980s, phosphorus needed to be removed as the limiting nutrient. Now also nitrogen. Other basins required nitrogen removal in the 1980s. What change in direction will be next? A water quality model needt obe developed from data gathered.
- Storm run off, agricultureal impact, other non point source discharge impacts
- Argricultural (animal-farming), logging operations, buffer zones, water quality modeling, storm water retentions, in-stream monitoring,
- In corporation of fate/trasport in evaluting total inputs of nutrients
- Properly acknowledge that nutrients runoff (NPS) all lands - with or without man. (e.g. background levels)
- Quantify NPS pollution from agriculture, forestry
- Determine degree of compliance w/BMP for agriculture, forestry, etc.
- Increasing public determination by producing accurate statistics such as sewers, crop farming, golf courses, etc.
- Defend your Data that you measure
- Do brochures and summaries, less zoot page plans - if in doubt, use a map or graph rather than text
- Goal for water quality; proposed measures to improve water quality, including point and nonpoint source control measures
- Agricultural discharges, erosion, and land quality
- Make the plan an action plan - not passive. You've ID'd specific problems - take specific actions, not just "encouraging" communities to do things like stormwater management
- Lagoons/waste treatment facilities etc. should be treated equally being either O discharge (completely) or allow discharge upon permit
- More complete basin Conservation plans. Priority for wetland restoration & degraded land restoration for water quality improvement
- Need a good summary for general public
- Color maps, actions that individuals and groups can take to help improve their own neighborhood

NEUSE BASIN WORKSHOP QUESTIONNAIRE

1) Do you live in the Neuse River Basin?

___ Yes ___ No ___ Not sure

2) How did you hear about the workshop?

___ Received announcement in mail
___ Heard from someone else
___ Other_____

3) How would you characterize your interest in attending the workshop?

___ Personal interest
___ Professional interest
___ Both

4) Which of the following would best represent your group affiliation in the Neuse River? (*check one*)

___ Homeowner
___ Farmer
___ Agricultural organization
___ Business/Industry
___ Environmental organization
___ Local government
___ State government
___ Federal government
___ Other _____

5) How do you or your group use or value the Neuse River? (*check all that may apply*)

___ Recreation
___ Water Supply
___ Economic development
___ Commercial fishing
___ Wastewater discharger
___ Other _____

6) How would you characterize the condition of the river?

___ Critical
___ Serious
___ Needs cleanup, but not as bad as they say
___ Not aware of a serious problem

7) How would you prioritize the water quality issues in the Neuse Basin (*rank the following in priority order with 1 being the most serious*)

___ Closed shellfish waters (from fecal coliform bacteria)
___ Algal blooms and fish kills
___ Toxic dinoflagellate (fish kills and human health concerns)
___ Erosion and sedimentation
___ Toxic substances (heavy metals, pesticides)
___ Other _____

8) What would you consider the most serious pollution sources? (*please rank the following in priority order with 1 being the most serious*)

___ Urban stormwater
___ Agriculture (crop-farming)
___ Agriculture (animal production)
___ Construction
___ Wastewater treatment plant discharges
___ Mining
___ Atmospheric Deposition
___ Other _____

9) What is your opinion of the adequacy of existing regulations to protect the Neuse River?

___ Grossly inadequate
___ Inadequate
___ Adequate but need better enforcement
___ Too much regulation

10) What role do you feel the basinwide plan should play in addressing water quality problems in the basin? (*check all that may apply*)

___ Make people aware of the problems
___ Recommend actions needed for protection
___ Call for stricter laws and regulations
___ None
___ Other _____

11) **If you are familiar with the 1993 basinwide plan, what would consider its strengths and weaknesses for use in updating the plan this year?**

a. Positive features to build on in updating the plan

b. Negative features to avoid

c. Areas that need improvement or strengthening

12) **Which of the following formats would be of most interest and use to you and your interest group? (check all that apply)**

___ Brochure with brief summary of plan highlights
___ 10 to 20 page summary of water quality information and recommendations relying
heavily on maps, figures and tables
___ 200+ page plan (similar in scope to the 1993 original plan) with detailed water quality
information, water quality program summaries,workshop details, descriptions of causes and sources of pollution, lists of dischargers, listings of all impaired waters and recommended management strategies.
___ Other_____

Thank you for attending the workshop and for providing your comments.

If you would like to provide any additional comments, please send them to:
Alan Clark, Basinwide Program Coordinator,
NC Division of Water Quality
P.O. Box 29535
Raleigh, NC 27626-0535

APPENDIX II

Neuse Basin 303(d) List

APPENDIX II

List of 303(d) Waters in the Neuse River Basin

What is the 303(d) list?

Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters not meeting water quality standards or which have impaired uses. Waters may be excluded from the list if existing control strategies for point and nonpoint source pollution will improve water quality to the point that standards or uses are being met. Listed waters must be prioritized, and a management strategy or total maximum daily load (TMDL) must subsequently be developed for all listed waters. The 303(d) process is presented in Figure 1.

303(d) List Development

Generally, there are four steps to preparing North Carolina's 303(d) list. They are (1) gathering information about the quality of North Carolina's waters, (2) screening those waters to determine if any are impaired and should be listed, (3) determining if a total maximum daily load (TMDL) has been developed, and (4) prioritizing impaired waters for TMDL development. This document also indicates whether the Division of Water Quality (DWQ) intends to develop a TMDL as part of a Management Strategy (MS) to restore the waterbody to its intended use. The following subsections describe each of these steps in more detail.

Sources of Information

For North Carolina, the primary sources of information are the basinwide management plans and accompanying assessment documents, which are prepared on a five-year cycle, and the 305(b) report, which is prepared biennially. Basinwide management plans include information concerning permitting, monitoring, modeling, and nonpoint source assessment by basin for each of the 17 major river basins within the state. Basinwide management allows the state to examine each river basin in detail and to determine the interaction between upstream and downstream point and nonpoint pollution sources. As such, more effective management strategies can be developed across the state.

The 305(b) report is used as a basis for developing the 303(d) list. Section 305(b) of the CWA requires states to report biennially to the US Environmental Protection Agency (EPA) on the quality of waters in their state. In general, the report describes the quality of the state's surface waters, groundwaters, and wetlands, and existing programs to protect water quality. Information on use support, likely causes (e.g., sediment, nutrients, etc.) and sources (point sources, agriculture, etc.) of impairment are also presented.

Many types of information were used to make use support assessments and to determine causes and sources of use support impairment. Chemical, physical, and biological data collected by DWQ were the primary sources of information used to make use support assessments.

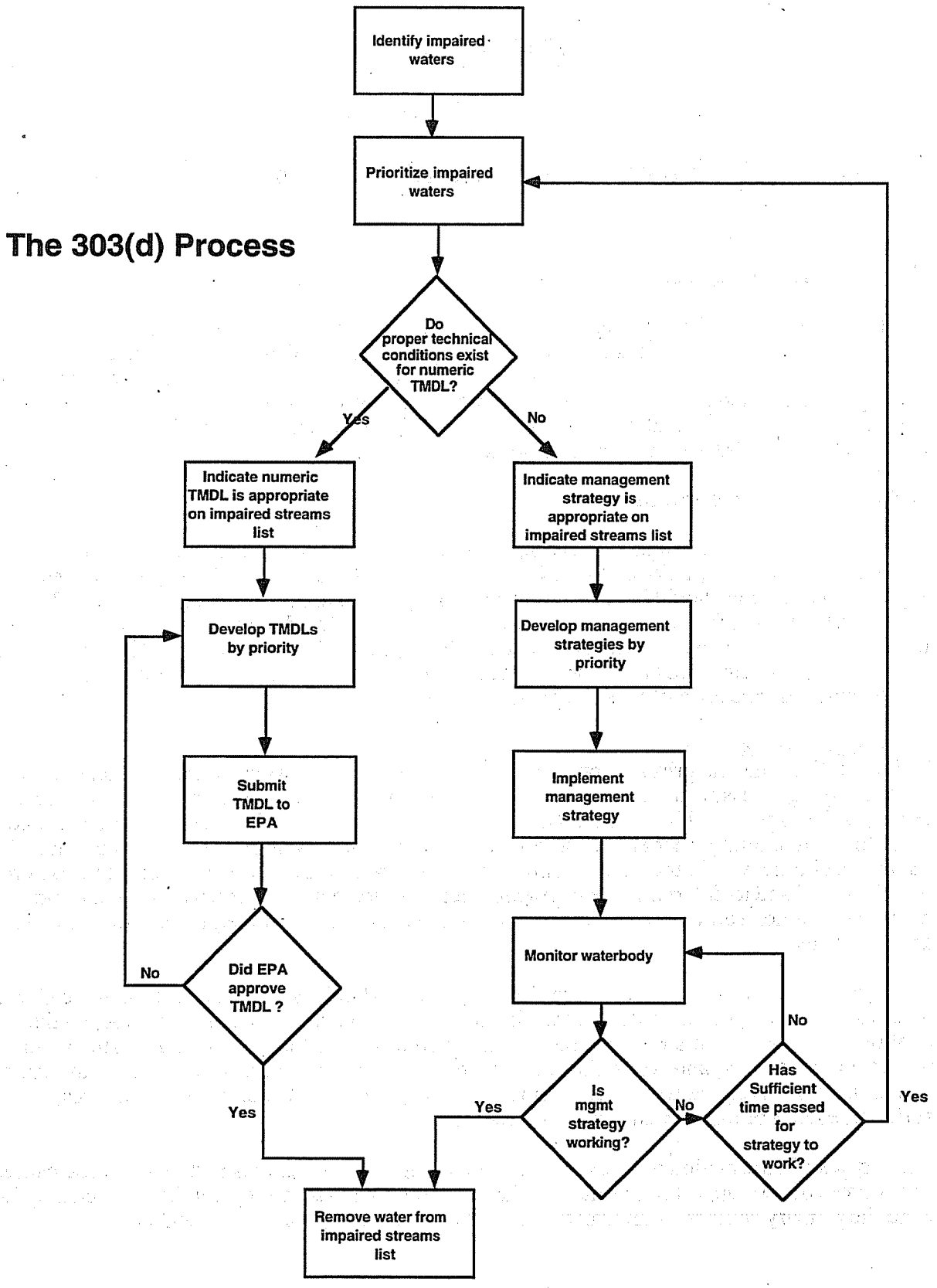

Figure 1. The 303(d) Process

North Carolina has an extensive ambient and biological monitoring network throughout the state. Benthic macroinvertebrate data, which indicate taxa richness and species diversity, are an important data source. North Carolina also collects fish tissue and fish community structure data, and phytoplankton bloom data that are used in the assessments. Shellfish closure data, fish kill data, reports, predictive modeling results, toxicity data, and self-monitoring data are considered when making final use support determinations.

Data from all readily available sources outside of DWQ are considered when evaluating use support. Many other agencies, universities, industries, point sources, and environmental groups collect data on North Carolina's surface waters. Published reports and data from ongoing studies that the DWQ has knowledge of are actively solicited during the assessment phase of the basin planning cycle. Data that are not collected and analyzed following procedures outlined by the Environmental Protection Agency (EPA) are used to quality assure other monitoring that may occur in the same water and identify areas to monitor in the future. The Division therefore uses all data.

Listing Criteria

Waters whose use support ratings were not supporting (NS), partially supporting (PS), and fully supporting but threatened (ST) based on monitored information in the 305(b) report were considered as initial candidates for the 303(d) list. Although support threatened waters currently meet their intended uses, these waters were reviewed to determine if there were sufficient data to determine if they would become impaired in the next two years. The list was then compared to the 1996 303(d) list to determine if additional waters should be added that were included on that 303(d) list that are still considered as impaired based on evaluated information.

Fish consumption advisory information was then reviewed to determine if other waters should be added to the list. Fish consumption advisories are no longer considered when determining use support since the entire state was posted in June 1997 for the consumption of bowfin from mercury contamination. It should be noted that bowfin do not occur statewide; they are found primarily within the coastal plain. While fish consumption advisories do indicate impairment, DWQ did not want to mask other causes and sources of impairment by having the entire state or an entire basin listed as impaired due to advisories. However, DWQ believes that advisories on specific waters are cause to include the water on the 303(d) list, therefore, advisories other than statewide bowfin mercury contamination were considered when developing the state's 303(d) list.

Guidance from EPA on developing 1998 303(d) lists indicates that impaired waters without an identifiable problem parameter should not be included on the 303(d) list. However, DWQ feels that waters listed in the 305(b) report as impaired for biological reasons where problem parameters have not been identified, should remain on the 303(d) list. The Clean Water Act states that chemical, physical, and biological characteristics of waters shall be restored. The absence of a problem parameter does not mean that the waterbody should not receive attention. Instead, DWQ should at a minimum resample those areas or initiate studies to determine why the waterbody is impaired. Thus, biologically impaired waters without identifiable problem parameters are on the 1998 303(d) list. Following is a summary of waters that were added to the Neuse 303(d) list:

- The following waters were not included on the 1996 303(d) list and they have been added to the 1998 list based on updated use support information: North Fork Little River, Toms Creek, Perry Creek, segments of Crabtree Creek, Black Creek (subbasin 030402), Hare Snipe Creek, Mine Creek, Walnut Creek, Mill Creek, Stony Creek, Bear Creek, Contentnea Creek, Beaverdam Creek, Nahunta Swamp, segments of Little Contentnea Creek, Clayroot Swamp, Lake Raleigh, Reedy Creek Lake, and Lake Wackena.
- Waters were removed from previous 303(d) lists because federal stormwater programs had been implemented in Durham and Raleigh that applied to them. Since the stormwater program is designed to address new development, it may not be sufficient to restore impaired

waters. Thus, the following waters are included on the 1998 list: Ellerbe Creek, Lick Creek, Pigeon House Branch, Marsh Creek, Swift Creek, and Little Creek.

- Acres of fecal coliform impaired waters have changed based on current closure information on waters classified for shellfishing.
- Brice Creek was studied but was not assigned a use-support rating since the biologists did not feel that the criteria should apply to it based on the depth of the water and the estuarine influence. Since no new information is available, the water will remain on the list until the DWQ determines a method to study it or information indicates that it is not impaired.

De-Listing Criteria

Waters included on the 1996 303(d) list were reviewed to determine if they may be removed from the list of impaired waters. If updated use support analyses indicated that the water was meeting its uses, the waterbody was dropped from the list. Other waters were dropped from the list if an approved TMDL is on file for the water and parameter listed.

Management strategies have been developed for a number of impaired waters. These waters remain on the list unless updated use support information indicated the water met its uses. In some cases, DWQ is confident that the management strategy will restore water quality, but it may take time to restore the water. For these waters, DWQ does not propose to do further modeling on the water, but the water will continue to be monitored to determine when it meets its uses. This approach is addressed further in the prioritization section of the document. A summary of waters that were removed from the 1996 303(d) list follows:

- The following waters are currently supporting their uses based on the latest use support information: Sanford Creek, Smith Creek, Middle Creek, Turner Swamp, Black Creek (subbasin 030404), Stone Creek, Hannah Creek, Moccasin Creek, Turkey Creek, Toisnot Swamp, Brooks Swamp, and Wheat Swamp Creek.
- Neuse River from the water intake at Wake Finishing to US 1 location is now within another segment that is rated as supporting.

Assigning Priority

North Carolina is required to prioritize its 303(d) list in order to direct resources to those waters in greatest need of management. The Clean Water Act states that the degree of impairment (use support rating) and the uses to be made of the water (stream classification) are to be considered when developing the prioritization. In addition, DWQ reviews the degree of public interest and the probability of success when developing its prioritization schemes. Waters harboring endangered species are also given additional priority. A method to assign ratings to freshwaters that have recent data indicating impairment has been devised based on these criteria. A summary of the prioritization scheme is included in Figure 2.

Estuarine areas were also prioritized. In general, waters with nutrient enrichment and dissolved oxygen issues were given a higher priority than waters impaired due to fecal coliform. Nutrient enrichment can impact several uses including aquatic life, fishing, and swimming. Fecal coliform usually impacts only the shellfish use. The public also appears to have a greater interest in the nutrient issues within North Carolina's coastal waters. Fish kills related to nutrient enrichment and the associated low dissolved oxygen concentrations draw much public attention. Pfiesteria may also be controlled through nutrient management. Finally estuarine responses to fecal coliform loads are difficult to capture using deterministic water quality models, and the results tend to be more suspect than results for processes that are better understood such as those for nutrients. Thus, the probability of developing a defensible numeric loading target may be lower for fecal coliform.

The prioritization process results in ratings of **high, medium, and low**. Generally, waters rated with the highest priority are classified for water supply, rated not supporting, and harbor an

Each of the waters on the 303(d) list were ranked in order to prioritize DWQ's resources. The ranking is based on the classification, use support rating, presence of endangered species, degree of public interest, and the probability of success. This ranking can be represented by

Rank = Σ (classification, use support rating, endangered species, public interest, probability of success)

Where the following numeric rankings were applied to the various categories:

Classification:

Water supply waters (WS-1, II, III, IV)	=	2
B	=	1
C	=	0
Supplemental classifications	=	+1
Tr (Trout fishing waters)		
NSW (Nutrient sensitive waters)		
HQW (High quality waters)		
ORW (Outstanding resource waters)		

Use Support Rating:

NS	=	1
PS	=	0

Endangered Species present:

Federally endangered	=	2
Other endangered or threatened	=	1
None present	=	0

Public interest expressed on particular water body:

Yes	=	1
No	=	0

Probability of success (subjective criteria depending upon problem parameters, type of sources of problem parameters, availability of technical tools to calculate numeric loads, NPS/319 priorities, etc.):

Yes	=	1
No	=	0

The sum of the individual category ranking is used to determine the priority for the impaired water body. If the overall rank is between 6 and 8, the water is prioritized as high. If the overall rank is between 3 and 5, the water body is prioritized medium, and overall ranks of below 3 are prioritized as low. Each category has equal weight in the determination of the overall ranking. For example, for Little Buffalo Creek in the Cape Fear River Basin, the overall ranking and priority of medium were determined as follows:

Category	Value	Comments	Rank
Classification	WS-IV	No supp classifications	2
Use support rating	NS	None	1
Public interest	No	None	0
Endangered species	Yes, federal	Cape Fear Shiner in subbasin 11	2
Prob of success	Sediment impaired, no standard, NPS sources	None	0
Total			5

Figure 2. Priority Ranking for Freshwaters

endangered species. Waters receiving a High priority are important natural resources for the state of North Carolina and generally serve significant human and ecological uses. High priority waters will likely be addressed first within their basin cycles.

EPA recently issued guidance that suggested states should develop TMDLs and management strategies on all of their impaired waters within the next eight to thirteen years. To meet this federal guidance, the DWQ is striving to address all waters on the 1998 303(d) list that have a priority of high, medium, or low within the next 10 years. Numeric TMDLs, if proper technical conditions exist, and management strategies will be developed for these waters. The DWQ is currently reviewing its resource needs in order to meet this aggressive schedule.

Other priorities have also been assigned to waters. A **Monitor** priority indicates that the waterbody is listed based on: 1) data older than 5 years; 2) biological monitoring and no problem pollutant has been identified; or 3) biological monitoring that occurred in waters where we now have evidence that the biological criteria should not have been applied. These waters will be resampled before a restorative approach may be developed because more information is required about the cause of impairment. Further information on the monitoring approaches that have a Monitor priority is provided in the next section.

The final priority listed on the 303(d) list is **N/A** for not applicable. This priority was assigned to waters that DWQ believes will meet their uses based on the current management strategies.

DWQ will not develop a new TMDL or management strategy for these waters unless data continue to indicate impairment and sufficient time has passed for the waterbody to respond to the management action. An example of this priority is a water impaired by a point source, and the pollutant causing the impairment has been completely removed from the point source.

Approaches to Restore Water Quality

EPA informed North Carolina at a TMDL workshop in January, that TMDLs must now be total, maximum, daily, and loads in order to be approved. Such a narrow definition of a TMDL severely limits states' abilities to develop numeric TMDLs. Given this narrow definition of a TMDL, North Carolina believes that TMDLs cannot be developed for waters impaired by sediment, turbidity, fecal coliform, and pH.

DWQ believes that TMDLs are only one tool that can be used to prioritize and direct resources for the restoration of impaired waters. There are other tools that can be used. In the management strategy approach included on the 303(d) list, the state can work to identify the causes and sources of impairment and implement strategies to reduce those sources so that water quality can ultimately be restored. As part of the management strategy approach, North Carolina may be able to develop numeric targets such as percentage reductions or other metrics that do not meet EPA's current definition of an approvable TMDL. However, DWQ would like to have adequate data and a defensible modeling approach to minimize challenges of the numeric goals which can exhaust our limited resources. DWQ is reviewing its options to address these impaired waters, and staff are currently working together to develop a process to encourage local watershed management plans. This process could include a combination of voluntary and mandatory control strategies. We anticipate that we will receive stakeholder input on the process in mid to late 1998 after it is presented to and approved by the Department's administration. DWQ has confidence that this approach will be successful in restoring impaired waters. Management strategies developed with strong stakeholder input have been shown throughout the nation to be effective in restoring water quality.

For both the numeric TMDL approach and management strategies that include alternative numeric targets, DWQ needs to ensure that defensible targets are developed. In order to have technically defensible numeric targets, the proper technical conditions are needed. EPA's guidance published in the December 28, 1978 Federal Register defined proper technical conditions as having the analytical methods, modeling techniques, and database necessary to develop a technically defensible TMDL.

North Carolina and EPA are currently reviewing methods to develop numeric targets for fecal coliform and sediment. As better models and data become available, North Carolina will review its approach column to include more TMDLs if EPA revises its current definition of a TMDL. In the interim, DWQ will develop other numeric goals when data are available to support them.

The 303(d) list contains information on whether the Division plans to pursue a numeric **TMDL** as currently defined by EPA or whether it will pursue a management strategy (**MS**). Some waters must have more data collected on them to determine the causes and sources of pollution before a management strategy or TMDL can be devised. These include the waters that are biologically impaired waters where no problem parameter has been identified or waters listed based on data older than five years.

It will be difficult to develop TMDLs or management strategies on waters where we have no problem pollutant identified even if the data were collected recently. DWQ proposes to collect more biological and chemical data to determine the causes and sources of the impairment for waters included on the list based on recent biological data. The approach for these waters is problem parameter identification or **PPI**. Monitor appears in the Priority column, corresponding to PPI in the approach column. DWQ will develop TMDLs or management strategies for these waters within two basin planning cycles from when data indicating causes and sources of impairment are available. We will collect this information on as many waters as resources allow during the next basin planning cycle.

Waters that are listed based on data older than 5 years may in fact be meeting their uses. Since many changes can occur within a watershed in a five-year period, conclusive information about a waterbed's use support cannot be made with older data. North Carolina will resample as many of these waters that have only historical data as staffing and time permit for subsequent updates of the basin plans and 303(d) list. Waters listed based on older information are indicated by a **RES** in the Approach column of the lists to denote that they will be resampled.

A TMDL or management strategy will not be developed for waters listed based on old data or an inappropriate use of biological criteria until we have updated sampling information that indicates the water is impaired. This process will ensure that DWQ has sufficient current information to determine if the impairment exists and to help identify the source of the impairment. This will enable DWQ to focus its limited resources on watersheds that are in greatest need of management.

If guidance is issued in the future which indicates that mandatory controls are to be placed on point or nonpoint sources on the basis that it is included on a state's 303(d) list, these controls should not be applied to waters listed based on older information or biological criteria that are not applicable to the water. Mandatory controls applied to these waters simply on the basis of being included on the 303(d) list could result in high costs to the regulated community with little or no environmental benefit.

Targeted Waters for TMDL Initiation by April 2000

North Carolina's focus for the next ten years is to develop strategies to restore impaired waters with a high, medium or low priority to their intended uses. Therefore, DWQ will spend significant resources deciding the best approaches and strategies for restoring waters. Some waters are

impaired due to problem parameters that are not necessarily conducive to a TMDL. In these cases, DWQ believes that resources are better utilized by developing a management strategy instead of attempting to develop a technically defensible TMDL

Summer phytoplankton blooms and fish kills continue to occur in the Neuse River Estuary. In response to these environmental crises, the nutrient sensitive waters (NSW) strategy has been revised for the basin. The Neuse River Basin NSW Management Strategy, which is in the rule-making phase, addresses a reduction of nitrogen in the Neuse River through a series of voluntary and mandatory controls. The nutrient sources specifically outlined in the strategy include point sources, urban stormwater management, agriculture, riparian area protection, and nutrient management. A draft TMDL for total nitrogen of 6.1 million lbs/year at New Bern has been developed as part of the NSW strategy. North Carolina and EPA are currently negotiating the TMDL submittal.

In order to implement an effective strategy for managing the Neuse River Basin, DWQ needs to understand the sources and fate of nutrients in the system. Thus, coordination for an integrated multimedia modeling effort to evaluate nutrient sources and fate in the Neuse River Basin has begun. The proposed modeling effort includes an airshed, watershed, groundwater, fate and transport model, sediment, probabilistic, and estuary model, as shown in Figure 3. The multimedia models will track the accumulation of nutrient loads from point sources, runoff, groundwater discharge, and atmospheric deposition, from the headwaters of the Neuse River through the estuary.

This integrated multimedia modeling approach has several related components in various stages of completion. For example, a screening-level, steady-state, nitrogen fate and transport model was developed by a Research Triangle Institute (RTI) and modified by DWQ to route nutrients from the mouth of subbasins to the estuary. Nitrogen loads determined from this model will be coupled to an estuarine model. DWQ and USGS developed a nutrient estuarine model to simulate dissolved oxygen, nutrients, and algae dynamics. The estuarine model is currently undergoing calibration and refinement as part of the MODeling and MONitoring (MODMON) project. MODMON, which is funded for June 1997 to May 1998, is a comprehensive project that includes the collection and application of data and modeling that will be used to understand nutrient cycling in the estuary. As part of MODMON, the real-time data is used to refine the nutrient water quality model and study fish habitat response. This phase of the estuarine model will be completed by December 1998. Investigations have begun regarding the watershed model, and applications of SWAT and HSPF are being considered.

DWQ is currently pursuing funding for the integrated multimedia modeling effort to provide further enhancements of the estuarine model and develop the other modeling components (e.g., the airshed model). DWQ anticipates that approximately five to seven years from the time of funding will be needed to collect the necessary data and develop the different models. A final report will then be prepared with management recommendations.

Additional Guidance on Using the 303(d) List

The column headings in the 303(d) list refer to the following:

Class - The information in this column indicates the classification assigned to the particular waterbody. Stream classifications are based on the existing and anticipated best usage of the stream as determined through studies and information obtained at public hearings. The stream classifications are described in 15 A NCAC 2B .0300, and are summarized in Appendix I.

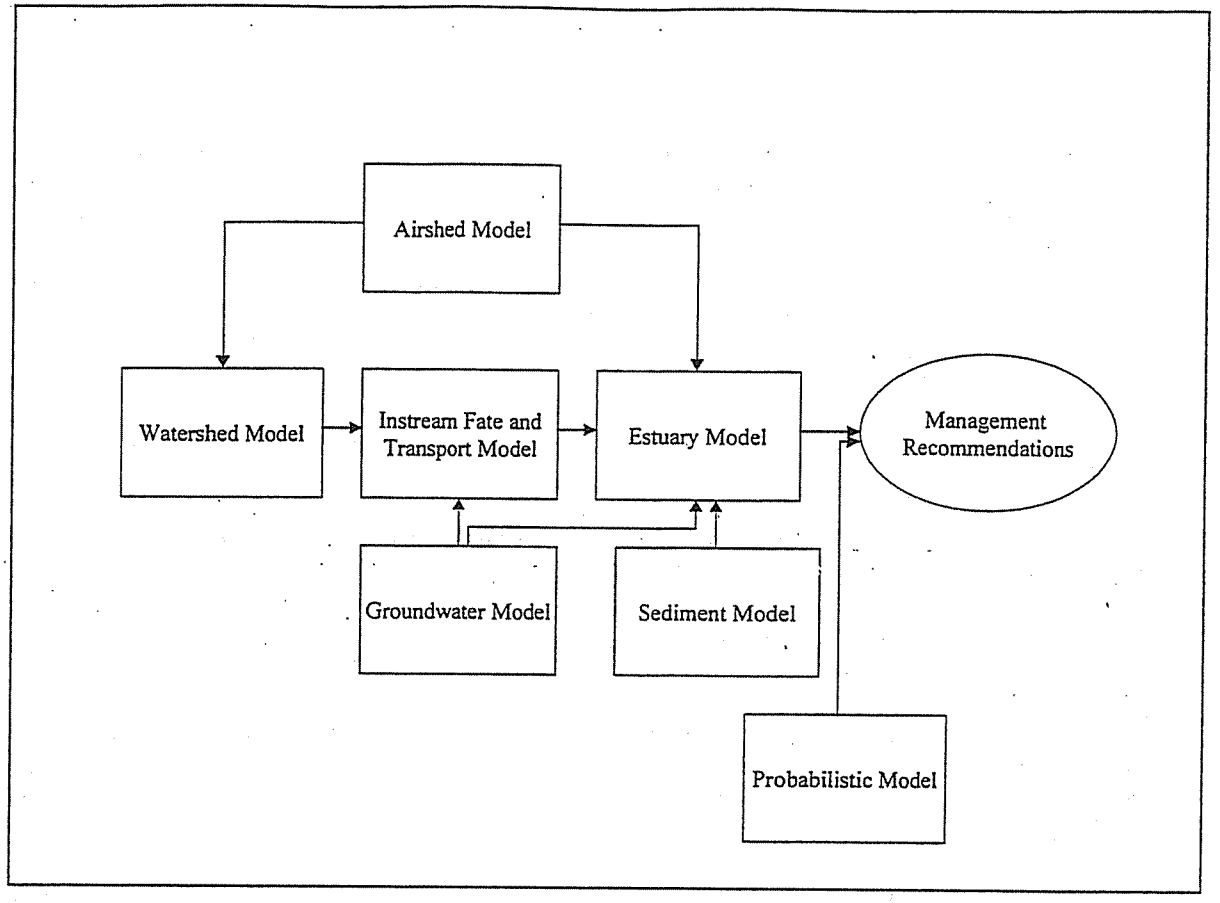

Figure 3. Proposed Neuse River Basin Multimedia Modeling Approach

Waterbody - The number in this column refers to the DWQ subbasin in which the waterbody is located. The NRCS 14 digit hydrologic units nest within the DWQ subbasins. On the lakes tables, this column is entitled subbasin.

Problem Parameter - These are the causes of impairment as identified in the 305(b) report. Where no cause is listed, the rating was based on biological data, and available chemical data showed no impairment. These biological data may include benthic and fish habitat and community structure. When a problem parameter is identified, the parameter listed exceeded the state's water quality standards for that substance or was identified by scientific personnel during field studies (e.g., sediment). This parameter is a potential cause of the impairment, but there may be other, unidentified causes contributing to the impairment as well. Problem parameters included in the 303(d) list are outlined below:

Chl *a* – chlorophyll-a
Cl – chlorine
Cu – copper
DO – dissolved oxygen
Fecal – fecal coliform bacteria
Hg – mercury
NH_3 – ammonia
Nutr – nutrients
Pb – lead
pH – pH
Sed – habitat impairment due to sediment
Tox – toxicity
Turb – turbidity
Aq. Weeds – aquatic weeds

Rating - This column lists the overall use support rating. These values may be NS (not supporting), PS (partially supporting) and NE (not evaluated). A rating of not evaluated is typically assigned to waters that were sampled using biocriteria that may not apply or there is no data available on the water. These waters appeared on earlier lists, and they continue to be listed, but no TMDL or management strategy will be developed until we have updated information that the water continues to be impaired. For waters listed solely on the basis of fish consumption advisories, the rating may also be fully supporting (FS) or fully supporting but threatened (ST). The 305(b) report describes these use support ratings further. On the lake tables, the overall use support rating is found in the column entitled "Overall use". Ratings for specific uses are found in the columns entitled "Fish Consump", "Aq. Life and Secondary Impact", "Swimming", and "Drinking Water".

Major Sources (P,NP) - This column indicates whether point (P) or nonpoint (NP) sources are the probable major sources of impairment.

Subcategory - This column breaks the probable point and nonpoint sources down further. A list describing what each number means is provided in Table 1.

Approach – This column indicates the approach DWQ will take to restore the waterbody. If more than one approach is listed, one is a TMDL. TMDLs are typically developed for DO, nutrients, ammonia, and metals. Management strategies are typically done for pH, sediment, turbidity, and fecal coliform. Further information on each approach is provided below.

> TMDL – A numeric TMDL as currently defined by EPA will be developed (e.g. is total, maximum, daily, load).
>
> MS – Management Strategy – These waters are on the list based on data collected within the five years prior to when the use support assessment was completed. A problem pollutant has been identified, but North Carolina cannot develop a numeric TMDL as EPA currently defines it. A management strategy may contain the following elements: further characterization of the causes and sources of impairment, numeric water quality goals other than TMDLs, and best management practices to restore the water.
>
> RES – This waterbody was identified as being impaired based on water quality data that were greater than 5 years old at the time the use support assessment was performed. This waterbody will be resampled prior to TMDL or management strategy development to ensure the impairment continues to exist. This will enable the Division to focus its limited resources on watersheds that are in greatest need of management.
>
> PPI – Problem Parameters Identification - Available chemical data do not show any parameters in violation of the standard, but biological impairment have been noted within the five years prior to use support assessment. DWQ will resample these waters for chemical and biological data to attempt to determine the potential problem pollutants. TMDLs or management strategies will be developed within 2 basin cycles of problem parameter identification.

TABLE 1. SOURCE SUBCATEGORIES

Category	*Subcategory*	*Description*
0		Point Sources
	01	Industrial
	02	Municipal
	03	Municipal pretreatment (indirect dischargers)
	04	Combined sewer overflows (end-of-pipe control)
	05	Storm sewers (end-of-pipe control)
	06	Schools
	08	Minor non-municipal
1		Nonpoint sources
10		Agriculture
	11	Non-irrigated crop production
	12	Irrigated crop production
	13	Specialty crop production (e.g., truck farming and orchard)
	14	Pasture land
	15	Range lots
	16	Feedlots – all types
	17	Aquaculture
	18	Animal holding/management areas
20		Silviculture
	21	Harvesting, reforestation, residue management
	22	Forest management
	23	Road construction/maintenance
30		Construction
	31	Highway/road/bridge
	32	Land development
40		Urban Runoff
	41	Storm sewers (source control)
	42	Combined sewers (source control)
	43	Surface runoff
	44	Finger canals
	45	Industrial
50		Resource Extraction/Exploration/Development
	51	Surface mining
	52	Subsurface mining

	53	Placer mining
	54	Dredge mining
	55	Petroleum activities
	56	Mill tailings
	57	Mine tailings
	58	Abandoned mines
60		Land Disposal (Runoff/Leachate from permitted areas)
	61	Sludge
	62	Wastewater
	63	Landfills
	64	Industrial land treatment
	65	On-site wastewater systems (septic tanks, etc.)
	66	Hazardous waste
70		Hydrologic/Habitat Modification
	71	Channelization
	72	Dredging, sand dipping
	73	Dam construction
	74	Flow regulation
	75	Bridge construction
	76	Removal of riparian vegetation
	77	Streambank modification/destabilization
	78	Collapsed dam
80		Other
	81	Atmospheric deposition
	82	Waste storage/storage tank leaks
	83	Highway maintenance and runoff
	84	Spills
	85	In-place contaminants
	86	Natural
	87	Marinas, harbors
	88	Airport
	89	Military activities (off-road)
90		Source Unknown
	91	General erosion (road erosion)

Priority – Priorities of high, medium and low were assigned for waters identified as being impaired based on data that were not greater than 5 years of age at the time the use support assessment was done and for which a problem pollutant has been identified. All waters assigned a priority of high, medium, or low will be addressed within the next two basin cycles. Priorities of monitor and N/A have also been assigned. Further explanation on each of these is provided below:

High – Waters rated High are important resources for the state of North Carolina in terms of human and ecological uses. Typically they are classified as water supplies, harbor federally endangered species, and are rated as not supporting. These waters will be addressed first within their basin cycles.

Medium – Waters rated Medium may be classified for water supply or primary recreational use, may have state endangered or other threatened species, and may be rated as partially or not supporting.

Low – Waters rated Low generally are classified for aquatic life support and secondary recreation (i.e., Class C waters), and harbor no endangered or threatened species.

Monitor – The waterbody is included on the 303(d) list based on: (1) data that are greater than 5 years of age when use support assessment done (denoted by RES in approach column) or (2) biological data collected within 5 years of use support assessment but no problem pollutant has been identified (available chemical data show full use support – denoted by PPI in approach column), and (3) freshwater biological criteria applied to swamp waters. In general, waters given this priority based on recent biological data will be sampled prior to waters listed based on older information and are therefore higher priority than waters listed based on older information or swamp waters. All waters with this priority will be resampled as resources allow. Waters with this priority will not have management strategy or TMDL developed for it before updated sampling or analyses of the biological criteria are done which indicates that the water continues to be impaired and a problem pollutant has been identified. Once updated sampling is done and problem pollutants have been identified, these waters will be addressed by either a management strategy or TMDL within two basin planning cycles (10 years). This approach will enable DWQ to focus its limited resources on watersheds that are in greatest need of management.

N/A – DWQ believes that its current management strategy will address the water quality impairment, but it may take a number of years before standards are met. In this case, DWQ plans to continue monitoring the water to determine if improvements are occurring, but no new management strategy or TMDL will be developed unless sufficient time has passed for improvement to occur, and data indicate the water is still impaired.

The lakes column entitled "Troph Status" refers to the trophic status of the lake, a relative description of the biological productivity of the lake. The lake may be hypereutrophic, eutrophic, mesotrophic, or oligotrophic. Oligotrophic lakes are nutrient poor and biologically unproductive, mesotrophic lakes have intermediate nutrient availability and biological productivity, eutrophic lakes are nutrient rich and highly productive, and hypereutrophic lakes are extremely eutrophic.

APPENDIX III

Benthic Macroinvertebrate Collections in the Neuse River Basin, 1983-1995

Benthic Macroinvertebrate Collections in the Neuse River Basin, 1983-1995

NEUSE 01

Site	Site#	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Sevenmile Cr, SR 1120, Orange	B-1	27-2-6	08/95	-/21	-/5.10	Good
			07/91	-/20	-/5.28	Good-Fair
Eno R, SR 1336, Orange	B-2	27-2-(1)	07/95	-/20	-/5.30	Good-Fair
			07/91	-/20	-/4.45	Good-Fair
Eno R, 1st US 70-Byp bridge, Orange	B-3	27-2-(1)	08/89	75/17	6.10/5.01	Good-Fair
Eno R, NC 86, Orange	B-4	27-2-(1)	08/89	89/24	6.24/5.31	Good-Fair
			06/88	70/18	6.34/5.24	Good-Fair
Eno R, above WWTP, Orange	B-5	27-2-(1)	09/94	72/15	6.01/4.61	Good-Fair
Eno R, below WWTP, Orange	B-6	27-2-(1)	09/94	71/13	6.09/4.54	Good-Fair
Eno R, 2nd US 70-Byp bridge, Orange	B-7	27-2-(7)	08/89	90/26	5.95/5.09	Good
			06/88	73/20	6.04/4.77	Good-Fair
Eno R, SR 1569, Cabes Ford, Orange	B-8	27-2-(10)	07/95	85/27	4.96/4.04	Excellent
			07/91	97/33	4.80/4.09	Excellent
			06/88	92/30	5.56/4.08	Good
Eno R, US 15/501, Durham	B-9	27-2-(16)	07/95	70/23	5.31/4.45	Good
			07/90	87/30	5.62/4.59	Good
			07/88	90/27	6.12/5.04	Good
			07/86	82/28	5.57/4.43	Good
			08/84	87/31	5.41/4.54	Good
Eno R, SR 1004, Durham	B-10	27-2-(19.5)	07/95	71/27	5.46/4.81	Good
			07/91	88/31	5.30/4.38	Good
			06/85	92/32	5.79/4.31	Good
Little R, SR 1461, Durham	B-11	27-2-21-(1)	07/95	81/28	5.59/4.53	Good
			07/91	82/31	4.79/3.88	Excellent
			09/90	100/36	5.04/3.83	Excellent
			07/89	82/30	5.22/4.64	Good
			10/90	79/25	5.70/4.02	NR
			10/89	93/34	4.89/3.49	NR
			04/90	96/37	4.77/3.86	NR
			04/89	78/30	4.51/3.84	NR
			01/90	86/31	5.11/4.20	NR
			02/89	102/33	5.69/3.64	NR
Little R, US 501, Durham	B-11a	27-2-21-(1)	07/87	113/38	5.46/4.34	Excellent
			07/85	91/31	5.08/3.73	Excellent
Little R, SR 1004, Durham	B-12	27-2-21-(1)	06/85	77/25	5.86/4.68	Good-Fair
S Fk Little R, SR 1538, Orange	B-13	27-2-21-1	08/95	-/19	-/4.45	Good-Fair
N Fk Little R, SR 1519, Orange	B-14	27-2-21-3	07/95	-/11	-/6.16	Fair
N Fk Little R, SR 1538, Orange	B-15	27-2-21-3	07/95	99/29	5.64/4.55	Good
N Fk Little R, SR 1461, Durham	B-16	27-2-21-3	07/91	103/33	5.55/4.38	Good
Mountain Cr, SR 1466, Durham	B-17	27-2-21-4-(1)	03/94	45/17	4.94/3.52	Good-Fair
Mountain Cr, SR 1464, Durham	B-18	27-2-21-4-(1)	03/94	50/16	5.56/4.29	Good-Fair
Flat R, SR 1737, Person	B-20	27-3-(1)	06/93	81/27	5.18/4.60	Good
			05/90	-/30	-/4.16	Good
Flat R, SR 1614 nr Quail Roost, Durham	B-21	27-3-(1)	07/95	86/27	5.71/4.85	Good
			03/95	102/42	4.96/3.96	Excellent
			07/93	99/32	5.14/4.32	Excellent
			02/93	92/33	4.91/3.69	Excellent
			07/91	100/36	5.09/4.38	Excellent
			07/90	107/37	5.78/4.64	Excellent
			07/88	91/26	5.52/4.41	Good
			07/86	92/28	5.50/4.70	Good
			08/84	84/26	5.03/4.40	Excellent

NEUSE 01, Continued

Site	Site#	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Flat R, SR 1004, Durham	B-22	27-3-(8)	08/95	61/12	7.04/5.31	Fair
			06/85	61/10	7.03/6.56	Fair
N Flat R, SR 1144, Person	B-23	27-3-2	07/93	77/24	4.84/4.11	Good
N Flat R, SR 1715, Person	B-24	27-3-2	07/93	77/24	4.84/4.11	Good
			02/93	80/29	4.75/3.60	Excellent
			07/91	-/21	-/4.66	Good
S Flat R, SR 1009, Person	B-25	27-3-3	05/90	-/11	-/5.56	Fair
S Flat R, NC 157, Person	B-26	27-3-3	06/93	90/24	5.79/4.96	Good
			05/90	-/28	-/4.73	Good
S Flat R, SR 1125, Person	B-27	27-3-3	07/93	75/23	5.09/3.91	Good
			02/93	76/28	4.49/3.42	Good
Brushy Fork Cr, SR 1108, Person	B-28	27--3-3-1	05/90	-/23	-/4.17	Good
Deep Cr, SR 1717, Person	B-29	27-3-4	02/93	67/20	-/4.97	Good
Deep Cr, SR 1715, Person	B-30	27-3-4	07/95	/22	-/4.42	Good
			03/95	112/41	5.08/4.24	Excellent
			02/93	80/31	5.17/4.07	Good
			05/90	-/32	-/3.85	Excellent
Deep Cr, SR 1734, Person	B-31	27-3-4	11/84	78/24	5.50/3.84	Good
Knap of Reeds Cr, SR 1004, Granville	B-32	27-4-(6)	06/85	65/15	6.71/6.29	Fair
Knap of Reeds Cr, ab WWTP, Granville	B-33	27-4-(6	09/94	78/12	6.86/5.79	Fair
			08/91	59/12	6.63/5.95	Fair
			02/87	62/14	6.89/5.00	Fair
			06/85	70/9	7.08/6.42	Fair
			05/82	61/11	7.09/6.44	Fair
Knap of Reeds Cr, 100m below WWTP, Granville	B-34	27-4-(6)	09/94	66/7	7.48/5.88	Fair
			08/91	46/8	7.08/5.88	Fair
			02/87	32/3	8.12/6.23	Poor
			06/85	19/0	7.92/-	Poor
			05/82	30/4	8.04/-	Poor
Knap of Reeds Cr, recovery site,Granville	B-35	27-4-(6)	02/87	39/3	8.32/-	Poor
			06/85	40/2	7.93/-	Poor
Ellerbe Cr, SR 1709, Durham	B-36	27-5	03/95	32/4	7.82/5.97	Poor
			08/91	41/0	8.44/-	Poor
Ellerbe Cr, SR 1636, Durham	B-37	27-5	03/95	38/3	7.74/6.11	Poor
			08/91	36/3	7.84/7.42	Poor
			06/85	35/2	8.65/7.51	Poor
L Lick Cr, SR 1815 ab WWTP, Durham	B-38	27-9	02/95	27/1	8.27/-	Poor
			08/91	56/7	7.79/6.25	Poor
			02/88	-/5	-/5.80	Poor
L Lick Cr, SR 1814, Durham	B-39	27-9	02/95	34/6	8.13/6.22	Poor
			08/91	59/7	7.21/6.34	Fair
			02/88	-/4	-/5.99	Poor
			06/85	76/11	7.09/5.87	Fair
Lick Cr, SR 1905, Durham	B-40	27-11	02/95	-/10	-/5.77	Fair
			02/88	-/5	-/4.31	Fair
Smith Cr, SR 1710, Granville	B-41	27-12-2	07/95	85/24	5.82/5.17	Good
			03/95	90/31	5.01/4.03	Good
			04/92	84/30	5.14/4.42	Good
			08/91	-/17	-/4.73	Good-Fair
			11/84	84/29	5.40/4.60	Good
			06/84	87/23	5.37/4.94	Good
			04/84	100/32	5.45/4.45	Good
			01/84	79/29	5.01/4.14	Good
New Light Creek, SR 1912, Wake	B-42	27-13-(2)	03/95	-/24	-/4.24	Good-Fair

NEUSE 01, Continued

Site	Site#	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Upper Barton Cr, NC 50, Wake	B-43	27-15	07/95	-/16	-/4.49	Good-Fair
			02/95	-/32	-/3.86	Good
			02/95	-/29	-/3.71	Good
			07/91	-/21	-/4.34	Good
Lower Barton Cr, SR 1844, Wake	B-44	27-16	02/95	-/31	-/3.82	Good-Fair
			06/85	83/19	6.05/5.30	Good-Fair
Horse Cr, SR 1923, Wake	B-45	27-17-(0.7)	03/95	-/28	-/4.14	Good

NEUSE 02

Site		Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Richland Cr, US 1, Wake	B-1	27-21	03/95	-/20	-/4.41	Good-Fair
			03/94	60/22	5.00/4.20	Good-Fair
			08/91	-/17	-/4.58	Good-Fair
Neuse R, US 401, Wake	B-2	27-(22)	07/95	56/22	5.81/4.85	Good-Fair
			07/91	71/21	5.83/5.06	Good-Fair
			08/89	53/15	6.15/5.31	Good-Fair
			06/87	74/21	6.14/4.78	Good-Fair
			12/86	-/12	-/4.97	Fair
			07/85	71/20	6.64/5.54	Good-Fair
			11/83	58/12	6.29/5.10	Fair
			10/83	70/19	6.44/5.33	Good-Fair
			09/83	68/13	6.57/5.41	Fair
			07/83	61/19	6.11/5.35	Good-Fair
Neuse R, US 1 Bus, Wake	B-3	27-(22)	12/86	-/12	-/5.36	Fair
			11/85	48/10	7.25/5.56	Fair
Neuse R, US 64, Wake	B-4	27-(22)	07/95	62/22	5.50/4.74	Good
			07/91	79/22	5.91/4.68	Good-Fair
			12/86	-/13	-/5.23	Fair
Neuse R, SR 2555, Wake	B-5	27-(22)	06/87	75/23	6.09/5.09	Good-Fair
Neuse R, SR 2509, Wake	B-6	27-(22)	06/87	71/23	5.88/4.99	Good-Fair
UT Neuse R, ab N Wake landfill, Wake	B-7		05/92	73/24	5.32/3.95	Good
UT Neuse R, be N Wake landfill, Wake	B-8		05/92	50/17	4.64/3.77	Good
UT Neuse R, (Mallinkrodt study), Wake	B-9		05/92	54/5	6.85/4.48	Fair
UT Neuse R, (Mallinkrodt study), Wake	B-10		05/92	49/2	7.39/6.05	Poor
Smith Cr, SR 2049, Wake	B-11	27-23-2	12/86	-/12	-/5.49	Fair
Smith Cr, SR 2044, Wake	B-12	27-23-2	12/86	/2	-/6.58	Poor
Smith Cr, SR 2045, Wake	B-13	27-23-2	07/95	-/15	-/5.38	Good-Fair
			12/86	-/4	-/6.07	Poor
Austin Cr, SR 2053, Wake	B-14	27-23-3-(2)	03/87	-/12	-/3.41	Fair
Sanford Br, SR 2049, Wake	B-15	27-23-5	12/86	-/9	-/5.99	Fair
Toms Cr, SR 2044, Wake	B-16	27-24	07/95	-/10	-/5.29	Fair
			08/91	61/17	5.74/4.22	Good
Perry Cr, SR 2006, Wake	B-17	27-25-(2)	07/95	-/8	-/5.87	Fair
Mango Cr, ab Knightdale WWTP, Wake	B-18	27-32	03/87	-/6	-/4.57	Poor
Mango Cr, be Knightdale WWTP, Wake	B-19	27-32	03/87	/3	-/5.97	Poor
Crabtree Cr, NC 54, Wake	B-20	27-33-(1)	07/95	-/6	-/6.49	Poor
			07/91	-/8	-/6.61	Fair
			08/88	-/5	-/6.38	Poor
			03/88	62/15	7.35/6.24	Fair
Crabtree Cr, be Morrisville WWTP, Wake	B-21	27-33-(1)	08/88	-/9	-/6.36	Fair
			03/88	66/12	7.34/6.18	Fair

NEUSE 02, continued

Site	Site#	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Crabtree Cr, ab Cary WWTP, Wake	B-22	27-33-(1)	04/94	51/6	7.59/7.17	Poor
			06/87	-/6	-/6.65	Poor
			10/84	73/11	6.44/5.59	Fair
			04/84	61/14	6.03/5.16	Good-Fair
Black Cr, Weston Pkwy, Wake	B-23	27-33-5	05/94	-/11	-/5.78	Fair
Crabtree Cr, I-40, Wake	B-24	27-33-(6)	04/94	55/11	7.11/5.56	Fair
			06/87	-/7	-/6.27	Fair
			10/84	56/8	7.20/6.60	Fair
			04/84	68/16	5.31/4.59	Good-Fair
Crabtree Cr, in Umstead Park, Wake	B-25	27-33-(6)	07/95	54/13	6.27/5.69	Good-Fair
			04/94	54/10	6.39/6.00	Fair
			07/87	55/9	6.51/6.69	Fair
			06/87	-/9	-/6.09	Fair
			04/86	80/20	6.18/5.09	Good-Fair
			10/84	65/14	6.10/5.39	Good-Fair
Sycamore Cr, SR 1649, Wake	B-26	27-33-9	07/91	-/5	-/5.77	Good-Fair
Crabtree Cr, SR 1649, Wake	B-27	27-33-(10)	04/94	-/9	-/5.62	Fair
			07/91	-/9	-/6.30	Fair
			06/87	/15	-/5.63	Good-Fair
Crabtree Cr, US 1, Wake	B-28	27-33-(10)	07/95	54/16	6.46/5.82	Good-Fair
			10/89	45/12	6.52/5.84	Fair
			07/89	54/12	6.46/5.94	Fair
			04/89	63/14	6.46/5.30	Fair
			02/89	46/9	7.14/6.29	Fair
			07/86	61/11	6.94/5.92	Fair
			09/84	56/10	6.76/5.65	Fair
Richland Cr, SR 1649, Wake	B-29	27-33-11	07/91	-/10	-/6.27	Fair
Hare Snipe Cr, NC 70, Wake	B-30	27-33-12-(2)	02/95	-/10	-/4.88	Fair
Mine Cr,1 mile ab Lake Shelley, Wake	B-31	27-33-14	09/95	-/7	-/5.71	Fair
Mine Cr, be Lake Shelley, Wake	B-32	27-33-14	02/95	-/4	-/6.05	Poor
Pigeon House Cr, Dortch St, Wake	B-33	27-33-18	07/95	30/1	8.85/6.58	Poor
Marsh Cr, nr US 1, Wake	B-34	27-33-20	07/95	44/6	6.86/6.47	Fair
			11/84	39/4	7.58/6.78	Poor
			06/84	48/6	7.53/6.53	Poor
			04/84	40/4	7.88/5.82	Poor
			01/84	20/4	7.59/5.57	Poor
Walnut Cr, SR 1700, Wake	B-35	27-34-(4)	11/85	49/3	7.61/6.84	Poor
Walnut Cr, Person St, Wake	B-36	27-34-(4)	11/85	36/5	8.27/6.97	Poor
Walnut Cr, Garner Rd, Wake	B-37	27-34-(4)	03/94	47/7	7.68/5.22	Poor
			11/85	36/2	8.26/7.69	Poor
Walnut Cr, State St, Wake	B-38	27-34-(4)	03/94	45/4	7.26/6.00	Poor
Walnut Cr, Rock Quarry Rd	B-39	27-34-(4)	03/94	44/5	7.33/6.11	Poor
Walnut Cr, SR 1730, Wake	B-40	27-34-(4)	07/91	-/9	-/6.04	Fair
Walnut Cr, SR 2551, Wake	B-41	27-34-(4)	07/95	51/10	7.02/5.52	Fair
			03/94	50/12	6.26/4.60	Fair
			11/85	42/13	6.32/5.63	Fair
UT Big Br, ab Goodmark, Wake	B-42	27-34-11	04/89	47/6	7.03/4.91	Fair
UT Big Br, be Goodmark, Wake	B-43	27-34-11	04/89	31/1	8.11/5.50	Poor

NEUSE 02, continued

Site	Site#	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Neuse R, NC 42 nr Clayton, Johnston	B-44	27-(36)	07/95	66/21	5.69/4.75	Good
			07/91	72/26	5.80/4.71	Good
			08/90	73/24	5.82/4.61	Good
			07/88	81/22	5.98/5.07	Good-Fair
			07/86	82/21	6.29/5.07	Good-Fair
			07/86	67/20	6.26/5.02	Good-Fair
			07/85	65/20	6.06/4.99	Good-Fair
			09/84	61/22	5.63/4.81	Good
			07/83	59/14	6.20/4.93	Good-Fair
Neuse R, SR 1201, Johnston	B-45	27-(36)	08/95	60/25	4.96/3.96	Good
			07/91	64/24	5.48/4.37	Good
UT Neuse R, SR 1903, Johnston	B-46	27-(36)	09/92	65/18	5.20/4.70	Good
Marks Cr, SR 1714, Johnston	B-47	27-38	07/95	-/18	-/4.81	Good-Fair
			07/91	-/17	-/4.47	Good-Fair
Swift Cr, Old Raleigh Rd, Wake	B-48	27-43-(1)	03/89	-/1	-/7.78	Poor
Swift Cr, US 1, Wake	B-49	27-43-(1)	07/95	-/4	-/7.41	Poor
			07/91	-/10	-/6.27	Fair
			03/89	-/9	-/6.34	Fair
Swift Cr, Hemlock Bluffs, Wake	B-50	27-43-(1)	03/89	/14	-/6.18	Good-Fair
Swift Cr, Holly Springs Rd, Wake	B-51	27-43-(1)	07/95	-/7	-/6.34	Fair
			03/89	-/9	-/6.17	Fair
UT Swidt Cr, nr Radio Tower, Wake	B-52	27-43-(1)	03/89	-/13	-/2.77	Good-Fair
UT Swift Cr B, nr Swift Creek, Wake	B-53	27-43-(1)	03/89	-/5	-/4.67	Poor
UT Swift Cr A, Wake	B-54	27-43-(1)	03/89	-/13	-/3.07	Good-Fair
UT Swift Cr, Hemlock Bluffs, Wake	B-55	27-43-(1)	03/89	-/23	-/2.91	Excellent
Williams Cr, Old Raleigh Rd, Wake	B-56	27-43-2	03/89	-/4	-/6.75	Poor
Swift Cr, NC 42 nr Clayton, Johnston	B-57	27-43-(8)	07/91	-/8	-/5.61	Fair
			07/86	53/8	6.75/5.36	Fair
Swift Cr, SR 1525, Johnston	B-58	27-43-(8)	07/95	-/14	-/5.14	Good-Fair
Swift Cr, SR 1501, Johnston	B-59	27-43-(8)	07/95	58/18	5.51/4.91	Good
			08/91	77/20	5.60/4.79	Good
UT Swift Cr, ab Mill Run MHP, Wake	B-60	27-43-(8)	03/87	-/15	-/4.09	Good-Fair
UT Swift Cr, be Mill Run MHP, Wake	B-61	27-43-(8)	03/87	-/16	-/4.06	Good-Fair
Little Cr, SR 1562, Johnston	B-62	27-43-12	07/95	-/10	-/5.53	Fair
			08/91	-/13	-/5.36	Good-Fair
Moccasin/Racoon Swp, SR 1007, Johnston	B-63	27-53	07/91	-/7	-/5.96	Fair

NEUSE 03

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
UT Middle Cr, ab Lufkin, Wake	B-1	27-43-15-(1)	02/87	29/2	8.09/2.66	Poor
UT Middle Cr, be Lufkin, Wake	B-2	27-43-15-(1)	02/87	27/1	8.90/7.78	Poor
Basal Cr, NC 55, Wake	B-3	27-43-15-3	05/86	95/16	6.08/4.65	Good-Fair
Middle Cr, SR 1301, Wake	B-4	27-43-15-(1)	05/86	65/9	7.06/5.65	Fair
Middle Cr, nr Tallicud Rd, Wake	B-5	27-43-15-(4)	05/86	72/10	6.93/5.89	Fair
Middle Cr, SR 1375, Wake	B-6	"	08/95	39/10	5.85/5.51	Good-Fair
		07/91	55/11	6.18/5.52	Good-Fair	
	05/86	67/14	6.82/4.95	Fair		
Middle Cr, off SR 2752 nr airport, Wake	B-7		06/86	96/26	6.20/4.84	Good-Fair
Middle Cr, SR 2739, Wake	B-8	"	06/86	82/12	6.51/5.02	Fair
Middle Cr, SR 1507, Johnston	B-9	"	06/86	74/13	6.57/5.22	Fair

NEUSE 03 Continued

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Middle Cr, nr Clayton, NC 50, Johnston	B-10	"	08/95	46/14	5.68/4.42	Good-Fair
		07/91	82/17	5.97/4.88	Good-Fair	
			07/90	84/18	6.16/4.76	Good-Fair
			07/87	80/17	6.61/4.83	Fair
			07/87	-/14	-/5.06	Good-Fair
Terrible Cr, SR 1301, Wake	B-11	27-43-15-8-(2)	9/90	81/16	6.25/4.36	Good-Fair

NEUSE 04

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Black Cr, SR 1330, Johnston	B-1	27-45-(2)	08/95	47/7	6.54/5.42	Fair
	07/91	62/10	7.09/5.82	Fair		
Black Cr, SR 1662, Johnston	B-2	27-45-(2)	07/83	50/19	6.27/4.83	Good-Fair
Mill Cr, SR 1009, Johnston	B-3	27-52	08/95	-/12	-/4.82	Good-Fair
		08/91	-/13	-/5.07	Good-Fair	
Mill Cr, SR 1200, Johnston	B-4	27-52	07/83	58/11	7.52/5.60	Fair
Stone Cr, SR 1138, Johnston	B-5	27-52-5	08/95	-/8	-/5.46	Good-Fair
Hannah Cr, SR 1009, Johnston	B-6	27-52-6	08/95	-/13	-/5.33	Good-Fair
		08/91	-/8	-/5.27	Fair	

NEUSE 05

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Neuse R, NC 58, Kinston, Lenoir	B-1	27-(56)	08/95	58/20	4.95/4.00	Good
		07/91	60/21	5.07/4.59	Good	
			07/90	70/24	5.28/4.36	Good
			07/88	71/24	5.57/4.78	Good
			07/87	76/23	5.83/4.80	Good-Fair
			06/86	74/23	6.21/4.97	Good-Fair
			09/85	74/22	5.77/4.57	Good
			09/84	63/20	5.55/4.41	Good
			07/83	60/18	5.57/4.73	Good
Stoney Cr, SR 1920, Wayne	B-2	27-62	08/95	-/4	-/5.96	Poor
Bear Cr, SR 1311, Lenoir	B-3	27-72	08/95	-/7	-/5.40	Fair
	07/91	-/14	-/4.92	Good-Fair		
Falling Cr, SR 1340, Lenoir	B-4	27-77	08/95	-/12	-/5.45	Good-Fair
		07/91	-/14	-/4.55	Good-Fair	
Southwest Cr, SR 1804, Lenoir	B-5	27-80	08/95	-/6	-/5.95	Fair
	07/91	-/11	-/5.46	Fair		
Stonyton Cr, SR 1742, Lenoir	B-6	28-81	11/93	25/1	7.52/5.50	Swp
Briery Run, SR 1732, Lenoir	B-7	27-81-1	11/93	23/1	8.78/6.37	Swp

NEUSE O6

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Little R, off NC 96, Wake	B-1	27-57-1	01/95	82/18	6.26/5.17	Good-Fair
Little R, NC 96, Wake	B-2	27-57-(1)	08/95	94/21	6.44/4.92	Good-Fair
			01/95	70/20	6.21/4.61	Good-Fair
			08/91	81/21	6.30/5.13	Good-Fair
			11/84	98/25	6.11/4.74	Good-Fair
			09/84	92/21	5.98/4.94	Good-Fair
			08/84	96/18	5.87/4.62	Good-Fair
			06/84	101/23	6.00/4.75	Good-Fair
			05/84	107/26	5.91/4.65	Good
			04/84	104/32	5.62/4.42	Good
			03/84	102/30	5.74/4.71	Good
			02/84	89/24	5.65/4.88	Good
			01/84	80/28	5.75/5.15	Good
			12/83	107/28	6.19/5.40	Good-Fair
			11/83	100/25	6.33/5.15	Good-Fair
			10/83	96/21	6.10/5.40	Good-Fair
			09/83	89/19	6.43/4.94	Good-Fair
Little R, SR 2224, Wake	B-3	27-57-1	01/95	75/15	6.16/5.01	Good-Fair
Little R, SR 1722, Johnston	B-4	27-57-(8.5)	07/91	77/19	6.13/4.70	Good-Fair
Little R, SR 2130, Johnston	B-5	27-57-(8.5)	08/95	75/16	5.98/4.83	Good-Fair
			07/91	-/23	-/4.37	Good
			07/91	75/24	5.34/4.67	Good
			03/88	-/37	- /3.61	Excellent
Little R, SR 2335, Johnston	B-6	27-57-(8.5)	03/88	-/16	- /5.17	Good-Fair
Little R, SR 2320, Johnston	B-7	25-57-(8.5)	07/89	64/17	5.57/4.95	Good-Fair
			07/87	83/23	5.73/4.95	Good
			09/85	78/13	6.50/5.31	Fair
			07/83	63/22	5.28/4.37	Good
Buffalo Cr, SR 1007, Wake	B-8	27-57-16-(2)	08/91	/2	- /7.63	Poor
Buffalo Cr, SR 1941, Johnston	B-9	27-57-16-(3)	07/91	-/9	- /4.62	Fair
Mill Cr, off SR 1390, Johnston	B-10	27-57-18	03/88	39/8	6.89/4.68	Fair
Mill Cr, off SR 1390, Johnston	B-11	27-57-18	07/91	56/5	7.25/6.57	Poor
			03/88	23/1	8.61/5.81	Poor
Little R, NC 581, Wayne	B-12	27-57-(20.2)	08/95	69/17	6.11/4.33	Good-Fair
			07/91	78/25	5.49/4.53	Good
Little R, off SR 1362, Wayne	B-13	27-57-(21.1)	07/94	84/20	6.42/4.87	Good-Fair
Little R, ab US 70, Wayne	B-14	27-57-(21.2)	07/94	69/21	5.75/4.84	Good
Little R, US 70, Wayne	B-15	27-57-(21.2)	07/94	-/14	-/4.81	Good-Fair

NEUSE 07

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Moccasin Cr, NC 231, Nash	B-1	27-86-2	08/95	-/16	-/5.38	Good-Fair
			07/91	-/17	- /4.97	Good-Fair
Moccasin Cr, SR 1131, Nash	B-2	27-86-2	05/91	64/16	5.84/5.07	Good-Fair
			05/88	79/25	5.74/4.95	Good
Little Cr, NC 39, Wake	B-3	27-86-2-4	07/91	46/2	7.92/7.64	Poor
Turkey Cr, SR 1101, Nash	B-4	27-86-3-(1)	05/91	74/14	6.60/5.75	Fair
			05/88	81/15	6.37/5.62	Good-Fair
Turkey Cr, SR 1128,Wilson	B-5	27-86-3-(1)	08/95	-/18	-/4.84	Good-Fair
			07/91	/13	-/5.13	Good-Fair
Beaverdam Cr, SR 1111, Nash	B-6	27-86-3-8	07/91	84/18	5.95/4.79	Good-Fair
Beaverdam Cr, SR 1112, Nash	B-7	27-86-3-8	05/91	75/11	6.53/5.61	Fair
			05/88	76/17	6.25/5.07	Good-Fair
Contentnea Cr, NC 58 nr Stantons.,Wilson	B-8	27-86-(7)	08/95	64/11	7.07/6.36	Fair
			07/91	78/19	6.26/5.34	Good-Fair
			07/90	54/13	6.96/5.46	Fair
			07/88	60/7	7.10/6.16	Fair
			07/86	88/16	6.56/5.29	Good-Fair
Contentnea Cr, SR 1800 at Grifton, Pitt	B-9	27-86-(7)	08/95	69/16	6.51/5.06	Good-Fair
			07/91	78/26	5.59/4.60	Good
			07/87	89/24	6.35/5.06	Good
			07/85	86/20	6.55/5.14	Good-Fair
			07/83	70/20	6.12/5.00	Good-Fair
Toisnot Swp, NC 222, Wilson	B-10	27-86-11-(5)	07/91	-/11	-/5.82	Fair
Nahunta Swp, SR 1058 nr Shine, Greene	B-11	27-86-14	08/95	57/6	6.40/5.76	Fair
			07/90	68/16	6.54/5.24	Good-Fair
			05/90	66/13	6.34/5.14	Good-Fair
			07/88	66/11	6.65/4.78	Good-Fair
Wheat Swp, SR 1091, Greene	B-12	27-86-24	02/92	82/7	7.29/6.58	NR
			07/91	-/2	- /6.28	Poor

NEUSE O8

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Neuse R, SR 1423 nr Streets Ferry, Craven	B-1	27-(85)	07/95	67/9	6.97/5.98	Good-Fair
			07/89	73/18	6.63/5.48	Good-Fair
			07/87	66/15	7.16/5.81	Good-Fair
			07/85	64/12	7.50/6.73	Fair
			07/83	52/9	7.18/5.33	Fair
Core Cr, NC 55, Craven	B-2	27-90	08/95	44/3	7.52/7.53	Fair
			07/91	-/8	-/6.26	Fair
Rollover Cr, SR 1224, Craven	B-3	27-98-2	05/89	49/5	6.96/5.48	Not Rated
			05/88	29/9	6.62/5.36	Not Rated
Beaverdam Cr, SR 1244, Craven	B-4	27-98-2	05/89	59/4	7.33/5.18	Not Rated
			05/88	36/6	7.15/6.06	Not Rated
Caswell Br, off SR 1243, Craven	B-5	27-98-2	05/89	52/10	6.33/4.58	Not Rated
			05/88	35/11	6.36/5.35	Not Rated

NEUSE 09

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Swift Cr, NC 102, Pitt	B-1	27-97	08/95	-/5	-/5.88	Poor
			07/91	-/8	-/6.04	Fair
Swift Cr, SR 1478, Craven	B-2	27-97	07/87	65/11	7.29/6.48	Fair
			07/85	55/2	7.88/6.18	Poor
			07/83	45/2	7.99/6.03	Poor
Swift Cr, NC 118 nr Vanceboro, Craven	B-3	27-97	08/95	59/6	7.05/6.01	Fair
			07/91	-/12	- /5.82	Good-Fair
Fork Swp, SR 1711, Pitt	B-4	27-97-4	08/95	46/2	7.39/5.99	NR
			03/95	42/2	7.65/7.00	NR
Clayroot Swp, SR 1941, Pitt	B-5	27-97-5	08/95	-/3	-/5.88	Poor
			07/91	-/9	-/5.57	Fair
Little Swift Cr, SR 1623, Craven	B-6	27-97-8	03/95	25/2	7.55/7.07	NR
Fisher Swp, SR 1621, Craven	B-7	27-97-8-3	08/95	35/2	7.25/6.82	NR
			03/95	48/4	6.84/6.24	NR

NEUSE 10

Site	Site #	Index#	Date	S/EBI	Salinity (ppt)
Mills Br, at mouth, Craven	B-1	27-99.5	08/95	35/8.30	3
Neuse R, US 17, New Bern, Craven	B-2	27-(101)	08/95	25/2.2	6
			07/84	30/1.7	-
			07/83	26/1.8	-
W Pr Brices Cr, SR 1101, Craven	B-3	27-101-40-(1)	04/86	53/6.16	0
Lawson Cr, at mouth, Craven	B-4	27-101-42	08/95	10/1.4*	5
Upper Broad Cr, SR 1612, Craven	B-5	27-106-(1)	03/95	35/7.06	0
Deep Run, NC 55, Pamlico	B-6	27-106-6	04/95	29/6.85	0
			03/95	24/5.93	0
Goose Creek, SR 1005, Pamlico	B-7	27-107-(1)	03/95	27/6.46	0
Upper Slocum Cr, at Turkey Gut,Craven	B-8	27-112	02/92	10/1.2*	0
Slocum Cr, at mouth, Craven	B-9	27-112	08/95	14/2.4	11
E Pr Slocum Cr, be Havelock WWTP,Craven	B-10	27-112-2	02/92	3/1.3*	0
Neuse R, Hancock Cr, Carteret	B-11	27-(115)	08/95	19/2.3	12
Hancock Cr, E of Cherry Pt airfield, Craven	B-12	27-115	02/92	12/1.5*	4
Clubfoot Cr, nr mouth, Craven	B-13	27-123	08/95	18/2.1	13
Fork Run, SR 1005, Pamlico	B-14	27-125-2	03/95	26/8.10	0
Neuse R, Oriental, Pamlico	B-15	27-(129)	07/84	29/1.8	-
Greens Cr, ab Kershaw Cr, Pamlico	B-16	27-129-(1)	02/92	16/1.3*	12
Greens Cr, at Kershaw Cr, Pamlico	B-17	27-129-(2)	08/95	10/1.9*	16
Oriental Hbr, at docks, Pamlico	B-18	27-129-8	02/92	7/1.2*	13
Oriental Hbr, Fulchers Seafood, Pamlico	B-19	27-129-8	08/95	9/1.3*	16
Oriental Hbr, nr Yacht Club, Pamlico	B-20	27-129-8	02/92	10/1.3*	14
South R, at mouth, Carteret	B-21	27-135	06/94	31/2.0	13
W Fk South R, nr Open Grounds, Carteret	B-22	27-135-1	06/94	33/2.0	7
Southwest Cr, nr Open Grounds,Carteret	B-23	27-135-9	06/94	34/2.0	11
Eastman Cr, upstream, Carteret	B-24	27-135-10	06/94	31/1.9	-
Eastman Cr, at WIRO sta 15, Carteret	B-25	27-135-10	06/94	10/1.5*	12
Mulberry Cr, at Isl, Carteret	B-26	27-135-16	06/94	31/2.0	11
Hardy Cr, upstream, Carteret	B-27	27-135-18	06/94	31/1.6	12
Hardy Cr, at mouth, Carteret	B-28	27-135-18	06/94	31/2.3	13

NEUSE 11

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Trent R, NC 58, nr Trenton, Jones	B-1	27-101-(1)	08/95	70/12	6.38/5.11	Good-Fair
			11/90	62/14	6.24/3.76	Good-Fair
			06/90	69/12	6.80/5.29	Fair
			05/90	71/19	5.90/4.41	Good-Fair
			06/89	73/20	6.43/4.64	Good-Fair
			06/87	86/22	6.47/4.50	Good
Trent R, NC 58, nr Trenton, Jones	B-1	27-101-(1)	06/86	80/21	6.46/4.95	Good-Fair
			09/85	77/14	6.08/4.74	Good-Fair
			07/83	65/13	6.29/5.18	Good-Fair
Trent R, NC 17, Jones	B-2	27-101-(1)	03/95	63/5	7.25/5.28	Swp
Beaverdam Swp, US 258, Lenoir	B-3	27-101-3	07/91	-/6	-/5.68	Fair
Tuckahoe Swp, SR 1105, Lenoir	B-4	27-101-5-1	08/92	23/2	7.07/5.88	Swp
			05/92	45/7	6.89/5.36	Swp
			02/92	62/10	6.45/5.18	Swp
Reedy Br, NC 41, Jones	B-5	27-101-7	07/91	-/6	-/5.02	Good-Fair
Cypress Cr, SR 1134, Jones	B-6	27-101-8	08/92	29/0	8.68/-	Swp
			05/92	51/3	7.36/5.37	Swp
			02/92	49/6	7.11/6.48	Swp
L Chinquapin Cr, SR 1131, Jones	B-7	27-101-11	07/91	-/7	-/5.79	Fair
Beaver Cr, SR 1316, Jones	B-8	27-101-15	07/91	-/9	-/5.48	Fair
Musselshell Cr, SR 1320, Jones	B-9	27-101-17	08/95	19/1	8.32/-	Swp
			03/95	15/1	7.23/-	Swp
Beaverdam Cr, SR 1002, Jones	B-10	27-101-21	03/95	44/11	6.04/4.16	Swp
Mill Run, NC 58,Jones	B-11	27-101-23	07/91	-/19	-/4.12	Good
UT Mill Run, SR 1119, Jones	B-12	27-101-23	07/91	-/13	-/4.60	Good-Fair
Island Cr, SR 1004, Jones	B-13	27-101-33	08/95	63/22	6.04/4.49	Good
			03/95	60/18	6.35/5.61	Good
			07/91	-/15	-/4.15	Good
			12/84	82/25	5.84/4.28	Good

NEUSE 12

Site	Site #	Index#	Date	S/EPT S	BI/BIEPT	Bioclass
Thoroughfare Swp, SR 1120, Wayne	B-1	27-54-5	02/92	72/9	7.56/7.07	Swp
		07/91	-/1	-/7.41	Swp	
Neuse R, NC 117, nr Goldsboro, Wayne	B-2	27-(56)	08/95	53/16	5.30/4.46	Good-Fair
		07/91	78/30	5.25/4.43	Good	
Neuse R, SR 1915, nr Goldsboro, Wayne	B-3	27-(56)	07/90	72/23	5.34/4.36	Good
			07/88	74/24	5.77/4.68	Good
			07/86	83/28	5.92/4.61	Good
			09/84	57/17	6.28/5.15	Good-Fair

NEUSE 13

Site	Site #	Index#	Date	S/EBI	Salinity
Bay River, nr Ball Cr, Pamlico	B-1	27-150-(20)	08/95	31/2.4	15
Jones Bay, S side, Pamlico	B-2	27-152	08/95	33/2.4	17

NEUSE 14

Site	Site #	Index#	Date	S/EBI	Salinity
West Bay, Green Pt, Carteret	B-1	27-148	09/93	42/2.2	20
West Bay, Tump Isl, Carteret	B-2	27-148	08/95	51.2.7	17
			09/93	44/2.4	20
West Bay, E side, Carteret	B-3	27-148	09/93	20/2.0*	21
West Bay, W side, Carteret	B-4	27-148	09/93	28/2.3	20
West Bay, Mkr 6, Carteret	B-5	27-148	09/93	16/2.0*	20
West Bay, Pamlico Sd, Carteret	B-6	27-148	09/93	15/2.5	20
Long Bay, Cornsage Pt, Carteret	B-7	27-148-1	09/93	39/2.4	20
W Thorofare Bay, Mkr 10, Carteret	B-8	27-148-2	09/93	19/1.4*	22
Cadaugen Bay, nr mouth, Carteret	B-9	27-148-2-2	09/93	50/2.7	20
Merkle Bay, in center, Carteret	B-10	27-148-3	09/93	21/1.7*	21
North Bay, nr Mouth, Carteret	B-11	27-148-10	09/93	41/2.4	20
Pamlico Sound, Hog Is, Carteret	B-12	27-148.5	09/93	22/3.1	20

*Quantitative sample