Section A: Chapter 4
Water Quality Issues Related to Multiple Watersheds in the Yadkin-Pee Dee River Basin

4.1 Overview

This chapter discusses water quality issues that relate to multiple watersheds within the basin. Habitat degradation, including sedimentation, which results from a variety of activities in the watershed, is the most prevalent water quality problem in the Yadkin-Pee Dee River basin. Other issues related to water quality include fish tissue contamination, population growth and urbanization. There are also a wide variety of concerns related to water quantity and flow management.

4.2 Habitat Degradation

Instream habitat degradation is identified in the use support summary (Appendix III) where there is a notable reduction in habitat diversity or a negative change in habitat. This term includes sedimentation, bank erosion, channelization, lack of riparian vegetation, loss of pools or riffles, loss of woody habitat, and streambed scour. Good instream habitat is necessary for aquatic life to survive and reproduce. Streams that typically show signs of habitat degradation are in watersheds that have a large amount of land-disturbing activities (construction, mining, timber harvest and agricultural activities) or a large percentage of impervious surfaces. A watershed in which most of the riparian vegetation has been removed from streams or channelization has occurred also exhibits instream habitat degradation. Streams that receive a discharge quantity that is much greater than the natural flow in the stream often have degraded habitat as well.

Determining the cause and quantifying amounts of habitat degradation is very difficult in most cases. To assess instream habitat degradation in most streams would require extensive technical and monetary resources and perhaps even more resources to restore the stream. Although DWQ and other agencies are starting to address this issue, local efforts are needed to prevent further instream habitat degradation and to restore streams that have been Impaired by activities that cause habitat degradation. As point sources become less of a source of water quality impairment, nonpoint sources that pollute water and cause habitat degradation need to be addressed to further improve water quality in North Carolina's streams and rivers.

4.2.1 Sedimentation

Introduction

Soil erosion, transport and redeposition are among the most essential natural processes occurring in watersheds. However, land-disturbing activities such as the construction of roads and buildings, crop production, livestock grazing and timber harvesting can accelerate erosion rates by causing more soil than usual to be detached and moved by water. If best management

practices (BMPs) are not used effectively, accelerated erosion can strip the land of its topsoil, decreasing soil productivity and causing sedimentation in streams and rivers (NCDENR-DLR, 1998). Sedimentation is the process by which eroded soil is deposited into waters. Sediment that accumulates on the bottom of streams and rivers smothers aquatic insects that fish feed upon and buries fish habitat that is vital to reproduction. Sediment filling rivers and streams decreases their storage volume and increases the frequency of floods (NCDENR-DLR, 1998).

Suspended sediment can decrease primary productivity (photosynthesis) by shading sunlight from aquatic plants, affecting the overall productivity of a stream system. Suspended sediment also has several effects on various fish species including avoidance and redistribution, reduced feeding efficiency, and therefore, reduced growth by some species, respiratory impairment, reduced tolerance to diseases and toxicants, and increased physiological stress (Roell, June 1999). Suspended sediment also increases the cost of treating municipal drinking water.

During 1999 basinwide monitoring, DWQ aquatic biologists reported streambank erosion and sedimentation throughout the Yadkin-Pee Dee River basin that was moderate to severe. Lower bioclassification ratings were assigned because of sedimentation; bottom substrate was embedded by silt and/or pools were partially filled with sediment. Unstable and/or undercut (eroding) streambanks were also noted in explanation of lower ratings (NCDENR-DWQ, June 2002).

Some Best Management Practices

Agriculture

- Using no till or conservation tillage practices
- Fencing livestock out of streams and rivers
- Leaving natural buffer areas around small streams and rivers

Construction

- Using phased grading/seeding plans
- Limiting time of exposure
- Planting temporary ground cover
- Using sediment basins and traps

Forestry

- Controlling runoff from logging roads
- Replanting vegetation on disturbed areas
- Leaving natural buffer areas around small streams and rivers

Land Clearing Activities

Erosion and sedimentation can be controlled during most land-disturbing activities by using appropriate BMPs. In fact, substantial amounts of erosion can be prevented by planning to minimize the (1) amount and (2) time the land is exposed. DWQ's role in sediment control is to work cooperatively with those agencies that administer sediment control programs in order to maximize the effectiveness of the programs and to protect water quality. Where programs are not effective, as evidenced by a violation of instream water quality standards, and where DWQ can identify a source, then appropriate enforcement action can be taken. Generally, this entails requiring the landowner or responsible party to install acceptable BMPs.

As a result of new stormwater rules enacted by EPA in 1999, construction or land development activities that disturb one acre or more are required to obtain a NPDES stormwater permit (refer to page 37). An erosion and sediment control plan must also be developed and approved for these sites under the state's Sedimentation Pollution Control Act (SPCA) administered by the NC Division of Land Resources. Site disturbances of less than one acre are required to use BMPs, but a plan is not required.

Forestry operations in North Carolina are subject to regulation under the Sedimentation Pollution Control Act of 1973 (G.S. Chapter 113A, Article 4 referred to as "SPCA"). However, forestry operations may be exempted from the permit requirements in the SPCA, if the operations meet compliance standards outlined in the *Forest Practices Guidelines Related to Water Quality* (15A NCAC 1I .0101-.0209, referred to as "FPGs") and General Statutes regarding stream obstruction (G.S. 77-13 and G.S. 77-14). Detailed information is available on the Water Quality Section of the DFR's website at http://www.dfr.state.nc.us.

For agricultural activities which are not subject to the SPCA, sediment controls are carried out on a voluntary basis through programs administered by several different agencies (see Appendix VI for further information).

Stronger Rules for Sediment Control

The Division of Land Resources (DLR) has the primary responsibility for assuring that erosion is minimized and sedimentation is reduced. In February 1999, the NC Sedimentation Control Commission adopted significant changes for strengthening the Erosion and Sedimentation Control Program. The following rule changes were filed as temporary rules, subject to approval by the Rules Review Commission and the NC General Assembly (NCDENR-DLR, July-September 1999):

- Allows state and local erosion and sediment control programs to require a preconstruction conference when one is deemed necessary.
- Reduces the number of days allowed for establishment of ground cover from 30 working days to 15 working days and from 120 calendar days to 90 calendar days. (Stabilization must now be complete in 15 working days or 90 calendar days, whichever period is shorter.)
- Provides that no person may initiate a land-disturbing activity until notifying the agency that issued the plan approval of the date the activity will begin.
- Allows assessment penalties for significant violations upon initial issuance of a Notice of Violation (NOV).

Additionally, during its 1999 session, the NC General Assembly passed House Bill 1098 to strengthen the Sediment Pollution Control Act of 1973 (SPCA). The bill made the following changes to the Act (NCDENR-DLR, July-September 1999):

- Increases the maximum civil penalty for violating the SPCA from $500 to $5000 per day.
- Provides that a person may be assessed a civil penalty from the date a violation is detected if the deadline stated in the Notice of Violation is not met.
- Provides that approval of an erosion control plan is conditioned on compliance with federal and state water quality laws, regulations and rules.
- Provides that any erosion control plan that involves using ditches for the purpose of de-watering or lowering the water table must be forwarded to the Director of DWQ.
- Amends the General Statutes governing licensing of general contractors to provide that the State Licensing Board for General Contractors shall test applicants' knowledge of requirements of the SPCA and rules adopted pursuant to the Act.
- Removes a cap on the percentage of administrative costs that may be recovered through plan review fees.

For information on North Carolina's Erosion and Sedimentation Control Program or to report erosion and sedimentation problems, visit the new website at http://www.dlr.enr.state.nc.us/ or you may call the NC Division of Land Resources, Land Quality Section at (919) 733-4574.

Recent Review of Sediment Control Research

The two most popular sediment control devices are silt fences and sediment basins. In 2001, DWQ staff conducted a review of peer-reviewed research publications and consulted with experts at NC State University (NCSU) to investigate the effectiveness of current sediment and erosion control practices. In addition, engineering calculations have been conducted to obtain theoretical effectiveness of sediment basins and silt fences. Research conducted in North Carolina showed that construction sites in North Carolina produce 10-188 tons per acre per year of sediment. Such wide variation might be attributed to the significant spatial and temporal differences in rainfall intensity and duration, soil characteristics, slope, and the type of soil cover. DLR currently uses the assumption that (on average) construction sites produce 84 tons/acre-year. For comparison, erosion in undisturbed natural systems is only 0.1-0.2 tons/acre-year.

Currently, sediment basins are designed to have 1,800 cubic feet of storage space for each acre of disturbed land. Based on the reference review and consultation, DWQ has concluded that these basins have numerous deficiencies, including:

1. Insufficient volume. [Pennsylvania requires 5,000 cubic feet; Maryland and Virginia require 3,600 cubic feet.]
2. Inadequate cleaning frequency. [In many cases, effectiveness of the basins is significantly reduced because they are only cleaned once a year.]
3. Short-circuiting. [In many cases, inlet and outlet in basins are constructed in very close proximity, which results in a shorter than predicted retention time.]
4. Water is not being removed from the surface where concentration of the sediment is the lowest.
5. Basins are designed with consideration of only cleared land. [In many cases, basins are treating runoff from the entire drainage area, which is significantly larger than that of cleared land.]

A sedimentation basin that is ideally designed and constructed is only able to capture 55 percent of all sediment in runoff. As a result, each acre of cleared land will deliver 38 tons of sediment to the waterways each year. After six months of operation, the effectiveness of the sediment basin will be reduced to 33 percent and the loss of sediment will approach 56 tons/acre-year.

Silt fences are even less effective. A typical silt fence can capture only 22 percent of all particles in runoff. Very often, they are improperly installed and receive inadequate maintenance that results in further reduction in their effectiveness.

New research indicates that use of new technologies such as installation of baffles in the sediment basins, application of flocculents, and use of skimmers can significantly increase efficiency of sedimentation basins. Experiments conducted at NCSU demonstrated that the current turbidity standard of 50 NTU (for waters not classified Tr) can be achieved in runoff if these devices are used. However, the most important factor in reducing sedimentation is timely

cover of cleared land with mulches or use of the flocculent solutions to prevent erosion. It has been conclusively proven that use of ground cover (temporary or permanent) dramatically reduces erosion rates.

Instream Mining Operations

The composition of the streambed and banks is an important facet of stream character, influencing channel form and hydraulics, erosion rates, sediment supply and other parameters. Channel bed and bank materials determine the extent of sediment transport and provide the means of dissipating energy in a stream or river. For a stream to be stable it must be able to consistently transport its sediment load, both in size and type, associated with local deposition and scour. Channel instability occurs when the scouring process leads to degradation (deepening or lowering channel elevation) or excess sediment results in aggradation (filling or raising channel elevation) (Rosgen, 1996).

In addition to physical stream changes, sedimentation and increased turbidity also can accrue from mining activities, wash water discharge, and storm runoff from active or abandoned mining sites. Other effects may include higher stream temperatures and reduced dissolved oxygen, lowering of the water table, and decreased wet periods in riparian wetlands. Expansion of a mine site or mining at a new site is often preceded by riparian forest clearing, which can affect instream habitat and contribute to bank instability (Meador and Layher, November 1998).

Two Types of Instream Mining Permits

Sand Dipping – Removes sand from the river bottom through the use of a dragline (a crane with a bucket) that sits on the riverbank. There is potential for large amounts of vegetation to be removed from the riverbank with this type of mining operation.

Sand Dredging – Hydraulically removes sand from the river bottom through the use of a floating dredge and a suction pump.

Processing typically includes screening and grading sand in wash water (usually stream water), and discharging the wash water into settling pits before releasing it back into the stream (Meador and Layher, November 1998).

The Division of Land Resources' (DLR) Mining Program "provide(s) for the mining of mineral resources while ensuring the usefulness, productivity and scenic value of all lands and waters" in North Carolina. DLR issues permits for two types of instream mining which are described in the text box: sand dipping and sand dredging. Typically, instream mining permits for sand dipping operations are issued for five years, and sand dredging operations are permitted for ten years. As of May 2002, there are approximately 17 permitted sand dredging operations and 12 permitted sand dipping operations in the Yadkin-Pee Dee River basin (NCDENR-DLR, January 16, 2003).

4.2.2 Loss of Riparian Vegetation

During 1999 basinwide sampling, DWQ biologists reported degradation of aquatic communities at numerous sites throughout the Yadkin-Pee Dee River basin in association with narrow or nonexistent zones of native riparian vegetation. Riparian vegetation loss was common in rural and residential areas as well as in urban areas (NCDENR-DWQ, June 2002).

Removing trees, shrubs and other vegetation to plant grass or place rock (also known as riprap) along the bank of a river or stream degrades water quality. Removing riparian vegetation eliminates habitat for aquatic macroinvertebrates that are food for trout and other fish. Rocks lining a bank absorb the sun's heat and warm the water. Some fish require cooler water temperatures as well as the higher levels of dissolved oxygen cooler water provides. Trees, shrubs and other native vegetation cool the water by shading it. Straightening a stream, clearing streambank vegetation, and lining the banks with grass or rock severely impact the habitat that aquatic insects and fish need to survive.

Livestock grazing with unlimited access to the stream channel and banks can cause severe streambank erosion resulting in degraded water quality. Although they often make up a small percentage of grazing areas by surface area, riparian zones (vegetated stream corridors) are particularly attractive to cattle that prefer the cooler environment and lush vegetation found beside rivers and streams. This concentration of livestock can result in increased sedimentation of streams due to "hoof shear", trampling of bank vegetation, and entrenchment by the destabilized stream. Despite livestock's preference for frequent water access, farm veterinarians have reported that cows are healthier when stream access is limited (EPA, 1999).

Establishing, conserving and managing streamside vegetation (riparian buffer) is one of the most economical and efficient BMPs. Forested buffers in particular provide a variety of benefits including filtering runoff and taking up nutrients, moderating water temperature, preventing erosion and loss of land, providing flood control and helping to moderate streamflow, and providing food and habitat for both aquatic and terrestrial wildlife (NCDENR-DWQ, February 2002). To obtain a free copy of DWQ's *Buffers for Clean Water* brochure, call (919) 733-5083, ext. 558.

4.2.3 Loss of Instream Organic Microhabitats

Organic microhabitat (leafpacks, sticks and large wood) and edge habitat (root banks and undercut banks) play very important roles in a stream ecosystem. Organic matter in the form of leaves, sticks and other materials serve as the base of the food web for small streams. Additionally, these microhabitats serve as special niches for different species of benthic macroinvertebrates, providing food and/or habitat. For example, many stoneflies are found almost exclusively in leafpacks and on small sticks. Some beetle species prefer edge habitat, such as undercut banks. If these microhabitat types are not present, there is no place for these specialized macroinvertebrates to live and feed. The absence of these microhabitats in some streams in the Yadkin-Pee Dee River basin is directly related to the absence of riparian vegetation (refer to Part 4.2.2 above). Organic microhabitats are critical to headwater streams, the health of which is linked to the health of the entire downstream watershed.

4.2.4 Channelization

Channelization refers to the physical alteration of naturally occurring stream and riverbeds. Typical modifications are described in the text box. Although increased flooding, bank erosion and channel instability often occur in downstream areas after channelization has occurred, flood control, reduced erosion, increased usable land area, greater navigability and more efficient drainage are frequently cited as the objectives of channelization projects (McGarvey, 1996).

Direct or immediate biological effects of channelization include injury and mortality of benthic macroinvertebrates, fish, shellfish/mussels and other wildlife populations, as well as habitat loss. Indirect biological effects include changes in benthic macroinvertebrate, fish and wildlife community structures, favoring species that are more tolerant of or better adapted to the altered habitat (McGarvey, 1996).

Typical Channel Modifications

- Removal of any obstructions, natural or artificial, that inhibit a stream's capacity to convey water (clearing and snagging).
- Widening, deepening or straightening of the channel to maximize conveyance of water.
- Lining the bed or banks with rock or other resistant materials.

Restoration or recovery of channelized streams may occur through processes, both naturally and artificially induced. In general, streams that have not been excessively stressed by the channelization process can be expected to return to their original forms. However, streams that have been extensively altered may establish a new, artificial equilibrium (especially when the channelized streambed has been hardened). In such cases, the stream may enter a vicious cycle of erosion and continuous entrenchment. Once the benefits of a channelization project become outweighed by the costs, both in money and environmental integrity, channel restoration efforts are likely to be taken (McGarvey, 1996).

Channelization of streams within the continental United States is extensive and promises to become even more so as urban development continues. Overall estimates of lost or altered riparian habitats within US streams are as high as 70 percent. Unfortunately, the dynamic nature of stream ecosystems makes it difficult (if not impossible) to quantitatively predict the effects of channelization (McGarvey, 1996). Channelization has occurred historically throughout the Yadkin-Pee Dee River basin and continues to occur in some watersheds, especially in small headwater streams.

4.2.5 Recommendations for Reducing Habitat Degradation

In March 2002, Environmental Management Commission (EMC) sent a letter to the Sedimentation Control Commission (SCC) expressing seven recommendations for improving erosion and sedimentation control, based on a comprehensive performance review of the turbidity standard conducted in 2001 by DWQ staff (refer to page 91 for a summary). Specifically the recommendations are that the EMC and SCC:

1. Evaluate, in consultation with the Attorney General's Office, whether statutory authority is adequate to mandate temporary ground cover over a percentage of the uncovered area at a construction site within a specific time after the initial disturbance of the area. If it is found that statutory authority does not exist, then the EMC and SCC should prepare resolutions for the General Assembly supporting new legislation to this effect.
2. Prepare resolutions supporting new legislation to increase the maximum penalty allowed in the Sedimentation Pollution Control Act from $5,000 to $25,000 for the initial response to a noncompliant site.
3. Jointly support a review of the existing Erosion and Sediment Control Planning and Design Manual by DLR. This review should include, but not be limited to, a redesign of the minimum specifications for sedimentation basins.

4. Evaluate, in consultation with the Attorney General's Office, whether the statutory authority is adequate for effective use of the "Stop Work Order" tool and, if found not to be adequate, to prepare resolutions for the General Assembly supporting new legislation that will enable staff to more effectively use the "Stop Work Order" tool.
5. Support increased research into and experimentation with the use of polyacrylamides (PAMs) and other innovative soil stabilization and turbidity reduction techniques.
6. Jointly support and encourage the awarding of significant monetary penalties for all activities found to be in violation of their Stormwater Construction General Permit, their Erosion and Sediment Control Plan, or the turbidity standard.
7. Hold those individuals who cause serious degradation of the environment through excessive turbidity and sedimentation ultimately responsible for restoration of the area.

DWQ will continue to work cooperatively with DLR and local programs that administer sediment control in order to maximize the effectiveness of the programs and to take appropriate enforcement action when necessary to protect or restore water quality. However, more voluntary implementation of BMPs is needed for activities that are not subject to these rules in order to substantially reduce the amount of widespread sedimentation present in the Yadkin-Pee Dee River basin.

Additionally, more public education is needed basinwide to educate landowners about the value of riparian vegetation along small tributaries and the impacts of sedimentation to aquatic life. Funding is available through numerous federal and state programs for landowners to restore and/or protect riparian buffer zones along fields or pastures, develop alternative watering sources for livestock, and fence animals out of streams (refer to Section C). EPA's *Catalog of Federal Funding Sources for Watershed Protection* (Document 841-B-99-003) outlines some of these and other programs aimed at protecting water quality. A copy may be obtained by calling the National Center for Environmental Publications and Information at (800) 490-9198 or by visiting the website at http://www.epa.gov/OWOW/watershed/wacademy/fund.html. Local contacts for various state and local agencies are listed in Appendix VI.

4.3 Fecal Coliform

Fecal coliform bacteria live in the digestive tract of warm-blooded animals (humans as well as other mammals) and are excreted in their waste. Fecal coliform bacteria do not actually pose a danger to people or animals. However, where fecal coliform are present, disease-causing bacteria may also be present and water that is polluted by human or animal waste can harbor other pathogens that may threaten human health.

The presence of disease-causing bacteria tends to affect humans more than aquatic creatures. High levels of fecal coliform bacteria can indicate high levels of sewage or animal wastes which could make water unsafe for human contact (swimming) or the harvesting and consumption of shellfish. Fecal coliform bacteria and other potential pathogens associated with waste from warm-blooded animals are not harmful to fish and aquatic insects. However, high levels of fecal coliform bacteria may indicate contamination that increases the risk of contact with harmful pathogens in surface waters.

Pathogens associated with fecal coliform bacteria can cause diarrhea, dysentery, cholera and typhoid fever in humans. Some pathogens can also cause infection in open wounds.

Under favorable conditions, fecal coliform bacteria can survive in bottom sediments for an extended period (Howell et al., 1996; Sherer et al., 1992; Schillinger and Gannon, 1985). Therefore, concentrations of bacteria measured in the water column can reflect both recent inputs as well as the resuspension of older inputs.

Sources of Fecal Coliform in Surface Waters

- Urban stormwater
- Wild animals and domestic pets
- Improperly designed or managed animal waste facilities
- Livestock with direct access to streams
- Improperly treated discharges of domestic wastewater, including leaking or failing septic systems and straight pipes

Reducing fecal coliform bacteria in wastewater requires a disinfection process, which typically involves the use of chlorine and other disinfectants. Although these materials may kill the fecal coliform bacteria and other pathogenic disease-causing bacteria, they also kill bacteria essential to the proper balance of the aquatic environment, and thereby, endanger the survival of species dependent on those bacteria.

Water quality standards for fecal coliform bacteria are intended to ensure safe use of waters for recreation and shellfish harvesting (refer to Administrative Code Section 15A NCAC 2B .0200). The North Carolina fecal coliform standard for freshwater is 200 colonies/100ml based on the geometric mean of at least five consecutive samples taken during a 30-day period and not to exceed 400 colonies/100ml in more than 20 percent of the samples during the same period. The 200 colonies/100ml standard is intended to ensure that waters are safe enough for water contact through recreation.

The standard for Class SA waters (waters used for shellfishing) is a median or geometric mean fecal coliform Most Probable Number (MPN) not greater than 14 MPN/100ml. In addition, not more than 10 percent of the samples can be in excess of 43 MPN/100ml. Many areas closed to shellfish harvesting have median levels below 14 MPN/100ml, but fail to meet the second criteria due to periodic contamination that occurs after moderate to heavy rainfall events.

The North Carolina Division of Environmental Health (DEH) has subdivided all of the state's coastal waters into shellfish growing areas in which a sanitary survey is conducted every three years. Beginning in the summer of 1997, DEH began assessing fecal coliform levels in coastal recreation waters. These assessments provide a gauge of water quality along the North Carolina coast over the short and long-term.

If a certain area along the coast is found to have potential water quality problems related to stormwater pipes or high levels of indicator bacteria, health officials will post signs recommending that people not swim there or harvest shellfish from the area. The location will be listed on the DEH website at (http://www.deh.enr.state.nc.us/shellfish/), and local media and county health departments will be notified.

The state does not encourage swimming in surface waters since a number of factors which are beyond the control of any state regulatory agency contribute to elevated levels of disease-causing

bacteria. To assure that waters are safe for swimming indicates a need to test waters for pathogenic bacteria. Although fecal coliform standards have been used to indicate the microbiological quality of surface waters for swimming and shellfish harvesting for more than 50 years, the value of this indicator is often questioned. Evidence collected during the past several decades suggests that the coliform group may not adequately indicate the presence of pathogenic viruses or parasites in water.

The detection and identification of specific pathogenic bacteria, viruses and parasites such as *Giardia*, *Cryptosporidium* and *Shigella* are expensive, and results are generally difficult to reproduce quantitatively. Also, to ensure the water is safe for swimming would require a whole suite of tests for many organisms, as the presence/absence of one organism would not document the presence/absence of another. This type of testing program is not possible due to resource constraints.

4.4 Urban Runoff

Urbanization often has greater hydrologic effects than any other land use, as native watershed vegetation is replaced with impervious surfaces in the form of paved roads, buildings, parking lots, and residential homes and yards. Urbanization results in increased surface runoff and correspondingly earlier and higher peak flows after storms. Flooding frequency is also increased. These effects are compounded when small streams are channelized (straightened) or piped and storm sewer systems are installed to increase transport of drainage waters downstream. Bank scour from these frequent high flow events tends to enlarge streams and increase suspended sediment. Scouring also destroys the variety of habitat in streams leading to degradation of benthic macroinvertebrate populations and loss of fisheries (EPA, 1999).

In and around municipalities in the Yadkin-Pee Dee River basin, 1999 DWQ biological assessments revealed that streams are being impacted by urban stormwater runoff. Most of the impacts are in terms of habitat degradation (see Part 4.2 of this section), but runoff from developed and developing areas can also carry toxic pollutants to a stream (NCDENR-DWQ, June 2002).

As populations expand, so do developed areas. Some local governments in the Yadkin-Pee Dee River basin have prioritized water quality planning; however, proactive planning efforts at the local level are needed across the entire basin in order to assure that development is done in a manner that minimizes impacts to water quality. A lack of good environmental planning was identified by participants at the public workshops as a threat to water quality in the Yadkin-Pee Dee River basin.

The presence of intact riparian buffers and/or wetlands in urban areas can lessen these impacts and restoration of these watershed features should be considered where feasible; however, the amount of impervious cover should be limited as much as possible. Wide streets, huge cul-de-sacs, long driveways and sidewalks lining both sides of the street are all features of urban development that create excess impervious cover and consume natural areas.

Recommendations for Reducing Urban Runoff

Proactive planning efforts at the local level are needed to assure that development is done in a manner that minimizes impacts to water quality. These planning efforts must find a balance among water quality protection, natural resource management and economic growth. Growth management requires planning for the needs of future population increases as well as developing and enforcing environmental protection measures. These actions are critical to water quality management and the quality of life for the residents of the basin.

Planning Recommendations for New Development

- Minimize number and width of residential streets.
- Minimize size of parking areas (angled parking and narrower slots).
- Place sidewalks on only one side of residential streets.
- Vegetate road right-of-ways, parking lot islands and highway dividers to increase infiltration.
- Plant and protect natural buffer zones along streams and tributaries.
- Minimize floodplain development.
- Protect and restore wetland/bog areas.

Public education is needed in the Yadkin-Pee Dee River basin in order for citizens to understand the value of urban planning and stormwater management. Action should be taken by county governments and municipalities to plan for new development in urban and rural areas. For more detailed information regarding recommendations for new development found in the text box, refer to EPA's website at www.epa.gov/owow/watershed/wacademy/acad2000/protection.

4.5 On-Site Wastewater Treatment

In the Yadkin-Pee Dee River basin, there are other types of wastewater treatment besides WWTPs with NPDES permits. Wastewater from many homes and commercial businesses, such as campgrounds and convenience stores, is treated by septic systems. Septic systems can be a safe and effective method for treating wastewater if they are sized, sited and maintained properly. However, if the tank or drainfield are improperly placed, constructed or maintained, nearby wells and surface waters may become contaminated causing potential risks to human health. Section .1961(a) of the Laws and Rules for Sewage Treatment and Disposal Systems requires that the person owning or controlling the property upon which a septic system is sited be responsible for that system's operation and maintenance. Many homeowners are unaware of this legal responsibility, as well as the steps that must be taken to assure proper operation. Often owners do not realize they have an on-site wastewater treatment system until they experience problems. At this point, serious damage may have already occurred.

4.5.1 Reasons for Septic System Failure

Septic systems fail for a variety of reasons. Most of the time the failure is related to improper operation (use) and maintenance. Owners are often unaware of the necessity of pumping their tanks on a regular basis. Tanks need to be pumped every three to eight years depending on the size of the tank, the daily flow of waste and the amount of solids in the waste. It is important that owners prevent unnecessary solids such as grease, food, cigarette butts, sanitary products,

disposable diapers and kitty litter from entering the septic tank system. Neglecting to do so will cause pipes to clog, tanks to fill up quickly, and can lead to premature drainfield failure.

Hydraulic overload is a significant cause of system failure. This may result from excessive water use or leaking plumbing fixtures in the home. It can also result from increasing the wasteload that a particular system was designed to handle. Failure to use low flow toilets, showerheads or other water-saving devices will contribute to overload. Leaking tanks, groundwater, stormwater, gutters and poor landscaping also hydraulically overloads systems. Drainfields must have time to rest between doses of effluent, or the life of the drainfield may be shortened significantly.

Chemicals, pesticides, paint products, cleaners, etc. dumped into a tank can kill the bacteria in a system. Bacteria in the septic tank and the drainfield are an essential part of a properly functioning system. Bacteria in the tank help reduce solids; bacteria in the drainfield treat the effluent before it reaches ground or surface waters.

Proper maintenance of the drainfield is also necessary to prevent system failure. Suitable vegetative covers must be maintained to prevent erosion and divert stormwater from the field. Appropriate vegetation helps disperse water and removes nutrients from the wastewater. Poor landscaping over the septic system can contribute thousands of additional gallons. Trees and shrubs must be located far enough away so their roots do not interfere with the systems pipes. Lastly, owners must assure drainfields remain free from vehicle traffic, impervious surfaces, construction or other activities that can compress the soil and damage trenches, pipes and, ultimately, effluent dispersion.

Improper maintenance is not the sole cause of system malfunction and failure. Septic tank systems that are installed incorrectly or are defective from the outset will fail. North Carolina does not require the certification of installers. Without suitable training, installers may be unaware of the fact that trenches should not be dug during rainy periods or care must be taken to avoid compacting the drainfield. They may not have the expertise necessary to recognize defects in the system components such as precast concrete tanks or poor gravel quality. Any one of these situations can lead to system failure and unnecessary owner expense.

Finally, problems have arisen when maintenance is required on underground utilities. Workers installing various underground utilities have damaged drainfields, as well as system components. Little or no effort is made by these underground utility contractors to locate the system and report the damage once it occurs.

More information about the installation and maintenance of septic tanks can be obtained from the NCDENR, Division of Environmental Health, On-Site Wastewater Section website at http://www.deh.enr.state.nc.us/oww/ or by contacting your county's Cooperative Extension Service Center. See Appendix VI for contact information for Cooperative Extension Service Centers in the Broad River basin.

4.5.2 Straight Piping

Sometimes pollutants associated with on-site wastewater disposal are also discharged directly to surface waters through straight pipes. Straight pipes are direct pipe connections between the

septic system and surface waters, thus, bypassing the drainfield. In some cases, straight pipes pipe wastewater directly from the home or business into a stream, bypassing any type of treatment. Not only is straight piping illegal, the discharge of untreated sewage can be extremely harmful to humans and the aquatic environment. In all cases, straight pipes should be eliminated.

The Wastewater Discharge Elimination (WaDE) Program, within the Division of Environmental Health, is helping to identify and remove straight pipes in western North Carolina. This program uses door to door surveys to locate straight pipes and failing septic systems and then offers low interest loans or grants to homeowners who wish to eliminate the straight pipe by installing a septic system. The program also offers low interest loans and grants to repair malfunctioning septic systems. However, no such program is in place in the Yadkin-Pee Dee River basin. County health departments should request funding from the Clean Water Management Trust Fund and Section 319 Program to develop a straight pipe elimination program for the Yadkin-Pee Dee River basin. More information about the Clean Water Management Trust Fund can be found on page 275, and information about the Section 319 Program can be found on page 273.

4.5.3 Recommendations

On-site wastewater treatment systems should be located at least 100 feet from your well and allow access for maintenance and repair. Know the location, age, size and condition of your system. Although the maintenance schedule may vary according to the size of tank and number of uses, solids from a septic tank should be pumped every three to five years. Additives for septic systems to "clean, repair or rejuvenate, etc." have limited benefit and do not replace proper maintenance.

Keep the soil over the drainfield covered with grass or plants to prevent erosion. Avoid planting trees or deep-rooted shrubs—roots can clog systems. Do not drive on or compact the soil above drainfields. Flush only toilet paper and human wastes in toilets. Fix leaky pipes and dripping faucets and avoid excessive water use; it will overload the system.

Do not use toilet cleaners that hang in toilet tank. Keep bleach, solvents or other harmful chemicals out of drains and toilets. All of these products can destroy beneficial bacteria that help cleanse the sewage. They can also contaminate groundwater. Keep grease and oil (and their residues) out of the drain, and do not use or limit the use of a garbage disposal in your sink.

For more specific maintenance information, see *Improving Septic Systems*, published by North Carolina Home*A*Syst online at http://ces.soil.ncsu.edu/soilscience/publications/farmassist/homeassist/Septic/ or the *Septic System Owner's Guide* from the North Carolina Cooperative Extension at http://ces.soil.ncsu.edu/soilscience/publications/Soilfacts/AG-439-22/. You may also call (919) 513-3152 to request a copy (Publication No. AG-439-13).

For information on maintenance, innovative systems and current rules, see the NCDENR-Division of Environmental Health, On-Site Wastewater Section website at http://www/deh.enr.state.nc.us/owow/ or call (919) 733-2895. You may also call 1-800-9SEWAGE for

technical assistance, to order a copy of the On-Site Wastewater Management Guidance Manual, or to report straight pipes and septic system failures.

4.6 Water Quality Concerns Associated with Drought Conditions

Water quality problems associated with rainfall events usually involve degradation of aquatic habitats because the high flows carry increased loadings of substances like metals, oils, herbicides, pesticides, sand, clay, organic material, bacteria and nutrients. These substances can be toxic to aquatic life (fish and insects) and may result in oxygen depletion or sedimentation. During drought conditions, these pollutants become more concentrated in streams due to reduced flow.

Summer months are generally the most critical months for water quality. Dissolved oxygen is naturally lower due to warmer water temperatures, algae are more abundant due to longer periods of sunlight, and streamflows are reduced. In a long-term drought, such as the one the basin is currently experiencing, these problems can be greatly enhanced and the potential for water quality problems to become catastrophic is increased.

The frequency of acute impacts due to nonpoint source pollution (runoff) is minimized during drought conditions. However, when rain events do occur, pollutants that have been collecting on the land surface are quickly delivered to streams. When streamflows are well below normal, this polluted runoff becomes a larger percentage of the water flowing in the stream. Point sources may also impact water quality during drought conditions, even when permit limits are being met. Facilities that discharge wastewater have permit limits that are based on the historic low flow conditions. During the record low flows currently being experienced in parts of North Carolina, these wastewater discharges make up a larger percentage of the water flowing in streams than normal and might contribute to lowered dissolved oxygen concentrations and increased levels of other pollutants.

The record low flows observed in many streams are putting a strain on the state's water resources and aquatic habitats. As streamflows decrease, there is less habitat available for aquatic insects and fish, particularly around lake shorelines. There is also less water available for irrigation and for water supplies. The dry conditions and increased removal of water for these uses further increases strain on the resource. With less habitat, naturally lower dissolved oxygen levels and higher water temperatures, the potential for large kills of fish and aquatic insects is very high. These conditions may stress the fish to the point where they become more susceptible to disease and where stresses that normally would not harm them result in mortality.

Large, slow-moving waters found in reservoirs, behind dams and in estuarine areas naturally stratify in summer months. This stratification results in oxygen depletion (hypoxia) in the lower water column. During drought conditions, stratification results in hypoxia higher in the water column that lasts for longer periods of time. In addition to reducing the amount of habitat available to fish and aquatic insects, this extensive stratification creates a situation that could result in fish kills once rain or other events mixes the unoxygenated waters into the entire water column.

These are also areas where longer retention times due to decreased flows allow algae to take full advantage of the nutrients present resulting in algal blooms. During the daylight hours, algae greatly increase the amount dissolved oxygen in the water, but at night algal respiration and die off can cause dissolved oxygen levels to drop low enough to cause fish kills. Besides increasing the frequency of fish kills, algae blooms can also cause difficulty in water treatment resulting in taste and odor problems in finished drinking water.

4.7 Low Dissolved Oxygen Concentrations

Maintaining an adequate amount of dissolved oxygen (DO) is critical to the survival of aquatic life and to the general health of surface waters. A number of factors influence DO concentrations including water temperature, depth and turbulence. Additionally, in the Yadkin-Pee Dee River basin, flow management from several impoundments also influences DO. The dissolved oxygen water quality standard for Class C waters is "not less than a daily average of 5.0 mg/l with a minimum instantaneous value of not less than 4.0 mg/l". Swamp waters (Class C Sw) "may have lower values if caused by natural conditions" (NCDENR-DWQ, 2000a).

Oxygen-consuming wastes such as decomposing organic matter and some chemicals can reduce dissolved oxygen levels in surface water through biological activity and chemical reactions. NPDES permits for wastewater discharges set limits on certain parameters in order to control the effects that oxygen depletion can have in receiving waters. This section discusses discharges of oxygen-consuming wastes in the Yadkin-Pee Dee River basin and studies that have been, or are currently being, conducted to better understand dissolved oxygen in the Yadkin-Pee Dee River mainstem.

For more information about oxygen-consuming wastes and what DWQ does to limit water quality impacts from these wastes, refer to *A Citizen's Guide to Water Quality Management in North Carolina*. This document is available online at http://h2o.enr.state.nc.us/basinwide/ or by calling (919) 733-5083.

Discharges to Zero Flow Streams

Because of the nature of the coastal plain region of the state, some streams, primarily in the southeastern portion of the Yadkin-Pee Dee River basin, have a low potential for sustaining base flow. This low flow frequency, measured by a 7Q10 (annual minimum 7-day consecutive low flow, which on average, will be exceeded 9 out of 10 years) flow calculation, is zero for all but the largest watersheds. This very low flow over the hottest several months of the year limits streams' ability to maintain high dissolved oxygen levels (temperature increases depleting dissolved oxygen while velocity decreases so there is little reaeration). The capacity for streams to assimilate oxygen-consuming wastes is also limited under these conditions. DWQ developed regulations for evaluating discharges to such waters.

In 1980, a study was performed on zero flow streams (7Q10 = 0 cfs and 30Q2 = 0 cfs) to determine the effect of wastewater discharges. The study concluded that:

- Steady-state models do not apply to zero flow streams, particularly those receiving waste from small discharges.
- The pool/riffle configuration of these small streams results in violations of the DO standard even when wastewater is well treated.
- Small streams receiving wastes from schools, mobile home parks, subdivisions, etc. flow through populated areas where children have easy access to streams.
- Noxious conditions were found in the low flow streams that were part of the study.

As a result of the study, regulations [15A NCAC 2B .0206 (d)] were developed that prohibit new or expanded discharges of oxygen-consuming wastes to zero flow streams. Existing facilities discharging to zero flow streams were evaluated for alternatives to discharge. Many facilities found alternatives to a surface water discharge, and some built new treatment plants to meet advanced tertiary limits for BOD_5 and NH_3-N.

This policy typically covers small discharges such as schools, mobile home parks, subdivisions and rest homes, which discharge to zero flow streams in headwater areas. Such discharges generally do not cause significant water quality problems in the mainstem of the Yadkin-Pee Dee River or larger tributaries, but they can cause localized problems in the zero flow receiving streams.

The results of the 1980 study were extrapolated to facilities discharging to low flow streams (those with a 7Q10 = 0, but with a 30Q2 > 0) since similar adverse impacts are expected in these waters. Regulations [15A NCAC 2B .0206 (d)] were developed to set effluent limitations for new and expanding discharges to 5 mg/l BOD_5, 2 mg/l NH_3-N and 6 mg/l dissolved oxygen (DO) unless it is determined that these limitations will not protect water quality standards.

4.8 Fish Consumption Advice and Advisories

In April 2002, the NC Department of Health and Human Services (NCDHHS) developed new guidelines to advise people as to what fish are safe to eat. DWQ considers uses of waters with a consumption advisory for one or more species of fish to be impaired. Elevated methylmercury levels have been found in shark, swordfish, king mackerel, tilefish, largemouth bass, bowfin (or blackfish) and chain pickerel (or jack), and these fish species fall under the NCDHHS guidelines.

4.8.1 Mercury-Related Fish Consumption Information

The presence and accumulation of mercury in North Carolina's aquatic environment are similar to contamination observed throughout the country. Mercury has a complex life in the environment, moving from the atmosphere to soil, to surface water and into biological organisms. Mercury circulates in the environment as a result of natural and human (anthropogenic) activities. A dominant pathway of mercury in the environment is through the atmosphere. Mercury that has been emitted from industrial and municipal stacks into the ambient air can circulate across the globe. At any point, mercury may then be deposited onto land and water. Once in the water, mercury can accumulate in fish tissue and humans. Mercury is also commonly found in wastewater. However, mercury in wastewater is typically not at levels that could be solely responsible for elevated levels in fish.

The NC Department of Health and Human Services issues fish consumption advisories for those fish species which have median and/or average methylmercury levels at 0.4 mg/kg or greater. These fish include shark, swordfish, king mackerel, tilefish as well as largemouth bass, bowfin (or blackfish) and chain pickerel (or jack) south and east of Interstate 85. In addition, a specific advisory is posted for consumption of largemouth bass from Ledbetter Lake due to elevated mercury concentrations. As a result of this guidance, DWQ considers many waters in the Yadkin-Pee Dee River basin to be Impaired for the fish consumption use support category. Refer to Appendix III for more information regarding use support ratings and assessment methodology.

DWQ has sampled fish tissue from a variety of species at two locations in the Yadkin-Pee Dee River basin. Mercury levels in one largemouth bass from the Pee Dee River exceeded the North Carolina action level for mercury in fish.

Fish Consumption Advice

Fish is an excellent source of protein and other nutrients. However, several varieties of freshwater fish may contain high levels of mercury, which may pose a risk to human health. These guidelines will help you make healthy food choices. A "meal" is defined as six ounces of cooked fish for adults and children 15 years or older and two ounces of cooked fish for younger children.

Women of childbearing age (15-44 years), pregnant or nursing women, and children under 15:

- Do not eat shark, swordfish, tilefish or king mackerel; or blackfish (bowfin), largemouth bass or jack fish (chain pickerel) caught in North Carolina waters south and east of Interstate 85. These fish likely contain high concentrations of mercury.
- Eat up to two meals per week of other fish.

Men, other women, and children 15 years and older:

- Eat no more than one meal per week of shark, swordfish, tilefish or king mackerel; or blackfish (bowfin), largemouth bass or jack fish (chain pickerel) caught in North Carolina waters south and east of Interstate 85. These fish likely contain high concentrations of mercury.
- Eat up to four meals per week of other fish.

For more information regarding fish consumption, visit the NC Department of Health and Human Services website at http://www.schs.state.nc.us/epi/fish/current.html or call (919) 733-3816.

4.8.2 2002 Recommendations

DWQ will work closely with the Department of Health and Human Service's Division of Public Health to monitor fish tissue in the Yadkin-Pee Dee River basin to assess the need to lift these advisories when there is no longer a risk to human health from consumption of fish. DWQ also strives to understand the interaction of mercury in the aquatic environment through an internal mercury workgroup, improved ambient water chemistry sampling techniques, and through participation in a regional mercury study. Each is described in further detail below.

DWQ Mercury Workgroup

DWQ is committed to characterizing methylmercury exposure levels and determining if NPDES sources need to be controlled. DWQ formed an internal Mercury Workgroup to improve communication from all programs which directly affect mercury issues (i.e., Pretreatment, Environmental Sciences, Basinwide Planning, etc.). The workgroup meets as needed to share information and determine next steps in addressing mercury issues associated with the aquatic environment.

Improved Ambient Sampling Techniques

DWQ aims to stay abreast of new technology and sampling techniques to ensure that water quality data are accurate, precise and of highest value. In 2000, DWQ started training water quality sampling staff on the new EPA Method 1631 technique. Current monitoring using a higher detection limit (EPA Method 245.1) has consistently yielded non-detected values, and DWQ aims to use the 1631 method to allow detection levels three orders of magnitude lower than EPA Method 245.1.

Regional Mercury Study

In an effort to better manage state waters that may have methylmercury issues, DWQ initiated a study through EPA 104(b)(3) funds. The study aims to provide information that may be used in water quality standard and TMDL development. The study goals include:

- determining levels of ambient mercury in the surface water system;
- estimating site-specific total mercury: methylmercury translators to evaluate water quality criteria;
- develop site-specific water to fish bioaccumulation factors; and
- determine levels of mercury in treatment plant effluent.

DWQ aims to complete this study in 2003, and results will be available to the public. For more information, contact the DWQ Planning Branch Modeling/TMDL Supervisor at (919) 733-5083.

DWQ will continue to host an internal workgroup to stay abreast of current mercury issues. The public has voiced concerns that DWQ should be working on the ecological components and consequences of mercury bioavailability to biota in these areas and the biogeochemical cycling and production of methylmercury from associated wetlands along these streams. Though the workgroup does not have a mandate to conduct research into mercury, the workgroup will better communicate its purpose and accomplishments to the public through periodic updates on the DWQ website.

DWQ will also provide interested members of the public with an overview of the new ambient monitoring sampling technique to gather feedback and insights on how DWQ can best accomplish its data collecting goals.

DWQ will continue to monitor concentrations of various contaminants in fish tissue across the state and will work to identify and reduce wastewater contributions of mercury to surface waters.

The Division of Air Quality (DAQ) evaluates mercury levels in rainwater on a regular basis through the EPA Mercury Deposition Network. EPA continues to focus on nationwide mercury reductions from stack emissions and through pollution prevention efforts. Pollution prevention efforts are being investigated on a state and federal level to reduce mercury emissions.

4.9 Management Strategy and Recommendations for the High Rock Lake Watershed

Located on the mainstem of the Yadkin River in Rowan and Davidson counties, High Rock Lake is the largest and most upstream of the Yadkin-Pee Dee chain lakes. Completed in 1929, the reservoir was constructed to provide hydroelectric power and is owned and operated by Yadkin Division of APGI. The 3,850-square mile watershed lies within seven subbasins (03-07-01 through 03-07-07). Figure C-4 on page 279 presents a map of the entire High Rock Lake watershed. Water quality concerns for High Rock Lake date back to the mid-1970s, and the need for nutrient reduction strategies to address problems due to accelerated eutrophication has been apparent since the mid-1990s.

4.9.1 Watershed Overview

The High Rock Lake watershed had an estimated population of 723,100 in 1990. Winston-Salem is the largest urban area; however, significant amounts of population are also located in Thomasville, Lexington and Salisbury along I-85, and in Statesville. Portions of 11 counties and 34 municipalities are located in the watershed. Although more than 60 percent of the High Rock Lake watershed is forested, 30 percent is described as pasture or managed herbaceous land and nearly three percent is urban (Figure A-20).

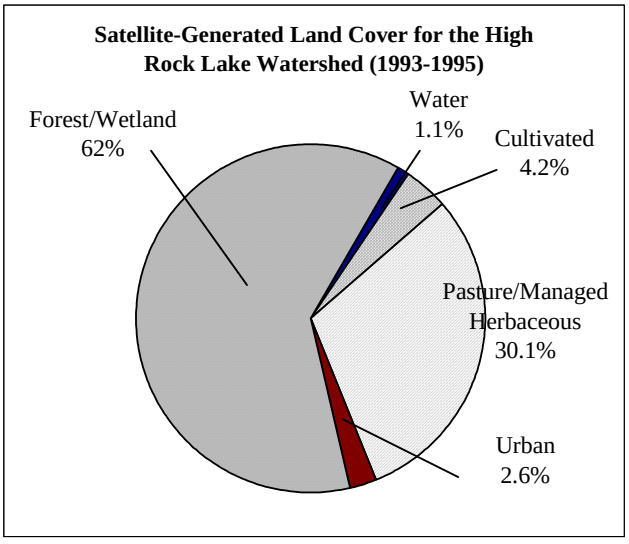

Figure A-20 Percentages within Major CGIA Land Cover Categories in the High Rock Lake Watershed (Subbasins 03-07-01 through 03-07-07) (1993-1995)

Although numerous tributaries enter the lake, the Yadkin and South Yadkin Rivers account for more than 90 percent of the total inflow. Average daily flows in the Yadkin River mainstem

above the lake normally exceed 3,000 cubic feet per second. Detention time is relatively short, with estimates ranging from about 15 to 30 days (EPA, 1975; Weiss et al., 1981; NCDENR-DWQ, 1997a). These estimates exclude periods of extended low flow, such as those experienced in the basin in recent years.

The waters of the lake are classified WS-V upstream of a line connecting the downstream sides of Crane Creek and Swearing Creek. Below this line, the lake is classified as WS-IV & B, except for the upper half of the Abbotts Creek arm (above SR 2294), which is classified as WS-V & B. Additionally, the area within 0.6 miles of the dam is classified as CA due to the presence of the water supply intake for the Town of Denton a short distance below the dam. No drinking water is withdrawn directly from the reservoir, although Salisbury's water supply intake is located at the confluence of the Yadkin and South Yadkin Rivers, just upstream of the headwaters of the reservoir. In addition, Color/Tex Finishing and Duke Power's Buck Steam Station withdraw process and cooling water from the upper portion of the lake.

The watershed contains 76 registered animal operations; 68 of them (89 percent) are cattle facilities. A large percentage of the state's total capacity for dairy production (both registered and unregistered facilities) is found within the High Rock Lake watershed, mostly in Iredell County. However, dairy production in the watershed fell 27 percent between 1994 and 1998 and continues to decline. Poultry production increased 13 percent over the same four-year period.

There are 155 individual NPDES permitted dischargers in the watershed, 23 of which are major facilities that have a permitted flow of one million gallons per day (MGD) or more. Of the 126 MGD discharge capacity in the watershed, about 93 percent, or 117 MGD, is from the major facilities presented in Table A-40. Eight facilities discharge directly to the lake or to streams in the immediate proximity. The City of Salisbury WWTP and ColorTex Finishing discharge to the Yadkin River at the head of High Rock Lake. Additionally, Duke Power's Buck Steam Station discharges cooling water into the upper portion of the reservoir. Lexington's discharge to Abbotts Creek and Salisbury's Sowers Ferry Road WWTP (minor) on Grants Creek are in close proximity to the lake. Other minor discharges in close proximity are the Hilltop Living Center, Norfolk Southern Corp. and PPG Industries, Inc.

4.9.2 Summary of Historical Monitoring and Modeling Studies

Studies by DWQ (NRCD-DEM, 1974, 1975) and the EPA (EPA, 1975) in the mid-1970s documented eutrophic conditions in High Rock Lake for the first time. The EPA-sponsored research, conducted as part of the National Eutrophication Survey, indicated that High Rock Lake was the most eutrophic of the 16 North Carolina lakes studied in 1973. In 1981, a study by the University of North Carolina at Chapel Hill (Weiss et al., 1981) documented high nutrient loading to the lake as well as high levels of chlorophyll and in-lake nutrients. An intensive investigation of the lake by DWQ in 1989 and 1990 (NCDEHNR-DEM, 1993) provided additional data to allow a detailed evaluation of the reservoir and to support water quality modeling. On-going monitoring (e.g., NRCD-DEM, 1988, 1989; NCDEHNR-DEM, 1992a; NCDENR-DWQ, 1997b, June 2002) indicates that the lake continues to exhibit eutrophic conditions.

Table A-40 Major NPDES Permitted Dischargers in the High Rock Lake Watershed (2001)

NPDES Permit No.	Company/Facility Name	County	Type of Discharge	Receiving Stream	MGD	Subbasin
NC0005266	Louisiana Pacific ABT Co. Mill	Wilkes	Industrial Process	Yadkin River	1.0	03-07-01
NC0020761	Town of North Wilkesboro WWTP	Wilkes	Municipal	Yadkin River	2.0	03-07-01
NC0021717	Town of Wilkesboro WWTP	Wilkes	Municipal	Yadkin River	4.9	03-07-01
NC0005312	West Point Stevens	Surry	Industrial Process	Yadkin River	4.0	03-07-02
NC0020338	Town of Yadkinville WWTP	Yadkin	Municipal	North Deep Creek	2.5	03-07-02
NC0020567	Town of Elkin WWTP	Surry	Municipal	Yadkin River	1.8	03-07-02
NC0021121	City of Mount Airy WWTP	Surry	Municipal	Ararat River	7.0	03-07-03
NC0026646	Town of Pilot Mountain WWTP	Surry	Municipal	Ararat River	1.5	03-07-03
NC0037834	City of Winston-Salem Archie Elledge WWTP	Forsyth	Municipal	Salem Creek[1]	30.0	03-07-04
NC0050342	City of Winston-Salem Muddy Creek WWTP	Forsyth	Municipal	Yadkin River	21.0	03-07-04
NC0005487	Color/Tex Finishing Corporation	Rowan	Industrial Process	High Rock Lake[1]	4.25	03-07-04
NC0023884	City of Salisbury Grants Creek WWTP	Rowan	Municipal	High Rock Lake[1]	7.5	03-07-04
NC0004774	Duke Energy Corp. Buck Steam Station	Rowan	Industrial Process	High Rock Lake[1]	No Limit	03-07-04
NC0004286	Fieldcrest Cannon	Rowan	Industrial Process	Grants Creek[1]		03-07-04
NC0004944	Arteva Specialties KOSA	Rowan	Industrial Process	Second Creek	2.3	03-07-06
NC0005126	Tyson Foods Inc. Harmony Plant	Iredell	Industrial Process	Hunting Creek	1.7	03-07-06
NC0024872	Davie County Cooleemee WWTP	Davie	Municipal	South Yadkin River[1]	1.5	03-07-06
NC0020591	City of Statesville Third Creek WWTP	Iredell	Municipal	Third Creek[1]	4.0	03-07-06
NC0031836	City of Statesville Fourth Creek WWTP	Iredell	Municipal	Fourth Creek[1]	4.0	03-07-06
NC0024112	City of Thomasville Hamby Creek WWTP	Davidson	Municipal	Hamby Creek[1]	4.0	03-07-07
NC0024228	City of High Point Westside WWTP	Davidson	Municipal	Rich Fork[1]	6.2	03-07-07
NC0055789	City of Lexington WWTP	Davidson	Municipal	Abbotts Creek[1]	5.5	03-07-07

[1] A portion of this waterbody is currently rated Impaired.

The nutrient response model BATHTUB was applied to High Rock Lake in the mid-1990s. BATHTUB was developed by the US Army Corps of Engineers (Walker, 1986, 1985a, 1985b) to simulate eutrophication in spatially segmented reservoirs. BATHTUB is a steady state empirical lake model which predicts average in-lake nutrient and algal levels based upon phosphorus and nitrogen loading, turbidity and detention time.

The objectives of DWQ's modeling effort were: 1) to estimate nutrient loading to High Rock Lake; 2) to assess the assimilative capacity of the reservoir for phosphorus and nitrogen; and 3) to develop a predictive tool that could be used to evaluate the potential impacts of alternative management strategies on nutrient and algal levels in the lake.

The modeling effort focused on growing season (May-September) loading and algal response and yielded extensive information regarding nutrient loads to the lake. However, attempts to develop an adequately calibrated nutrient response model were less successful. While the model adequately predicts phosphorus levels in key areas of the lake, such as the mainstem and the Abbotts Creek Arm, chlorophyll *a* levels are predicted very poorly throughout the lake. Potential reasons for this are discussed in the modeling report (NCDENR-DWQ, 1997a).

4.9.3 Management Strategy and Recommendations from the 1998 Basin Plan

Phosphorus is the limiting nutrient in most freshwater systems. Nitrogen generally becomes limiting in freshwaters only under extremely eutrophic conditions (Welch, 1992). Under nitrogen limiting conditions, N-fixation by blue-green algae may encourage the dominance of blue-green algae over other algal groups and stimulate the growth of noxious blooms. For this reason, where lakes have elevated levels of both nitrogen and phosphorus, reductions in phosphorus rather than nitrogen have generally been recommended (Welch, 1992; Thomann and Mueller, 1987). While both nitrogen and phosphorus are routinely present in High Rock Lake in concentrations high enough to support algal blooms, management strategies focus on reducing phosphorus concentrations in order to limit algal growth. The main body of High Rock Lake was rated Support Threatened at the time of the 1998 basin plan. Therefore, priority was placed on tributary watersheds that were rated Impaired.

Abbotts Creek Arm

The 1998 basin plan recommended that each of the three major dischargers in the Abbotts Creek watershed (High Point, Thomasville and Lexington) receive summer mass Total Phosphorus limits based upon current permitted flow capacity and a Total Phosphorus concentration of 0.5 mg/l. The limits would go in effect for the permit cycle that begins in 2004. In order to reduce phosphorus loading in the shorter term, facilities were required to conduct an operation and maintenance assessment in order to identify methods of optimizing phosphorus removal with existing facilities. The plan also recommended that existing minor facilities be required to monitor total phosphorus and nitrogen concentrations and that no additional phosphorus loading would be permitted (individual NPDES permits for discharges containing phosphorus).

Other Arms

The only major NPDES discharges into the Grants Creek and Crane Creek arms were the two WWTPs operated by the City of Salisbury. The 1998 basin plan discusses Salisbury's plans to build a new outfall on the Yadkin River mainstem and the elimination of the two discharges into

Town and Grants Creeks when the new outfall became operational. The management strategy states that these facilities would not receive nutrient limits as long as the City of Salisbury was proceeding in good faith with construction of the new outfall. Other recommendations were for the Town of Spencer to connect to a regional WWTP. Spencer was required to conduct an engineering assessment to identify ways of optimizing phosphorus removal with current facilities.

Main Body of Lake

The 1998 basin plan also strongly recommends that the local governments (Davidson and Rowan County health departments) work with the Division of Environmental Health to identify failing on-site systems and to develop or strengthen outreach and education efforts regarding the operation and maintenance of these systems. Additionally, lake shore property owners were encouraged to establish and maintain adequate riparian buffers. The plan also expresses support for the efforts of Yadkin Division of APGI to maintain vegetated areas around High Rock Lake as recommended in its Shoreline Management Plan. DWQ planned to investigate the feasibility of developing a nutrient reduction strategy for the watershed and consider reclassifying the lake as Nutrient Sensitive Waters.

4.9.4 Current Status

Eight stations on High Rock Lake were monitored by DWQ in 1999, 2000 and 2001. Surface dissolved oxygen concentrations were elevated at most of the sampling sites, and the associated percent dissolved oxygen saturation ranged from 148 to 157 percent; the water quality standard is 110 percent. Surface pH values were also elevated, suggesting increased algal productivity.

Decreased transparency due to suspended sediments in the water column is also common in High Rock Lake. Turbidity concentrations in the Abbotts Creek and Crane Creek arms, as well as the main body of the lake, were greater than water quality standards in more than 10 percent of samples collected. In addition, transported sediment has reduced the depth of the upper end of the lake such that at low flow periods, the uppermost sampling site can no longer be reached by boat. In addition to reducing the clarity of the lake water, these sediments also contribute nutrients.

High Rock Lake was determined to be eutrophic again in 2001. Blue-green algae species, commonly found in eutrophic waters and often associated with taste and odor problems in drinking water, dominated samples collected in July and August 1999. As has been observed in previous years, total phosphorus and total organic nitrogen concentrations were high. These nutrients continued to support increased algae productivity as evidenced by chlorophyll *a* values greater than the state water quality standard of 40 ug/l.

Increased monitoring of High Rock Lake over the most recent assessment period has allowed DWQ to determine that the lake is Impaired. The decision is based on high levels of nutrients, combined with chlorophyll *a*, turbidity and percent dissolved oxygen saturation in excess of state standards. Low dissolved oxygen and high turbidity in the Abbotts Creek and Town Creek Arms are also contributing to aquatic life impairment.

Phosphorus limits, as outlined in the 1998 management strategy summary above, were placed in the most recent NPDES permits issued to the Lexington, Thomasville and High Point WWTPs in the Abbotts Creek watershed to become effective at the time of renewal in 2004. As a result of this strategy, summer point source loads of total phosphorus to the Abbotts Creek arm are projected to decline to one fifth of 1994-96 levels. Ambient phosphorus levels are projected to decline by 30 to 40 percent in the upper portion of the Abbotts Creek arm and by 20 to 25 percent in the middle portion of the arm. It is anticipated that this will lessen the incidence and severity of nuisance conditions in the lake, but these actions may not completely resolve eutrophication issues in the Abbotts Creek arm.

The Town of Spencer connected to the City of Salisbury WWTP, eliminating one discharge to Grants Creek. The City of Salisbury constructed a new WWTP which discharges to the Yadkin River in the upper reaches of High Rock Lake, eliminating one discharge to Grants Creek and one discharge to Town Creek. In addition, steps have already been taken to prioritize the High Rock Lake watershed for nonpoint source pollution reduction measures.

4.9.5 2002 Recommendations and Management Strategies

The current NPDES permits for the High Point Westside WWTP, Thomasville WWTP and Lexington WWTP outline mass-based summer and winter discharge limits for total phosphorus, which will be required beginning in 2004. No new NPDES permitted discharges will be permitted into the Abbotts, Swearing, Grants and Crane Creek arms of High Rock Lake. No increase in loading will be permitted for existing NPDES discharges into these same arms. Other existing discharges (in addition to the three major discharges mentioned above) will receive notification that discharge limits for total phosphorus may be required in the future.

A percent DO saturation TMDL for High Rock Lake will require the development of both a nutrient response model and a watershed loading model. DWQ staff will begin review of existing monitoring locations, frequency and parameters in preparation for designing a TMDL field study for High Rock Lake and the upper Yadkin River basin. DWQ will focus on developing and conducting the field study during this basinwide planning cycle. The field study will likely require 18 months to complete. The Yadkin-Pee Dee River Basin Association (details on page 296) has expressed interest in modeling the High Rock Lake watershed. DWQ will continue to work with the association to understand and manage this complex watershed.

DWQ will continue to place priority on developing TMDLs for streams in the High Rock Lake watershed. TMDLs for fecal coliform in the Fourth Creek and Grants Creek watersheds have been approved by the USEPA; and in the case of Fourth Creek, plans to implement the TMDL are being developed. Fecal coliform TMDLs are underway in the Salem Creek and Rich Fork watersheds as well. Strategies used to reduce fecal coliform concentrations in these watersheds will also help reduce nutrient and sediment loading to the upper portion of the basin, and ultimately High Rock Lake.

In addition, DWQ will work more closely with other agencies that set priorities for nonpoint source pollution reduction in the Yadkin-Pee Dee River basin, such as the NC Wetlands Restoration Program, NC Division of Soil and Water Conservation, and USDA Natural

Resources Conservation Service, to get funding for best management practices targeted towards the High Rock Lake watershed.

4.10 Davidson County Schools

In 1990, DWQ issued a Special Order of Consent (SOC) to provide relaxation of the NPDES permit limits of 14 WWTPs in subbasins 03-07-04 and 03-07-07 owned and operated by the Davidson County School District. Currently, DWQ and the school system are negotiating an amendment to extend the SOC to 2006 for nine schools: Central Davidson Jr/Sr (NC0041599), Leadford High (NC004208), Northwest Elementary (NC0042072), Midway Elementary (NC0042145), Pilot Elementary (NC0042129), Silver Valley (NC0041602), Southwood Elementary (NC0042749), Tyro Middle (NC0042056), and West Davidson High (NC0031950).

The goal of the SOC is for the nine remaining schools to tie into the City of Lexington, Tyro, Pilot or Handy Sanitary Districts' collection system which would eliminate the problem discharges. Since 1999, the school system has paid $2,000 in penalties and costs for discharge violations at two schools.

4.11 FERC Relicensing of Hydropower Projects

The licenses issued by the Federal Energy Regulatory Commission (FERC) to Yadkin Division of APGI for the operation of the High Rock, Tuckertown, Narrows and Falls dams, and to Carolina Power and Light for the operation of the Tillery and Blewett Falls dams will expire in 2008. The relicensing process is just beginning and will include an assessment of how current and future project operations may affect environmental resources in the Yadkin-Pee Dee River basin. The next *Yadkin-Pee Dee River Basinwide Water Quality Plan* will summarize relevant data collected during this process.

Recommendations
DWQ will continue to follow these studies and provide assistance and input as is appropriate. Any results that become available over the next five-year basinwide planning cycle will be discussed in the revised *Yadkin-Pee Dee River Basinwide Water Quality Plan* (2007).

4.12 Biological Community Assessment Issues

DWQ strives to properly evaluate the health of biological communities throughout the state. Swamp stream systems, small streams, nonwadeable waters and coldwater fisheries have presented unique challenges. This section discusses some of these challenges. This section also discusses the accumulation of contaminants in fish tissues and how waters with consumption advisories are assessed by DWQ.

4.12.1 Draft Criteria for Assessing Benthic Macroinvertebrates in Swamp Streams

Extensive evaluation, conducted by DWQ, of swamp streams across eastern North Carolina suggests that different criteria must be used to assess the condition of water quality in these systems. Swamp streams are characterized by slower flow, lower dissolved oxygen and lower

pH. Sometimes they also have very complex braided channels and dark-colored water. Since 1995, benthos swamp sampling methods have been used at over 100 sites in the coastal plain of North Carolina, including more than 20 reference sites. In 1999, 16 sites on swamp streams in the Yadkin-Pee Dee River basin were sampled by DWQ. Preliminary investigations indicate that there are at least four unique swamp ecoregions in the NC coastal plain. The lowest "natural" diversity has been found in low-gradient streams (especially in the outer coastal plain east of the Suffolk Scarp) and in areas with poorly drained soils.

DWQ has developed draft biological criteria that may be used in the future to assign bioclassifications to these streams (as is currently done for other streams and rivers across the state). However, validation of the swamp criteria will require collecting data for several years from swamp stream reference sites. The criteria will remain in draft form until DWQ is better able to evaluate such things as: year-to-year variation at reference swamp sites, effects of flow interruption, variation among reference swamp sites, and the effect of small changes in pH on the benthos community. Other factors, such as whether the habitat evaluation can be improved and the role fisheries data should play in the evaluation, must also be resolved. While it may be difficult to assign use support ratings to these swamp streams, these data can be used to evaluate changes in a particular stream between dates or to evaluate effects of different land uses on water quality within a relatively uniform ecoregion.

DWQ is also developing criteria for use in determining whether a stream should receive the supplemental classification of Sw. Once completed the criteria will be applied to at least three streams in the southeastern portion of the Yadkin-Pee Dee River basin: Brown Creek, Marks Creek and Lanes Creek. Section A, Chapter 3 (page 54) contains details about North Carolina's surface water classification system.

4.12.2 Assessing Benthic Macroinvertebrate Communities in Small Streams

The benthic macroinvertebrate community of small streams is naturally less diverse than the streams used to develop the current criteria for flowing freshwater streams. The benthic macroinvertebrate database is being evaluated, and a study to systematically look at small reference streams in different ecoregions is being developed with the goal of finding a way to evaluate water quality conditions in such small streams. DWQ will continue to work toward criteria to assess water quality in small streams.

Presently, a designation of Not Impaired may be used for flowing waters that are too small to be assigned a bioclassification (less than 4 meters in width), but meet the criteria for a Good-Fair or higher bioclassification using the standard qualitative and EPT criteria. This designation will translate into a use support rating of Supporting. However, DWQ will use the monitoring information from small streams to identify potential impacts to small streams even in cases when a use support rating cannot be assigned.

4.13 Use Restoration Waters (URW) Approach

DWQ has developed a conceptual strategy to manage watersheds with nonpoint source impairments as determined through the use support designations. In July 1998, the state Environmental Management Commission approved the Use Restoration Waters (URW) Program

concept which will target all NPS Impaired waters in the state using a two-part approach. As envisioned, this concept will apply to all watersheds that are Impaired. The program will catalyze voluntary efforts of stakeholder groups in Impaired watersheds to restore those waters by providing various incentives and other support. Simultaneously, the program will develop a set of mandatory requirements for NPS pollution categories for locations where local groups choose not to take responsibility for restoring their waters. This URW concept offers local governments an opportunity to implement site-specific projects at the local level as an incentive ("the carrot"). If the EMC is not satisfied with the progress made towards use restoration by local committees, impairment based rules will become mandatory in those watersheds ("the stick"). These mandatory requirements may not be tailored to specific watersheds, but may apply more generically across the state or region.

With more than 400 Impaired waters on stream segments in the state, it is not realistic for DWQ to attempt to develop watershed specific restoration strategies for nonpoint source pollution. By involving the stakeholders in these watersheds, DWQ can catalyze large-scale restoration of Impaired waters. One of the major implementation challenges of this new program will be educating public officials and stakeholders at the local level as to the nature and solutions to their impairments. To address this challenge, the state plans to develop a GIS-based program to help present information at a scale that is useful to local land management officials. Other incentives that the state might provide include seed grants and technical assistance, as well as retaining the authority to mandate regulations on stakeholders who are not willing to participate.

In cases where incentives and support do not result in effective watershed restoration strategies, mandatory management requirements would be implemented in the watershed. This is not the state's preferred alternative, as it would add to state monitoring and enforcement workload. However, in areas where it is necessary, DWQ plans to implement such requirements. In the management area, DWQ would be assisted by regulatory staff from the Division of Coastal Management, Division of Environmental Health, Division of Land Resources and the Division of Marine Fisheries to insure compliance.

4.14 Priority Issues for the Next Five Years

Clean water is crucial to the health, economic and ecological well-being of the state. Tourism, water supplies, recreation and a high quality of life for residents are dependent on the water resources within any given river basin. Water quality problems are varied and complex. Inevitably, water quality impairment is due to human activities within the watershed. Solving these problems and protecting the surface water quality of the basin in the face of continued growth and development will be a major challenge. Looking to the future, water quality in this basin will depend on the manner in which growth and development occur.

The long-range mission of basinwide management is to provide a means of addressing the complex problem of planning for increased development and economic growth while protecting and/or restoring the quality and intended uses of the Yadkin-Pee Dee River basin's surface waters. In striving towards its mission, DWQ's highest priority near-term goals are to:

- identify and restore Impaired waters in the basin;

- identify and protect high value resource waters and biological communities of special importance; and
- protect unimpaired waters while allowing for reasonable economic growth.

4.14.1 Strategies for Restoring and Protecting Impaired Waters

Impaired waters are identified in Section A, Chapter 3 as those not meeting their designated uses based on DWQ assessments of monitoring data. These waters are summarized by subbasin in Table A-38 and indicated on the subbasin maps in Section B. The Impaired waters are also discussed individually in the subbasin chapters in Section B.

These waters are Impaired, at least in part, due to nonpoint sources (NPS) of pollution. The tasks of identifying nonpoint sources of pollution and developing management strategies for these Impaired waters are very resource intensive. Accomplishing these tasks is overwhelming, given the current limited resources of DWQ, other agencies (e.g., Division of Land Resources, Division of Soil and Water Conservation, Cooperative Extension Service, etc.) and local governments. Therefore, only limited progress towards restoring NPS Impaired waters can be expected during this five-year cycle unless substantial resources are put toward solving NPS problems.
DWQ plans to further evaluate the Impaired waters in the Yadkin-Pee Dee River basin in conjunction with other NPS agencies and develop management strategies for a portion of these Impaired waters for the next Yadkin-Pee Dee River Basinwide Water Quality Plan, in accordance with the requirements of Section 303(d) (see below).

4.14.2 Addressing Waters on the State's Section 303(d) List

For the next several years, addressing water quality impairment in waters that are on the state's 303(d) list will be a priority. The waters in the Yadkin-Pee Dee River basin that are on this list are presented in the individual subbasin descriptions in Section B. For information on listing requirements and approaches, refer to Appendix IV.

Section 303(d) of the federal Clean Water Act requires states to develop a 303(d) list of waters not meeting water quality standards or which have Impaired uses. States are also required to develop Total Maximum Daily Loads (TMDLs) or management strategies for 303(d) listed waters to address impairment. In the last few years, the TMDL program has received a great deal of attention as the result of a number of lawsuits filed across the country against EPA. These lawsuits argue that TMDLs have not adequately been developed for specific Impaired waters. As a result of these lawsuits, EPA issued a guidance memorandum in August 1997 that called for states to develop schedules for developing TMDLs for all waters on the 303(d) list. The schedules for TMDL development, according to this EPA memo, are to span 8-13 years.

There are 2,830.4 miles and approximately 388,000 acres of Impaired waters on the draft 2002 303(d) list in NC. The rigorous and demanding task of developing TMDLs for each of these waters during an 8 to 13-year time frame will require the focus of much of the water quality program's resources. Therefore, it will be a priority for North Carolina's water quality programs over the next several years to develop TMDLs for 303(d) listed waters.