PROTECTING WATER QUALITY IN NORTH CAROLINA'S FLAT RIVER WATERSHED: POLICY OPTIONS AND PROCESSES

A REPORT PREPARED FOR THE UPPER NEUSE RIVER BASIN ASSOCIATION AND JURISDICTIONS IN THE UPPER NEUSE RIVER BASIN

MAY 1, 2004

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A Report Prepared for the Upper Neuse River Basin Association

May 1, 2004

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EXECUTIVE SUMMARY

To preserve water quality in the Flat River watershed[1] in the long term, we recommend that Person, Durham, and Orange Counties and Durham and Roxboro Cities cooperatively protect critical lands in the watershed and negotiate a set of performance standards, limiting pollutant levels in the watershed. We also recommend that Person County expand its ability to educate developers and the public about best management practices (BMPs) and low impact design of land uses, and conduct outreach to landowners about land conservation opportunities. Durham and Person Counties should also improve the compatibility of their codes and ordinances with water quality protection. Lastly, the jurisdictions in the watershed, as part of a mediated negotiation process, should explore options for Durham County and the City of Durham to cooperate with Person County in funding BMPs, low impact design, and land protection.

Future decentralized growth has the potential to significantly impact water quality. The Triangle region of North Carolina has experienced nearly 40% population growth in each of the last four decades, a rate four times the national average. Growth has been rapid and decentralized.[2] Person County has remained largely rural, but its growth has accelerated rapidly in the past decade, jumping from under 5% per decade during 1960-1990 to 18% between 1990 and 2000.[3]

Development poses a risk to drinking water, ecosystem health, and recreation in the Flat River watershed, because of the consistently associated increases in nutrients, pollutants, and silt runoff. Water quality modeling based on growth projections for the year 2025 suggests that drinking water in the Flat River will continue to meet current standards set by the EPA and the state of North Carolina. A model based on the allowable development in the watershed, based on current zoning laws and population predictions, estimates that water quality will no longer meet standards some time after 2025.[4]

The purpose of this report is to examine policy alternatives and processes for protecting water quality in the Flat River watershed, contained in Durham, Orange, and Person Counties. The watershed supplies approximately half of the City of Durham's municipal water, but most of the watershed is located in Person County. Consequently, the costs and benefits of many water quality protection measures may accrue to different groups and jurisdictions.

We assess several alternative strategies to protect water quality in the Flat River watershed. The preferred alternative should: 1) protect water quality in the Flat River watershed, 2) be acceptable to all stakeholders, 3) be perceived as worthwhile and cost

[1] The Flat River watershed is also known as the Lake Michie watershed.
[2] The Raleigh-Durham metropolitan area is the third most sprawling metro area in the nation. Ewing, R., R. Pendall, D. Chen. "Measuring Sprawl and its Impact." 2002. http://www.smartgrowthamerica.com.
[3] U.S. Census. http://www.census.gov/population/cencounts/nc190090.txt. April 2004.
[4] Upper Neuse River Basin Association. "Upper Neuse Watershed Management Plan." May 2003.

effective, 4) be administratively affordable 5) be technologically feasible, 6) provide flexibility to adapt to future needs and technologies, and 7) improve local governments' capacity to solve future water quality problems.

Local governments may choose among several basic approaches for protecting water quality. Local governments can either work to improve water quality voluntarily, or state or federal governments may mandate action. Local governments may choose to implement these solutions either independently or cooperatively. Although local policy-makers increasingly discuss water quality from a watershed-based perspective in forums such as the Upper Neuse River Basin Association (UNRBA), they have historically not cooperated to protect water quality across jurisdictions. Without a willingness to approach water quality issues more cooperatively, water quality protection is likely to continue to be a piecemeal effort that reflects the individual priorities of counties and cities rather than a watershed-based group of landowners and water users.

In our analysis, we consider nine options, any of which could be instituted independently or cooperatively among local jurisdictions, or be mandated by the state. We recommend that local jurisdictions implement options 4b, 6, 7, and 8, using cooperative processes.

Infrastructure

1. Water treatment facility upgrade
2. Lake Michie Dam level increase
3. New reservoir above Lake Michie

Land Use Limits

4. Zoning and density
   a. Large-scale zoning changes
   b. Codes and ordinances affecting small-scale land uses
5. Impervious surface limits
6. Targeted land protection

Land Use Practices

7. Best management practices and low impact design

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CHAPTER 1: BACKGROUND ON FLAT RIVER WATER QUALITY

The Flat River and its associated tributaries drain approximately 170 square miles at the extreme upstream end of the Neuse River Basin in North Carolina's Piedmont Region. The primary tributaries in the Flat River watershed (also called the Lake Michie watershed) are the North and South Fork of the Flat River, and Deep Creek (see Figure 1). The watershed is bounded by Roxboro to the north, the City of Durham to the southwest, and the Falls Lake Reservoir to the southeast. It is located almost entirely in southern Person County and northern Durham County; small portions of the watershed are in northern Orange County and eastern Granville County. In 2000, approximately 12,000 people resided in the watershed.

In this section, we summarize the recent history and current land and water use in the Flat River watershed. We then describe the current federal, state, and local water quality laws and regulations that apply to the Flat River.

1.1 HISTORY OF LAND AND WATER USE IN THE FLAT RIVER WATERSHED

Through the early 19th century the Flat River provided power to a number of mills serving area farmers.[5] Durham's population began to expand rapidly in the mid-19th century with consolidation and growth in the tobacco and textile industries, and the city installed municipal water and sewer services, and extended these services as it annexed more land.

In 1916 the City of Durham decided to build a dam on the Flat River and establish it as its primary water supply.[6] Activities in Hillsborough had polluted the Eno River, and a cotton mill at Orange Factory Road had degraded the water in the Little River, both of which had served as Durham's drinking water supply.[7] Ten years later, in 1926, Durham completed the Lake Michie Dam and Reservoir.

In the 1950s Durham expanded the size and capacity of the reservoir to allow increased and improved supply to a growing population.[8] At the time of the reservoir expansion, the population of Durham County (much of which has been incorporated into the City of Durham) was over 100,000.[9] The population of Person County at the time is estimated at 25,000.[10] Over the ensuing decades, Person County remained largely rural and experienced steady but slow population growth, averaging 0.75% annual growth from 1960 – 2000.[11]

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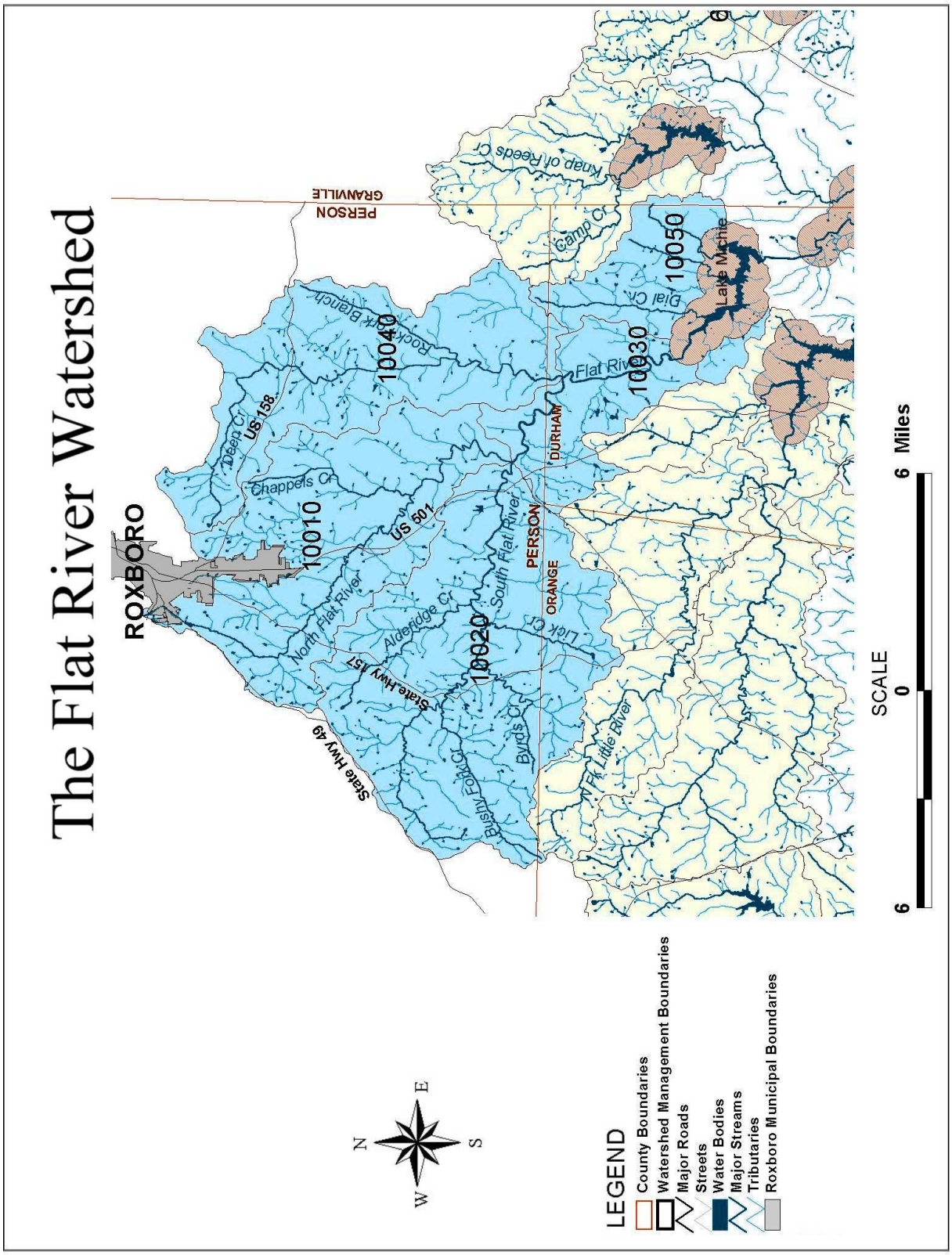
[5] Anderson, J. *Durham County*. Durham, NC: Duke University Press. 1990. p.73.
[6] Anderson, J. *Durham County*. Durham, NC: Duke University Press. 1990. p.187.
[7] Rolan, Terry. Personal interview. February 24, 2004.
[8] Anderson, J. *Durham County*. Durham, NC: Duke University Press. 1990. p. 358.
[9] 1950 Durham County population – 101,639 ; 1960 population – 111,995. US Census Bureau data. Accessed March 2004 at http://recenter.tamu.edu/data/popcd/popcs37.html.
[10] US Census Bureau data: 1950 Person County population – 24,361 ; 1960 population – 26,394.
[11] US Census Bureau data.

Figure 1. The Flat River Watershed

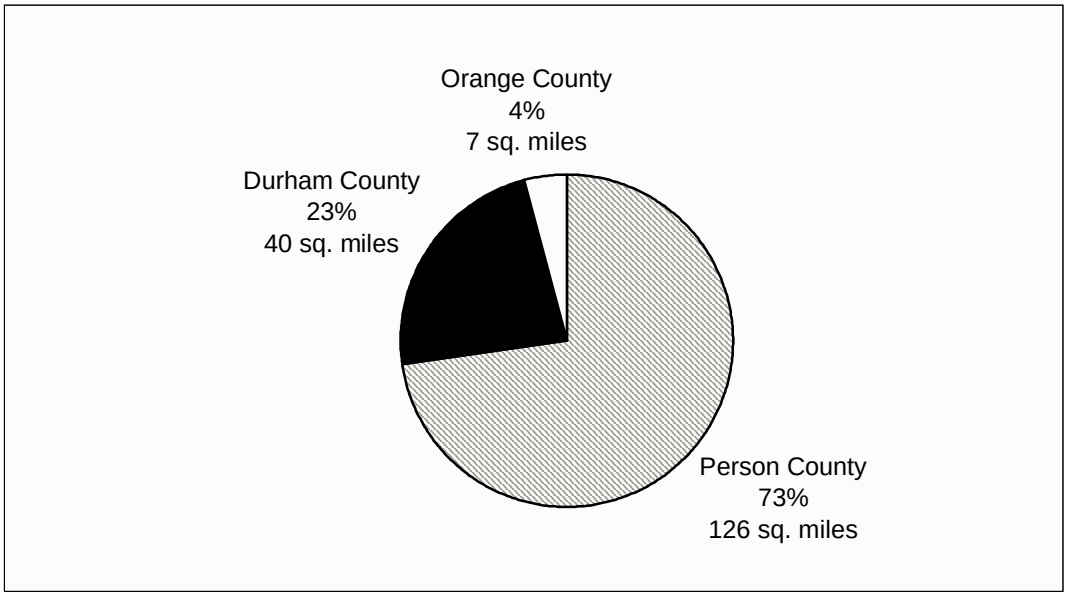


During the late twentieth century, Durham County, fueled by growth at Research Triangle Park and local universities as the tobacco industry faded, has experienced a growth rate roughly two-and-a-half times greater than Person County.[12]

1.2 CURRENT LAND AND WATER USE

Water quality in the Flat River watershed above the Lake Michie Dam is currently good, or "unimpaired," according to the North Carolina Department of Environment and Natural Resources.[13,14] The primary reason for this is the largely undeveloped nature of the watershed; approximately 58% of the watershed is forested and 26% is agricultural land. Just 3% of the land use in the watershed is low density residential, and less than 1% is high and medium density residential.[15] Both the southern portion of Person County in the watershed, and the northern part of Durham County to a lesser extent, remain largely undeveloped. Seventy-three percent of the Flat River watershed is within Person County, and 23% is in Durham County, with most of the remainder in Orange County.[16] A negligible part of the watershed is within Granville County. Figure 2 presents the percentage of the watershed area by county.

Figure 2. Percentage of Watershed Area by County



The City of Durham is the primary user of the Flat River's surface water. (Residents in more rural areas of the watershed rely on groundwater.) The City of Durham's water consumption has grown in proportion with its population, serving 180,000 customers with roughly 28.3 million gallons a day (mgd) in 1997, and a safe supply capacity of 37 mgd. A

[12] US Census Bureau data.
[13] DENR. "Neuse River Basin, Basinwide Assessment Report." November 2001.
[14] DENR. "Neuse River Basinwide Water Quality Plan." July 2002.
[15] UNRBA. "Upper Neuse Watershed Management Plan." May 2003.
[16] Ibid.

small number of those served by the City of Durham live in unincorporated Durham County but have received municipal utilities as part of planned extensions. In recent years, Durham has drawn approximately half its water from the Flat River watershed (18 mgd), and half from the Little River watershed (17 mgd).[17] Durham has also acquired from the City of Cary rights to an additional 3 mgd from Jordan Lake. Additionally, Durham is completing a reserve supply of roughly 2 billion gallons at the Nello Teer Quarry.

In anticipation of continued growth, it is in the City of Durham's interest to maintain both the quantity and quality of its supply. By 2010, the City estimates it will serve 212,900 people, with an average daily demand of 35 mgd, and an average available daily safe supply of 45.5 mgd.[18]

Since the City of Durham and Durham County combined their planning departments in the 1990s, they have worked together to guide development in the northern part of the county. This collaboration has been the result of an effort, in part, to rein in impacts to water quality in northern Durham. However, no local government acting alone will be able to ensure protection of the entire watershed. Full protection will require the participation of Durham, Orange, and Person Counties.

1.3 REGULATORY SETTING

The Flat River watershed is subject to protection at the federal, state, and local levels. Federal water quality protection laws include the Clean Water Act and the Safe Drinking Water Act. Relevant state regulations are the Water Supply Watershed Protection Act and the Neuse Rules. The watershed is also subject to local ordinances, such as protective zoning, impervious surface limits, and performance standards.

Federal Rules

The Clean Water Act, as part of its goal of "water quality [that] provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water," prohibits discharging pollutants from point sources into navigable waters without a permit. [19,20] It does not directly regulate non-point source pollution (pollution from urban and agricultural land that is transported by precipitation and runoff), but Congress has amended the law to establish programs for the control of non-point source pollution. This type of pollution is now the leading cause of impairment across states, for all types of water bodies, including the Flat River.[21]

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[17] Durham City/County Planning Department. "Durham Comprehensive Plan." May 2003.
[18] DENR. "North Carolina State Water Supply Plan." January 2001. Accessed April 2004 at http://www.ncwater.org/Reports_and_Publications/swsp/swsp_jan2001/swsp_j01.php.
[19] The CWA mandated that this goal be met by July 1, 1983. EPA. "Federal Water Pollution Control Act, as amended through November 27, 2002." http://www.epa.gov/region5/water/pdf/ecwa.pdf.
[20] EPA. "Clean Water Act History." February 20, 2003. http://www.epa.gov/region5/water/cwa.htm.
[21] EPA. "2000 National Water Quality Inventory." March 30, 2004. http://www.epa.gov/305b/2000report/.

The Safe Drinking Water Act (SDWA) allows the EPA to limit the amount of contaminants in drinking water.[22] Both the EPA and the state governments can take action such as lawsuits or fines against water systems that do not meet safety standards. The act also established the Drinking Water State Revolving Fund, which states can draw on to improve their water systems' infrastructure or management, or to assess and protect source water.[23]

North Carolina Rules

Because many water supply watersheds fall under the jurisdiction of multiple local governments, state policymakers developed minimum statewide measures to protect water supply quality in the 1989 Water Supply Watershed Protection Act (WSWPA). Under the WSWPA, the state classifies surface water supply watersheds according to levels of protection and sets water protection standards that control the density of development and limit the total amount of pollutants. Municipalities and counties develop water protection ordinances to comply with these standards.[24]

Under the WSWPA, Lake Michie has a WS-III status, a status for low to moderately developed watersheds. The regulations associated with the WS-III status prohibit new landfills and require agriculturalists to use best management practices (BMPs) in "critical areas" near water supply intakes.[25] The WS-III regulations also allow local governments to concentrate development at high densities in areas away from water supply intakes and to use lower densities and stormwater management techniques to mitigate the effects of increased impervious areas.[26]

The Flat River watershed is also subject to the Neuse Rules. The Neuse Rules – in full, the Nutrient Sensitive Waters Management Strategy for the Neuse River – are based on a General Assembly bill that established a goal of a 30 % reduction below 1995 levels in the nitrogen discharged or running into the Neuse.[27] There are five subcategories of rules.

- The Riparian Area Rule limits disturbance of plant cover in the first 50 feet of land surrounding each lake, stream, or other body of water.[28]

- The Agriculture Rule provides two strategies by which farmers can reduce nitrogen pollution: 1) work with state and local committees to

[22] EPA. "Setting Standards for Safe Drinking Water." March 30, 2004. http://www.epa.gov/OGWDW/standard/setting.html.
[23] EPA. "Understanding the Safe Drinking Water Act." December 1999. http://www.epa.gov/safewater/sdwa/understand.pdf.
[24] DENR. "History of the N.C. Water Supply Watershed Protection Program." February 9, 2001. http://h2o.enr.state.nc.us/wswp/history.html.
[25] These areas include only land within one-half mile upstream and draining to a river intake or within one-half mile and draining to the normal pool elevation of water supply reservoirs. DENR. "Water supply watershed classifications." November 15, 2003. http://h2o.enr.state.nc.us/wswp/wsclasses.html.
[26] DENR. "Frequently asked questions." November 15, 2003. http://h2o.enr.state.nc.us/wswp/FAQs.html.
[27] DENR. "Why is there a riparian area rule for the Neuse River?" Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/cheat-s3.htm.
[28] DENR. "What does the Neuse River Riparian Area Rule require?" Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/cheat-s3.htm.

tailor nitrogen reduction goals for each farm, or 2) implement standard BMPs.[29]

- The Stormwater Rule requires the largest and fastest-growing local jurisdictions to develop plans to reduce nitrogen runoff in stormwater.[30]

- The Nutrient Management Rule requires people who manage 50 or more acres of land to either 1) complete training and continuing education in nutrient management, or 2) develop a written nutrient management plan for their property.[31]

- The Wastewater Discharge Rule establishes limits, in terms of pounds of nitrogen discharged per year, for wastewater facilities in the Neuse River Basin. Dischargers could either meet individual mass-based limits or join a nitrogen trading coalition.[32]

Local Rules

In 1949, reacting to rapid growth, Durham County became the second North Carolina county to obtain legislative authority to zone land. By 1956, the county had implemented a comprehensive zoning ordinance. The Durham City / County Planning Department currently has twenty-three zoning districts with eight different overlay districts, including one for watershed protection. The watershed protection overlay mandates buffer zones around reservoirs and streams as well as impervious surface limits that decrease in areas closer to a reservoir. The county has also delineated an "Urban Growth Area" (UGA) and subjected the area outside the UGA to stricter development controls through minimum lot sizes and other restrictions. High density options within the UGA may also require stormwater controls to deal with the first inch of rainfall for any given rain event.[33]

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[29] DENR. "What does the Neuse River Agriculture Rule say?" February 10, 2002. http://h2o.enr.state.nc.us/nps/ag.htm.

[30] DENR. "What does the Neuse River Stormwater Rule say?" Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/cheat-sh.htm. Large, fast-growing local jurisdictions include the City of Durham, Durham County, and Orange County. Person County and Roxboro are not included. North Carolina Administrative Code 15A 02B .0235. "Neuse River Basin – Nutrient Sensitive Water Management Strategy: Basinwide Stormwater Requirements." Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/2b-0235.pdf.

[31] DENR. "What does the Neuse River Nutrient Management Rule say?" February 10, 2002. http://h2o.enr.state.nc.us/nps/nmgt.htm.

[32] DENR. "What does the Neuse River Wastewater Discharge Rule say?" Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/pt-sourc.htm. Although at least 40 facilities expressed interest in joining, the coalition has not yet been established, and no trades have occurred. EPA. "A Summary of U.S. Effluent Trading and Offset Projects." http://envstudies.brown.edu/Thesis/2002/caton/case%20study%20pages/north%20carolina/S_Neuse%20River.htm. November 1999.

[33] Durham City/County Planning Department. "Durham Zoning Ordinance." Accessed March 2004 at http://www.ci.durham.nc.us/departments/planning/zoneord/section5/55.cfm.

Person County had few land-use ordinances until North Carolina's watershed water supply rules went into effect and counties were required to adopt certain ordinances in response to this ruling.[34] Person County has on several occasions updated its ordinances, with increasing detail. Currently, Person County has five zoning districts (Rural Conservation, Residential, Highway Business, Neighborhood Business, and General Industrial) and three zoning overlays, including an overlay for watersheds that incorporates state mandated water supply protection provisions.[35] In most of Person County the minimum developable lot size is one acre. The Rural Conservation zoning district covering about 80% of the county, including most of the Flat River watershed within the county, allows many different kinds of development.

Orange County contains only a few square miles of the Flat River watershed, but for this and other watersheds the county has maintained a proactive program for water quality protection. The county government has used fees and money leveraged from several state and national trust funds to run their Lands Legacy Program, a targeted land protection program that works both through purchases of easements and occasional outright purchases of land from willing sellers. The County Commission, the Planning Department and the Environmental and Resource Conservation Department have also increased the minimum allowable lot size in many crucial, relatively undeveloped watershed areas, particularly in the northern part of the county. The county continues to hold public meetings regarding additional increases. These increases, however, have not yet included the Flat River watershed.[36]

Appendix I provides further detail on federal, state, and local regulations.

[34] Steve Carpenter and Paula Murphy. Personal Interview. February 16, 2004.
[35] Person County Planning and Zoning Department. "General Overview." Accessed March 31, 2004 at http://www.personcounty.net/sections.php?op=viewarticle&artid=19.
[36] Altieri, Tom. Personal Interview. March 4, 2004.

CHAPTER 2: GROWTH PROJECTIONS AND TWO PROBLEMS

Despite the various agencies empowered to protect water quality through regulations governing land uses and water pollution, current regulations are not sufficient to prevent degradation of water quality in the Flat River watershed. If land development in the Flat River watershed proceeds as current zoning ordinances, Water Supply Watershed Protection Act rules, and the Neuse Rules allow, watershed models predict that water quality will be degraded some time after 2025.[37] Evidence of some water quality impairment is present in the South Fork of the Flat River.[38]

The potential for degraded water quality in the Flat River watershed is a long term and two-fold problem: *1) a challenge of adopting and implementing the best policies that will protect water quality in the Flat River watershed*, and *2) a challenge posed by the multi-jurisdictional nature of the problem.* In Section 2.1, we discuss the relationship between land use and water quality, and evaluate the evidence behind projections of long-term degradation. In Section 2.2, we consider the cross-jurisdictional aspects of the problem that complicate efforts to protect water quality, and discuss the need for a policy process that will address concerns of equity and fairness among jurisdictions.

2.1 LAND USE, GROWTH, AND WATER QUALITY DEGRADATION

Key Problem: *Future growth in the Flat River watershed, much of which will occur in Person County, is likely to degrade water quality in the watershed.*

Land Use and Water Quality

Water quality is fundamentally a function of land use and human activity. Altered land uses typically associated with growth can cause water quality degradation in a number of ways. Growth can decrease the natural filtration capacity of ecosystems through decreases in forested areas and wetlands. Growth also typically leads to an increase in pollutant loading into watersheds from household chemicals, metals, fertilizers and oil.

Water quality research has established a strong connection between the extent of impervious surfaces and the water quality in a watershed. Though degradation can also occur in areas with low levels of impervious surface, the literature suggests that noticeable degradation can begin once 10% of a watershed is made impervious.[39] Impervious surfaces created by roads, driveways, rooftops, and parking lots can increase runoff volumes and rates, increasing stream flooding, erosion, and sedimentation. Runoff from impervious

[37] UNRBA Watershed Management Plan.
[38] DENR. "Neuse River Basinwide Water Quality Plan." July 2002.
[39] Univeristy of Connecticut, Nonpoint Education for Municipal Officials Program. Accessed April 2004 at http://nemo.uconn.edu/publications/fact_sheets/nemo_fact_sheet_4_s.pdf. April 2004.

surfaces can also increase stream temperatures, altering the biological habitat for many aquatic species.[40]

Keeping in mind the effect of growth on water quality, an assessment of the potential for future water quality degradation in the Flat River rests upon two estimates:

1) Projections for the amount and type of future growth in the watershed based on reasonable scenarios and on the real constraints upon growth (including allowable development under zoning ordinances).

2) A model that estimates the impacts of growth scenarios on water quality.

Projecting Growth in the Flat River Watershed

While population in the Flat River watershed has not been as marked as in the Triangle region as a whole, there are many reasons to believe that there will be significant growth in the future. The Triangle Region has experienced nearly 40% population growth in each of the last four decades, a rate roughly four times the national average. Growth has been rapid and decentralized: according to Smart Growth America, the Raleigh-Durham metropolitan area is the third most sprawling metro area in the nation.[41] Commutes and commuting times have grown more quickly in the past decade in the Durham metro area than in *any* other metro area in the county.[42]

Land consumption in the Triangle Region has also outpaced population growth in recent decades, with clearly negative impacts on water quality in the watershed.[43] Farmland in the metropolitan area, in particular, has been declining rapidly. Between 1969 and 1997, the amount of land in farms in the Raleigh-Durham area declined forty percent, from 1.11 million acres to 0.66 million acres, with much of the land developed for new housing.[44] In 1997, the average age of farmers in Durham County and Person County was 58 and 55, respectively.[45] As farmers and other rural residents approach retirement age, and as land prices increase at the periphery of the metropolitan area, landowners may be increasingly likely to sell their land. More proactive water quality planning is necessary as the watershed experiences increased rates of turnover in land ownership that are a precursor to more development proposals.

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[40] EPA. "Growth and Water Resources: The link between land use and water resources." June 2002.
[41] Ewing, R., R. Pendall, D. Chen. "Measuring Sprawl and its Impact." 2002. http://www.smartgrowthamerica.com.
[42] The Road Information Program (using US Census data). Accessed April 2004 at http://www.tripnet.org/CensusDataCongestionJun2002.PDF.
[43] American Rivers, NRDC, and Smart Growth America. Paving the Way to Water Shortages: How Sprawl Aggravates the Effects of Drought. August 2002.
[44] US Census of Agriculture data. US Department of Agriculture, National Agricultural Statistics Service. Accessed April 2004 at http://www.nass.usda.gov/census/.
[45] US Department of Agriculture. 1997 Census of Agriculture: North Carolina State and County Data. March 1999. Accessed April 2004 at http://usda.mannlib.cornell.edu/reports/census/ac97anc.pdf.

Through 1990, growth in Person County was much slower than in the Raleigh-Durham metro area. (See Table I, below, for recent and projected growth rates for Durham and Person Counties through 2030, as well as recent and projected population densities.) Between 1960 and 1990 the county averaged less than 5% growth per decade, but between 1990 and 2000 grew 18%.[46] The populations of both Durham and Person Counties are expected to grow between 10-15% per decade through 2030.[47] However, the rapid increase in the previous decade as well as the rapidly growing number of roads connecting areas north of Durham to the entire Triangle region suggest that these estimates are conservative and may underestimate future growth.

Table 1. Current and Projected Growth in Durham and Person Counties[48]

	Durham County			Person County		
Year	*Population*	*Population Density*	*% Growth over Previous decade*	*Population*	*Population Density*	*% Growth over Previous Decade*
1970	132,681	457	18.5	25,914	66	-1.9
1980	152,785	527	15.2	29,164	75	12.5
1990	181,835	627	19.0	30,180	77	3.5
2000	223,314	769	22.8	35,623	91	18.0
2010	257,367	887	15.2	40,777	104	14.5
2020	292,639	1,008	13.7	45,898	117	12.6
2030	328,573	1,132	12.3	50,678	129	10.4

New road construction, increasing the connection between neighboring counties and the Triangle, will almost certainly encourage population growth in areas north of Durham, thereby increasing the pressure on the Flat River watershed and endangering water quality. Work on I-85 is widening the interstate from four to eight lanes and will also greatly facilitate connections to Route 70, which in turn can carry commuters southwards more quickly, facilitating the sprawling growth that has characterized the region in recent decades. In addition, several road projects north of Durham will increase the potential for growth in neighboring areas north of Durham.[49,50]

[46] U.S. Census Bureau.
[47] The UNRBA Watershed Management Plan indicates that the Flat River watershed had 12,000 residents in 2000 and estimates 16,000 in 2025 (This represents 30% growth over 25 years, approximately 12.5% per decade); NC State Demographics unit predicts growth rates in Person County would decrease. North Carolina State Demographics, "State Demographics." Accessed March 31, 2004 at http://demog.state.nc.us/.
[48] North Carolina State Demographics. "State Demographics." Accessed March 31, 2004. http://demog.state.nc.us/.
[49] Guess Road, an arterial road stretching north from the City of Durham, is being widened at bottleneck points. The "East-End Connector," expected to be complete in 2007-2008, will connect Route 70 with NC-147 (the Durham Freeway) and will also make it easier to connect from areas north of Durham to Durham or areas to the south. The state will also extend NC-147 to the south so that it connects directly to I-540, the "Raleigh Outer Loop." The planned Durham Northeast and Northwest Loops, collectively known as "Eno Drive," will provide alternate routes around congested areas of downtown Durham – another route for large numbers of commuters to travel from areas north of Durham to centers of employment in the city and to the south.

To determine the eventual effect of growth on water quality, local governments should consider not only the near term growth rates and additional transportation infrastructure, but also the ultimate constraints on growth, including zoning ordinances. Durham County has in the past allowed relatively unconstrained growth in other local watersheds. More recently, Durham and Orange Counties have gradually constrained potential land uses in their portion of the Flat River watershed. The minimum developable lot size in most of Person County is one acre and the Rural Conservation zoning district covering most of the Flat River watershed within Person County allows many different kinds of development.[51] These low constraints could allow significant growth and ensuing water degradation. Person County officials have commented that growth is constrained by other kinds of limits, such as public health regulations of septic systems (which is how nearly all of southern Person County treats its wastes).[52,53] This constraint may not hold in the long term, however, as demand for housing and infrastructure could result in the extension of sewer lines into the area.

Predicting the Effects of Growth

Two recent water quality models predict that growth will lead to significantly degraded water quality sometime after 2025. TetraTech, Inc. completed one of these watershed-scale models for the UNRBA in 2003, and students at Duke's Nicholas School of the Environment have recently completed another.[54] TetraTech used a relatively modest 20-year growth projection for the watershed, estimating that the population in the watershed would grow from 12,000 to 16,000 in 2025. However, projecting the average actual growth rates for Durham and Person Counties between 1990 and 2000 yields an estimate of 19,000 residents by the same date, 75% more than the predicted growth. Thus, the conclusion that water quality will not be significantly degraded between now and 2025 is based on a conservative and potentially underestimated level of growth.

To predict long-term impacts on water quality, the TetraTech model assumed that the long-term constraints upon growth were the zoning ordinances in the watershed's three counties and the development options allowed under the Water Supply Watershed regulations. TetraTech modeled two reasonable scenarios of growth up to allowable limits or "buildout" in the Flat River watershed.[55] A lower-density scenario projected a population of 165,000 residents, which could be reached at an undetermined time in the future if land is developed as zoned and as allowed under the Water Supply Watershed "low density" option. The higher-density scenario estimated a population of 300,000 residents, reachable under the "high density" option allowed under Water Supply Watershed rules.

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[50] Frank, Neal. Personal interview. April 7, 2004. Foyle, R.S., Goode, L.R., Milazzo, J.S. II. "Accelerating Highway Improvements for North Carolina's Research Triangle Area: Final Report." Raleigh, NC: North Carolina State University. February 1999. http://itre.ncsu.edu/highways/download/RTPimprovements.pdf.
[51] Steve Carpenter and Paula Murphy. Personal interview. February 16, 2004.
[52] Steve Carpenter and Paula Murphy. Personal interview. February 16, 2004.
[53] NC Department of Public Health requires certain amounts of land for a septic tank to percolate properly, depending on types of soil.
[54] Kwok, Rose, Michael Osland, and Katherine Wolff. "Lake Michie Management Plan: Current and Future Analysis of Water Quality." April 23, 2004.
[55] UNRBA Watershed Management Plan.

A limitation of the model is that water quality was estimated only for three future scenarios: 2025 projections, and the two buildout projections. Consequently the model did not provide a prescriptive estimate of the growth level at which water quality will be degraded. And, as mentioned above, impacts to water quality are primarily a function of land use changes, and growth rates are merely a useful predictor and correlate of land use changes; thus, there is a necessary margin of error in a model that relies upon estimates of growth.

Person County officials have voiced concern that the UNRBA's Watershed Management Plan's growth projections and other assumptions on development are inaccurate. County officials have not offered alternate growth projections or substantiated greater constraints to growth than those used in the model. If they do so, the model may be improved; until then, its assumptions are the most reasonable ones available.

Despite disagreement over long-term growth, there is little disagreement that between now and 2025, growth in the watershed will not lead to significant degradation of water quality. Because the problem lies in the more distant future, local policy-makers may feel that it is not necessary to address the issue now. However, planning ahead may be crucial for protecting water quality cost-effectively. It is important to acknowledge that land use planning decisions are path dependent. For example, road construction often eventually commits a jurisdiction to other types of infrastructure, and generates dependency upon automobiles. The initial trajectory of growth may have a great influence on future development and future water quality impacts. Planning in advance may leave local governments with more options and greater flexibility for planning in the future.

2.2 CROSS-JURISDICTIONAL COMPLICATIONS

Key Problem: *The fact that water users and landowners in the Flat River watershed live in different jurisdictions makes it difficult for Person County, Durham County, and the City of Durham to work together to protect water quality in the Flat River.*

Conflicting Economic Interests

In watersheds where the landowners are also water users, the decision to protect water quality is relatively simple: if the net benefits of protecting water quality appear to outweigh the costs, those in the watershed will act to protect water quality. Ideally, if every local government protected its watershed as if its residents were also the water users, water supply protection would be maximized. In the Flat River watershed, however, the costs and benefits of protection will accrue to different groups in different jurisdictions. In this watershed, downstream water users in the City of Durham and Durham County, including residential, commercial, and industrial sectors of the local economy, are the primary beneficiaries of clean water, although clean water and clean watersheds benefit many others as well.

Water users fear that upstream landowners may use their land in ways that degrades water quality. Users would then have to pay excessive costs as a result of that degraded water quality, and the ancillary benefits of water quality protection would be lost for both users and residents in the watershed. Upstream landowners may bear many of the costs of protecting water quality to the extent that protection is achieved through greater constraints on current and future land use or on the level of pollutants they can release. What landowners can and cannot do on their land also affects the value of land. The potential for water quality protection to lead to a drop in land values is a major concern of Person County officials and their constituents.

Political Complications

Aside from costs and benefits accruing to different individuals and jurisdictions, there are also cross-jurisdictional political complications. No one local government alone can ensure water quality protection for the entire watershed, but the local governments in the Flat River watershed do not have a history of inter-jurisdictional cooperation. Local governments have little incentive to protect water quality as though their constituents were using the watershed's water resources, even though such an approach would be better for all. They have traditionally favored independent approaches to protect water quality and have not considered downstream impacts unless required to by law. In many cases, residents and officials are actively suspicious of the motivations of those in other jurisdictions, and the apparently conflicting economic interests worsen this political divide.

CHAPTER 3: CRITERIA AND LIMITATIONS OF ANALYSIS

We first propose seven criteria by which to evaluate options to protect water quality in the Flat River watershed. We then discuss the difficulty of using cost-benefit analysis in the decision-making process, and some of the ancillary benefits of water quality protection that policy makers may pursue.

3.1 DESCRIPTION OF CRITERIA

Two of our seven criteria apply to our discussion of policy processes, and six of the seven criteria apply to our consideration of options to protect water quality.

1. Any solution must protect water quality in the Flat River watershed.
The primary goal of any solution is to ensure that water quality in the Flat River watershed does not deteriorate.

In addition, an ideal solution:

2. Will be acceptable to all stakeholders.
A solution to which all parties can agree should be more equitable. This criterion applies to both policy processes and water quality options.

3. Will be perceived as cost effective.
Local governments should consider whether the social benefits of a proposed water quality solution outweigh the social costs. Policymakers should implement the policy that protects water quality at the least cost, and that provides the most ancillary benefits. We recommend cost-effectiveness as a criterion, rather than a strict comparison of the costs and benefits of policies to protect water quality because such a comparison may not be feasible. See section 3.2 for further explanation.

4. Will be administratively affordable.

5. Will be technologically feasible.

6. Will provide flexibility to adapt to future needs and technologies.
With changing technologies, regulatory systems, and needs of stakeholders, an ideal solution would allow some flexibility to adapt to future conditions. Policymakers should consider the flexibility of the local jurisdiction to adapt requirements over time to protect water quality, and the flexibility that landowners or those who are regulated have in meeting those requirements.

7. Will improve local governments' capacity to solve future water quality problems.
Ideally, the solution will expand institutional capacity of local governments to protect water quality at the watershed scale. This criterion applies only to policy processes.

Criteria 2 and 7 apply to our consideration of policy processes to protect water quality, and criteria 1 through 6 apply to the water quality options we consider.

3.2 BENEFITS OF CLEAN WATER AND LIMITATIONS OF COST BENEFIT ANALYSIS

We cannot perform a full cost-benefit evaluation of options in this study. First, data on the costs and benefits of many of the options are either incomplete or do not exist. Second, our proposed policies are not specific enough to undertake a full cost-benefit analysis. For example, we cannot perform a cost-benefit analysis of the concept of BMPs. Analysis would require the details of a specific BMP.

One may be able to determine the costs of implementing many of the options, but it is difficult or impossible to assign a value to the benefit of clean water. This difficulty complicates policy-makers' ability to use cost benefit analysis to rank options to protect water quality. Nevertheless, policymakers should consider the ancillary benefits when evaluating options to protect water quality. We recommend a more feasible criterion of cost-effectiveness, and consideration of the distribution of the costs and benefits by jurisdiction.

Clean water in the Flat River provides many benefits to the local area. Our lives and health depend on clean, drinkable water. Recreation, (including fishing, birding, hiking, canoeing, and kayaking), irrigation, livestock, and local quality of life are all dependent upon clean water. The freshwater aquatic ecosystem of the Flat River, which includes rare freshwater mussels, is also dependent upon clean water. Figure 3 describes some of the benefits of water quality protection.

Figure 3. Uses and Benefits of Clean Water and Watershed Protection

Clean Water
- Drinking
- Recreation
- Agriculture

Watershed Protection
- Reduced water costs and water treatment costs
- Recreation and tourism
- High land values and maintenance of property tax bases
- Freshwater ecosystem health and biodiversity
- Preserves biological indicators of watershed health
- Protects public and private infrastructure: reduced flooding, flood risks, bank instability
- Increases groundwater recharge and reduces hydrological drought and water loss[56]
- Outdoor education opportunities
- Reduced pollutants and pesticides in surface and ground water
- Protection of local farmland

[56] Water loss is a serious problem caused by increases in impervious surfaces. A report from American Rivers, NRDC, and Smart Growth America estimated that 207,000 acres were developed in the Raleigh-Durham Metropolitan Statistical Area between 1982 and 1997. This amount represented a 95% increase in developed land compared to 1982 (while population grew 44% between 1980 and 2000). The report's model estimated that this increase in impervious surfaces caused an annual loss in water infiltration of 9.4 to 21.9 billion gallons in the Raleigh-Durham area. This water is lost downstream.

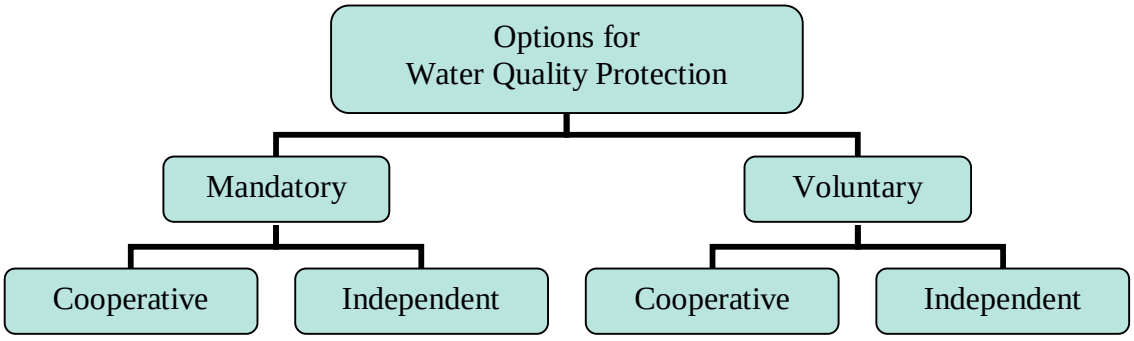
CHAPTER 4: THE PROCESS OF PRESERVING WATER QUALITY

We have described the problem facing the Flat River watershed as one of guaranteeing better protection of water quality, and of overcoming the inter-jurisdictional obstacles to a solution. We have recommended criteria for a solution with the same two-fold approach, which we now follow in outlining and evaluating options, first for the appropriate policy process in this chapter and then for the options to protect water quality in Chapter 5.

In this chapter we evaluate the potential processes by which local governments in the Flat River watershed may arrive at solutions to protect water quality. The processes used to protect water quality are crucial because they are likely to affect the efficiency, flexibility, perceived fairness, and hence the success of any water quality protection options.

All of the water quality options we identify (see Chapter 5) can be implemented either voluntarily or as the result of a mandate, and in Section 1 of this chapter we evaluate these types of processes. In Section 2 we look at how voluntary and mandated processes can in turn be pursued either independently or cooperatively by two or more local governments. See Figure 4 below. In Section 3 we discuss the possibility of compensation as part of a cooperative, equitable solution. In Section 4 we provide examples of situations in which local governments have used different combinations of these processes.

Figure 4. Types of Processes to Protect Water Quality in the Flat River Watershed



4.1 MANDATED VS. VOLUNTARY PROCESSES

Higher governmental bodies are in a position to mandate additional regulation to protect water quality. The threat of a mandate can often prompt local governments to act. In the Flat River watershed, state and local officials do not anticipate any new mandates in the near future, leaving voluntary activity as the principal short run option.

Local governments and residents will almost always perceive voluntary action to be more equitable than a mandate, though they may wish for other jurisdictions to be more

closely regulated. Voluntary action is dependent on local policy-makers seeing the necessity of action, which may happen at different times in different local governments (or not at all). Voluntary action may also be undertaken independently or in tandem with other local governments.

4.2 INDEPENDENT VS. COOPERATIVE PROCESSES

Local governments can and should work independently to maintain or improve water quality if political difficulties and/or separate interests prevent cooperation. Independent action may require less administrative or logistical work in the short run, which increases the short run attractiveness of independent options. Through cooperation and negotiation, however, more and better options for protecting water quality will be available to the stakeholders. Local governments can share resources and ideas to achieve economies of scale when watershed protection is pursued at the watershed level. By creating a more efficient process, cooperation can increase the benefits for landowners in the watershed as well as users of Flat River water. Finally, cooperation breeds more cooperation, and increased communication and common institutions will leave local governments better prepared to respond to pressures the watershed will face in the future. Our assessment of the process options according to our criteria is shown in Table 2, below.

4.3 POSSIBILITIES FOR COMPENSATION

Efficiency gains from cooperative solutions may only be available if a downstream local government (here, the City of Durham and Durham County) is willing to help finance upstream water protection. Downstream governments have often found it cheaper to finance cooperative, upstream protection rather than pursue other, treatment-related options. [57] Such financial assistance could proceed either with direct payments from one government to another, payments from governments to individuals, or through third-party, non-governmental organizations focused on water quality protection. Whatever their form, such payments are essentially payment for environmental services. Compensation could also come in the form of services or other assistance which one local government might offer another.

Where significant differences in outlook or opinion exist among local negotiating governments, unbiased, third-party negotiation may increase the likelihood of a cooperative solution. If a third party is needed to help negotiate a cooperative solution, many major universities, including UNC-Chapel Hill, provide negotiation services.

[57] New York City owns less than 10% of the land in watersheds that provide its drinking water, but has protected land through attractive compensation packages to dairy farmers and loggers upstream. World Bank/WWF Alliance for Forest Conservation and Sustainable Use. "Running Pure." Accessed on April 29, 2004 at http://lnweb18.worldbank.org/ESSD/envext.nsf/80ByDocName/RunningPure Theimportanceofforestprotectedareastodrinkingwater/$FILE/RunningPure2003+.pdf.

4.4 EXAMPLES OF PROCESSES

Mandated Cooperation

The state of North Carolina mandated that High Point and Guilford County work together to protect the Randleman Lake water supply and watershed.[58] To meet the state's requirements, these two local governments traded impervious surface levels to achieve greater protection in areas near the lake.

Mandated Independent Action

The Neuse Rules require each local government to reduce and control nutrient loading in Neuse River waters within their jurisdiction.

Voluntary Independent Action

Many local governments have chosen to voluntarily exceed mandated water quality protection levels through ordinances relating to land use, stream buffers, zoning limits, or stormwater control. The efforts of the combined Durham Planning Board to restrict growth outside of the Urban Growth Area is an example, as are informal efforts by members of the Person County Planning Board to promote low-impact design features in new developments.

Voluntary Cooperation

Durham County and Orange County are currently working together to develop the 391-acre Little River Regional Park, which straddles county boundaries.

Montgomery, Prince George, and Howard Counties in Maryland have created and signed the Patuxent Reservoirs Watershed Protection Agreement (PRWPA).[59] The jurisdictional setting is similar to the Flat River watershed, in that the jurisdictions with much of the watershed's land area (Howard and Montgomery Counties) are not the primary users of its water.

The goal of the PRWPA is an inter-jurisdictional partnership "to implement strategies to protect the long-term biological, physical, and chemical integrity of the Patuxent Reservoirs Watershed." All three counties, which became signatories to the agreement, committed to a watershed management approach to protect water at a reasonable cost, and aimed to protect watershed resources including parks, wildlife habitat, farmland, and recreational areas. The agreement has so far resulted in increased water quality monitoring and modeling, a cost-sharing plan for conservation planning, and other outreach activities. The agreement has also resulted in increased acceptance of the watershed activities because they are built upon a consensus.

[58] Kimberly Brewer, March 2, 2004.
[59] National Association of Counties. Protecting Drinking Water—County Partnerships that Work. June 2000. Accessed April 2004 at http://www.epa.gov/safewater/protect/features.html.

Table 2. Evaluation of Policy Processes

Criteria / **Policy Processes**	Acceptable to stakeholders?	Improves future problem solving capacity?
1. Mandated-independent	No	No
2. Mandated-cooperative	No	Yes
3. Voluntary-independent	Yes	No
4. Voluntary-cooperative	Yes	Yes

CHAPTER 5: POLICY OPTIONS

In this chapter, we present nine water quality options in four basic categories: infrastructure, land use limits, land use practices, and pollution controls. We evaluate each option in relation to our six criteria and present the results in Table 3 at the end of the chapter.

5.1 POLICY SPECTRUM: DIRECT AND INDIRECT STRATEGIES

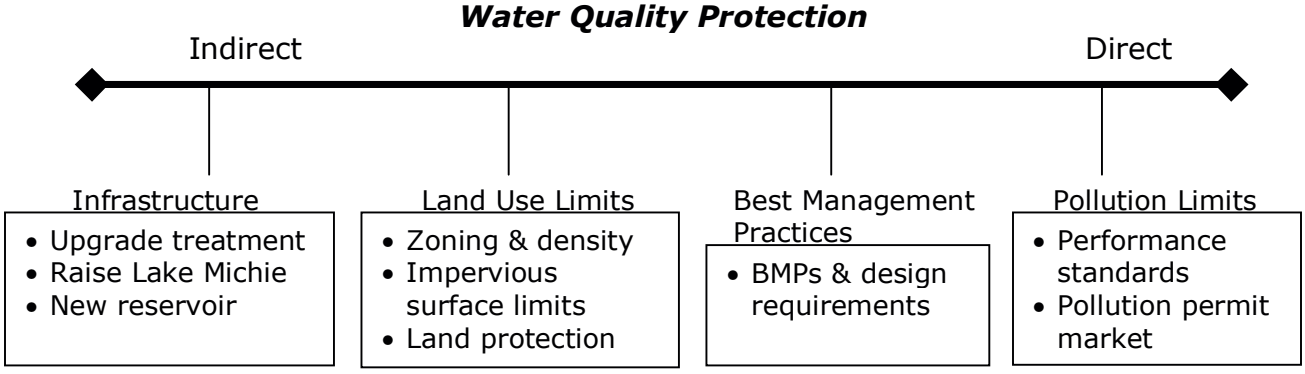
One way to organize and differentiate among strategies to protect water quality is the directness with which they affect water quality. Figure 5 illustrates how the potential water quality options fall on a spectrum from indirect to direct.

Options that would change infrastructure in the watershed are the least direct approach because they contribute to the quality of water in the pipes, not in the river.

A more direct approach is to mandate or negotiate land uses or practices in order to reduce pollution. Approaches in this category include zoning and density changes, land protection, and best management practices. Under a direct strategy, these approaches would be available as tools to meet a required standard; in an indirect strategy, these approaches would simply be mandated.

A direct solution would be to mandate or negotiate a maximum acceptable amount of pollution in a watershed, either at the watershed or sub-watershed level. A "cap" or standard would be set at the point beyond which pollution becomes unacceptably or unnecessarily costly and damaging. In the ideal situation, pollution sources subject to the standard would be allowed complete flexibility in the choice of methods and tools used to fulfill their obligation. All other things being equal, direct methods are preferable because the more flexibility people have to comply with regulations, the more able they are to meet the standard at the least possible cost. However, direct methods may be more administratively burdensome and may require a costly amount of information to enforce.

Figure 5. The Spectrum of Policy Options: Indirect to Direct



5.2 INFRASTRUCTURE

The City of Durham could construct new infrastructure or modify its existing infrastructure to protect drinking water quality and increase supplies. These infrastructural modifications could include an upgrade of water treatment facilities, raising the Lake Michie Dam to increase its capacity, or building a new dam and reservoir upstream of Lake Michie. However, additional infrastructure options may not involve cooperation among jurisdictions, and the cost-effectiveness of projects is not clear at this point. The primary reason why additional infrastructure options are not ideal is that the options provide few ancillary benefits, and none of the options will protect water quality in the Flat River itself.

Option 1: Upgrade Water Treatment Facilities

The City of Durham could upgrade its water treatment facilities if the water quality in the Flat River deteriorates due to upstream development in Person County and rural Durham County. Currently, two water treatment plants, the Williams Water Treatment Plant (built in 1917) and the Brown Water Treatment Plant (built in 1977) supply treated water to the city, using conventional water treatment processes.[60] To meet drinking water quality standards with a water source of deteriorated quality, treatment processes may require extensive use of chemicals such as alum or other coagulants, or adoption of new technologies.

Evaluation of Option 1

1. Protects water quality: **No**. Water treatment is not related to water quality protection in the watershed, only to drinking water for the City of Durham. Additional benefits from good water quality, such as recreational uses and biodiversity, would not result.

2. Is acceptable to stakeholders: **Yes**. Presumably, water treatment will not be upgraded until it is absolutely necessary and the only remaining option, so stakeholders in the City of Durham would not object.[61]

3. Is perceived as cost-effective: **Unclear**. This option is likely to be cost-effective at preserving water quality at the end of the pipe, but is not relevant to protecting water quality in the watershed.

4. Is affordable: **Yes**. The upgrade costs are likely to be affordable to the City of Durham. Over time, the costs of water treatment may increase due to further degradation of the water quality in Lake Michie.

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[60] At the water treatment facilities, raw water is mixed with lime to adjust the pH and alum to coagulate particles. After mixing, the water flows into settling basins where the particle clump together (coagulation) and become heavy and settle to the bottom of the basins (flocculation). The clearer water flows through filters to remove the remaining particles prior to final disinfection with chloramines. Fluoride is then added prior to distribution. City of Durham. "Tap Into Quality." Water Quality Report. 2002. http://www.ci.durham.nc.us/departments/environ/water_quality_report_02.pdf.

[61] Rolan, Terry. Personal inteview. February 24, 2004.

5. Is technologically feasible: **Yes**. The upgrade could be made using current technology.

6. Is flexible: **Yes**. Within certain limits, the city's environmental managers can increase or decrease the level of treatment as needed according to fluctuations in water quality.

Option 2: Raise the Lake Michie Dam

The City of Durham could raise the Lake Michie dam by 40 feet, thereby expanding the capacity and extent of the reservoir. The City of Durham has begun purchasing land surrounding the reservoir to hold a larger reservoir and to provide an appropriate buffer zone.[62]

Evaluation of Option 2

1. Protects water quality: **No**. A reservoir expansion would not protect water quality in the watershed at large, although it would dilute the pollution in the reservoir. Whether or not the dam is raised, the land purchases around the existing reservoir may help protect water quality.

2. Is acceptable to stakeholders: **Mixed**. Rural Durham County residents may oppose selling their property or complying with regulations to protect water quality in the additional area. Person County may not agree if the reservoir expands into lands within its jurisdiction. The state and federal government and open space advocates may object to the loss of land, free-flowing water in the Flat River, and other environmental impacts.

3. Is perceived as cost-effective: **Unclear**. As with other infrastructure options, this option may be cost-effective at preserving water quality at the end of the pipe, but is not relevant to protecting water quality in the watershed at large.

4. Is affordable: **Unclear**. The UNRBA Watershed Management Plan indicates the reservoir expansion could cost $129 million, plus the cost of land acquisition. This may not be affordable, as the construction costs may exceed the City of Durham's budget for water treatment. Raising the dam could entail the costly construction of a new higher dam immediately downstream of the current dam.

5. Is technologically feasible: **Yes**. The construction can be done using current technology.

[62] Rolan, Terry. Personal interview. February 24, 2004.

6. Is flexible: **No**. The dam could not be substantially changed once underway or completed, and dams do not improve watershed water quality in the long or short term.

Option 3: Build a New Dam Upstream from Lake Michie

The City of Durham could build a new dam and reservoir upstream of Lake Michie. The new reservoir could likely be confined to Durham County rather than extending into Person County.

Evaluation of Option 3

1. Protects water quality: **No**. Like the other infrastructure options, the new dam and reservoir would not protect water quality in the watershed; it would only filter pollutants out of water before they could reach Lake Michie.[63] A new dam and reservoir could increase runoff during construction, inundate riparian habitat, and alter water flow both upstream and downstream of the dam. In addition, if a new dam were intended as a water supply, the same water quality concerns that exist for Lake Michie would hold for the new dam.

2. Is acceptable to stakeholders: **No**. Person County would not likely agree if the new reservoir extends into lands within its jurisdiction. In addition, the state and federal governments are not likely to approve such a project.

3. Is perceived as cost-effective: **Unclear**. Data are unavailable.

4. Is affordable: **No**. The construction costs and land purchases may exceed the City of Durham's budget for water treatment, and this option would compete with other programs and policies for public funds.

5. Is technologically feasible: **Yes**. The construction can be done using current technology.

6. Is flexible: **No**. The approval for a new dam involves several state and federal agencies and the approval and construction process can take decades to complete.[64] The dam could not be substantially changed once constructed, and dams do not improve watershed water quality in the long or short term.

[63] This consecutive reservoir system has been constructed in Greensboro and its reservoir, Lake Townsend. Rolan, Terry. Personal interview. February 24, 2004

[64] Rolan, Terry. Personal communication. April 13, 2004.

5.3 LAND USE LIMITS

Land use limits are an indirect method of preserving water quality by reducing the amount of stormwater, erosion, and other pollutants entering the streams. As development increases, increasingly tight limitations will be necessary to protect the remaining undeveloped land if water quality is to remain at its current high level. Locally imposed limits are important options to maintain water quality in the watershed, as they allow local governments to enforce their vision of the appropriate character of land use. The three land use limits that we evaluate are zoning and density changes, impervious surface limits, and targeted land protection.

Option 4: Zoning and Density Changes

Local governments can protect water quality by increasing the minimum lot size allowable in tracts of development and by concentrating higher-density development away from parts of the watershed that are particularly sensitive to pollution and habitat degradation. Regulations limiting the density of septic tank placement in the types of soils found in the Flat River watershed currently limit the density of development in the watershed's rural areas. These regulations exist to protect public health, not water quality, but they serve as an effective limit on the density of development possible as long as residents in the rural areas remain independent of municipal water and sewer systems.

Local governments may also provide additional protection of water quality by improving local codes and ordinances. These codes and ordinances address streets, cul-de-sacs, parking ratios, parking lots, open space allowances, setbacks, sidewalks, buffers, tree conservation, and other small-scale land use elements. These codes and ordinances are generally associated with zoning regulations. Local governments may make many of these improvements without large-scale changes in zoning or in minimum lot sizes. For example, counties may choose to enact improvements included in the Center for Watershed Protection's Codes and Ordinances Worksheet.[65] Person, Durham, and Orange Counties have already filled out this worksheet, and may choose to enact its provisions.

Evaluation of Option 4

1. Protects water quality: **Unclear**. This option could indirectly protect water quality by limiting uses and densities that contribute to water quality degradation. The degree to which zoning changes protect water quality depends on the details of the zoning changes.

2. Is acceptable to stakeholders: **Mixed**. Large-scale zoning changes may be acceptable to individual jurisdictions, but are not likely to be accepted by many stakeholders, especially those facing "downzoning." If local governments or land conservancies could arrange mechanisms to compensate landowners for the potentially lower value of land that cannot be developed as

[65] Center for Watershed Protection. Codes and Ordinances Worksheet. Accessed April 2004 at http://www.cwp.org/COW_worksheet.htm

densely, then more landowners may support ordinances to reduce zoning densities. In contrast, smaller revisions to local codes and ordinances should be more acceptable.

3. Is perceived as cost-effective: **Unclear**. Data are unavailable.

4. Is affordable: **Yes**. Zoning ordinances may be some of the simplest and cheapest regulatory tools to achieve water quality protection.

5. Is technologically feasible: **Yes**. Current technology, including watershed models, might assist in more strategic zoning changes.

6. Is flexible: **Mixed**. Local jurisdictions can change zoning ordinances as research improves our understanding of the effects of land use on water quality. However, large-scale zoning changes are usually politically contentious and in practice difficult to change. Developers and landowners can obtain variances, so they would have some flexibility in compliance with the ordinances. Revisions to the more detailed code and ordinance provisions such as those suggested by the Center for Watershed Protection may be more easily made, but are not effective if a significant amount of development occurs before local governments make the revisions.

Option 5: Impervious Surface Limits

Local governments can protect water quality by limiting the percentage of surfaces in a given area (such as lot, tract, zoning area or county) that are impervious to water. When more rainwater percolates into the ground, there is less runoff that can wash silt, nutrients, and other pollutants into bodies of water. As with zoning and density changes, it is possible to target certain sensitive areas with limits on impervious surfaces. It may also be possible to trade different levels of impervious surfaces between areas in order to concentrate development away from undeveloped areas that are important to maintaining high water quality.[66]

Evaluation of Option 5

1. Protects water quality: **Unclear**. This option indirectly protects water quality by limiting the amount of land cover that contributes to water quality degradation.

2. Is acceptable to stakeholders: **Mixed**. Impervious surface limits, by limiting the options for development, can effectively limit development. Over time, however, the amount of development that is achievable under a given

[66] Trading of development rights has questionable legal status in North Carolina, but carefully designed plans can accomplish it, as the Town of Cary and High Point / Guildford County did in the state-mandated effort to protect Randelman Lake. Brewer, Kimberley. Personal interview. March 2, 2004. Carpenter, Scott. Personal interview. March 16, 2004.

impervious surface limit is likely to increase, as better designs are implemented.

3. Is perceived as cost-effective: **Unclear**. Data are unavailable.

4. Is affordable: **Yes**. Impervious surface limits may be some of the simplest and cheapest regulatory tools to achieve water quality protection.

5. Is technologically feasible: **Yes**. It is possible to accurately monitor and model the percentage of impervious land surface in an area with current technologies, including ground-truthing (spot-checking) and aerial or satellite photography.

6. Is flexible: **Mixed**. As the design technologies and BMPs designed to protect water quality improve, it may be possible to relax the limits on impervious surfaces. However, it may be difficult to reduce the impervious surfaces associated with certain types of land use.

Option 6: Targeted Land Protection

Targeted land protection refers to the purchase of land or the development rights to land (conservation easements) for the purposes of preserving water quality, ecosystem quality, and the open space on which many kinds of activities rely. Riparian zones, wetlands, and buffer areas around watershed streams and lakes are of particular interest to those aiming to protect water quality.

Money for both kinds of purchases is available from private donors, foundations, government agencies, and special funds such as the North Carolina Clean Water Management Trust Fund. Appendix II provides examples of local private conservation groups and funding sources. Fee-simple purchases are generally a more expensive option than easements for targeted land protection. With some landowners, special prices or even donations of land in title or easement can be arranged. Prices vary depending on the market and the level of existing regulation of acceptable uses for the land. Easements are increasingly common and establish a co-ownership situation on the land.

Evaluation of Option 6

1. Protects water quality: **Unclear**. This option reduces water pollution by preventing development from taking place. Less development results in fewer nutrients washing into streams. Undeveloped lands are also more effective in filtering pollutants out of runoff from developed land. We rate this option as unclear because it is an indirect option that does not preclude pollution in other areas.

2. Is acceptable to stakeholders: **Yes**. Government agencies and non-governmental land conservancies buy land and conservation easements only from willing sellers.

3. Is perceived as cost-effective: **Unclear**. Data are unavailable.

4. Is affordable: **Unclear**. Purchase of land fee-simple and conservation easements can strain available funding. Local jurisdictions and small land conservancies often lack sufficient funds to purchase all the land that their open space protection plans call for. Alternative sources of funding exist, but funds such as the state Clean Water Management Trust Fund regularly have more requests for funding than they can grant.

5. Is technologically feasible: **Yes**. Assessments of appropriate lands to conserve can be made with current technology, and money for purchase can be acquired from existing funds.

6. Is flexible: **Mixed**. Not all land conservation is equally useful for water quality purposes, and not all landowners are willing sellers. Conservation easements sold in perpetuity cannot be changed. However, it is possible to sell conservation easements for specified periods of time, and land used for other purposes can be reclaimed for conservation purposes.

5.4 BEST MANAGEMENT PRACTICES

Jurisdictions could adopt certain best management practices (BMPs) and low impact designs to reduce nonpoint source pollution in the Flat River watershed.

Option 7: Adopt Best Management Practices

The term "best management practice" encompasses a myriad of options. For the purpose of this report, BMPs are defined as practices, techniques, and measures that help reduce or prevent water pollution from nonpoint sources. BMPs can either be constructed systems (structural BMPs) or institutional, education, or pollution prevention practices (non-structural BMPs) that limit the generation of runoff or reduce the amounts of pollutants contained in the runoff.[67] Structural BMPs might include water retention ponds, vegetated buffers, and special types of porous pavement. Non-structural BMPs could include certain farming practices that attempt to avoid soil disturbance or construction practices that attempt to avoid soil compaction.

To be effective, local jurisdictions must monitor BMP implementation to ensure that BMPs are installed or practiced properly. Jurisdictions must also monitor water quality to ensure that BMPs are reducing pollution. Government officials, inspectors, or multi-agency

[67] EPA. "Urban Stormwater BMP Study—U.S. EPA." August 1999. http://www.epa.gov/OST/stormwater/usw_c.pdf.

teams of government officials, industry representatives, and scientists could serve as inspectors.[68]

Examples of Best Management Practices

Following are some examples of BMPs for different kinds of activities which help preserve water quality: agriculture, forestry, construction, and residential and urban areas. Appendix III provides further description.

Agriculture
- Conservation tillage
- Crop nutrient management

Forestry
- Timber harvesting practices that reduce water quality impacts
- Road construction/reconstruction management
- Drainage management
- Rehabilitation of skid trails

Construction
- Installation of fabric fences around construction sites
- Preservation of existing vegetation
- Sedimentation traps
- Mulch

Residential and Urban
- Parking lot design
- Reduced fertilizing
- Pervious pavements
- Vegetated buffers in street designs
- Roof runoff controls

Evaluation of Option 7

1. Protects water quality: **Yes**. Practices must be monitored. Different BMPs provide varying amounts of water quality protection, though their effects can be difficult to monitor and measure.

2. Is acceptable to stakeholders: **Yes**. Stakeholders are likely to accept BMPs because of the many choices available and because some of them can be cost-reducing. Some parties may oppose certain BMPs due to costs of implementation, but BMPs are a generally acceptable alternative.

[68] EPA. "Watersheds: Implementing Controls." August 23, 2002. http://www.epa.gov/owow/watershed/focus/focusch7.htm.

3. Is perceived as cost-effective: **Unclear**. Data are unavailable. It may be difficult to convince governments that BMPs are being implemented correctly unless a rigorous monitoring system is in place.

4. Is affordable: **Yes**. Because costs of BMPs vary, affordability would depend on BMPs chosen. However, the City of Durham or private sources could provide funding to support BMP implementation upstream. Administrative costs may rise if the policy includes monitoring and enforcement, depending on who is responsible for monitoring.

5. Is technologically feasible: **Yes**. BMPs can be put into practice with existing technologies.

6. Is flexible: **Yes**. BMPs are flexible to accommodate changes in land use and water quality.

5.5 POLLUTION LIMITS

This option category includes the most direct measures among our options: performance standards and a market for pollution permits.

Option 8: Implement Performance Standards

Performance standards are specific amounts of pollution allowed in a body of water. They are typically measured either as a maximum total amount of pollutants that a body of water can sustain, or as a maximum discharge per time period from a particular area. Jurisdictions in the watershed could set performance standards that would directly protect water quality by requiring nutrient pollution to fall beneath the allowable load. Because performance standards are goals rather than processes, this option could be implemented through various tools, such as BMPs or markets for pollution permits. [69,70]

[69] In North Carolina, under the Water Supply Watershed Protection Program, high-density development is allowed in critical area and non-critical areas of WS-II, WS-III, and WS-IV by meeting certain requirements such as storm water controls with 85% reduction of total suspended solid (TSS). To facilitate the compliance with this requirement NCDENR also proposes several design options and corresponding performance of each option. "Using the High Density Option." *Streamlines* 1(3). May 1996. http://h2o.enr.state.nc.us/wswp/SL/v1n3.html.
Wet detention ponds (85%), extended detention wetlands (85%), pocket wetlands (35%), bioretention areas (85%), sand filters (85%), grassed swales (85%), filter strips (35%), extended dry detention (50%), and infiltration practices (85%). "Alternatives to Wet Ponds Now Available." *Streamlines* 1(2). March 1996. http://h2o.enr.state.nc.us/wswp/SL/v1n2.html#TSSremoval.

[70] In Florida, under the Urban Stormwater Program, based on performance and cost-effectiveness investigations of urban stormwater BMPs, the performance standard for the stormwater treatment was established as 80% reduction of the average annual loading of total suspended solids for most discharges, or 95% for direct discharges to Outstanding Florida Waters. Florida Department of Environmental Protection. "Nonpoint Source Management: Urban Stormwater Program." March 16, 2004. http://www.dep.state.fl.us/water/nonpoint/urban1.htm.

Evaluation of Option 8

1. Protects water quality: **Yes**. Performance standards would directly improve water quality, if enforced.

2. Is acceptable to stakeholders: **Mixed**. The clear goal of a performance standard may improve public acceptance. Acceptance is likely to increase as people are given more options to meet the standard. However, some stakeholders may question whether the chosen performance standard is appropriate. Parties that will implement BMPs may oppose having to meet a specific target in their pollution reduction.

3. Is perceived as cost-effective: **Unclear**. Cost-effectiveness varies depending on the BMP.

4. Is affordable: **No**. The monitoring necessary to enforce a performance standard is currently too expensive.

5. Is technologically feasible: **Yes**. The tools to comply with a performance standard and monitor a performance standard are available.

6. Is flexible: **Yes**. Local jurisdictions could adjust the performance standard as necessary to maintain high water quality. Polluters should have choices for how they meet their targets under the standard.

Option 9: Create a Market for Pollution Permits

The City of Durham, Durham County, Person County, the City of Roxboro, and Orange County could develop a market for pollution permits in the watershed. Nonpoint sources, such as agricultural land and urban pavement that contribute pollutants to runoff, are currently a major cause of water quality impairment.[71] As research quantifies and estimates the pollution from non-point sources, jurisdictions can focus on discharges from nonpoint sources by creating markets for pollution permits. Sources that have difficulty reducing their pollution can buy pollution permits from sources that are easily able to reduce their pollution. These sources can use the payments for implementing BMPs to reduce discharges.

Markets may be established as follows:[72]

1. Jurisdictions jointly establish an office to administer a permit trading system.
2. The office works with jurisdictions, landowners, or other stakeholders to establish performance standards within the watershed, setting the level of pollution allowable from each source.

[71] Although point sources have reduced their pollution discharges since 1972, some of the nation's water bodies are impaired due to stormwater runoff. Stormwater runoff contributes 40% of water body impairment. EPA. Stormwater Phase II Final Rule Fact Sheet Series. http://www.epa.gov/npdes/pubs/fact1-0.pdf.
[72] Miller, Sydney. Personal interview. March 5, 2004.

3. The office allocates permits among the sources according to some systematic measure, such as present pollution, allowable land uses, or expected levels of development.
4. Permit holders freely participate in the pollution permit market facilitated by the office. Other interested parties may buy permits; for example, conservation agencies that wish to reduce the number of available permits.

Evaluation of Option 9

1. Protects water quality: **Yes**. A performance standard combined with a market for pollution permits more flexibly improves water quality if the system is carefully designed, monitored, and enforced, and if there is sufficient participation to allow a competitive market to emerge.[73]

2. Is acceptable to stakeholders: **Yes**. This option would allow greater flexibility in compliance than performance standards alone.

3. Is perceived as cost-effective: **Unclear**. Data are unavailable.[74]

4. Is affordable: **No**. The additional monitoring that would be needed may be too expensive. Establishing an office to oversee the pollution permit market could be a significant and costly effort.

5. Is technologically feasible: **Yes**. Other jurisdictions around the country have already implemented pollution permit market systems, and a market for Jordan Lake is in development.[75]

6. Is flexible: **Yes**. Local jurisdictions could adjust the performance standards as necessary to maintain high water quality. Permit holders could choose how to meet their target. The market mechanism would allow responsiveness to changes in future land development and new pollution control technologies.

[73] For example, three trading permit projects in Wisconsin failed, since the pollution limit was a concentration-based limit rather than a TDML or actual performance standard based limit.
[74] Markets for pollution permits proved to be cost effective in several experiences elsewhere. For example, the Tar-Pamlico Nutrient Reduction Trading Program in North Carolina saved $6 million to the watershed communities. The City of Boulder in Texas had net savings of $1.6 to 5.6 million from the Boulder Creek Trading Program. EPA. "A Summary of U.S. Effluent Trading and Offset Projects." November 1999. http://envstudies.brown.edu/Thesis/2002/caton/case%20study%20pages/north%20carolina/S_Neuse%20River.htm.
[75] Miller, Sydney. Personal interview. March 5, 2004.
EPA. "A Summary of U.S. Effluent Trading and Offset Projects." November 1999. http://envstudies.brown.edu/Thesis/2002/caton/case%20study%20pages/north%20carolina/S_Neuse%20River.htm.

Table 3. Evaluation of Water Quality Options

Criteria / Water Quality Options	Protects water quality?	Acceptable to stakeholders?	Perceived as cost-effective?	Affordable?	Technologically feasible?	Flexible?
Infrastructure						
1. Upgrade Treatment Plant	No*	Yes	Unclear**	Yes	Yes	Yes
2. Raising Lake Michie Dam	No*	Mixed	Unclear**	Unclear	Yes	No
3. New Reservoir	No*	No	Unclear**	No	Yes	No
Land Use Limits						
4. Zoning and Density	Unclear	Mixed	Unclear	Yes	Yes	Mixed
5. Impervious Surface Limits	Unclear	Mixed	Unclear	Yes	Yes	Mixed
6. Targeted Land Protection	Unclear	Yes	Unclear	Unclear	Yes	Mixed
BMP and Design Requirements						
7. BMP and Design Requirements	Yes	Yes	Unclear	Yes	Yes	Yes
Pollution Limits						
8. Performance Standards	Yes	Mixed	Unclear	No	Yes	Yes
9. Market for Pollution Permits	Yes	Yes	Unclear	No	Yes	Yes

* Infrastructure options protect water quality at the end of the pipe, rather than in the watershed.

** Because infrastructure options do not protect water quality in the watershed, their cost-effectiveness is necessarily limited to providing clean drinking water at the end of the pipe.

CHAPTER 6: RECOMMENDATIONS

In this section we make six recommendations based on our evaluation of the options. Our first recommendation is a process recommendation, and succeeding recommendations are the best available options according to our criteria. Local governments could pursue recommendations 2, 3, and 4 immediately, whereas local governments do not currently have the capacity to implement recommendation 5.

Recommendation 1: Voluntary Cooperative Process

Voluntary, cooperative processes best satisfy our criteria, so local government officials should first attempt to protect water quality through collaboration and consensus with other local governments. A negotiated solution is especially likely to seem fair to all stakeholders and improve local governments' capacity to address future water quality problems. We believe that third-party mediators, such as state government officials or environmental conflict resolution experts, could help to enhance the negotiation process.

Recommendation 2: Codes and Ordinance Revision (part of Option 4)

Though the impact of improvements in zoning ordinances on water quality is difficult to predict, local governments can easily revise codes and ordinances for small-scale land uses (such as driveways, streets, parking lots, setbacks, and more) at minimal cost. Local governments have already examined the compatibility of their current codes and ordinances with water quality protection, as measured by the Center for Watershed Protection's Codes and Ordinances Worksheet. Local governments should improve the compatibility of such codes and ordinances with water quality protection.

Recommendation 3: Targeted Land Protection and Outreach (Option 6)

The governments of Person County, Durham County, and the City of Durham should begin voluntary, cooperative action to purchase conservation easements on land critical to the Flat River's water quality. Private and local government funding can be used to leverage additional land protection funding from state and federal sources. In addition, funding may be directed toward stewardship and conservation organizations. Through negotiation, each local government's contribution should be established in line with the benefits they would receive from the land protection. Local governments should conduct an outreach effort to inform landowners about the opportunities to protect open space, including the tax incentives and other benefits of easements.

Recommendation 4: BMP Education and Outreach (Option 7)

As a precursor to requiring the use of best management practices, the governments of Person County, Durham County, and the City of Durham should ensure that they, landowners, and developers are aware of the most up-to-date BMPs. These stakeholders

would become aware of low impact design options that could be cost-effective or cost-reducing means of decreasing the water quality impacts of new developments.

Recommendation 5: Performance Standards (Option 8)

The governments of Person County, Durham County, and the City of Durham should establish performance standards for all water pollutants to maintain the current water quality in Lake Michie. In the near term, the performance standard would be met indirectly through BMPs and low impact designs mandated by each jurisdiction. In the future, when developments and land uses can be designed to enable cost-effective monitoring of runoff from a discrete parcel, each landowner would be given the option to freely select BMPs or other actions to meet the performance standard. Water users could assist landowners with the cost of implementing any BMPs that impose additional costs on landowners.

Recommendation 6: Further Study

As a possible future extension of performance standards, Person County, Durham County, and the City of Durham should consider a pollutant trading system as a direct and flexible option for water quality protection. Due to current technological uncertainties and high potential administrative costs, this option is not viable as an immediate solution.

We also recommend further modeling to project demographic changes in the Flat River watershed and the ensuing pressures on water quality. Policy makers would benefit from more accurate predictions about the constraints to growth and about when water quality will be threatened. Concrete figures are more conducive to concrete action.

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APPENDIX I: LAND USE REGULATIONS IN THE FLAT RIVER WATERSHED

FEDERAL RULES

The Clean Water Act, developed during the 1970s, gives the U.S. Environmental Protection Agency (EPA) authority to regulate pollutant discharges into water and requires states and other jurisdictions to adopt EPA-approved water quality standards for their waters.[76] The act prohibits discharging from point sources into navigable waters without a permit.[77] However, non-point source pollution (pollution from urban and agricultural land that is transported by precipitation and runoff) is now the leading cause of impairment across states and jurisdictions, for all types of bodies of water.[78] Motivated by this fact, EPA and the local agencies that implement the Clean Water Act have shifted their attention away from solely the chemical aspects of water quality protection and toward the physical and biological aspects of water quality.[79]

The Clean Water Act also authorized the National Pollutant Discharge Elimination System (NPDES), which regulates municipal, industrial, and commercial point sources of pollutants, as well as construction sites. This goal is accomplished by requiring point sources to have permits for discharging. Permits provide two levels of protection, one based on the use of pollutant-controlling technologies and the other based on overall water quality.[80] There are also two phases of rules. Phase I mainly requires that large cities, such as Durham and Raleigh, control stormwater runoff. Phase II extends these requirements to less populous areas, including "urbanized" areas of more than 10,000 people, such as Durham County and Orange County. North Carolina is in the process of developing rules for Phase II.[81]

The Safe Drinking Water Act (SDWA), passed in 1974 and amended in 1986 and 1996, gives the EPA the authority to set standards for the levels of contaminants in drinking water. These standards are part of the Safe Drinking Water Act's "multiple barrier" approach to drinking water protection, which includes protecting drinking water sources; making sure water is treated by qualified operators; ensuring the integrity of distribution systems; and making information available to the public on the quality of their drinking water.[82] Both the EPA and the state governments can take action (such as legal actions or fines) to enforce the SDWA against water systems that do not meet safety standards. The act also established the

[76] EPA. "The Watershed Protection Approach." March 30, 2004. http://www.epa.gov/OWOW/watershed/statewide/chaptr1.htm.
[77] EPA. "Clean Water Act History." February 20, 2003. http://www.epa.gov/region5/water/cwa.htm.
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Drinking Water State Revolving Fund, which states can draw on to improve their water systems' infrastructure or management, or to assess and protect source water.[83]

NORTH CAROLINA RULES

Water Supply Watershed Protection Act

The state agency with jurisdiction over water quality in the Flat River is the Division of Water Quality (DWQ) within the North Carolina Department of Environment and Natural Resources (DENR). The DWQ issues pollution permits, monitors permit compliance, evaluates environmental quality, and enforces environmental regulations.[84] The regulations that the DWQ implements come from the Environmental Management Commission (EMC), a group appointed by the governor and the legislature that works to create regulations based on the elected officials' laws and policies.[85]

Before 1989, the EMC and the DWQ administered a Water Supply Protection Program on a voluntary basis with local governments. However, given that many water watersheds fell under the jurisdiction of multiple local governments, policymakers found it necessary to develop minimum statewide measures to protect the quality of water supplies. In 1989 the General Assembly passed the Water Supply Watershed Protection Act, which required the EMC to adopt water protection standards (which involve controlling development density and providing for performance-based alternatives) and classify surface water supply watersheds according to levels of protection. Municipalities and counties submit water protection ordinances to the EMC for review and approval.[86]

The four categories of watershed classification under the Water Supply Watershed Protection Act are partially descriptive (what land uses they contain) and partially prescriptive (what types of development and discharges are allowed). Lake Michie, and by extension the Flat River watershed, has a WS-III status, which indicates that it is a low to moderately developed watershed. In its critical areas (adjacent to water supply intakes), no new landfills are allowed and agricultural BMPs are required, while in the rest of the watershed, landfills may not do any new discharging, and agricultural BMPs are not required.[87] Table 4 details the levels of protection available for the four categories of watersheds.

As part of the Water Supply Watershed Protection Act, the Flat River watershed is eligible for the 10/70 provision and the low- and high-density development options, which allow some flexibility in implementing the Water Supply Watershed Protection Act's

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[83] EPA. "Understanding the Safe Drinking Water Act." December 1999 http://www.epa.gov/safewater/sdwa/understand.pdf.
[84] DENR. "About the Division of Water Quality." July 24, 2003. http://h2o.enr.state.nc.us/admin/about.html.
[85] DENR. "Environmental Management Commission." February 16, 2004 http://h2o.enr.state.nc.us/admin/emc/.
[86] DENR. "History of the N.C. Water Supply Watershed Protection Program." February 9, 2001. http://h2o.enr.state.nc.us/wswp/history.html.
[87] DENR. "Water supply watershed classifications." November 15, 2003. http://h2o.enr.state.nc.us/wswp/wsclasses.html.

standards. The high-density option allows for more built-upon area as long as stormwater management techniques are installed to mitigate the effects of the increased impervious surface area. Low-density allows up to 2 dwelling units per acre or 24% impervious surface cover. The 10/70 provision allows local governments to reserve 10% of the non-critical area of each watershed for development up to a 70 % built-upon area limit, as long as they use the low-density option throughout the rest of the watershed. This arrangement allows developers to concentrate growth away from lands that are, for example, sensitive or flood-prone.[88]

Table 4. Water Supply Watershed Protection Rules Summary[89]

Watershed Classification	Allowable Dischargers	Allowable Development: Low Density	Allowable Development: High Density	Stormwater Controls: High Density	10/70 Provision	Residuals Application	Landfills	Agriculture BMPs (5)
WS-I Watershed	None	None	None	NA	None	None	None	Required
WS-II Critical Area	General Permits	1du/2ac or 6% built upon (2)	6-24% built upon area	Control the 1" storm	Not Allowed	No new sites	No new landfills	Required
WS-II Balance of Watershed	General Permits	1du/ac or 12% built upon area	12-30% built upon area	Control the 1" storm	Allowed	Allowed	No new discharging landfills	Not Required
WS-III Critical Area	General Permits	1du/ac or 12% built upon area	12-30% built upon area	Control the 1" storm	Not Allowed	No new sites	No new landfills	Required
WS-III Balance of Watershed	Domestic & Non-process Industrial	2du/ac or 24% built upon area	24-50% built upon area	Control the 1" storm	Allowed	Allowed	No new discharging landfills	Not Required
WS-IV Critical Area	Domestic & Industrial (1)	2du/ac or 24% built upon (3)	24-50% built upon area (3)	Control the 1" storm	Not Allowed	No new sites	No new landfills	Required
WS-IV Protected Area	Domestic & Industrial	2du/ac or 24% built upon (3,4)	24-70% built upon area (3,4)	Control the 1" storm	Allowed	Allowed	Allowed	Not Required
WS-V Watershed or River Segment	Domestic & Industrial	No categorical restrictions other than in-stream water quality standards applicable to all surface water supply waters.						

Notes:
(1) New industrial process wastewater discharges are allowed but will require additional treatment.
(2) Residential development may apply dwelling units per acre or use % built-upon surface area. Non-residential development must use % built-upon surface area.
(3) Applies only to projects requiring a Sedimentation / Erosion Control Permit.
(4) One-third acre lot or 36% built-upon area is allowed for projects without curb and gutter street drainage systems.
Additional notes:
(5) In WS-I watersheds and critical areas of WS-II, WS-III, and WS-IV watersheds, agricultural operations must maintain a ten-foot vegetated buffer or equivalent control along all perennial streams. Permitted animal operations are allowed in all water supply watersheds.
(6) Municipal with pretreatment program (2H .0904) is considered industrial discharge.
(7) Discharges qualifying for a General Permit pursuant to 2H .0127 will also be allowed in all areas of WS-III and WS-IV watersheds along with the allowed discharges noted in the table.
(8) Groundwater remediation discharges may be allowed when no other practicable alternative exists.
(9) Local governments will assume ultimate responsibility for operation and maintenance of stormwater controls.

[88] DENR. "Frequently asked questions." November 15, 2003. http://h2o.enr.state.nc.us/wswp/FAQs.html.
[89] Source: DENR. "WSW Protection Rule Summary Table." June 8, 1995. http://h2o.enr.state.nc.us/wswp/TablClas.html.

The Neuse Rules

Political pressure for the Neuse Rules (the Nutrient Sensitive Waters Management Strategy for the Neuse River) stemmed from the deaths of millions of fish in 1995, killed by large nitrogen loads flushed into the river during record rainfalls. The North Carolina General Assembly passed H.B. 1339, which established the goal of a 30 % reduction in the nitrogen load below 1995 levels to be achieved within five years.[90] The EPA approved this amount, and in 1999 based its official total maximum daily load (TMDL) for the Neuse River on this goal.[91] The EMC adopted the permanent rules in 1997.[92] There are five subcategories of the rules: riparian area, agriculture, stormwater, nutrient management, and wastewater discharge.

The Riparian Area Rule mandates levels of protection for the land adjacent to bodies of water. It establishes two zones around each body of water; Zone 1, closer to the water, must remain basically undisturbed, while Zone 2, outside Zone 1, has slightly lighter protection that requires dense plant cover and prohibits use of fertilizer.[93]

The Agriculture Rule provides two strategies by which farmers can reach the 30 % goal in nitrogen reduction. First, farmers could participate in a Local Nitrogen Reduction Strategy, in which state and local committees would work with farmers to tailor nitrogen reduction goals for each farm. If farmers do not sign up for that option, they must implement standard best management practices (BMPs).[94]

The Stormwater Rule applies to the largest and fastest-growing local jurisdictions in the Neuse River basin, which includes the City of Durham, Durham County, and Orange County. Person County and Roxboro are not included, but the EMC can designate additional local jurisdictions if they contribute significant nutrient loads to the Neuse River.[95] Under this rule, the DWQ works with local governments to develop plans to reduce nitrogen runoff in stormwater.[96]

The Nutrient Management Rule applies to people who apply fertilizer to or manage fifty or more acres of land each year. These people can satisfy the rule by either 1) completing training and continuing education in nutrient management, or, if they do not sign

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[90] DENR. "Why is there a riparian area rule for the Neuse River?" Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/cheat-s3.htm.
[91] EPA. "A Summary of U.S. Effluent Trading and Offset Projects." November 1999. http://envstudies.brown.edu/Thesis/2002/caton/case%20study%20pages/north%20carolina/S_Neuse%20River.htm.
[92] DENR. "The Neuse Rules." Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/neuse.htm.
[93] DENR. "What does the Neuse River Riparian Area Rule require?" Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/cheat-s3.htm.
[94] DENR. "What does the Neuse River Agriculture Rule say?" February 10, 2002. http://h2o.enr.state.nc.us/nps/ag.htm.
[95] North Carolina Administrative Code 15A 02B .0235. "Neuse River Basin – Nutrient Sensitive Water Management Strategy: Basinwide Stormwater Requirements." Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/2b-0235.pdf.
[96] DENR. "What does the Neuse River Stormwater Rule say?" Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/cheat-sh.htm.

up for training, 2) developing a written nutrient management plan for their property, according to various government and industry standards.[97]

The Wastewater Discharge Rule establishes limits on pounds of nitrogen discharged per year for the roughly 180 wastewater facilities in the Neuse River Basin that have discharge permits from the DWQ. Facilities are grouped by area (above and below the Falls Lake Dam) and by volume of permitted flows (less than or more than 0.5 million gallons per day). To reach their limits, dischargers could either meet individual mass-based limits that are proportional to their permitted flows, or they could join a nitrogen trading coalition.[98] Although at least 40 facilities expressed interest in joining, the coalition has not yet been established, and no trades have occurred.[99]

The Wastewater Discharge Rule also places a 2.0 milligrams per liter (mg/L) limit on phosphorus dischargers throughout the Neuse River basin and places stricter limits on new or expanding dischargers, of 3.5 mg/L for nitrogen and 1.0 mg/L for phosphorus. If new or expanding facilities cannot obtain an allocation for nitrogen from existing dischargers, they must make offset payments to the North Carolina Wetland Restoration Fund at the rate of $11 per pound per year.[100]

LOCAL RULES

In 1949, Durham, reacting to rapid growth, became the second North Carolina county to get legislative authority to zone land, and by 1956 had implemented a comprehensive zoning ordinance. The Durham City / County Planning Department currently has twenty-three zoning districts with eight different overlay districts, including one for watershed protection. The watershed protection overlay mandates buffer zones around reservoirs and streams as well as impervious surface limits which decrease the closer the development is to a reservoir. There is also an "Urban Growth Area" (UGA) overlay, which allows growth in certain areas, but restricts development in areas lying outside of the designated area. High density options within the UGA may also require stormwater controls to deal with the first inch of rainfall for any given rain event. [101]

In Person County, there was very little by way of land-use ordinances until late 1988, when North Carolina's watershed water supply rules went into effect and counties were required to adopt certain ordinances in response to this ruling. Person County has on several

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[97] DENR. "What does the Neuse River Nutrient Management Rule say?" February 10, 2002. http://h2o.enr.state.nc.us/nps/nmgt.htm.

[98] DENR. "What does the Neuse River Wastewater Discharge Rule say?" Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/pt-sourc.htm.

[99] EPA. "A Summary of U.S. Effluent Trading and Offset Projects." November 1999. http://envstudies.brown.edu/Thesis/2002/caton/case%20study%20pages/north%20carolina/S_Neuse%20River.htm.

[100] North Carolina Administrative Code 15A 02B .0240. "Neuse River Basin – Nutrient Sensitive Water Management Strategy: Nutrient Offset Payments." Accessed March 28, 2004 at http://h2o.enr.state.nc.us/nps/2b-0240.pdf.

[101] Durham City/County Planning Department. "Durham Zoning Ordinance." Accessed March 2004 at http://www.ci.durham.nc.us/departments/planning/zoneord/section5/55.cfm.

occasions updated its ordinances, with increasing detail. Currently, Person County has five zoning districts (Rural Conservation, Residential, Highway Business, Neighborhood Business, and General Industrial) and three zoning overlays, including an overlay for watersheds that incorporates state mandated water supply protection provisions.[102] In most of Person County the minimum developable lot size is one acre, and the Rural Conservation zoning district covering about 80% of the county, including most of the Flat River watershed with the county, allows many different kinds of development.

Orange County contains only a few square miles of the Flat River watershed, but for this and other watersheds the county has maintained a proactive program for water quality protection. The county government has used fees and money leveraged from several state and national trust funds to run its Lands Legacy Program, a targeted land protection program that works both through purchases of easements and occasional outright purchases of land from willing sellers. The County Commission, the Planning Department and the Environmental and Resource Conservation Department have also increased the minimum allowable lot size in many crucial, relatively undeveloped watershed areas, particularly in the northern part of the county. The county continues to hold public meetings regarding additional increases. These increases, however, have not yet included the Flat River watershed.[103]

[102] Person County Planning and Zoning Department. "General Overview." Accessed March 31, 2004 at http://www.personcounty.net/sections.php?op=viewarticle&artid=19.
[103] Altieri, Tom. Personal Interview. March 4, 2004.

APPENDIX II: LOCAL LAND CONSERVANCIES AND FUNDING SOURCES

Piedmont Land Conservancy

The Piedmont Land Conservancy was founded in 1990 and works to preserve land in Piedmont North Carolina. The Conservancy works primarily in areas to the north and west of the Triangle, including Greensboro and Winston-Salem. On January 1, 2004, the Conservancy announced the protection of more than 10,000 acres of watershed land, working farms, urban green space, historic land, and natural heritage area. It has received funds from NCDOT, the USDA, and the NC Clean Water Management Trust Fund to help match its private donations. On average, using additional funds leveraged with the private funds, the Conservancy has arranged protection of one acre of land for every $60 in private donations they have received.[104]

Triangle Land Conservancy

The Triangle Land Conservancy was founded in 1983 and works in the six counties generally considered to be part of the Triangle (Chatham, Durham, Wake, Johnston, Lee, and Orange Counties). The Conservancy partners with or assists other non-profits in acquiring key tracts for conservation. It has over 2,000 members and to date has protected over 6,500 acres. The Conservancy owns 24 properties and owns easements on 23 more, the latter of which total 2,300 of the acres. Finally, the conservancy has transferred 4 tracts of land to local and state governments to be included in greenways or parks.[105,106]

Clean Water Management Trust Fund

Well-publicized pollution spills from North Carolina hog farms in 1996 heightened the political salience of water quality and created an opportunity for environmentally concerned state legislators to establish a policy for cleaning polluted waters as well as protecting water quality before pollution could occur.[107] Lawmakers reasoned that preventing water quality degradation would, in the long run, be less expensive than restoring areas after pollution had occurred. The General Assembly enacted the Clean Water Management Trust Fund (CWMTF) in 1996. By 2001, it had disbursed more than $220 million to projects around the state.[108]

Any local government, state agency, or non-profit organization that is organized to conserve, preserve, or restore natural resources can apply for a CWMTF grant. Grant

[104] Piedmont Land Conservancy – North Carolina. April 8, 2004. http://www.piedmontland.org/.
[105] Triangle Land Conservancy. Accessed April 2004 at http://www.tlc-nc.org/.
[106] Triangle Land Conservancy. "State of Open Space 2000: The Status of the Triangle's Green Infrastructure." 2000. http://www.tlc-nc.org/sos2000.pdf.
[107] Dyer, Eric. "Safeguarding an important N.C. resource." News & Record (Greensboro, NC). August 18, 2003.
[108] Bevington, Steve. "CWMTF Funded Projects Sorted by Riverbasin." May 17, 2001. http://www.cwmtf.net/reports/fpwater.html.

recipients can use the funds to purchase rights to development (*conservation easements*) or land (*fee simple*). The purchases must serve any of the following purposes:

- Establish riparian buffers that protect environmental and drinking water quality and establish a network of riparian greenways for environmental, educational, and recreational purposes.
- Protect surface waters and drinking water supplies.
- Restore degraded lands to improve water quality.
- Repair or eliminate failing or illegal waste treatment systems, septic tank systems, or drainage systems, especially in economically distressed areas.
- Improve stormwater controls and management.
- Facilitate planning to reduce water pollution.[109]

These criteria for grants direct money toward surface water projects, not groundwater. Recipients also may not use grants for projects that replace or protect areas similar to habitats lost through development (*compensatory mitigation*).[110]

[109] NC General Statutes, Chapter 113, Article 13A. "Enabling legislation." Accessed February 17, 2004 at http://www.cwmtf.net/leg01.html.
[110] McGrath, Gareth. "Inlet project may still float; New Hanover undaunted by current hurdle." Wilmington Star (Wilmington, NC). October 14, 2001.

APPENDIX III: EXAMPLES OF BEST MANAGEMENT PRACTICES

Category	BMP	Description	Effectiveness	Cost
Agriculture[111]	Conservation Tillage	Farmers plow soil as infrequently as possible. Farmers also leave residual from crops, to prevent runoff.	10% crop residual – 30% erosion reduction. 40% crop residual – 75% erosion reduction. 80% crop residual – 94% erosion reduction.	Corn: (-) $17/acre. Soybean: (+) $22/acre. Wheat: (+) $5/acre.
	Crop Nutrient Management	Farmers manage and track fertilizer application to fields, ensuring no excessive nutrients in runoff.		Fertilizer savings: $2 –$32/acre depending on crop type. $5/acre management cost.
Forestry[112]	Timber Harvesting Practices	Workers avoid tree removal near waterways. Where tree harvesting disturbs the soil, workers can cover the area with mulch, plant new ground cover, or install sediment control structures.	Careful harvesting practices only disturb 8% of the soil, compared with 40% with normal logging.	Increased labor that might be required.
	Road Construction/ Reconstruction	Engineers design roads to minimize erosion. Engineers can decrease grades and construct water bars. They can also use sediment traps, gravel, and grass.	Different practices can decrease erosion by 12-99%.	Costs vary depending on type of BMP.
	Rehabilitation of Skid Trails	Workers plant vegetation in disturbed areas.		$360/acre.

[111] USDA. "Conservation Practices Training Guide." Accessed April 15, 2004 at http://www.nrcs.usda.gov/technical/ECS/agronomy/core4.pdf.
[112] EPA. "Non-Point Source Pollution: Management Measures for Forestry." Accessed April 10, 2004 at http://www.epa.gov/owow/nps/MMGI/Chapter3/.

Category	BMP	Description	Effectiveness	Cost
Construction[113]	Silt Fence Installation	Workers install fabric fences to catch runoff from disturbed soil.	Removes 70% of total suspended solids, 80-90% of sand, 50-80% of silt-loam, and 0-20% of silt-clay-loam.	$2-$6/ft.
	Mulch	Workers mulch areas to prevent soil erosion.	53-99.8% soil loss reduction depending on type of mulch used.	$800-$3,500/acre
	Natural Vegetation Preservation	Workers protect desirable trees, vines, bushes, and grasses from damage during construction.	Soil is not disturbed, preventing erosion.	Increased labor that might be required to maneuver around trees or protected areas.
	Sediment traps	Workers build small impoundments that allow sediment to settle out of runoff water.	Reduces total suspended solids by 60%.	$0.20-$2.00/ft, about $1,100/acre.
Residential and Urban[114,115]	Parking Lot Design	Engineers and planners can minimize lot space dimensions, create vegetated islands, and utilize pervious surfaces for overflow parking.		In one case, impervious surface was reduced by 40% and construction costs were reduced by 20%, compared to a conventional design.
	Pervious Pavements	Engineers can replace conventional asphalt or concrete with more pervious surfaces, such as gravel, bricks, or paving blocks.	Can reduce runoff by as much as 80%.	More expensive than traditional asphalts. Costs can be offset by reduction of traditional curb and gutter systems.
	Grassed Channels and Swales	Engineers can design highways and roads with grassed channels along the roads that remove sediment.	Grassed channels remove 81% of total suspended solids, 38% of nitrogen, and 50% of bacteria.	$0.50/ square ft.
	Roof Runoff Controls	Architects can design roofs that direct runoff into a rain barrel, cistern, or retention pond. Another option is vegetated roof covers, which decrease the amount of impervious surface.	Vegetated roof covers can reduce annual runoff by 50%.	Vegetated roofs are approximately double the cost of a premium conventional roof.
	Stormwater Retention Ponds	Developers or landowners can direct runoff into a water retention pond.	Removes 0-80% of phosphorous, 37-80% of nitrogen.	

[113] EPA. "Construction Site Storm Water Runoff Control." Accessed April 9, 2004 at http://cfpub.epa.gov/npdes/stormwater/menuofbmps/con_site.cfm.
[114] EPA. "Storm Water Phase II Menu of BMPs." Accessed April 10, 2004 at http://cfpub.epa.gov/npdes/stormwater/menuofbmps/menu.cfm.
[115] EPA. "Low Impact Development: A Literature Review." Accessed April 3, 2004 at http://www.epa.gov/owow/nps/lid/lid.pdf.

APPENDIX IV: GLOSSARY

Best management practices (BMPs): Practices, techniques, and structures that reduce or prevent water pollutants from point or nonpoint sources.

Buffer zone: An undeveloped, vegetated area along a body of water through which runoff can flow in a diffuse manner and infiltrate into the soil, allowing filtration of pollutants.

Buildout: An estimate of the potential future development within the watershed.

Critical area (Water Supply Watershed Protection Act): Land within one-half mile upstream and draining to a river intake or within one-half mile and draining to the normal pool elevation of water supply reservoirs.

Effluent: The treated liquid that a wastewater treatment plant discharges.

Eutrophication: The process in which nutrients, organic matter, or silt enrich a body of water and cause physical, chemical, or biological changes, including excessive growth of algae that can deplete dissolved oxygen, threaten aquatic life, and cause taste and odor problems.

Impaired: The term for a body of water that partially supports, or does not support, its determined uses.

Impervious surface: Any surface that water cannot easily penetrate, thereby causing runoff. Examples include pavement and rooftops. Water quality often becomes degraded when approximately 10 % of a watershed becomes covered with impervious surfaces.

Land cover: The observed physical cover, including the vegetation (natural or planted) and human construction that covers the earth's surface.

Land use: The type of development, activity, or natural state that occupies a tract of land. Examples include residential, agricultural, or forest.

Nonpoint source: Any source of discharged pollutants that is not discernible, confined, and discrete. Usually associated with rainfall and snowmelt runoff. The amount of runoff is strongly dependent on the type of land cover and land use.

Nutrients: Elements such as nitrogen and phosphorus, which pollute water by stimulating the growth of algae and leading to biological processes that deplete the oxygen content of water.

Nutrient concentration: The amount of nitrogen or phosphorus in a defined volume of water.

Nutrient load: The total amount of nitrogen or phosphorus entering the water during a given time.

Overlay district: A type of zoning district superimposed over other districts. Allows special regulations to apply to specific areas.

Performance standard: A measurable number that specifies the acceptable outcome, such as the maximum number of milligrams of nitrogen per liter of water.

Market for pollution permits: A system whereby government officials cap total allowable pollution (specifying one or more pollutants). The government would then distribute permits totaling that amount among landowners. Landowners for whom pollution reduction is more expensive would then be able to buy additional permits from landowners who can reduce their pollution more efficiently.

Point source: Any discernible, confined, and discrete location that discharges pollutants.

Runoff: Rainfall that does not evaporate or infiltrate the ground, but flows across land and into bodies of water.

Targeted land protection: Conservation measures to preserve a certain tract of land. It usually means the direct purchase of land or conservation easements.

Total maximum daily load (TMDL): The amount of a given pollutant that a body of water can assimilate and maintain its uses and water quality standards.

Water supply watershed: A watershed that contains a body of water that supplies drinking water and other human uses.