

# Chapter 12

## Population Growth, Land Cover Changes and Water Quality

### 12.1 General Sources of Pollution

Human activities can negatively impact surface water quality, even when the activity is far removed from the waterbody. With proper management of wastes and land use activities, these impacts can be minimized. Pollutants that enter waters fall into two general categories: *point sources* and *nonpoint sources*.

#### Point Sources

Piped discharges from:

- Municipal wastewater treatment plants
- Industrial facilities
- Small package treatment plants
- Large urban and industrial stormwater systems

Point sources are typically piped discharges and are controlled through regulatory programs administered by the state. All regulated point source discharges in North Carolina must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from the state.

Nonpoint sources are from a broad range of land use activities. Nonpoint source pollutants are typically carried to waters by rainfall, runoff or snowmelt. Sediment and nutrients are most often associated with nonpoint source pollution. Other pollutants associated with nonpoint source pollution include fecal coliform bacteria, heavy metals, oil and grease, and any other substance that may be washed off the ground or deposited from the atmosphere into surface waters.

#### Nonpoint Sources

- Construction activities
- Roads, parking lots and rooftops
- Agriculture
- Failing septic systems and straight pipes
- Timber harvesting
- Hydrologic modifications

Unlike point source pollution, nonpoint pollution sources are diffuse in nature and occur intermittently, depending on rainfall events and

land disturbance. Given these characteristics, it is difficult and resource intensive to quantify nonpoint contributions to water quality degradation in a given watershed. While nonpoint source pollution control often relies on voluntary actions, the state has many programs designed to reduce nonpoint source pollution.

Every person living in or visiting a watershed contributes to impacts on water quality. Therefore, each individual should be aware of these contributions and take actions to reduce them.

#### Cumulative Effects

While any one activity may not have a dramatic effect on water quality, the cumulative effect of land use activities in a watershed can have a severe and long-lasting impact.

## **12.2 Managing the Impacts of Growth, Development, and Stormwater Runoff**

### **12.2.1 Introduction**

Urban growth poses one of the greatest threats to aquatic resources. The impacts on rivers, lakes and streams as development surrounding metropolitan areas consumes neighboring forests and fields can be significant and permanent if stormwater runoff is not controlled. Greater numbers of homes, stores and businesses require greater quantities of water. Growing populations not only require more water, but they also lead to the discharge and runoff of greater quantities of waste and pollutants into the state's streams and groundwater. Thus, just as demand and use increase, some of the potential water supply is lost (Orr and Stuart, 2000).

In addition, as watershed vegetation is replaced with impervious surfaces in the form of paved roads, buildings, parking lots, and residential homes and driveways, the ability of the environment to absorb and diffuse the effects of natural rainfall is diminished. Urbanization results in increased surface runoff and correspondingly earlier and higher peak streamflows after rainfall. 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 urban 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).

Most of the impacts result in habitat degradation (Chapter 13), but urban runoff also carries a potentially toxic cocktail including oil and grease from roads and parking lots, street litter and pollutants from the atmosphere. Cumulative impacts from developing and urban areas can cause severe impairment to urban streams.

### **12.2.2 Effects of Growth and Development in the Roanoke River Basin**

Although the Roanoke River basin is not one of the fastest developing basins in the state, the effects of development are impacting water quality. Seven of the fifteen counties in the basin experienced growth rates in excess of 13 percent in the last decade of the 20<sup>th</sup> century. The sparsely developed watersheds the western foothills portion of the basin generally contain streams with high water quality, excellent aquatic species populations, and Supporting use support ratings. Water quality declines dramatically in streams in the central piedmont watersheds, in rural and urbanized areas.

Populations of counties that are wholly or partly contained within the basin increased by over 115,000 people between 1990 and 2000. Appendix I presents projected population growth by county for the Roanoke River basin from 2000 to 2020. Forsyth, Granville, Orange, Person and Stokes counties are growing the fastest in the basin. These counties have an estimated growth rate of over 20 percent by 2020. Wentworth, Rural Hall and Kernersville had high growth rates. Walkertown increased population substantially in the last ten years. Although the Roanoke River basin population is growing slower than some other river basins, there will be increased

drinking water demands and wastewater discharges. There will also be loss of natural areas and increases in impervious surfaces associated with construction of new homes and businesses.

The overall population of the basin based on 2000 Census data is 344,638, with approximately 98 persons/square mile. Population density estimated by subbasin is presented in Appendix I.

Refer to Appendix II for local governments' listing and Appendix III for land cover changes related to urbanization.

The Roanoke River basin has an abundance of surface water that has supported industrial and domestic expansions of the mid-20<sup>th</sup> century. Even today, there is sufficient water to serve its diverse domestic, agricultural, industrial, energy production and recreational needs except in periods of severe drought. However, as population increases in the basin, the availability and needs of those water supplies will need to be carefully planned and coordinated between state and local governments. Clean water can likely be provided in sufficient quantity to supply the future needs of the basin, but only with inspired foresight, planning and management. See Chapter 18 on Water Resources for more information.

Also, in times of drought much coordination between state and local agencies needs to be maintained to assure not only sufficient flows for water supply but also for downstream water quality.

### **12.2.3 The Role of Local Governments**

A summary of necessary management actions needed by local authorities is provided here, followed by discussions on large, watershed management issues. These actions are necessary to address current sources of impairment and to prevent future degradation in all streams. The intent of these recommendations is to describe the types of actions necessary to improve stream conditions, not to specify particular administrative or institutional mechanisms for implementing remedial practices. Those types of decisions must be made at the local level.

Because of uncertainties regarding how individual remedial actions cumulatively impact stream conditions and how aquatic organisms will respond to improvements, the intensity of management effort necessary to bring about a particular degree of biological improvement cannot be established in advance. The types of actions needed to improve biological conditions can be identified, but the mix of activities that will be necessary – and the extent of improvement that will be attainable – will only become apparent over time as an adaptive management approach is implemented. Management actions are suggested below to address individual problems, but many of these actions are interrelated.

Actions one through five are important to restoring and sustaining aquatic communities in the watershed, with the first three recommendations being the most important.

- 1. Feasible and cost-effective stormwater retrofit projects should be implemented throughout the watershed to mitigate the hydrologic effects of development** (increased stormwater volumes and increased frequency and duration of erosive and scouring flows). This should be viewed as a long-term process. Although there are many uncertainties, costs in the range of \$1 million per square mile can probably be anticipated.

- a. Over the short-term, currently feasible retrofit projects should be identified and implemented.
  - b. In the longer term, additional retrofit opportunities should be implemented in conjunction with infrastructure improvements and redevelopment of existing developed areas.
  - c. Grant funds for these retrofit projects may be available from EPA initiatives, such as Section 319 funds, or the North Carolina Clean Water Management Trust Fund.
2. **A watershed scale strategy to address toxic inputs should be developed and implemented, including a variety of source reduction and stormwater treatment methods.** As an initial framework for planning toxicity reduction efforts, the following general approach is proposed:
- a. Implementation of available BMP opportunities for control of stormwater volume and velocities. As recommended above to improve aquatic habitat potential, these BMPs will also remove toxics from stormwater.
  - b. Development of a stormwater and dry weather sampling strategy in order to facilitate the targeting of pollutant removal and source reduction practices.
  - c. Implementation of stormwater treatment BMPs, aimed primarily at pollutant removal, at appropriate locations.
  - d. Development and implementation of a broad set of source reduction activities focused on: reducing non-storm inputs of toxics; reducing pollutants available for runoff during storms; and managing water to reduce storm runoff.
3. **Stream channel restoration activities should be implemented in target areas, in conjunction with stormwater retrofit BMPs, in order to improve aquatic habitat.** Before beginning stream channel restoration, a geomorphologic survey should be conducted to determine the best areas for stream channel restoration. Additionally, it would probably be advantageous to implement retrofit BMPs before embarking on stream channel restoration, as restoration is probably best designed for flows driven by reduced stormwater runoff. Costs of approximately \$200 per foot of channel should be anticipated (Haupt et al., 2002 and Weinkam et al., October 2001). Grant funds for these retrofit projects may be available from federal sources, such as EPA's Section 319 funds, or state sources including North Carolina Clean Water Management Trust Fund.
4. Actions recommended above (e.g., stormwater quantity and quality retrofit BMPs) are likely to reduce nutrient/organic loading and associated impacts to some extent. Activities recommended to address this loading include the identification and elimination of illicit discharges; education of homeowners, commercial applicators, and others regarding proper fertilizer use; street sweeping; catch basin clean-out practices; and the installation of additional BMPs targeting BOD and nutrient removal at appropriate sites.
  5. Prevention of further channel erosion and habitat degradation will require effective post-construction stormwater management for all new development in the study area.
  6. Effective enforcement of sediment and erosion control regulations will be essential to the prevention of additional sediment inputs from construction activities. Development of improved erosion and sediment control practices may be beneficial.

7. Watershed education programs should be implemented and continued by local governments with the goal of reducing current stream damage and preventing future degradation. At a minimum, the program should include elements to address the following issues:
  - a. redirecting downspouts to pervious areas rather than routing these flows to driveways or gutters;
  - b. protecting existing woody riparian areas on all streams;
  - c. replanting native riparian vegetation on stream channels where such vegetation is absent; and
  - d. reducing and properly managing pesticide and fertilizer use.

#### **12.2.4 Maintain and Develop Riparian Buffers**

The presence of intact riparian buffers and/or wetlands can reduce the impacts of stormwater flow from development in urban and rural areas as well as from various agricultural practices. Establishment and protection of buffers should be considered where feasible, and the amount of impervious cover should be limited as much as possible. Wide streets, large cul-de-sacs, and 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.

Preserving the natural 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, trapping bacteria, 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. Counties and municipalities should adopt ordinances that require buffers along streams whether in urban or rural areas. To obtain a free copy of DWQ's *Buffers for Clean Water* brochure, call (919) 733-5083, ext. 558.

#### **12.2.5 Protecting Headwaters**

Many streams in a given river basin are only small trickles or seeps of water that emerge from the ground. A larger stream is formed at the confluence of these trickles (Figure 17). This constant merging eventually forms a large stream or river. Most monitoring of fresh surface waters evaluates these larger streams. The many miles of small trickles, collectively known as headwaters, are not directly monitored and in many instances are not even indicated on maps. These streams account for approximately 80 percent of the stream network and provide many valuable services for quality and quantity of water delivered downstream (Meyer et al., September 2003). However, degradation of headwater streams can (and does) impact the larger stream or river and should be protected.

There are three types of headwater streams: ephemeral (flow only after precipitation events), intermittent (flow during wet seasons), and perennial (flow year-round). All types of headwater streams provide benefits to larger streams and rivers. Headwater streams control flooding, recharge groundwater, maintain water quality, reduce downstream sedimentation, recycle nutrients, and create habitat for plants and animals (Meyer et al., September 2003). In smaller headwater streams, fish communities are not well developed and benthic macroinvertebrates dominate aquatic life. Benthic macroinvertebrates are often thought of as "fish food" and, in mid-sized streams and rivers, they are critical to a healthy fish community.

However, these insects, both in larval and adult stages, are also food for small mammals, such as river otter and raccoons, birds and amphibians (Erman, 1996). Benthic macroinvertebrates in

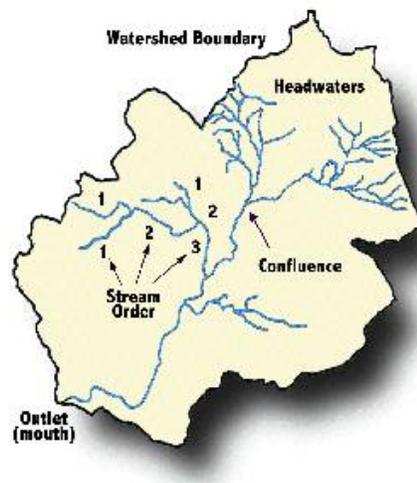


Figure 17 - Diagram of Headwater Streams within a Watershed Boundary

headwater streams also perform the important function of breaking down coarse organic matter, such as leaves and twigs, and releasing fine organic matter. In larger rivers, where coarse organic matter is not as abundant, this fine organic matter is a primary food source for benthic macroinvertebrates and other organisms in the system (CALFED, 1999). When the benthic macroinvertebrate community is changed or extinguished in an area, even temporarily, as occurs during land use changes, it can have repercussions in many parts of both the terrestrial and aquatic food web.

Headwater streams also provide a source of insects for repopulating downstream waters where benthic macroinvertebrate communities have been eliminated due to human alterations and pollution. Adult insects have short life spans and generally live in the riparian areas surrounding the streams from which they emerge (Erman, 1996). Because there is little upstream or stream-to-stream migration of benthic macroinvertebrates, once headwater populations are eliminated, there is little hope for restoring a functioning aquatic community. In addition to macroinvertebrates, these streams support diverse populations of plants and animals that face similar problems if streams are disturbed. Headwater streams are able to provide these important ecosystem services due to their unique locations, distinctive flow patterns, and small drainage areas.

Because of the small size of headwater streams, they are often overlooked during land use activities that impact water quality. All landowners can participate in the protection of headwaters by keeping small tributaries in mind when making land use management decisions on the areas they control. This includes activities such as retaining vegetated stream buffers, minimizing stream channel alterations, and excluding cattle from streams. Local rural and urban planning initiatives should also consider impacts to headwater streams when land is being developed. For a more detailed description of watershed hydrology and watershed management,

refer to EPA's Watershed Academy website at <http://www.epa.gov/OWOW/watershed/wacademy/acad2000/watershedmgt/principle1.html>.

### 12.2.6 Reduce Impacts of Future Development

Proactive planning efforts at the local level are needed to assure that development is done in a manner that maintains water quality. These planning efforts will need to find a balance between water quality protection, natural resource management and economic development. 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.

Areas adjacent to the high growth areas of the basin are at risk of having Impaired biological communities. These biological communities are important to maintaining the ecological integrity in the Roanoke River basin. These streams will be important as sources of benthic macroinvertebrates and fishes for reestablishment of biological communities in nearby streams that are recovering from past impacts or are being restored.

To prevent further impairment to aquatic life in streams in developing watersheds local governments should:

1. identify waters that are threatened by development;
2. protect existing riparian habitat along streams;
3. implement stormwater BMPs during and after development;
4. develop land use plans that minimize disturbance in sensitive areas of watersheds;
5. minimize impervious surfaces including roads and parking lots; and
6. develop public outreach programs to educate citizens about stormwater runoff.

Action should be taken at the local level to plan for new development in urban and rural areas.

For more detailed information regarding recommendations for new development found in the text box (right), refer to EPA's website at [www.epa.gov/owow/watershed/wacademy/acad2000/protection](http://www.epa.gov/owow/watershed/wacademy/acad2000/protection), the Center for Watershed Protection website at [www.cwp.org](http://www.cwp.org), and the Low Impact Development Center website at [www.lowimpactdevelopment.org](http://www.lowimpactdevelopment.org). Additional public education is also needed in the Roanoke River basin in order for citizens to understand the value of urban planning and stormwater management. DWQ recently developed a booklet that discusses actions individuals can take to reduce stormwater runoff and improve stormwater quality entitled *Improving Water Quality In Your Own Backyard*. To obtain a free copy, call (919) 733-5083, ext. 558. For an example of local community planning, visit the website at <http://www.charneck.org/Home.htm>.

#### *Planning Recommendations for New Development*

- Minimize number and width of residential streets.
- Minimize size of parking areas (angled parking & narrower slots).
- Place sidewalks on only one side of residential streets.
- Minimize culvert pipe and hardened stormwater conveyances.
- Vegetate road right-of-ways, parking lot islands and highway dividers to increase infiltration.
- Plant and protect natural buffer zones along streams and tributaries.

