CHAPTER 3

CAUSES AND SOURCES OF WATER POLLUTION IN THE CAPE FEAR RIVER BASIN

3.1 INTRODUCTION

Water pollution is caused by a number of substances including sediment, nutrients, bacteria, oxygen-demanding wastes, metals, color and toxic substances. *Sources* of these pollution-causing substances are divided into broad categories called *point* sources and *nonpoint* sources. Point sources are typically piped discharges from wastewater treatment plants, large urban stormwater systems (from municipalities with a population greater than 100,000) and industrial stormwater systems. Nonpoint sources can include stormwater runoff from smaller urban areas (population less than 100,000), forestry, mining, agricultural lands and others. **Section 3.2** identifies and describes the major causes of pollution in the Cape Fear basin. **Sections 3.3** and **3.4** describe point and nonpoint source pollution in the basin.

3.2 CAUSES OF POLLUTION

The term *causes* of pollution refers to the substances which enter surface waters from point and nonpoint pollution sources and result in water quality degradation. The major causes of pollution discussed throughout the basin plan include biochemical oxygen demand (BOD), sediment, nutrients, toxicants (such as heavy metals, chlorine, pH and ammonia) and fecal coliform bacteria.

3.2.1 Oxygen-Consuming Wastes

Oxygen-consuming wastes are substances such as decomposing organic matter or chemicals which reduce dissolved oxygen in the water column through chemical reactions or biological activity. Raw domestic wastewater contains high concentrations of oxygen-consuming wastes that need to be removed from the wastewater before it can be discharged into a waterway. Maintaining a sufficient level of dissolved oxygen in the water is critical to most forms of aquatic life.

The concentration of dissolved oxygen (DO) in a water body is one indicator of the general health of an aquatic ecosystem. The United States Environmental Protection Agency (EPA) states that 3.0 milligrams per liter (mg/l) is the threshold dissolved oxygen concentration needed for many species' survival (EPA, 1986). North Carolina has adopted a water quality standard of 5.0 mg/l (daily average with minimum instantaneous measurements not permissible below 4.0 mg/l) in order to protect the majority of its waters. Higher concentrations are needed to promote propagation and growth of a diversity of aquatic life in North Carolina's surface waters. Exceptions to this standard exist for waters supplementally classified as *trout waters* (not found in the Cape Fear River Basin) and those supplementally classified as *swamp*. Trout waters have a dissolved oxygen standard of 6.0 mg/l due to the higher sensitivity of trout to low dissolved oxygen levels. Swamp waters often have naturally low levels of dissolved oxygen, and aquatic life typically found in these waters are adapted to the lower dissolved oxygen levels. Sluggish swamp waters in the Coastal Plain portion of the state may have natural dissolved oxygen levels of 3.0 to 4.0 mg/l or less at times. Therefore, the dissolved oxygen standard for swamp waters may be less than 5.0 mg/l if that lower level is judged to be the result of natural conditions. Many of the freshwater streams in the Coastal Plain portion of the basin are supplementally classified by the state as swamp waters (see section 2.5 for further discussion on standards and classifications).

Dissolved oxygen concentrations are affected by a number of factors. Higher dissolved oxygen is produced by turbulent actions which mix air and water such as waves, rapids and water falls. In addition, lower water temperature generally allows for retention of higher dissolved oxygen concentrations. Therefore, the cool swift-flowing streams of the mountains are generally high in dissolved oxygen. Low dissolved oxygen levels tend to occur more often in warm, slow-moving waters that receive a high input of effluent from wastewater treatment plants during low flow conditions. In general, the lowest dissolved oxygen concentrations occur during the warmest summer months and particularly during low flow periods. Water depth is also a factor. In deep slow-moving waters, such as reservoirs or estuaries, dissolved oxygen concentrations may be very high near the surface due to wind action and plant (algae) photosynthesis but may be entirely depleted (anoxic) at the bottom.

Causes of dissolved oxygen depletion can include wastewater treatment plant effluent and the decomposition of organic matter such as leaves, dead plants and animals, and organic waste matter that may be washed or discharged into the water. Sewage from human and household wastes is high in organic waste matter, and bacterial decomposition can rapidly deplete dissolved oxygen levels unless these wastes are adequately treated at a wastewater treatment plant to remove much of the organic component. In addition, some chemicals may react with and bind up dissolved oxygen.

A large portion of the organic material discharged into the water from a wastewater treatment plant is readily decomposed as the oxygen-consuming decay process may begin to occur within a matter of hours. As this decay process occurs in a moving water column, the area of greatest impact may be several miles below the point of discharge. This area can often be identified by a marked reduction in instream dissolved oxygen concentrations and is commonly referred to as the *sag zone*. Frequently, dissolved oxygen concentrations will gradually rise downstream of the sag zone as the amount of readily decomposed organic matter is reduced. However, a significant portion of the organic matter in wastewater treatment plant effluent may take days to decompose.

Biochemical oxygen demand, or BOD, is a technical term that describes the overall demand on dissolved oxygen from the various oxygen-depleting processes presented above. A commonly used measure of BOD is called BOD_5 where the "5" stands for the amount oxygen demand exerted over five days. BOD_5 is a standard waste limit in most discharge permits. A limit of 30 mg/l of BOD_5 is the highest concentration allowed by federal and state regulations for municipal and domestic wastewater treatment plants. Limits less than 30 mg/l and sometimes as low as 5 mg/l are becoming more common in order to protect dissolved oxygen standards in the receiving waters.

Oxygen-Consuming Wastes in the Cape Fear River Basin

The protection of dissolved oxygen through management of the discharge of oxygen-consuming wastes into waters of the Cape Fear River basin continues to be a high priority. Efforts to limit the discharge of these wastes from NPDES discharge facilities have been largely successful over the past two decades. The total daily loading of biochemical oxygen demanding wastes (BOD) from NPDES (National Pollutant Discharge Elimination System) municipal dischargers in the Cape Fear River Basin in 1993 is estimated to be significantly lower than it was 20 years ago despite a large increase in the total volume of treated wastewater. As depicted in Figure 3.1a, the total loading of BOD has decreased from approximately 33 tons per day in the mid-1970s to approximately 9.7 tons per day in 1993 while the total daily volume of effluent discharged increased by 38% from 173.3 MGD in the mid 1970s to 239.1 MGD in 1993 (Figure 3.1b). This reduction in BOD loading is the result of several factors including 1) more stringent point source pollution control requirements mandated by the federal Clean Water Act, 2) management actions implemented through the state's NPDES program and 3) major efforts by municipalities, industries and others, in the form of wastewater treatment plant upgrades and improved plant operation, to meet these requirements for water quality protection.

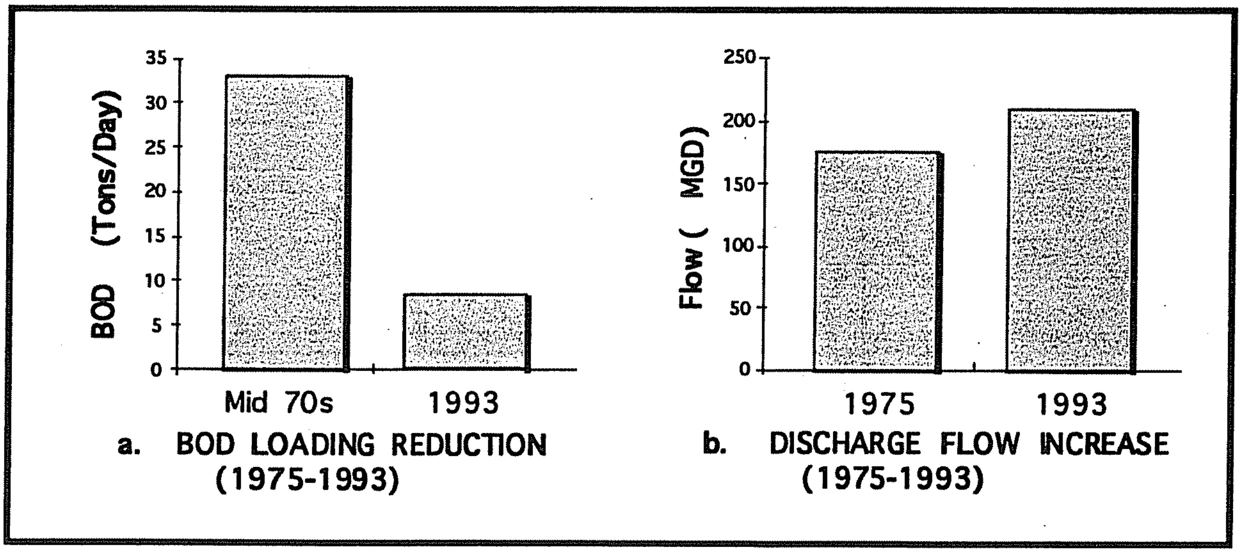


Figure 3.1 Comparison of (a) Total BOD Loading and (b) Effluent Flows from Municipal NPDES dischargers in the Cape Fear River Basin Between Mid-1970s and 1993

In general, while water quality standards for dissolved oxygen are being met throughout most of the basin, modeling studies have indicated that the BOD assimilative capacity is either limited or has been exhausted in some waters in the basin. Also, treatment of BOD will need to continue to improve in order to maintain water quality standards in the face of future plant expansions. Recommended strategies for addressing BOD are presented in Section 6.3 of Chapter 6.

3.2.2 Nutrients

The term *nutrients* in this document refers to the substances phosphorus and nitrogen, two common components of plant fertilizers, animal and human wastes, vegetation and some industrial processes. Nutrients in surface waters come from both point and nonpoint sources. While nutrients can be beneficial to aquatic life in small amounts, in overabundance and under favorable conditions, they can stimulate the occurrence of algal blooms and excessive plant growth in quiet waters such as ponds, lakes, reservoirs and estuaries.

Algal blooms, through respiration and decomposition, deplete the water column of dissolved oxygen and can contribute to serious water quality problems. Nutrient overenrichment and the resultant problems of low dissolved oxygen are called *eutrophication.* In addition to problems with low dissolved oxygen, the blooms are aesthetically undesirable, impair recreational use, impede commercial fishing and pose difficulties in water treatment at water supply reservoirs. Excessive growth of larger plants, or macrophytes, such as milfoil, alligator weed and Hydrilla, can also be a problem. These plants, in overabundance, can reduce or eliminate swimming, boating and fishing in infested waters.

Agricultural runoff and wastewater treatment plants along with urban stormwater, forestry and atmospheric deposition are the main sources of nutrients. Nutrients in nonpoint source runoff come mostly from fertilizer and animal wastes (See Section 3.4.1). Nutrients in point source discharges are from human wastes, food residues, some cleaning agents and industrial processes. A statewide phosphorus detergent ban implemented in 1988 significantly reduced the amount of phosphorus reaching and being discharged into surface waters from wastewater treatment plants. A report was prepared by the North Carolina Department of Environment, Health, and Natural Resources in 1991 to evaluate the effects of the ban. (NCDEHNR, 1991).

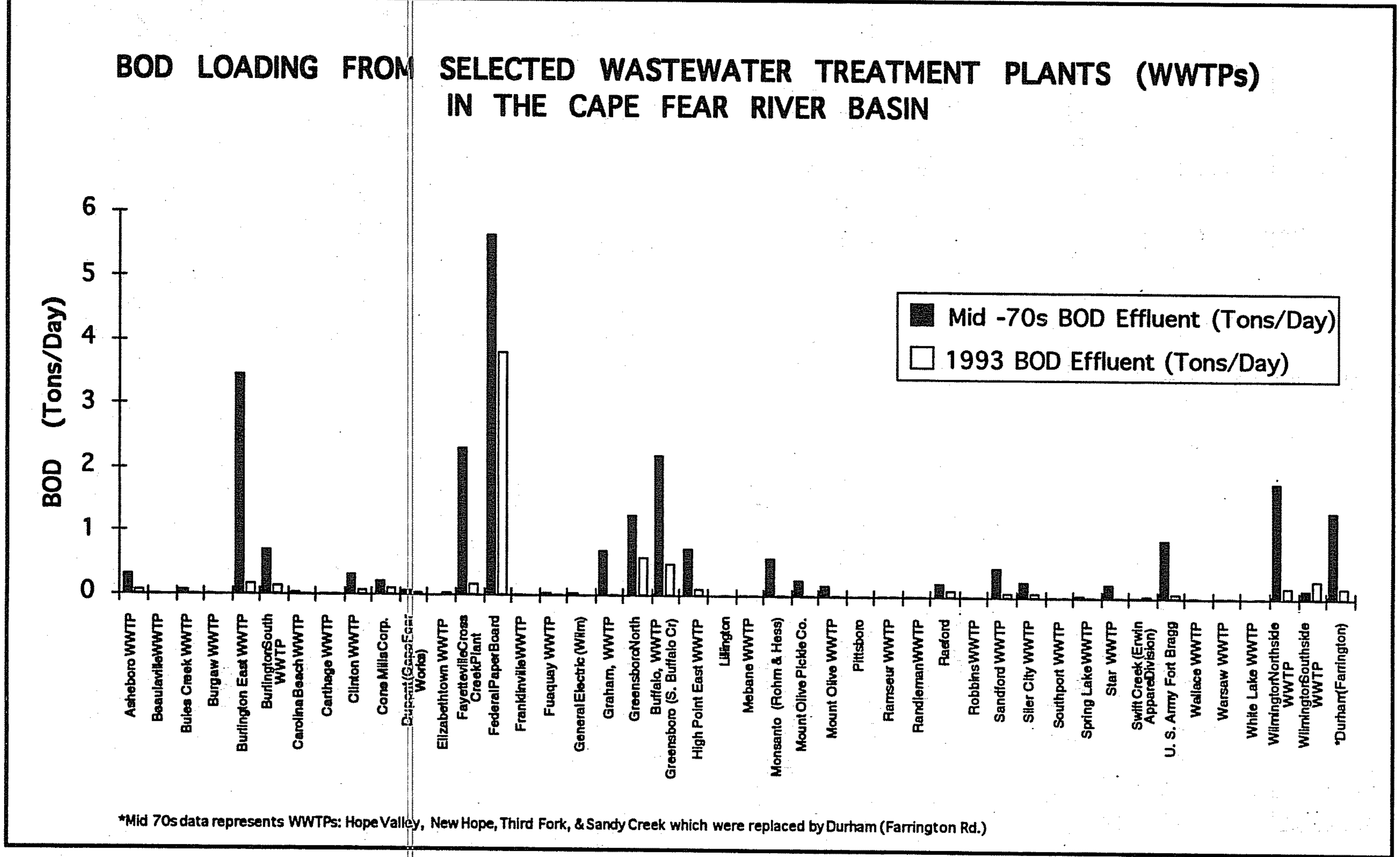


Figure 3.2 Comparison of Permitted BOD (Biochemical oxygen demand) Loadings from Selected NPDES Dischargers in the Cape Fear River Basin Between the Mid-1970s and 1993

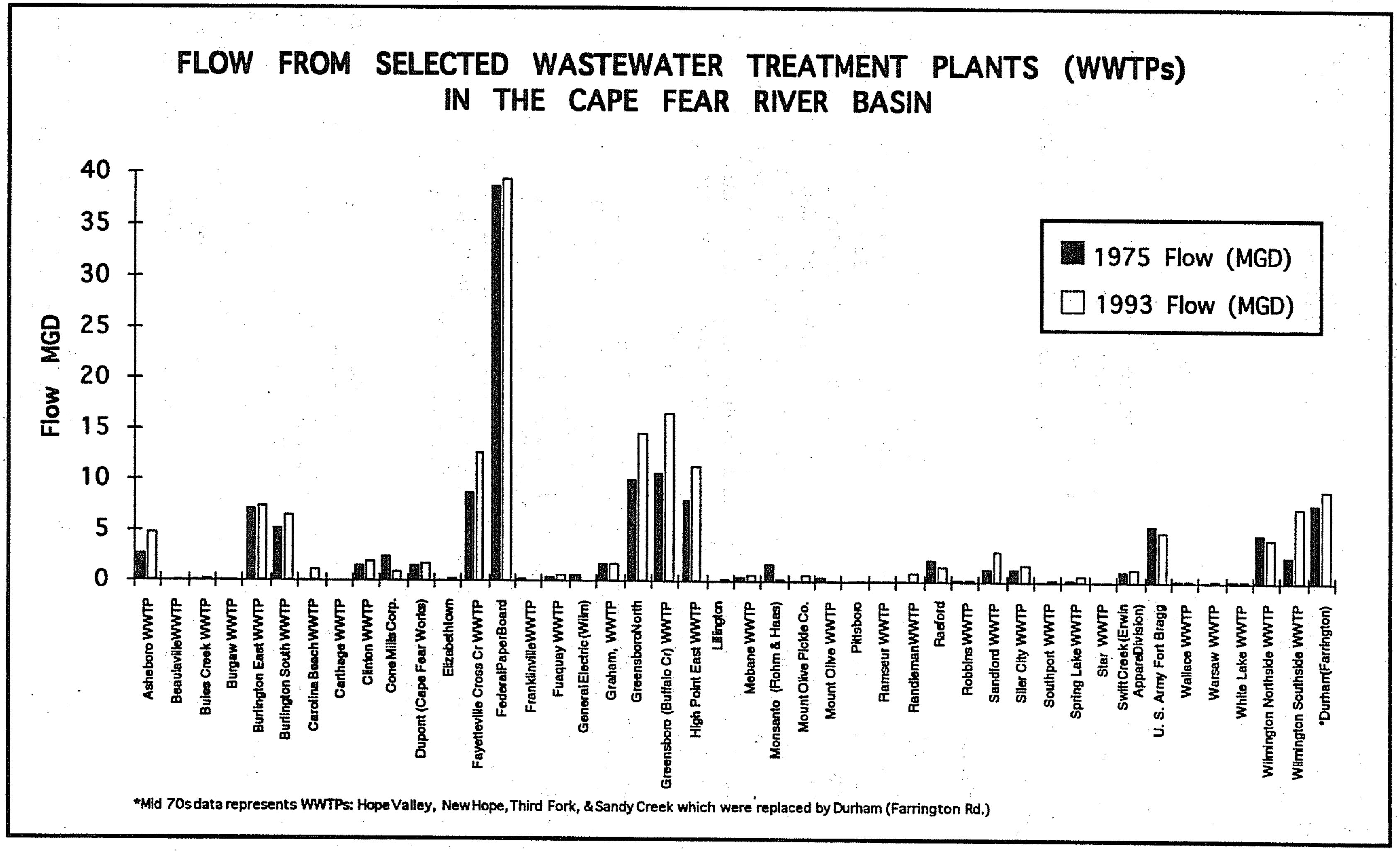


Figure 3.3 Comparison of Permitted Flows from Selected NPDES Dischargers in the Cape Fear River Basin Between the Mid-1970s and 1993

At this time, North Carolina has no numeric instream standards for total phosphorus (TP) and total nitrogen (TN), but analysis is underway, and standards or instream criteria may be developed for these parameters in the future. In addition, the State has a standard of 40 ug/l (micrograms per liter or parts per billion) for chlorophyll *a* . Chlorophyll *a* is a constituent of most algae (it gives algae its green color). A chlorophyll *a* reading above the 40 ug/l standard is indicative of excessive algal growth and portends bloom conditions.

Nutrients in the Cape Fear Basin

The control of nutrients, especially phosphorus, is an important water quality concern in the Cape Fear River Basin. There are 16 lakes in the basin, including Jordan Reservoir, which are rated as threatened due to nutrient overenrichment (see Figure 4.3 in Chapter 4). Greenfield Lake in New Hanover County is considered hypereutrophic and not supporting its uses because of excessive nutrients and noxious aquatic weed growth. Nutrients are also a major concern in the upper Deep River watershed in the vicinity of the proposed Randleman Reservoir because of the potential for eutrophication occurring in the lake (Section 6.4.3 in Chapter 6). Nutrient management strategies for the basin, overall, are presented in Section 6.4.

3.2.3 Toxic Substances

Regulation 15A NCAC 2B. 0202(36) defines a toxicant as "any substance or combination of substances ... which after discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, has the potential to cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions or suppression in reproduction or growth) or physical deformities in such organisms or their offspring or other adverse health effects". Toxic substances frequently encountered in water quality management include *chlorine*, *ammonia*, *organics* (hydrocarbons, pesticides, herbicides), and *heavy metals*. These materials are toxic to different organisms in varying amounts, and the effects may be evident immediately or may only be manifested after long-term exposure or accumulation in living tissue.

North Carolina has adopted standards and *action levels* for several toxic substances. These are contained in 15A NCAC 2B .0200. Usually, limits are not assigned for parameters which have action levels, such as copper, unless monitoring indicates that the parameter may be causing toxicity or federal guidelines exist for a given discharger for an action level substance. This process of determining action levels exists because these toxic substances are generally not bioaccumulative and have variable toxicity to aquatic life because of chemical form, solubility, stream characteristics and/or associated waste characteristics. Water quality-based limits may also be assigned to a given NPDES permit if data indicate that a substance is present for which there is a federal criterion but no water quality standard.

Whole effluent toxicity (WET) testing is required on a quarterly basis for major dischargers and any discharger containing complex (industrial) wastewater. There are 119 such dischargers in the Cape Fear River Basin. A complete listing of these facilities is included in Appendix II. This test shows whether the effluent from a treatment plant is toxic, but it does not identify the specific cause of toxicity. If the effluent is found to be toxic, further testing is done to determine the specific cause. This follow-up testing is called a *toxicity reduction evaluation* (TRE). WET testing is discussed in Sections 4.2.4 and 5.2.5 of Chapters 4 and 5, respectively. Strategies to address toxicity problems associated with dischargers are presented in Section 6.5 of the Chapter 6.

Metals

According to Table 4.13 in Chapter 4, 55 miles of streams in the basin are estimated to be impaired by metals. In addition, 10 fish tissue samples at seven sampling locations in the basin had mercury concentrations that exceeded the federal Food and Drug Administration limit of 1.0 parts per million (Section 4.2.2). Municipal and industrial dischargers along with urban runoff, and possibly atmospheric deposition, are the main sources of metals contamination in surface water. North Carolina has stream standards for many heavy metals, but the most common ones in municipal permits are cadmium, chromium, nickel, lead, mercury, silver and zinc. Each of these, with the exception of silver, is also monitored at the 69 ambient monitoring stations in the basin along with aluminum and arsenic. Point source discharges of metals are controlled through the NPDES permit process. Mass balance models (Appendix III) are employed to determine appropriate limits. Municipalities with significant industrial users discharging wastes to their treatment facilities limit the heavy metals coming to them from their industries through their *pretreatment program.* Source reduction and wastewater recycling at WWTPs also reduces the amount of metals being discharged to a stream. Nonpoint sources of pollution are controlled through best management practices. The new urban stormwater NPDES program described in Chapter 5 and in Section 6.7 of Chapter 6 should help address nonpoint source metals loading in the Greensboro and Fayetteville areas.

Chlorine

Chlorine is commonly used as a disinfectant at NPDES discharge facilities which have a domestic (i.e., human) component. These discharges are a major source of chlorine in the State's surface waters. Chlorine dissipates fairly rapidly once it enters the water, but it can have significant toxic effects on sensitive aquatic life such as trout and mussels. North Carolina has adopted a freshwater action level of 17 ug/l (micrograms per liter) to protect against chronic toxicity. It is recommended that new and expanding discharges provide dechlorination or alternate disinfection of wastewater. A total residual chlorine limits is assigned based on the freshwater action level of 17 ug/l (13 ug/l for salt water) or a maximum concentration of 28 ug/l for protection against acute effects in the mixing zone. In 1993, letters were sent to existing facilities with chlorine monitoring requirements. These letters encouraged permittees to examine their effluent chlorine levels and noted that limits may be implemented in the future. At this time, the State is not requiring chlorine limits at existing treatment facilities.

Ammonia (NH_3)

According to Table 4.13 in Chapter 4, 24 miles of streams in the basin are estimated to be impaired by ammonia. Point source dischargers are one of the major sources of ammonia. In addition, decaying organisms which may come from nonpoint source runoff and bacterial decomposition of animal waste products also contribute to the level of ammonia in a waterbody. At this time, there is no numeric standard for ammonia in North Carolina.

3.2.4 Erosion and Sedimentation

Sedimentation and erosion is the most widespread cause of nonpoint source pollution in the state. It impacts streams in several ways. Eroded sediment may gradually fill lakes and navigable waters and may increase drinking water treatment cost. Sediment may clog the gills of fish, eliminate the available habitat of organisms which serve as food for fish, or even completely cover shellfish beds. Sediment also serves as a carrier for other pollutants including nutrients (especially phosphorus), toxic metals and pesticides. Most sediment-related impacts are associated with nonpoint source pollution generated by ground-disturbing activities such as building and road construction and farming. Streambank erosion caused by increased runoff is also a problem.

North Carolina does not have a numeric water quality standard for suspended solids, however all discharges must meet federal effluent guideline values at a minimum (e.g. 30 mg/l for domestic discharges). Also, most point source BOD limitations usually require treatment to a degree that removes sediments to a level below federal guidelines requirements. Discharges to high quality waters (HQW) must meet a total suspended solids (TSS) limit of 10 mg/l for trout waters and primary nursery areas and 20 mg/l for all other HQWs. In addition, the state has adopted a numerical instream turbidity standard for point and nonpoint source pollution. Nonpoint sources are considered to be in compliance with the standard if approved best management practices (BMPs) have been implemented.

Statistics compiled by the US Department of Agriculture, Natural Resources Conservation Service indicate a statewide decline in erosion from 1982 to 1992 (USDA, NRCS, 1992) as shown in Table 3.1.

Table 3.1 Overall Erosion Trends in North Carolina

	1982	1987	1992
Area (1,000 acres)	33,708.2	33,708.2	33,708.2
Gross Erosion (1,000 tons/yr)	46,039.5	43,264.6	36,512.9
Erosion Rate (Tons/Yr/Ac)	1.4	1.3	1.1

The NRCS statistics also indicate a statewide reduction per acre on cropland erosion using the Universal Soil Loss Equation (Table 3.2).

Table 3.2 USLE Erosion on Cultivated Cropland in North Carolina

	1982	1987	1992
Cropland Area (1,000 acres)	6,318.7	5,956.8	5,538
Gross Erosion (1,000 tons/yr)	40,921.4	37,475.3	30,908.3
Erosion Rate (Tons/Yr/Ac)	6.5	6.3	5.6

While there is an overall 10-year downtrend statewide in the erosion rate on agricultural lands, the erosion rate/acre and the 10-year trends vary by region as shown in Table 3.3. The greatest improvement in erosion control is seen in the Southern Piedmont and Sand Hills with a small uptrend in the tidewater area and a significant increase in the mountains. In the mountain region, it is noted that while the 10-yr trend is up, the five-year trend from 1987 to 1992 was down. The reasons for the dramatic changes in the mountain basin erosion rates are not fully known. One factor changes in some erosion rates assigned to soils in this region. Another may be related to the growth in the Christmas tree industry. Christmas trees plantations are considered to be agricultural lands, and many of these are located on steep hillsides.

Table 3.3 North Carolina Erosion on Major Land Resource Areas (MLRA) in Tons/acre/yr

	1982	1987	1992
Blue Ridge Mountains	12.7	20.8	18.3
Southern Piedmont	12.3	12.0	10.5
Carolina and Georgia Sand Hills	6.0	5.6	5.1
Southern Coastal Plain	3.9	3.9	4.0
Atlantic Coast Flatwoods	3.2	3.1	3.2
Tidewater Area	1.4	1.5	1.6

Sedimentation in the Cape Fear River Basin

Sedimentation and erosion is the most widespread cause of freshwater stream impairment in the Cape Fear River Basin. Use support information presented in Table 4.13 of Chapter 4 indicates that over 600 miles of streams were thought to be impaired as a result of sedimentation. Sediment-related stream impairment is listed by subbasins. It should be pointed out that the most of the stream miles identified as being impaired by sediment are based on the best professional judgment of field personnel from various nonpoint source agencies that were presented at a series of nonpoint source workshops held in the mid to late 1980s. Accordingly, the figures presented here are, for the most part, at least eight years old and predate many advancements made in sediment control in several programs. The NRCS data indicate statewide improvements in overall erosion rates and in cropland erosion rates over the ten-year period from 1982 to 1992. Sections 5.3.1, 5.3.3 and 5.3.6 describe sediment control programs for agriculture, construction and forestry in which significant improvements have been made or mandated since 1989. Section 6.6 of Chapter 6 discusses strategies for improving sediment control.

3.2.5 Fecal Coliform Bacteria

Fecal coliforms are bacteria typically associated with the intestinal tract of warm-blooded animals and are widely used as an indicator of the potential presence of pathogenic, or disease-causing, bacteria and viruses. They enter surface waters from improperly treated discharges of domestic wastewater and from nonpoint source runoff. Common nonpoint sources of fecal coliforms include leaking or failing septic systems, leaking sewer lines or pump station overflows, runoff from livestock operations and wildlife.

Fecal coliforms are used as indicators of waterborne pathogenic organisms (which cause such diseases as typhoid fever, dysentery, and cholera) because they are easier and less costly to detect than the actual pathogens. Fecal coliform water quality standards have been established in order to ensure safe use of waters for water supplies, recreation and shellfish harvesting. The current State standard for fecal coliforms is 200 MF/100 ml for all waters except SA waters. MF is an abbreviation for the Membrane Filter procedure for determining fecal coliform concentrations. This procedure entails pouring a 100 ml water sample through a membrane filter. The filter is then placed on a cultured medium and incubated for a specified period of time. The number of colonies of bacteria that grow on the medium is then compared to the standard of 200 colonies per 100 ml. Fecal coliforms in treatment plant effluent are controlled through disinfection methods including chlorination (sometimes followed by dechlorination), ozonation or ultraviolet light radiation

Fecal Coliform Bacteria in the Cape Fear River Basin

According to Table 4.13 in Chapter 4, there are 26 miles of streams in subbasin 02 considered to be use-impaired due to elevated levels of fecal coliform bacteria at ambient monitoring stations. This impairment was determined based on stations where the geometric mean for all samples (minimum 10 samples) exceeded 200 MPN. In addition, there are approximately 4,800 acres of shellfish (SA) waters in the coastal portion of the basin that are closed to harvesting because of unacceptably high levels of fecal coliform bacteria (Table 4.14 of Chapter 4). Management strategies for addressing fecal coliform bacteria are presented in Section 6.9 of Chapter 6.

3.2.6 Color

Color in wastewater is generally associated with industrial wastewater or with municipal plants that receive certain industrial wastes, especially from textile manufacturers, that use dyes to color their fabrics, and from pulp and paper mills. For colored wastes, 15A NCAC 2B .0211(b)3(F) states that the point sources shall discharge only such amounts as will not render the waters injurious to public health, secondary recreation, or aquatic life and wildlife or adversely affect the palatability of fish, aesthetic quality or impair the waters for any designated uses. NPDES permit requirements regarding color are included on a case-by-case basis since no numeric standard exists for color, and because a discharger may have high color values but no visual impact instream due to dilution or the particular color of the effluent. While no waters in the basin have been identified as use-impaired due to color, color has been identified as a concern in several streams in subbasins 01, 02, 08 10 and 22. Section 6.8 in Chapter 6 discusses ongoing efforts to study color and to develop a realistic approach to addressing this problem.

3.3 POINT SOURCES OF POLLUTION

3.3.1 Defining *Point* Sources

Point sources refers to discharges that enter surface waters through a pipe, ditch or other well-defined points of discharge. The term most commonly refers to discharges associated with wastewater treatment plant facilities. These include *municipal* (city and county) and *industrial* wastewater treatment plants as well as small *domestic* discharging treatment systems that may serve schools, commercial offices, residential subdivisions and individual homes. In addition, discharges from *stormwater systems* at industrial sites are now considered point source discharges and are being regulated under new urban stormwater runoff regulations being required by the U.S. Environmental Protection Agency (EPA). The urban stormwater runoff program is discussed in more detail in Chapter 5 and Section 6.8 in Chapter 6. The primary water quality pollutants associated with point source pollution are oxygen-demanding wastes, nutrients, color and toxic substances including chlorine, ammonia and metals. In the Cape Fear River Basin, there are an estimated 181 miles of freshwater streams impaired due to point sources.

Point source discharges are not allowed in North Carolina without a permit from the state. Discharge permits are issued under the National Pollutant Discharge Elimination System (NPDES) program delegated to North Carolina from EPA. The amount or loading of specific pollutants that may be allowed to be discharged into surface waters are defined in the NPDES permit and are called *effluent limits*. Under the NPDES permitting program, each NPDES discharger is assigned either *major* or *minor* status. Major facilities are large with greater flows. For municipalities, all dischargers with a flow of greater than 1 million gallons per day (MGD) are classified as major. Most point source discharges, other than urban and industrial stormwater discharges, are continuous and do not occur only during storm events as do nonpoint sources. They generally have the most impact on a stream during low flow conditions when the percentage of stream flow composed of treated effluent is greatest. Permit limits are generally set to protect the stream during low flow conditions. The standard low flow used for determining point source impacts is called the *7Q10*. This is the lowest flow which occurs over seven consecutive days and which has an average recurrence of once in ten years.

Information is collected on NPDES permitted discharges in several ways. The major method of collection is facility self-monitoring data which are submitted monthly to the DWQ by each individual permittee. NPDES facilities are required to monitor for all pollutants for which they have limits as well as other pollutants which may be present in their wastewater. All domestic wastewater dischargers are required to monitor flow, dissolved oxygen, temperature, fecal coliform, BOD, ammonia, and chlorine (if they use it as a disinfectant). In addition, facilities with industrial sources may have to monitor for chemical specific toxicants and/or whole effluent toxicity (see Section 3.2.3); and all dischargers with design flows greater than 50,000 gallons per day (GPD) monitor for total phosphorus and total nitrogen. Minimum NPDES monitoring requirements are provided in 15A NCAC 2B .0500.

Other methods of collecting point source information include effluent sampling by DWQ during inspections and special studies. The regional offices may collect data at a given facility if they believe there may be an operational problem or as a routine compliance check. In addition, the DWQ may collect effluent data during intensive surveys of segments of streams, and extensive discharger data have been collected during onsite toxicity tests.

3.3.2 Point Source Discharges in the Cape Fear River

In the Cape Fear River Basin, there are 641 permitted NPDES dischargers. Table 3.1 summarizes the number of dischargers and their total permitted and actual 1993 flows for each subbasin and by broad categories of dischargers including majors, minors, domestic, municipal, industrial (process and nonprocess) and stormwater. A distribution map of the discharge facilities is shown in Figures 3.4a, b and c (upper, middle and lower basin).

Of the total 641 dischargers, 54 are major facilities, 228 are domestic, 58 are municipalities and 212 are industries. The total permitted flow for all facilities is 397 million gallons per day (MGD) with the actual measured flows being 524 MGD. The reason that the average actual flow is higher than the permitted flow is because some industrial discharges, such as those for cooling water, stormwater or nonprocess wastewater, do not have a total flow limit specified in their permit although they monitor and report total flow anyway. Meaningful comparisons between permitted and actual flows can be seen in the municipal and domestic wastewater categories where the actual flows are 60% and 47% of their respective permitted flows.

Table 3.5 lists municipal wastewater treatment facilities that accept discharges from industries that must be pretreat their wastes prior to discharging them to the municipal facility. These industries are referred to as significant industrial users or SIUs. The state's pretreatment program is described briefly in Section 5.2.6 in Chapter 5.

3.4 NONPOINT SOURCES OF POLLUTION

Nonpoint source (NPS) refers to runoff that enters surface waters through stormwater or snowmelt. There are many types of land use activities that can serve as sources of nonpoint source pollution including land development, construction, crop production, animal feeding lots, failing septic systems, landfills, roads and parking lots. As noted above, stormwater from large urban areas (>100,000 people) and from certain industrial sites is technically considered a point source since NPDES permits are required for piped discharges of stormwater from these areas. However, a discussion of urban runoff will be included in this section.

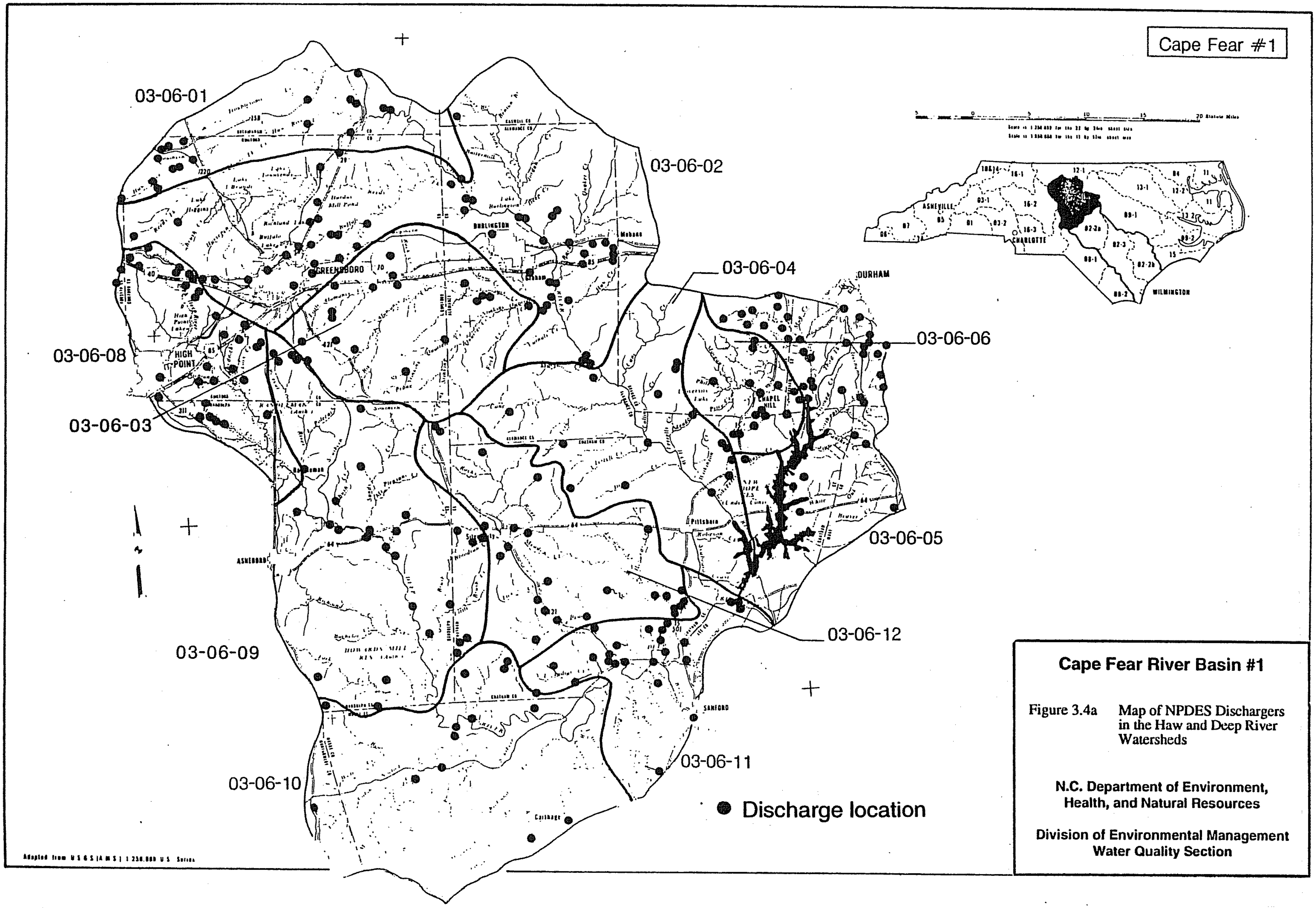
Sediment and nutrients are major pollution-causing substances associated with nonpoint source pollution. Others include fecal coliform bacteria, heavy metals, oil and grease, and any other substance that may be washed off the ground or removed from the atmosphere and carried into surface waters. Unlike point source pollution, nonpoint pollution sources are diffuse in nature and occur at random intervals depending on rainfall events. Below is a brief description of major areas of nonpoint sources of concern in the Cape Fear Basin.

3.4.1 Agriculture

There are a number of activities associated with agriculture that may impact water quality if not done properly. Land clearing and plowing render soils susceptible to erosion which in turn can cause stream sedimentation. Contour plowing, no-till conservation tillage, terracing and grassed waterways are several common methods used by most farmers to minimize soil loss. Maintaining a vegetated buffer between fields and streams is another excellent means of minimizing soil loss to streams although this practice is not always utilized because it may necessitate taking some land out of production. While sedimentation is the most widespread cause of stream impairment resulting from agricultural activities, it should be noted that statewide agricultural soil loss rates had dropped from 1982 to 1992 based on statistics compiled by the USDA Natural Resources Conservation Service (Section 3.2.4).

Table 3.4 Summary of NPDES Discharger Data in the Cape Fear River Basin by Category and Subbasin (6/1/93 to 6/1/94)

	SUBBASINS																								
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
Total Facilities	21	105	23	23	36	19	38	52	36	13	21	22	15	16	23	8	89	13	10	2	4	26	19	7	641
Facs. w/o Stmwtr & Gen Perm.	14	39	11	9	7	8	19	27	19	5	7	4	6	11	6	6	67	3	7	2	3	13	6	6	305
Total Permitted Flow (MGD)	7.76	69.46	0.15	0.84	26.68	23.24	13.22	16.23	8.49	1.76	6.02	4.02	9.03	2.72	37.91	8.21	141.96	0.10	4.33	0.62	1.40	9.85	2.45	0.12	396.57
# of Facilities Reporting	12	34	11	9	6	6	18	25	16	5	7	4	6	9	6	6	52	2	7	2	2	11	6	3	265
Total Avg. Flow (MGD)	3.14	50.88	0.41	0.45	13.28	10.53	282.27	17.56	6.21	0.84	3.91	1.92	5.11	6.39	22.00	18.65	68.42	0.02	3.03	0.58	1.24	5.18	1.32	0.33	523.67
Major Dischargers	2	8	0	0	2	1	5	1	2	1	1	1	3	2	4	3	12	0	1	0	2	2	1	0	54
Total Permitted Flow (MGD)	7.59	67.30	0.00	0.00	26.00	8.00	11.59	16.00	7.75	1.00	5.00	4.00	6.70	1.50	37.89	7.50	36.63	0.00	3.00	0.00	1.40	5.97	1.07	0.00	255.88
# of Facilities Reporting	2	8	0	0	2	1	5	1	2	1	1	1	3	2	4	3	11	0	1	0	2	2	1	0	53
Total Avg. Flow (MGD)	2.96	48.66	0.00	0.00	12.43	6.87	281.17	11.47	5.75	0.57	3.22	1.92	4.79	6.21	21.41	17.87	63.77	0.00	2.10	0.00	1.24	2.70	0.67	0.00	495.79
Minor Dischargers	12	31	11	7	5	7	11	26	16	4	6	3	3	9	2	3	55	3	6	2	1	11	5	6	245
Total Permitted Flow (MGD)	0.17	2.16	0.15	0.84	0.68	15.24	1.63	0.23	0.75	0.76	1.02	0.02	2.33	1.22	0.03	0.71	5.33	0.10	1.33	0.62	0.00	3.88	1.38	0.12	40.69
# of Facilities Reporting	10	26	11	9	4	5	13	24	14	4	6	3	3	7	2	3	41	2	6	2	0	9	5	3	212
Total Avg. Flow (MGD)	0.18	2.22	0.41	0.45	0.85	3.65	1.10	6.09	0.46	0.27	0.69	0.01	0.32	0.18	0.59	0.78	4.65	0.02	0.93	0.53	0.00	2.48	0.65	0.33	27.83
100% Domestic Wastewater	12	31	14	20	27	13	10	14	23	5	11	16	1	6	1	1	17	1	1	1	0	0	3	0	228
Total Permitted Flow (MGD)	0.17	0.62	0.15	0.06	0.68	0.13	0.12	0.23	0.20	0.01	0.01	0.02	0.33	1.13	0.03	0.01	1.82	0.05	0.01	0.02	0.00	0.00	0.23	0.02	6.04
# of Facilities Reporting	9	18	10	5	3	2	5	11	8	2	2	3	1	5	1	1	16	1	1	1	0	0	3	0	108
Total Avg. Flow (MGD)	0.05	0.22	0.09	0.04	0.19	0.07	0.02	0.14	0.07	0.01	0.00	0.01	0.21	0.18	0.00	0.00	0.39	0.01	0.00	0.06	0.00	0.00	0.08	0.00	1.84
Municipal Facilities	1	6	0	2	2	2	4	2	3	3	1	1	2	2	3	1	9	0	6	1	1	4	1	1	58
Total Permitted Flow (MGD)	7.50	66.00	0.00	0.78	26.00	8.00	2.20	16.00	8.23	1.75	5.00	4.00	4.20	1.56	37.00	0.70	28.09	0.00	4.33	0.60	1.00	1.88	0.50	0.10	225.40
# of Facilities Reporting	1	6	0	2	2	1	4	1	3	3	1	1	2	2	3	1	6	0	6	1	1	4	1	1	53
Total Avg. Flow (MGD)	2.88	47.59	0.00	0.35	12.43	6.87	1.41	11.47	5.96	0.83	3.22	1.92	1.48	0.83	20.92	0.52	13.85	0.00	3.03	0.51	0.84	1.02	0.27	0.08	138.29
Major Process Industrial	2	2	0	0	0	0	4	0	0	0	0	0	1	1	1	3	8	0	0	0	1	2	1	0	26
Total Permitted Flow (MGD)	0.09	1.30	0.00	0.00	0.00	0.00	10.39	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.89	7.50	110.78	0.00	0.00	0.00	0.40	5.97	1.07	0.00	140.88
# of Facilities Reporting	1	2	0	0	0	0	4	0	0	0	0	0	1	1	1	3	8	0	0	0	1	2	1	0	25
Total Avg. Flow (MGD)	0.08	1.08	0.00	0.00	0.00	0.00	280.34	0.00	0.00	0.00	0.00	0.00	1.67	5.39	0.49	17.87	50.28	0.00	0.00	0.00	0.40	2.70	0.67	0.00	360.96
Minor Process Industrial	0	8	1	0	0	2	4	14	2	1	3	0	2	0	0	2	17	2	0	0	0	3	2	1	64
Total Permitted Flow (MGD)	0.00	0.04	0.00	0.00	0.00	0.11	0.51	0.00	0.07	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.91	0.05	0.00	0.00	0.00	2.00	0.65	0.00	5.35
# of Facilities Reporting	0	5	0	0	0	2	4	12	4	0	2	0	0	0	0	1	14	1	0	0	0	4	1	1	51
Total Avg. Flow (MGD)	0.00	1.66	0.00	0.00	0.00	0.07	0.46	5.48	0.11	0.00	0.49	0.00	0.00	0.00	0.00	0.25	0.72	0.01	0.00	0.00	0.00	1.46	0.30	0.25	11.25
Nonprocess Industrial	1	21	2	2	2	1	5	4	3	2	3	3	4	5	6	0	27	3	1	0	1	13	8	5	122
Total Permitted Flow (MGD)	0.00	1.50	0.00	0.00	0.00	15.00	0.00	0.00	0.00	0.00	0.01	0.00	2.00	0.02	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.90
# of Facilities Reporting	1	3		2	1	1	1	1	1	0	2	0	2	1	1	0	8	0	0	0	0	1	0	1	27
Total Avg. Flow (MGD)	0.13	0.34	0.32	0.06	0.66	3.51	0.04	0.47	0.07	0.00	0.19	0.00	0.11	0.01	0.58	0.00	2.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.22
Stormwater Facilities	5	37	6	1	5	1	11	18	5	2	3	2	5	2	12	1	11	7	2	0	1	4	4	0	145
Total Avg. Flow (MGD)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

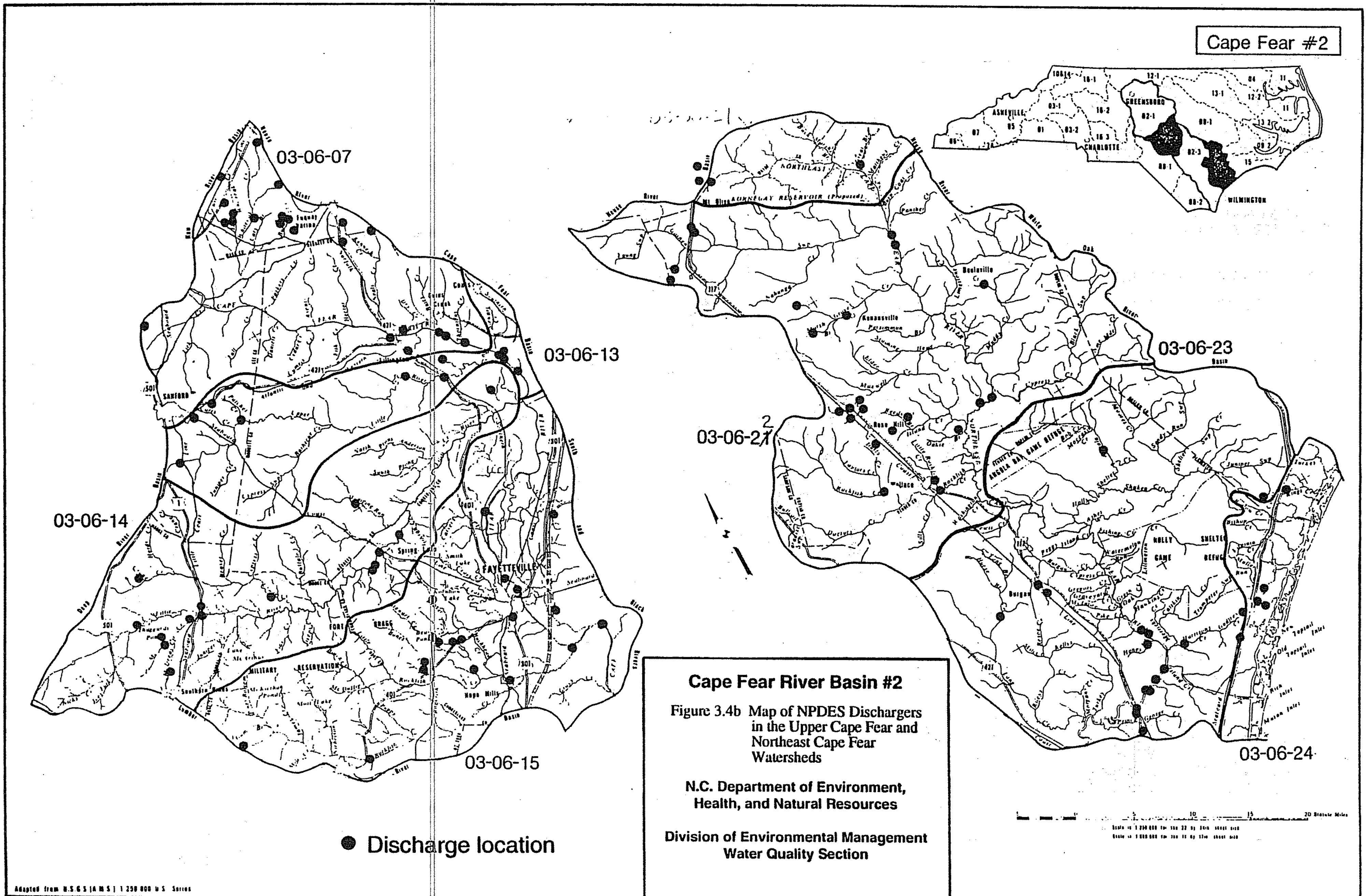


Cape Fear River Basin #1

Figure 3.4a Map of NPDES Dischargers in the Haw and Deep River Watersheds

N.C. Department of Environment, Health, and Natural Resources

Division of Environmental Management Water Quality Section

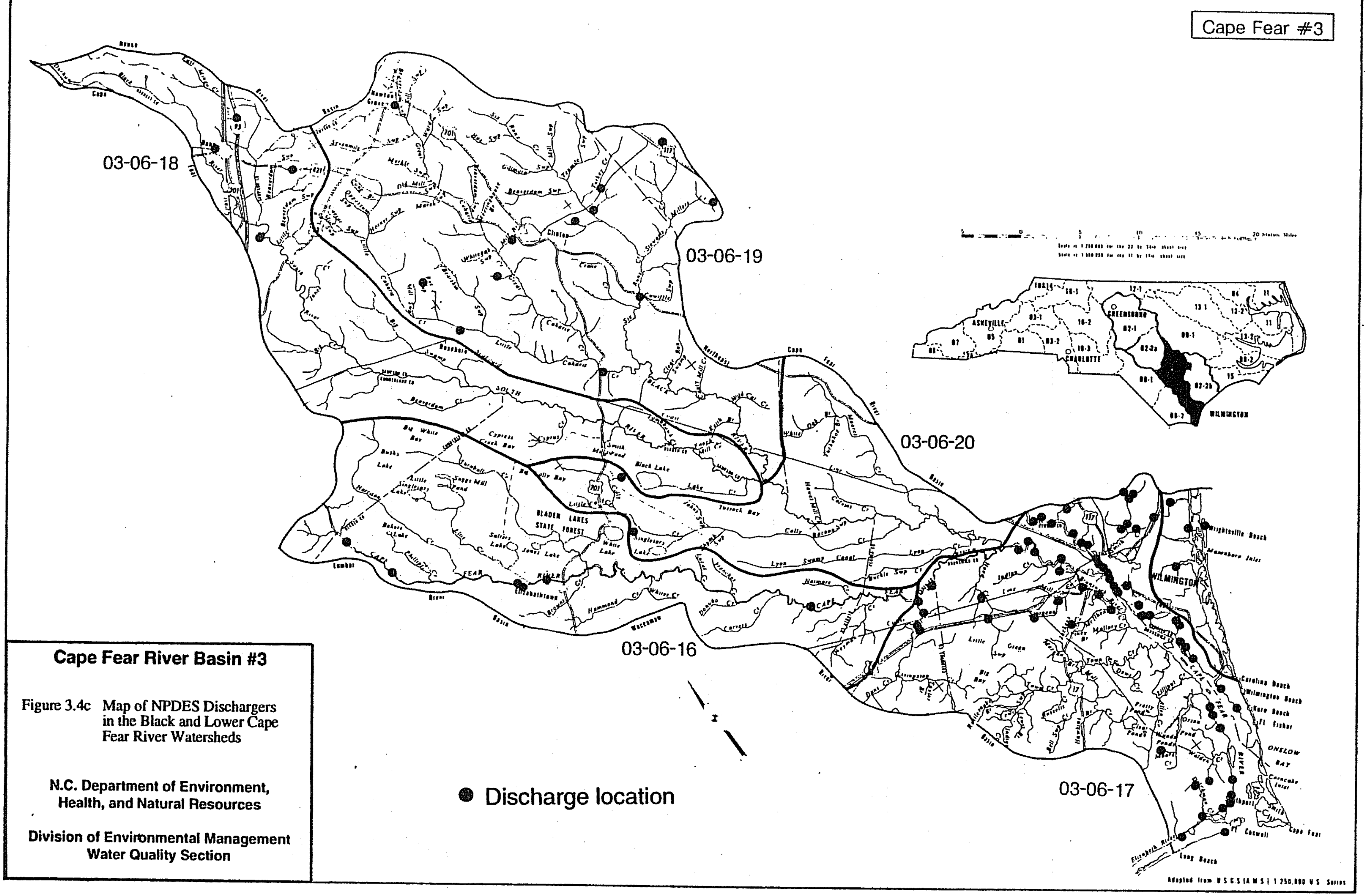


Cape Fear River Basin #2

Figure 3.4b Map of NPDES Dischargers in the Upper Cape Fear and Northeast Cape Fear Watersheds

N.C. Department of Environment, Health, and Natural Resources

Division of Environmental Management Water Quality Section



Cape Fear River Basin #3

Figure 3.4c Map of NPDES Dischargers in the Black and Lower Cape Fear River Watersheds

N.C. Department of Environment, Health, and Natural Resources

Division of Environmental Management Water Quality Section

Table 3.5 NPDES Facilities in the Cape Fear River Basin with Pretreatment Programs

Subbasin	Facility Name	NPDES or ND #	WWTP SIUs	Region
01	Reidsville	NC0024881	10	Winston-Salem
02	Graham	NC0021211	9	Winston-Salem
	Burlington-S	NC0023876	19	Winston-Salem
	Burlington-E	NC0023868	13	Winston-Salem
	Greensboro-N. Buffalo	NC0024325	11	Winston-Salem
	Greensboro-T.Z. Osborne	NC0047384	21	Winston-Salem
	Mebane	NC0021474	10	Winston-Salem
05	Durham-Farrington	NC0047597	6	Raleigh
	Durham County-RTP	NC0026051	23	Raleigh
06	OWASA	NC0025241	0	Raleigh
07	Fuquay-Varina	NC0028118	2	Raleigh
	High Point-W	NC0024228	7	Winston-Salem
	Lillington	NC0021636	1	Fayetteville
	Thomasville	NC0024112	12	Winston-Salem
08	Randleman	NC0025445	5	Winston-Salem
	High Point-Eastside	NC0024210	26	Winston-Salem
09	Ramseur	NC0026565	1	Winston-Salem
	Asheboro	NC0026123	13	Winston-Salem
10	Star	NC0058548	4	Fayetteville
	Robbins	NC0062855	3	Fayetteville
	Candor	ND9900633	1	Fayetteville
11	Sanford	NC0024147	13	Raleigh
12	Siler City	NC0026441	5	Raleigh
15	Fayetteville-Rockfish Cr	NC0050105	6	Fayetteville
	Fayetteville-Cross Creek	NC0023957	13	Fayetteville
16	Elizabethtown	NC0026671	1	Fayetteville
17	Wilmington-Northside	NC0023965	5	Wilmington
19	Clinton	NC0020117	7	Fayetteville
23	Burgaw	NC0021113	1	Wilmington

NPDES or ND# = Facility's discharge permit no.
POTW = Publicly Owned Treatment Work
SIU = Significant Industrial User

Improper application of pesticides and fertilizers (including chemical fertilizers, manure and spray application of lagoon wastewater) can result in these substances being washed from fields. Field buffers would again minimize this potential problem. Improperly designed storage or disposal sites can also be a problem. Construction of drainage ditches on poorly drained soils enhances the movement of stormwater into surface waters, and channelization of natural streams destroys habitat values. In addition, use of small streams for irrigation can dewater the streams and cause severe localized impacts.

Animal wastes are of particular interest in the Cape Fear River Basin because of the high swine and poultry populations (See Table 2.6 and Figures 2.6 and 2.7 in Chapter 2). Concentrated animal operations can be a significant source of nutrients, biochemical oxygen demand and fecal coliform bacteria if wastes are not properly managed (see Section 5.3.1 of Chapter 5 for discussion of animal waste rules). Impacts can result from overapplication of wastes to fields, from leaking lagoons and from unpermitted flows of lagoon liquids to surface waters from improper waste lagoon management. At the present time, widespread water quality impacts from animal operations have not been documented, but localized impacts have been found. Also there are potential concerns associated with nitrate-nitrogen movement through the soil from poorly constructed lagoons and from wastes overapplied to the soil surface (i.e., in excess of agronomic rates).

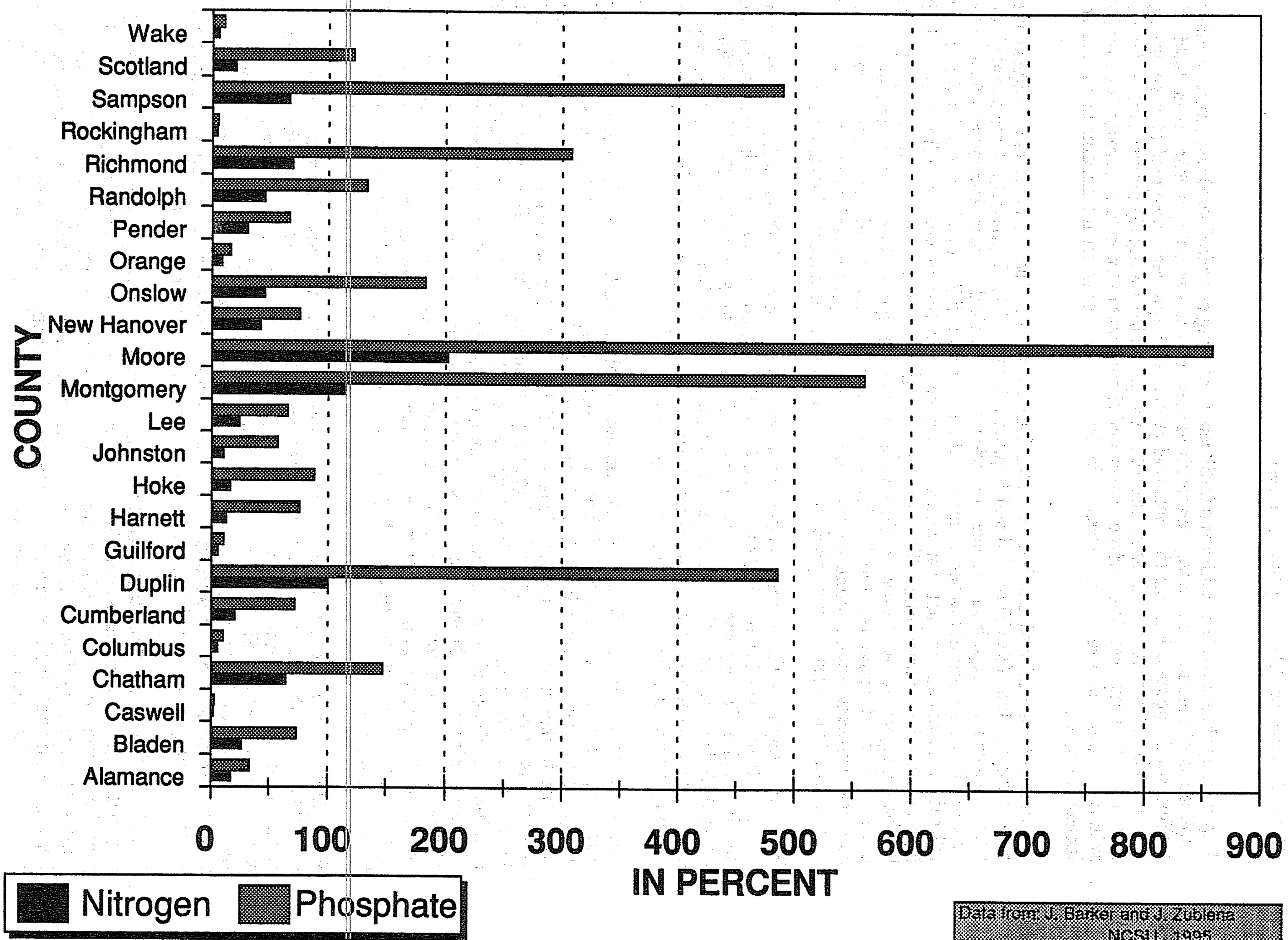
Five major lagoon spills occurred in the state during the summer of 1995 and four of these were in the Cape Fear River basin. Of those in the Cape Fear Basin, two occurred in Sampson County, one in Duplin County and one in Brunswick County. As September 25, 1995, 60% of the concentrated animal operations in those counties located in the Cape Fear basin had been inspected. Of this total, seven operations were found to have a discharge into state waters by man-made ditch, flushing system, or other similar man-made devices.

The bar chart in Figure 3.5 presents the amount of plant available nutrients from manure as a percentage of plant nutrient needs (defined as non-legume agronomic crop and forage nitrogen and phosphorus) for each county in the Cape Fear River basin. These nutrient data were calculated by Dr. James Barker and Dr. Joseph Zublena of NCSU for a draft report entitled "Livestock Manure Nutrient Assessment in North Carolina" (Barker and Zublena, 1995). The report was initiated to: 1) geographically depict where the livestock are located and identify "clustering effects", i.e., high densities of livestock production around support facilities such as feed mills, hatcheries, processing plants, etc.; 2) assess current generation of manure by county; 3) determine the amount of nutrients from manure which can be recovered and made available to agronomic crops; 4) determine the quantity of nutrients required for non-legume agronomic crops and forages in each county; and 5) calculate the percent of agronomic crop and forage nutrients which can be supplied by animal manure.

As explained in the report, plant recoverable manure nutrients are those that remain from the time the animal voids the manure till the time it is transported to the field for spreading. During this period, much of the nutrients can be lost through drying or dilution, surface runoff, volatilization or microbial digestion. Since different manure management systems either conserve or sacrifice varying amounts of nutrients, an estimate was made of the percentage of farms using specific systems. These percentages were applied to the manure characteristics appropriate to the specific method which gave the remaining nutrients after storage and treatment losses.

As indicated in Figure 3.5, plant available nitrogen from manure equals or exceeds 100% of the crop and forage plant nitrogen needs in Duplin, Montgomery and Moore Counties. Plant available phosphorus from manure equals or exceeds 100% of the plant phosphorus needs in Chatham, Duplin, Montgomery, Moore, Onslow, Randolph and Sampson Counties. It should be noted that these figures do not take into account commercial fertilizer applications in the counties. It is clear based on this information, that animal waste management in a number of counties in the basin is

Figure 3.5 Percent of Agronomic Crop and Forage [1]Nitrogen and Phosphorus Needs Supplied by Recoverable Plant Available Manure Nutrients (NCSU 1995)



[1] Non-legume crops only

becoming a critical issue, and that the animal carrying capacity of these lands (from a waste disposal standpoint) needs to be closely examined. Alternatives to cropland application need to be considered in these counties such as application on forest land or transportation/distribution of the collectable manure to counties that have capacity and could use this nutrient source in lieu of commercial fertilizers.

In the Cape Fear River Basin, it is estimated that 462 (or 40%) of the miles of freshwater streams estimated to be impaired from nonpoint sources of pollution are thought to be attributed to agriculture. The highest number of impaired stream miles in any subbasin attributed to agriculture is 73 miles in subbasin 22 (Duplin County portion of the Northeast Cape Fear watershed). Other subbasins with 20 or more stream miles thought to be impaired by agriculture include 31 miles in subbasin 01 (upper Haw River), 44 miles in subbasin 03 (Alamance Creek watershed), 47 miles in subbasin 11 (Deep River watershed in Chatham and Lee Counties), 32 miles in subbasin 16 (Cape Fear river drainage in Bladen County) and 44 miles in subbasin 18 (upper South River watershed). This information is derived from the table in Section 4.5 of Chapter 4 entitled Probable Sources of Use Support Impairment.

While, as noted above, the most widespread cause of freshwater stream impairment associated with agriculture is sedimentation, other potential concerns include nutrients, fecal coliform bacteria and biochemical oxygen demand. Nutrient-related problems, primarily seen as excessive algal or aquatic weed growth, are not always evident in the receiving stream adjoining a farm. Rather, they may be seen in a downstream impoundment, sluggish creek or estuary many miles away. Jordan Reservoir watershed, for example, is classified as nutrient sensitive waters. And there are a number of lakes in the basin that are threatened by nutrient overenrichment. In regard to pesticides, a number of fish tissue samples taken from the basin have shown concentrations of organic chemicals such as chlordane, DDT and dieldrin (Table 4.2 in Chapter 4). Chapter 5 discusses programs aimed at minimizing agricultural nonpoint source pollution. Recommended management strategies for reducing nutrients and sediment runoff are found in Sections 6.4 and 6.6 respectively, in Chapter 6. A list of agricultural BMPs is included in Appendix V.

3.4.2 Urban

Runoff from urbanized areas, as a rule, is more localized but generally more severe than agricultural runoff. The rate and volume of runoff in urban areas is much greater due both to the high concentration of impervious surface areas and to storm drainage systems that rapidly transport stormwater to nearby surface waters. These drainage systems, including curb and guttered roadways, allow urban pollutants to reach surface waters quickly and with little or no filtering by vegetated areas. These affects are further exacerbated by replacement of small streams and riparian vegetation with pipes. Urban pollutants include lawn care products such as pesticides and fertilizers; automobile-related pollutants such as fuel, lubricants, abraded tire and brake linings; lawn and household wastes (often dumped in storm sewers); and fecal coliform bacteria (from animals and failing septic systems). Many urban streams are rated as biologically poor. The population density map in Chapter 2 is a good indicator of where urban development and potential urban stream impacts are likely to occur. As summarized in Table 4.12 in Chapter 4, it is estimated that there are approximately 200 miles of streams in the Cape Fear Basin that are thought to be impaired due to urban runoff. Those subbasins with the greatest number of impaired miles associated with urban runoff include 44 miles in subbasin 02 (Greensboro/Burlington area), 30 miles in subbasin 05 (Durham/Chapel area), 41 miles in subbasin 15 (Fayetteville area) and 19 miles in subbasin 23 (Pender and Onslow county area).

3.4.3 Construction

Construction activities that entail excavation, grading or filling, such as road construction or land clearing for development, can produce large amounts of sediment if not properly controlled. As a pollution source, construction-related activities are temporary in nature; however, as discussed under the section on sediment, above, the results can be severe and long-lasting.

Those areas where construction-related impacts are most obvious tend to be concentrated in the more rapidly developing areas of the basin. For example, subbasin 17, which includes much of the Brunswick and New Hanover County portion of the basin was estimated to have nearly 50 miles of streams impaired due to construction activities; and subbasin 05, which includes portions of Durham, Orange, Wake and Chatham Counties around Jordan Lake was estimated to have 36 miles impaired by construction. However, localized, but significant impacts are possible in every subbasin if adequate best management practices are not applied. As summarized in Table 4.12 in Chapter 4, it is estimated there are 150 miles of streams impaired due to construction activity in the basin. A list of BMPs to address construction-related water quality impacts is presented in Appendix V.

3.4.4 Forestry

Forestry, a major industry in North Carolina, can impact water quality in a number of ways. Ditching and draining of naturally forested low-lying lands in order to create pine or hardwood plantations can change the hydrology of an area and significantly increase the rate and flow of stormwater runoff. Clearing of trees through timber harvesting and construction of logging roads can produce sedimentation. Removing riparian vegetation along stream banks can cause water temperature to rise substantially, and improperly applied pesticides can result in toxicity problems. Timber harvesting occurs throughout much of the upper basin and is often done at the onset of clearing for site development. As summarized in Table 4.12 in Chapter 4, there were an estimated 23 miles of streams impaired due to forestry activities in subbasins 08, 09 and 17 based on public nonpoint source workshops in the late 1980s. A list of forestry BMPs is presented in Appendix V.

3.4.5 Mining

Mining is a common activity in the Piedmont and Coastal Plain regions and can produce high localized levels of stream sedimentation. Sediment may be washed from mining sites or it may enter streams from the wash water used to rinse some mined products. In addition, abandoned gold mined lands are suspected of being the sources of mercury in stream waters because of its historic use for the amalgamation of gold. The most prevalent type of mining activity in the Cape Fear River basin is for sand and gravel. It is estimated that 34 miles of streams have been impaired by mining activities in subbasins 02, 07, 08 and 11 according to Table 4.12 in Chapter 4. A list of BMPs to address mining is presented in Appendix V.

3.4.6 Onsite Wastewater Disposal

Septic tank soil absorption systems are the most widely used method of on-site 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.

Onsite wastewater disposal is most prevalent in rural portions of the basin and at the fringes of urban areas. Nutrients from failing septic systems also contribute to eutrophication problems in some impoundments and coastal waters. A list of BMPs for onsite wastewater disposal is presented in Appendix V.

3.4.7 Solid Waste Disposal

Solid wastes may include household wastes, commercial or industrial wastes, refuse or demolition waste, infectious wastes or hazardous wastes. Improper disposal of these types of wastes can serve as a source of a wide array of pollutants. The major water quality concern associated with modern solid waste facilities is controlling the leachate and stabilizing the soils used for covering many disposal facilities. Properly designed, constructed and operated facilities should not significantly effect water quality.

3.4.8 Atmospheric Deposition

Recent studies in Europe (Buijisman et al. 987; Loye-Pilot et al. 1990; Fischer and Oppenheimer. 1991) and North American (NAPAP 1990; Paerl 1993; 1995) indicate that the atmosphere serves a quantitatively-important, and rapidly-growing, role in the emission and transport of anthropogenically-generated nitrogen (N) compounds. Sources include agricultural emissions of ammonia/ammonium (NH_3/ NH_4) and organic N from animal wastes and fertilizer applications, and oxides of N (NOx) emitted from fossil fuel combustion. Atmospheric deposition of N is of considerable concern from watershed and larger regional perspectives, because nitrogen is often the nutrient controlling (or limiting) plant primary production (algae and higher plants) in downwind estuarine and coastal waters (Ryther and Dunstan 1971; Nixon 1986). Excessive N loading has been implicated as a chief cause of coastal eutrophication and associated toxic algal blooms, which have increased at an alarming rate in NC waters (Paerl 1993). There is evidence that atmospherically-derived N, either as direst deposition or surface water runoff, represents a significant fraction (25->50%) of anthropogenically-derived "new" N being loaded into these waters (Duce et al. 1991; Fischer and Oppenheimer 1991). Overall, it is the second largest source (behind surface nonpoint N loading) of N impacting estuaries and coastal waters.

Coastal waters in which N is a concern include the Neuse, Tar-Pamlico, White Oak and New Rivers. The Cape Fear River estuary, unlike those of the other river systems, is open to the ocean, has much better tidal exchange and is much less conducive to algal growth than the other systems.

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