Little Lick Creek

Local Watershed Plan

Upper Neuse River Basin
December 2006

Ecosystem Enhancement Program

Little Lick Creek

Local Watershed Plan

Developed by the North Carolina Ecosystem Enhancement Program

Produced by the Upper Neuse River Basin Association, Center for Watershed Protection, and North Carolina Division of Water Quality

December, 2006

Table of Contents

Table of Figures

Table of Tables

Executive Summary

The Little Lick Creek Local Watershed Plan recommends nine comprehensive watershed management strategies for restoring the Watershed's water quality and aquatic habitat in the short-term and protecting them in the long-term. Little Lick Creek is on the NC Section 303(d) list of impaired water bodies, due primarily to the Creek's poor aquatic life ratings and to low levels of dissolved oxygen. The Creek is also a tributary of Falls Lake, for which the State of NC is currently developing a nutrient management strategy.

The NC Ecosystem Enhancement Program (NC EEP) funds planning efforts that help the program proactively address environmental impacts. In particular, this plan was funded through a broad initiative to help the State's Division of Water Quality achieve nutrient loading requirements in the Neuse River Basin. This watershed plan, therefore, identifies projects and develops strategies to help meet Neuse River Basin nutrient loading requirements. The two year-long Little Lick Creek planning effort identified a host of opportunities to restore water quality and aquatic habitat in the 21 square-mile Watershed, including 24 stream repair locations, 24 buffer restoration sites, 71 stormwater retrofit projects, and hundreds of problem on-site wastewater systems. The plan recommends the following watershed restoration strategies:

Stream Repair Projects
Riparian Buffer Restoration
Stormwater Retrofits

Little Lick Creek Partners identified these projects through extensive field work, and each project is technically feasible. Modeling done for the project predicts that implementing these recommendations will result in significant improvements in water quality. However, it is very clear that Little Lick Creek is zoned for much more development in the future, and only a comprehensive management approach stands a chance of protecting water quality and aquatic habitat in the long-run. How will local communities improve water quality and aquatic habitat while the remaining forest and agricultural lands are converted residential development? This plan recommends the following strategies to prevent future degradation:

Critical Lands Protection
Better Site Design
Improved Enforcement of Existing Rules

The field teams also identified specific actions by homeowners and businesses at home and work that increased pollutant loads. This included trash dumping, poor maintenance of on-site wastewater treatment systems, small vehicle maintenance and repair operations, outdoor materials storage, grease storage, and wash water disposal. To address these issues, this plan recommends the following strategies to increase watershed stewardship:

Watershed Outreach and Education
Adopt-a-Stream Programs

The partners recognize the need for on-going, adaptive management, and laid out plans for monitoring the success of the proposed techniques and overall condition of the Watershed in

Stream and Watershed Monitoring

The Little Lick Creek Local Watershed Plan comprises this document and several technical memoranda from the Upper Neuse River Basin Association and the Center for Watershed Protection. These documents can be accessed through NC EEP's website for the Little Lick Creek Local Watershed Plan (http://www.nceep.net/services/lwps/little_lick).

Section 1: Background: NC Ecosystem Enhancement Program Planning Process

During the summer of 2004, the Upper Neuse River Basin Association (UNRBA), the Center for Watershed Protection (CWP), and the City and County of Durham proposed that the North Carolina Ecosystem Enhancement Program (NC EEP) fund a watershed management plan in the Little Lick Creek Watershed. The UNRBA proposed: an innovative approach to assessing watershed conditions; an assessment of lands critical for the protection of water resources; identification and prioritization of priority watershed restoration projects; a watershed stakeholder process; and a set of comprehensive watershed management recommendations. NC EEP funded the project in late summer, and work began in September of 2004.

NC EEP Local Watershed Planning

The mission of the NC EEP is to restore, enhance, preserve and protect the functions associated with wetlands, streams and riparian areas, including but not limited to those necessary for the restoration, maintenance and protection of water quality and riparian habitats throughout North Carolina. The NC EEP Local Watershed Planning process seeks to achieve the Program's mission by developing Local Watershed Plans that outline steps needed to achieve a functional uplift of a watershed's water quality, habitat and hydrology. By working in smaller, local watersheds, the Program is able to work at a scale where it is easier to characterize the problems and assets of a watershed. As a result, the plans are customized to achieve local watershed needs.

In Little Lick Creek, NC EEP used the State's Nutrient Offset Program to fund a plan that identifies projects that reduce nutrients and improve water quality. The Little Lick Creek Local Watershed Plan identifies a number of projects to improve water quality including stream repair and riparian buffer restoration. As part of the comprehensive management approach, however, the Local Watershed Plan also recommends stormwater retrofits, critical land protection, better site design, improved enforcement of existing regulations, improved watershed stewardship and an ongoing water quality monitoring network.

NC EEP requires that Local Watershed Planning include resource professionals and concerned citizens as a part of a stakeholder team that guides the planning process in their watershed. Stakeholders have a vested interest in improving water quality in the watersheds where they live and work because of the positive benefits such improvements can bring to their own health, safety, and enjoyment. The framework of the Local Watershed Planning process allows stakeholders to use the State as a technical and funding resource to develop and implement local recommendations. The NC EEP believes that this is how good resource planning occurs and that water quality improvements can only occur when local stakeholders understand the issues and the range of solutions to address them. The insight and experience brought to the process by local citizens and groups who live in the area is extremely valuable and complements the information collected by the Division of Water Quality and other project partner organizations. To learn more about the NC EEP and the Local Watershed Planning process, visit: http://www.nceep.net/pages/lwplanning.htm

The Little Lick Creek Local Watershed Planning Group

During the fall of 2004, the NC EEP and the UNRBA identified and contacted interested groups with a stake in the management of the Little Lick Creek watershed. These groups attended a December, 2004 project kickoff meeting (http://www.nceep.net/services/lwps/little_lick/). Several of this original group chose to become members of the group to guide the development of the Little Lick Creek Local Watershed Plan. The Local Watershed Planning Group consists of Project Partners, a Community Stakeholder group, and a Technical Team.

Project Partners

Project Partners worked to initiate, facilitate, organize, guide (through the development of technical information), and financially support the development and implementation of recommendations contained in the Local Watershed Plan. Project Partners are listed in the inset box.

The NC EEP Project Managers were Deborah Amaral, Chris Mankoff and Mike Herrmann. Chris Dreps (UNRBA) managed the watershed analysis, management strategy development, and stakeholder process.

John Hodges-Copple and Ben Bearden conducted the land use analysis. Sarah Bruce assisted in stakeholder management. September Barnes developed and managed the project website. Mary Giorgino and Silvia Terziotti developed the Upper Neuse Watershed Evaluation Tool Pilot Project, the mapping platform upon which the entire project GIS analysis was based. Sally Hoyt (CWP) managed the Unified Stream Assessment and Unified Subwatershed and Site Reconnaissance central to this project. Steve Kroeger and Stratford Kay (NC DWQ) managed the watershed monitoring and assisted with other fieldwork.

Project Partners Staff

<u>NC Ecosystem Enhancement Program</u>
Deborah Amaral, Chris Mankoff and Mike Herrmann, Planning and Project Management
<u>Upper Neuse River Basin Association</u>
Chris Dreps, Project and Stakeholder Management
<u>Triangle J Council of Governments</u>
September Barnes and Ben Bearden, Information Management and GIS
Sarah Bruce, Water Resources Planning
John Hodges-Copple, Regional Planning Director
<u>US Geological Survey</u>
Mary Giorgino, Water Resources Specialist
Silvia Terziotti, GIS Analyst
<u>Center for Watershed Protection (CWP)</u>
Sally Hoyt, Water Resources Engineer, with Ted Brown, Anne Kitchell, Jennifer Tomlinson, and Paul Sturm
<u>NC Division of Water Quality (NC DWQ)</u>
Stratford Kay, Water Quality Monitoring
Kathy Paull, Water Quality Monitoring
Steve Kroeger, Water Quality Monitoring

The Community Stakeholder Group

The Community Stakeholder Group consists of members of the local community who can affect or are affected by the Local Watershed Plan. The Community Stakeholder Group may include local landowners, businesspeople, elected officials, members of religious or environmental organizations, and others who are interested in improving the quality of the community's environment. The Community Stakeholder Group has few ongoing commitments to the project.

Their main role is to provide input into the process and to ensure that the Local Watershed Planning Group considers a broad, diverse range of community interests. The Community Stakeholder Group also has the critical role of helping the Local Watershed Planning Group understand and account for local watershed conditions and problems.

The Little Lick Creek Technical Team

The Technical Team provided technical support and expertise to the Local Watershed Planning Group in assessing the Watershed, conducting fieldwork, and developing the watershed management strategies. Members of the Technical Team represent various interests within the Watershed (e.g., agriculture, forestry, wildlife / habitat protection, local government, economic development, etc.). The Technical Team convened on January 18, 2005 and has since guided the development of this plan. Technical Team members are listed in the accompanying box.

Little Lick Creek Local Watershed Plan Technical Team

Local Government
Cherri Smith, Durham City/County Planning
Dave Brown, City of Durham Stormwater Services
Jacob Chandler, City of Durham Stormwater Services
John Cox, City of Durham Stormwater Services
Bobby Louque, City of Durham Stormwater Services
Chris Outlaw, City of Durham Stormwater Services
Laura Webb Smith, City of Durham Stormwater Services

George Rogers, City of Raleigh Public Utilities
Jane Korest, Durham County Engineering
Joe Pearce, Durham County Engineering

Joe Albiston, Durham County Engineering
Glen Whisler, Durham County Engineering
Dale Crisp, City of Raleigh Public Works

Farming Interests
Eddie Culberson, Durham Soil and Water Conservation Service

Local Water Quality and Habitat Interests
Jeff Masten, Triangle Land Conservancy
Dean Naujoks, Neuse River Foundation

Agency /Program Technical Advisors
Eric Alsmeyer, US Army Corps of Engineers
Shari Bryant, NC Wildlife Resources Commission
Scott Pohlman, NC Natural Heritage Program
Andy McDaniel, NC Department of Transportation
Mack Wiggins, NC Division of Water Quality

Landowners in Watershed
Allen McNally, The Crossings Golf Club
Amy Poole, Rollingview Marina

Section 2: Watershed Characterization

This section describes the geography, geology, soils, and other natural characteristics of the Little Lick Creek Watershed. For more detail, see *The Little Lick Creek Local Watershed Plan Memorandum #1—Initial watershed characterization, existing water quality data, stakeholder process and project goals* (UNRBA 2005a).

The Little Lick Creek Watershed is a 20.8 square mile area located in eastern Durham County, North Carolina. Figure 1 is a map of the Little Lick Creek Watershed.

Geography

Little Lick Creek's headwaters rise to the west of Highway 70 at the edge of the City of Durham. From there, the Creek flows to the north-east and is crossed by NC Highway 98, the main artery between Durham and Wake Forest. The Creek flows several miles through newly developing suburbs, a golf course, and a few remaining farms before it is joined by its major tributary, Chunky Pipe Creek. From there, the Creek flows into the federally protected land that forms Falls Lake State Recreation Area. Just past this junction, Patterson Waterfowl Impoundment dams Little Lick (an effort by the federal government to create wildlife habitat to mitigate for bottomland hardwood forests lost when it created Falls Lake). From here, the Creek slowly flows into Falls Lake near Rollingview State Recreational Area.

Geology

The Little Lick Creek Watershed lies over the Durham Triassic Basin. Geologists theorize that rifting of the Super-continent Pangaea during the Mesozoic period 200 million years ago created this formation. They believe the land masses that are now Africa and North America separated, and the separation left rift valleys many miles wide and thousands of feet deep. These rifts filled over time with sediment deposited by the then huge Appalachian Mountains. These compacted sediments now form the sedimentary parent material of the Triassic Basin (Clark et al 2001).

Intrusions of stronger, less erosive metamorphic diabase material rise through the softer Triassic material. These Diabase Sills were formed during the creation of the Triassic rift valleys, when magma escaped to the surface. Diabase Sills form soils distinct from the surrounding Triassic sandy-clay soils. These areas, although rare in the Triassic Basin, provide unique habitat for aquatic life and vegetation. The Santee Road water quality monitoring site, shown in Figure 5, is an example of a Diabase Sill.

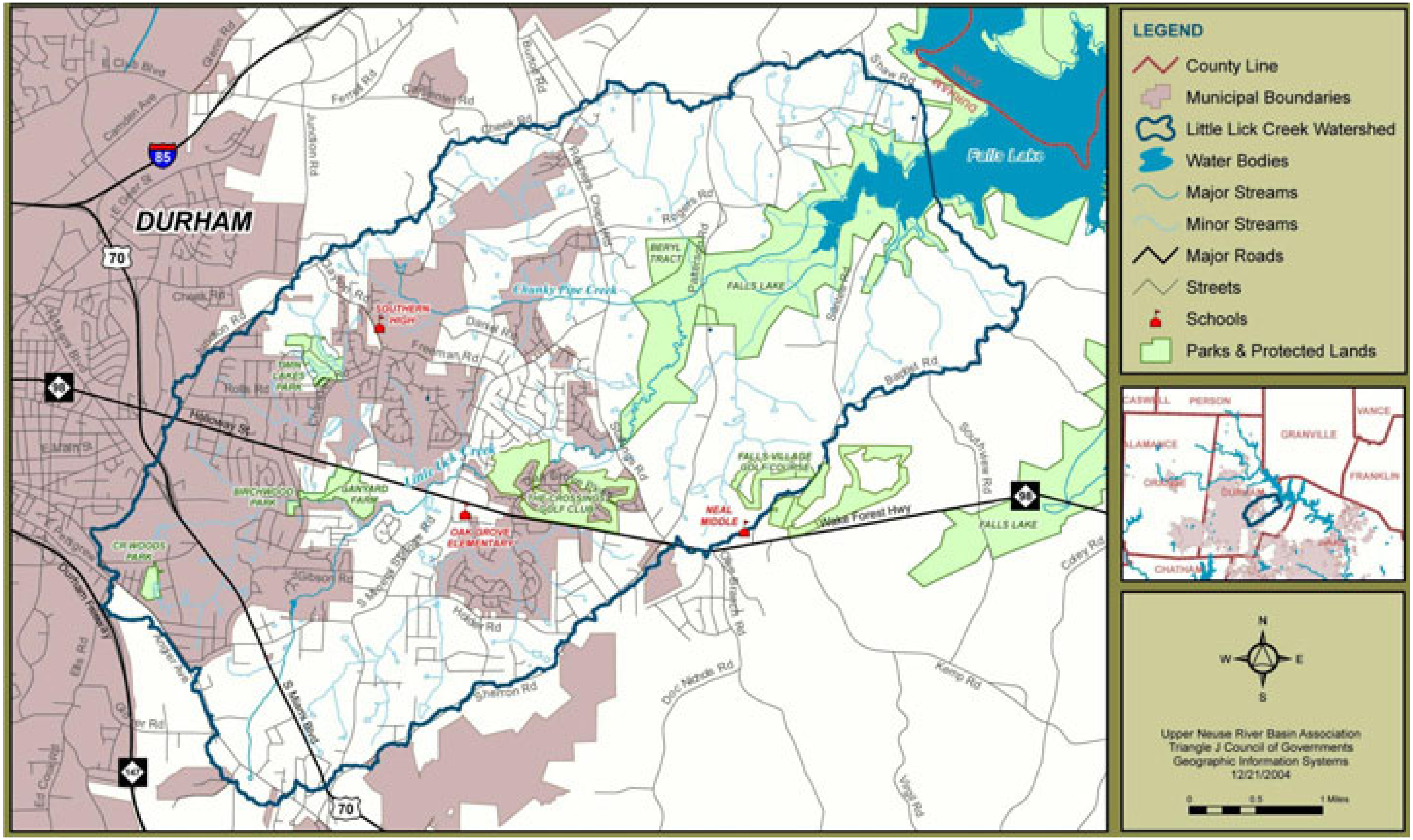

Figure 1. Little Lick Creek Watershed

Soils

The Watershed's soils are generally clay and have low nutrient levels (USDA 1971). The Watershed's upland areas are almost completely covered by the White Store soil series. Little Lick Creek's large, broad flood zone is predominated by Chewacla Soils. Little Lick Creek and its tributaries are mostly devoid of bedrock substrate. Subsequently, stream banks in Little Lick Creek are greatly impacted by the increased flows accompanying urban development because the sand and clay substrate material erodes easily.

Topography

The Watershed's general topography is flat, with few areas of steep gradient. The highest point in the Watershed is over 426 feet above sea level at the headwaters near US Highway 70 and Miami Boulevard. The lowest point, at the Falls Lake Reservoir is about 246 feet above sea level. This is a difference of only about 180 feet in elevation over a straight-line distance of about 6.6 miles, or a gradient of about 27 feet per mile.

Surface Hydrology

Little Lick Creek is a fifth-order stream draining an area of 20.8 square miles and about 73 miles of streams (Terziotti 2004). Little Lick Creek's hydrology is strongly affected by two impoundments, Falls Lake Reservoir and the Patterson Road Waterfowl Impoundment. The Falls Lake Reservoir, created in the early 1980's to provide flood storage and drinking water for Raleigh, changed the hydrology of the downstream portion of the Creek from what was a medium-sized, meandering piedmont stream into a shallow, lentic system subject to nutrient enrichment (eutrophication).

When Falls Lake was impounded, the new reservoir submerged over twenty-five stream miles of piedmont bottomland hardwood forest. In an attempt to mitigate for the loss of habitat in these ecologically valuable lands, the US Army Corps of Engineers constructed a series of waterfowl impoundments. The Little Lick Creek Watershed has one such impoundment called the Patterson Road Waterfowl Impoundment just upstream of where Patterson Road crosses the Creek.

Little Lick Creek has abundant wetlands due partly to low relief, sedimentary soils, and wide 100-year floodplains. Floodplains extend from Falls Lake upstream of NC Highway 98 and well into most of the tributaries.

Figure 2 divides the Watershed into 13 subwatersheds. Ten of these subwatersheds are surface water drainage areas of 3rd order streams flowing to Little Lick Creek, and the remaining three subwatersheds comprise the upper, middle, and lower sections of the Creek. These thirteen subwatersheds are the "management units" of the Little Lick Creek Local Watershed Plan. Each subwatershed was analyzed separately and targeted for specific management strategy recommendations.

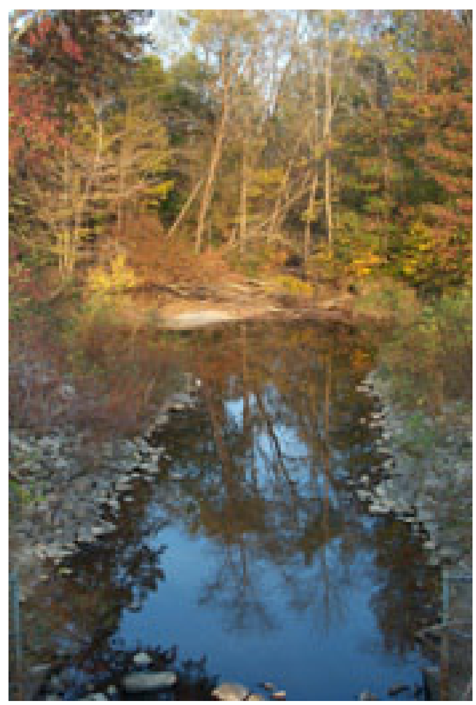

Figure 2. Patterson Waterfowl Impoundment

Habitat

Historically, the Little Lick Creek Watershed contained lowland hardwood forest habitat of high quality. According to the Durham County Natural Heritage Inventory, prior to the damming of the Neuse River at Falls of the Neuse, the Creek flowed into a Neuse River valley with "extensive tracts of swamp and alluvial forests…many of these stands were quite mature and high in quality" (Hall 1995). According to the same inventory, tributary Valleys, including Little Lick Creek, "once contained exemplary stands of swamp or alluvial forests." Much of this forest was cleared and flooded in the 1980s for Falls Lake's impoundment.

Falls Lake and the Patterson Road Waterfowl Impoundment fundamentally changed this habitat. According to Hall (1995), the most significant animals currently found in this area are "waterbirds that once would have passed through the area only during migration, if ever." Little Lick Creek contains a portion of the Falls Lake Shoreline and Tributaries Natural Heritage Area (Hall 1995). This area is of regional significance for its fauna, which include bald eagles, double-crested cormorants, and ospreys. The area's expanses of shallow water provide habitat for migratory shorebirds and post-breeding wading birds, and sub-impoundments like the one at Patterson Rd. provide significant wintering habitat for ducks and geese. Bottomland forest habitat along all the Falls Lake Tributaries may provide refuge for at least some species of forest interior animals (Hall 1995).

The Durham Natural Heritage Survey only cursorily studied sites in Little Lick Creek, and Hall recommends further study of the Little Lick Creek Lowlands. *The Little Lick Creek Local Watershed Plan Memorandum #1—Initial watershed characterization, existing water quality data, stakeholder process and project goals (February 18, 2005)* describes habitat and species in more detail.

Watershed Population

Population in Little Lick Creek has almost doubled during the last two decades from 10,500 in 1985 (Piatt and Co. 1985) to 17,071 in 2000 (TJCOG 2000). The Watershed is likely to experience even greater population gains in the future. Data collected and developed by the Triangle J Council of Governments for regional transportation suggest that approximately 18,000 people were living in the Watershed in 2002. The same data predict that population will grow to over 25,000 by the Year 2010; to over 33,000 by the Year 2020; and to over 41,000 by the Year 2030 (UNRBA 2005a).

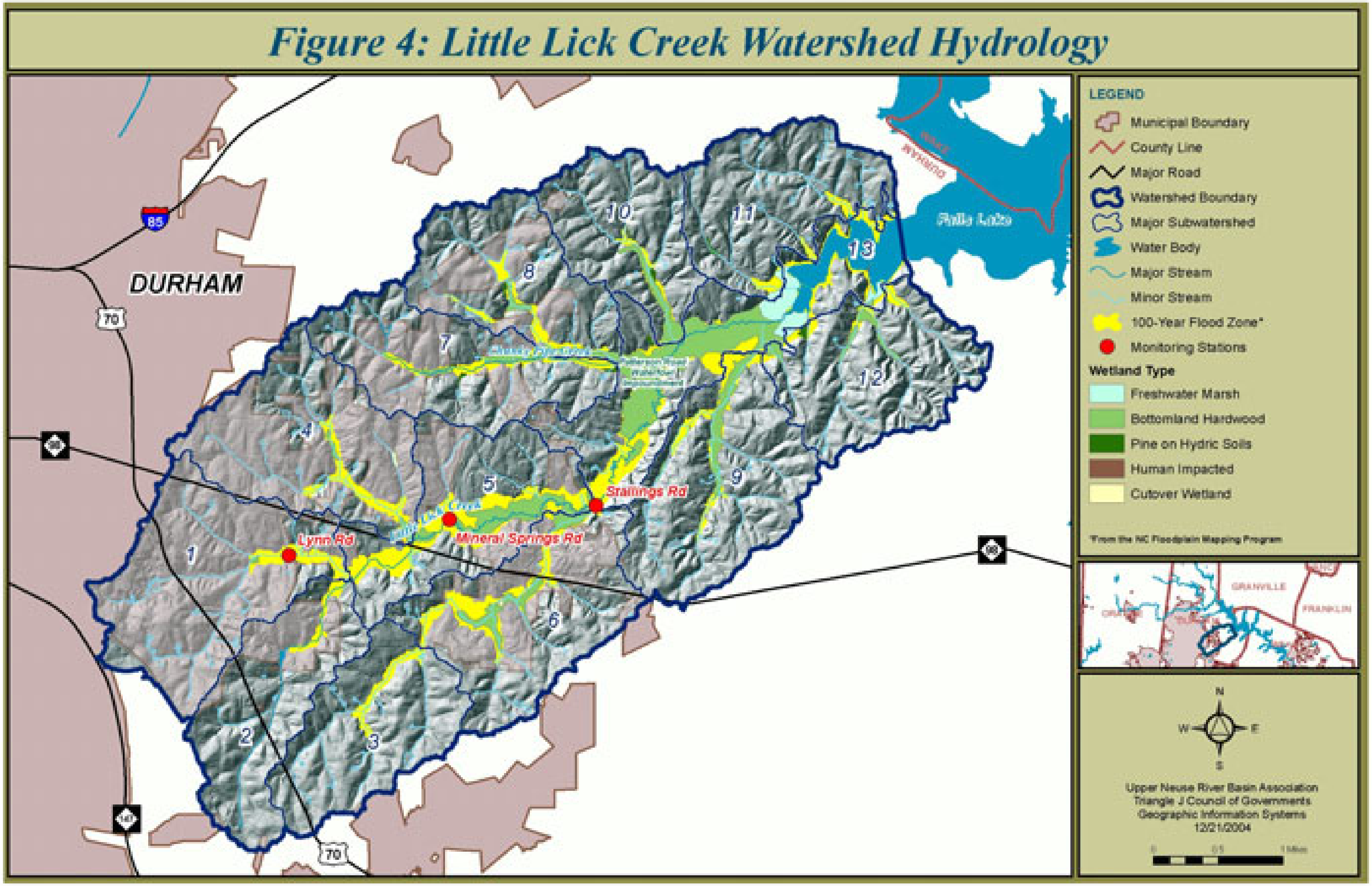

Figure 3. Little Lick Creek Surface Hydrology and Subwatersheds

Watershed Land Uses

The great majority of residents in the Little Lick Creek Watershed live in single-family, low-density neighborhoods. Figure 3 summarizes current watershed land uses in Little Lick Creek.

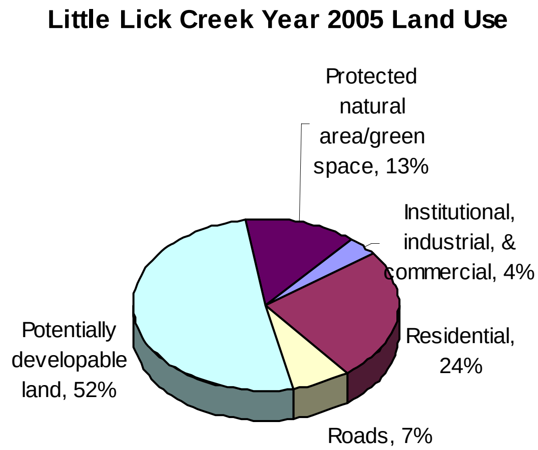

Figure 4. Little Lick Creek Land Use Categories (UNRBA 2005a)

This analysis shows that Little Lick Creek, although suburban, is very much undeveloped and in an active state of rural-to-urban transition. Agriculture, forestry, rural, and undeveloped land make up over 50% of the land uses. Since Durham's zoning laws zone these lands for more intensive development, these tracts are rapidly converting to residential and commercial properties.

Future Growth and Land Use Changes in Little Lick Creek

What will be the predominant land uses in Little Lick Creek once the Watershed is "built out" to the level allowed under current regulations? An analysis of future development based on the draft Durham Comprehensive Plan and Unified Development Ordinance (the UDO encodes the visions outlined in the Comprehensive Plan) reveals the future of development in the Little Lick Creek Watershed. Future watershed land uses in Little Lick Creek, illustrated in Figure 5, are based on the Comprehensive Plan, the UDO, and the most recent available parcels data from Durham City and County Planning Department.

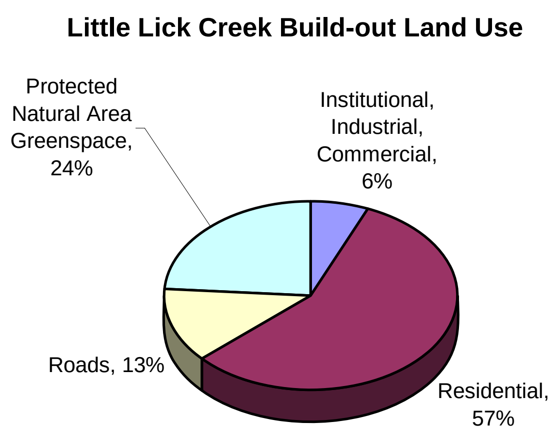

Figure 5. Little Lick Creek Predicted Future Land Use (UNRBA 2005a)

In the long-run, Little Lick Creek will be a heavily suburban watershed. All agricultural lands are assumed to convert to other uses, primarily residential (57%). A slightly higher amount of protected land is predicted, primarily because residential lots currently under development are using a cluster development option that protects a large portion of the site as open space to be managed by the homeowners.

The proposed Northern Durham Parkway will create a new road right through the heart of the Little Lick Creek Watershed. In the southern portion of the Watershed, the road will follow a tributary of subwatershed 3 until it connects with Mineral Springs Rd. and crosses Highway 98. From there, the road will go north-northwest along a new alignment on its way to a junction with I-85. The authorized East End Connector, an alternative to the now defunct Eno Loop, will connect the Durham Freeway (Highway 147) with Highway 70 in subwatershed 1 of Little Lick Creek.

Subwatershed Assessment

The Little Lick Creek Project Partners, led by the Triangle J Council of Governments, conducted a subwatershed-level land use analysis. Table 1 shows general results of the analysis. This table summarizes the current and predicted (i.e. built-out) levels of impervious cover for each subwatershed. Impervious cover indicates the amount of roads, rooftops, driveways, and other structures that prevent precipitation from infiltrating into the ground. Impervious cover is a widely accepted measure of urban development and levels above 10% can have significant impacts on water quality and aquatic habitat (CWP 2003).

Subwatersheds with the highest existing levels of impervious cover received the greatest attention during fieldwork to identify watershed restoration opportunities such as potential stream repair, riparian buffer restoration, and stormwater retrofit practices. Thus, the most urbanized subwatersheds (1-8) in Little Lick Creek received the most focus.

The land use change analysis clearly shows that all 13 subwatersheds in Little Lick Creek will undergo significant increases in impervious cover as each subwatershed is built out to the full extent allowable under current regulations. On average, the Watershed's impervious cover will more than

Land Use Change Analysis					
Sub-watershed	**Acres**	**Sq. Miles**	**Existing Impervious Cover**	**Buildout Impervious Cover**	**Increase in Impervious Cover**
1	1,323	2.07	19.5%	38.0%	95%
2	920	1.44	15.4%	35.0%	127%
3	910	1.42	10.8%	31.0%	187%
4	1,158	1.81	18.4%	30.0%	63%
5	999	1.56	21.8%	28.0%	28%
6	1,168	1.82	16.1%	24.0%	49%
7	967	1.51	5.9%	29.0%	392%
8	868	1.36	7.0%	27.0%	286%
9	1,172	1.83	3.5%	16.0%	357%
10	733	1.15	4.7%	17.0%	262%
11	926	1.45	4.5%	17.0%	278%
12	960	1.50	1.2%	6.0%	400%
13	1,230	1.92	2.3%	7.0%	204%
Total	**13,332**	**20.8**	**10.5%**	**23.0%**	**119%**

Table 1. Land Use (Impervious Cover) Change Analysis

double (119 percent increase). Subwatersheds 7-13, in the downstream rural area of the watershed, will experience over 300 percent growth, being transformed from rural areas to low-density suburban developments. This analysis makes clear the need not only for watershed restoration strategies but for preventative approaches that will protect water quality in the future.

What will being over 70% urban mean for watershed management efforts in Little Lick Creek? Certainly, environmental stresses on Little Lick Creek will become greater. How will local communities improve the water quality and aquatic habitat to meet the federal Clean Water Act while the remaining forest and agricultural lands are converted residential development?

Organizations and agencies responsible for the management of the Watershed must strongly consider adopting strategies like those recommended in this plan if there is to be a healthy Little Lick Creek in the future. First, it is important to understand the current conditions of the Watershed. Section 3 describes the watershed analyses that the Little Lick Creek Planning Team used to guide the planning process.

Figure 6. Farmlands in Little Lick Creek Are Threatened by Urban Development

.

Section 3: Watershed Analysis

The Little Lick Creek Local Watershed Plan is the result of several levels of analysis and assessment guided by the Little Lick Creek Project Partners, Technical Team, and watershed management goals. This section describes the components of the analysis and the major findings.

Local Watershed Plan Documents
(http://www.nceep.net/services/lwps/little_lick/)

Little Lick Creek Local Watershed Plan (this document);

Center for Watershed Protection Memorandum: Summary of Field Work Activities in Little Lick Creek-January 2005;

Center for Watershed Protection Memorandum: Summary of Field Work Activities in Little Lick Creek-March 2005;

Center for Watershed Protection Memorandum: Little Lick Creek-Watershed Treatment Model;

NC Division of Water Quality: Summary of Water Quality Monitoring in Little Lick Creek Watershed and Tributaries

Technical Memorandum #1—Initial watershed characterization, existing water quality data, stakeholder process and project goals;

Memorandum #2—Suggested approach for critical lands protection analysis;

Technical Memorandum #4—Priorities for watershed restoration in Little Lick Creek; and

Technical Memorandum #5—Watershed Management Strategies recommended for Little Lick Creek.

Watershed Management Goals

The Little Lick Creek Planning Group developed goals to guide the Little Lick Creek Local Watershed Plan. The goals, listed below, include both short and long-term strategies to restore, manage and protect vital functions in the Watershed.

- **Restore aquatic and riparian habitat in the Watershed**—in areas where impacts have occurred, implement projects that will provide measurable improvement to habitat in the stream and riparian system.
- **Improve and protect water quality and aquatic habitat in the Watershed**—implement management strategies that will improve water quality in Little Lick Creek so it can support its designated use.
- **Protect water quality and habitat in Falls Lake**—reduce nutrients, sediments, and toxic pollutants entering the Lake through multiple short and long-term management strategies. Falls Lake is a critical resource to the region for both drinking water supply and recreation.
- **Protect lands critical for habitat and water quality**—protect habitat and water quality functions by protecting critical lands such as wetlands and floodplains.
- **Improve natural conditions for people living in the Watershed—**search for opportunities to improve human use of managed natural areas and trails, improve aesthetics, and reduce destruction from flooding where these objectives align with the protection of water quality and habitat functions.

- **Foster community stewardship of the Watershed—**educate and involve the local community in the creation of the plan, implementation of projects, and long-term stewardship of the Watershed.

Detailed Watershed Assessments

Once the initial characterization was completed and watershed goals set, the Project Partners and Technical Team developed guidance for watershed assessment. The next steps in the process were to:

- Investigate the reasons for existing water quality and habitat degradation (in-stream and upland fieldwork, water quality monitoring, and analysis of resulting data);
- Assess water quality data and impacts observed in the field to determine the potential causes of degradation (technical team and project partner meetings, analysis of water quality data); and
- Conduct simple water quality modeling, additional monitoring and field visits to validate or update theories and to predict future conditions.

Water Quality Monitoring

The NC Division of Water Quality (NC DWQ) conducted subwatershed monitoring, described in "Summary of Water Quality Monitoring in the Little Lick Creek Watershed and Tributaries, Durham County, North Carolina" (Kroeger 2005). The NC DWQ sampled:

- Physical and chemical parameters in subwatersheds 1-6, 7-10, and 13; and
- Benthic macroinvertebrates in subwatersheds 1, 2, 5, and 9 (reference site).

Figure 5 is a map of the subwatersheds and sampling sites. The subwatersheds are numbered in purple, and the sampling sites are located by the orange circles.

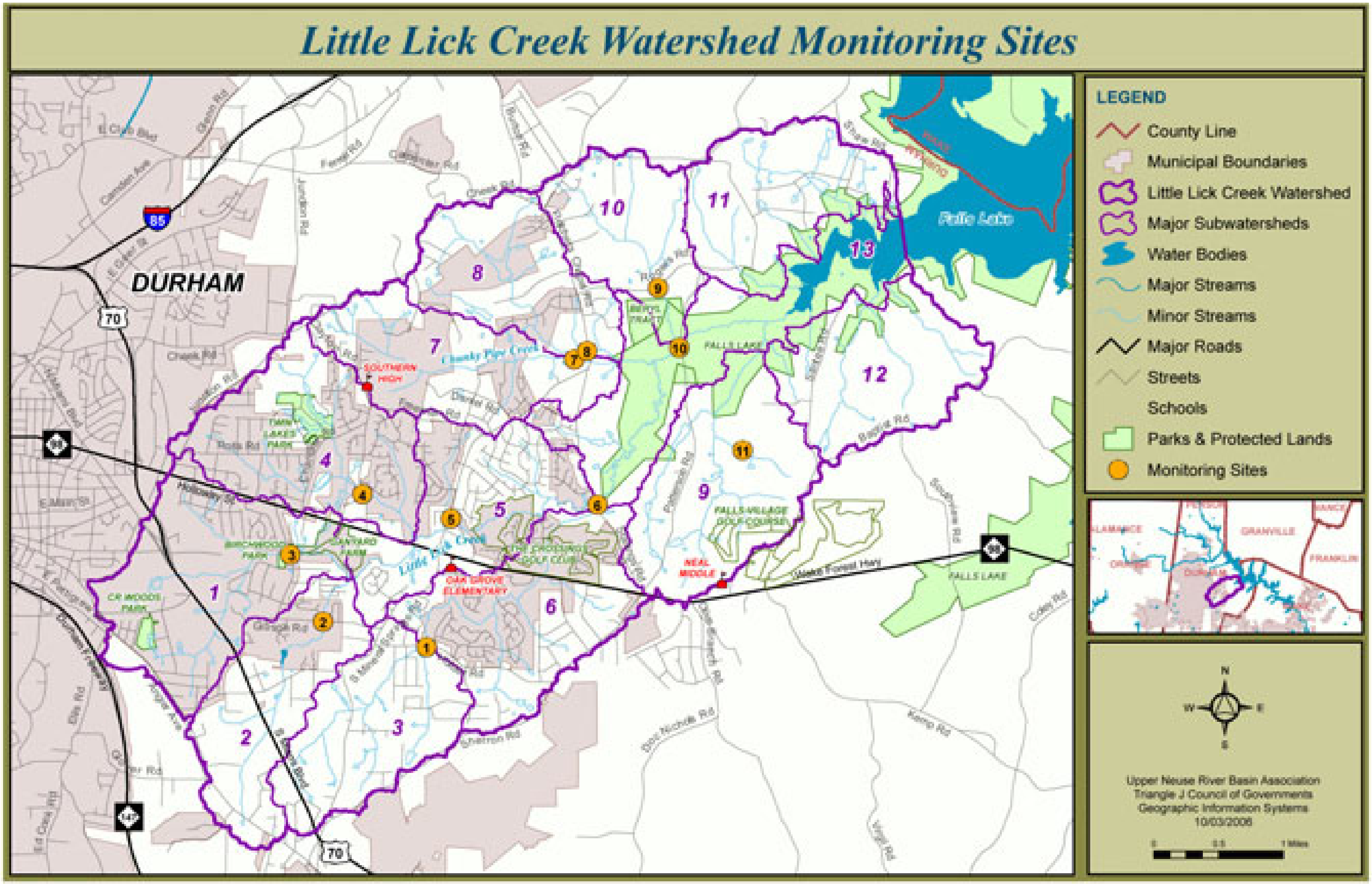

Figure 7. Little Lick Creek Monitoring Sites

The following is a summary of NC DWQ's water quality monitoring findings. Overall, the NC DWQ reports little variation among sites for most of the parameters sampled. However there are some noteworthy observations, discussed herein.

Physical and Chemical Parameters

- Results for dissolved oxygen were often below the 4.0 mg/L instantaneous and the 5.0 mg/L daily average concentration needed to support aquatic life at all monitoring sites. Low concentrations increased in frequency as temperature increased.
- The highest specific conductance was observed in subwatershed 3 at Holder Rd. High specific conductance may be the result of natural factors (geology) or pollution sources such as wastewater. Investigations into the source of the high specific conductance were inconclusive.
- A high result for ammonia collected during storm flow was observed in subwatershed 5.
- Concentrations for total Kjeldahl nitrogen (TKN) are higher at the Stallings Rd sampling site than the sampling site upstream at Mineral Springs Rd. Both sites are in subwatershed 5.
- Nitrite and nitrate concentrations are the greatest in subwatersheds 1, 2, 3, 4, and 5. These are the subwatersheds with the greatest impervious surface, although it is not know whether impervious surface is a factor explaining the higher concentrations.
- The lowest phosphorus concentrations where observed in subwatersheds 9 and 10.
- Residues (fixed, suspended and volatile), turbidity and concentrations of aluminum and iron were the greatest in subwatershed 8. This may be the result of a sediment and erosion control issue with Cardinal Lake. Follow-up sampling from subwatersheds 7and 8 for total suspended residue and turbidity were considerably less than those observed during the monitoring period in 2005.

Cluster Analysis

Cluster analysis is an exploratory data analysis tool for sorting different objects into groups. Cluster analysis groups both parameters and sites and depicts similarities between parameters or sites by using tree diagrams (dendrograms). NC DWQ conducted a cluster analysis on the mean concentrations of various water quality parameters. Kroeger (2005) describes the results of the cluster analysis. The results depicted in this section were obtained by using the mean concentration of the results.

- Subwatersheds 9 and 10 share similar water quality and biological characteristics. These sites suggest reference conditions for the Little Lick Creek Watershed since both sites had low concentrations of results from most parameters and both subwatersheds were relatively undeveloped.
- Subwatersheds 1-5 are grouped and show high concentrations of calcium, magnesium, specific conductance, fecal coliform, nitrates and nitrites, and pH.

- Subwatersheds 7, 8 and 13 formed a third group. These subwatersheds have high concentrations of aluminum, turbidity, residues, iron, zinc, copper, ammonia, manganese, phosphorous, and total Kjeldal nitrogen.

Little Lick Creek Monitoring Challenges

Triassic Basin Stream Reference Conditions
Streams located in the Triassic Basin have been observed to have little and sometimes no flow during the summer months. Dissolved oxygen concentrations are generally lower in streams with low flows and warm temperatures, and the NC DWQ has begun to refrain from rating streams located in the Triassic Basin using biological data. On the other hand, monitoring results from subwatershed 9 (monitoring site 11) suggests that relatively good water quality and rare aquatic habitat exist here.

Stormflow vs. Baseflow Results
During storms, concentrations of fecal coliform bacteria, total phosphorus, residues, aluminum and iron are generally higher than those found during baseflow conditions. In addition, higher turbidity very often occurs during stormflow.

Urbanization
Urbanization can confound water quality problems associated with streams in the Triassic Basin. Carle, et al. 2005 examined urban runoff in six urban watersheds in Durham, NC including Little Lick Creek. The authors used indicators of urbanization (e.g. household density, impervious surface, stormwater outfall density) in water quality models for total phosphorus, total Kjeldahl nitrogen, total suspended solids and fecal coliform bacteria. They concluded that development density was correlated to decreased water quality in each of the models.

Aquatic Life (Benthic macroinvertebrates)

Before the year 2000, the NC DWQ provided bioclassifications for streams in the Triassic Basin. There have been two Fair ratings and six Poor ratings for Little Lick Creek prior to the year 2000. The DWQ discontinued rating streams in the Triassic Basin because it began to recognize that composition of benthic macroinvertebrate communities may be largely affected by the natural low flows and low dissolved oxygen levels in streams in this geologic region.

As part of the monitoring for this Local Watershed Plan, NC DWQ sampled five sites for macroinvertebrates in the Little Lick Creek Watershed during 2005. One noteworthy outcome of this sampling was presence of insects at a site in a relatively unimpacted watershed (unnamed tributary off of Santee Rd.) that are normally not present in other sites in the Triassic Basin. The site was resampled in 2006, and a community similar to that found in 2005 was present.

It is difficult to determine the relative degree to which Triassic Basin characteristics and urban impacts affect the macroinvertebrate communities at the five study sites (see inset box). However, the presence of a unique community at the Santee Rd. site suggests that urbanization is a major factor impacting aquatic life at the four other sites.

Watershed Restoration Fieldwork and Prioritization

Based on findings from watershed characterization and water quality monitoring, project partners and technical team members decided to concentrate limited resources and staff time conducting restoration fieldwork in subwatersheds 1 through 8 and a few other locations of apparent human impact in subwatersheds 9-13, particularly the main stem in subwatershed 13. The following sections describe the steps from conducting fieldwork to assessing and prioritizing restoration projects in Little Lick Creek.

The first step in the Little Lick Creek restoration prioritization process was to conduct fieldwork to identify the most promising restoration projects watershed-wide. Center for Watershed Protection staff guided staff from the City of Durham Stormwater Services, Durham City-County Planning, Durham County Engineering, NC Division of Water Quality, and the Upper Neuse River Basin Association to conduct two stages of fieldwork:

1. *Unified Stream Assessment* (USA) to assess general stream corridor conditions and identify major impacts to water quality and aquatic habitat; and
2. *Unified Subwatershed and Site Reconnaissance* (USSR) and Retrofit Inventory to identify "hot spots" of pollution and identify promising opportunities for stormwater retrofit projects to remedy existing stormwater problems.

Unified Stream Assessments (USA)

During USA fieldwork, project partners walked and assessed over 30 stream miles (41%) of Little Lick Creek and tributaries, focusing primarily on impacted reaches in the urbanized, upstream subwatersheds (1-8). Fieldwork teams rated reach conditions based on Center for Watershed Protection's Unified Stream Assessment methodology (Hoyt 2005a). Table 2 shows the general channel conditions by subwatershed.

Sub-watershed	Stream Length Assessed (feet)	Percent of Total Length Assessed	Reach Conditions
1	19,694	52	Poor
2	17,697	97	Poor
3	11,649	43	Poor
4	17,816	49	Poor
5	21,294	83	Poor
6	16,842	55	Poor
7	9,006	32	Fair
8	25,165	88	Fair
9	894	2	Good
10	9,819	55	Fair
11	1,993	6	Poor
12	3,641	15	Good
13	4,142	10	Poor
LLC Total	159,652	41	Poor

Table 2. Unified Stream Assessment Coverage and reach conditions

In summary, USA fieldwork identified the impacts listed below (Hoyt 2005).

- 25 potential stream repair projects
- 23 riparian buffer restoration projects
- One potential wetland restoration project
- 52 inspection and enforcement action recommendations
- 10 needed homeowner education interventions
- 47 instances where maintenance is required
- 20 problem trash sites
- Over 20 potential stormwater retrofit projects
- Numerous failing sand filter-type household wastewater treatment systems (subsequent data analysis revealed 444 sand filter-type systems exist in the Watershed)
- Multiple problem erosion and sediment control sites
- 6 potential land preservation sites

Figure 8. Project partners assessed over 30 miles in Little Lick.

Unified Site Survey and Reconnaissance (USSR)

During USSR fieldwork, project partners conducted a windshield tour of the Watershed to identify potential stormwater retrofits and pollution “hot spots” such as problem dumpsters, gas stations, outdoor storage areas, vehicle operations, restaurants, and other potentially polluting sites. The GIS analysis and USSR fieldwork identified the impacts listed below (Hoyt and Tomlinson 2005).

- Over 60 potential stormwater retrofit projects that would treat over 530 acres of runoff
- 38 potential pollution hotspots
- Several enforcement action recommendations

Watershed Restoration Project Prioritization

After field work identified potential restoration sites, the Technical Team ranked sites according to a prioritization process, described in detail in UNRBA 2005c. This process resulted in 48 potential riparian buffer restoration and stream repair projects, and 71 stormwater retrofit opportunities in the Little Lick Creek Watershed. Section 4 of this plan, Watershed Management Strategies, describes this prioritization. Technical Memorandum 4 (UNRBA 2005c) also presents a more detailed description of the highest priority restoration project opportunities.

Modeling

Hoyt (2005b) describes the Center for Watershed Protection’s Watershed Treatment Model (WTM). CWP used the model in Little Lick Creek to:

1. Estimate pollutant loading under current watershed conditions;
2. Determine the effects of current management practices;
3. Evaluate effects of proposed structural and non-structural management practices; and
4. Evaluate the effects of future development.

The WTM is a planning level model, and its results are not calibrated with water quality monitoring data. Therefore, the results of the model simulations should be compared on a relative basis rather than used as absolute values. The WTM assesses uncontrolled pollutant loads from two broad categories of pollutant sources: *primary sources* and *secondary sources*. Primary sources are related to the urban storm water runoff loads from major land uses. Secondary sources are pollutant sources dispersed through the Watershed whose magnitude cannot easily be estimated from available land use information.

Secondary sources include sanitary sewer overflows, septic system failure, and channel erosion.

Project Partners used the WTM to calculate relative pollutant loads for each subwatershed in Little Lick Creek. The following is a summary of the model findings and predictions.

Current Management Practices

Of the practices already used in the Watershed, the most effective are currently:

- Erosion and sediment control practices, particularly in subwatersheds with current active construction (1, 2, 4, 5, 6, 8).
- Riparian buffers protection, especially in the least developed subwatersheds where many stream reaches have buffers greater than 75 feet. (9, 11, 12, 13).

Proposed Future Management

The increase in nutrient loads from urbanized land will exceed the decrease from rural land. This increase results even with the use of structural stormwater management practices that reflect the current Neuse nitrogen rules. Better site design and pollution prevention efforts are needed in conjunction with the structural stormwater controls. Notable reductions in TSS can be made through improved erosion and sediment control practices, stormwater management, and riparian buffer improvements. Watershed-wide TSS reductions are estimated at 16%.

- The largest reductions in annual nutrient (nitrogen and phosphorous) loads can be made through septic system education, repair and upgrade. Other future management practices contributing to the estimated load reduction include structural stormwater management, riparian buffers, and lawn care and pet waste education. Watershed-wide, these reductions are estimated at 28% of the annual load for total nitrogen (TN) and 15% for total phosphorous (TP).
- Structural stormwater retrofits would result in 0.4% reductions in TN and more than 1% reduction in TP over the entire Watershed. This effect would be greatest in subwatersheds 3 and 6, where proposed retrofits could reduce the TP by 6% in subwatershed 3 and 5% in subwatershed 6.
- Lawn care and pet waste education, if reaching 25% of the population and adopted by 60% of those reached, can reduce the nutrient loads by 2-3%.
- An improved erosion and sediment control program could result in an 8% reduction of TSS annual loading when compared to TSS loading under current management practices. Reduction in TSS was most dramatic in subwatersheds that currently have large active construction sites (subwatersheds 1, 2, 4, 5, 6, 8).
- Overall, structural stormwater management retrofits could reduce TSS by 2% throughout the Watershed. This effect is most significant in subwatershed 3 (13%) and 6 (5%). Other subwatersheds where structural stormwater management retrofits could reduce the loads by greater than 1% are 1, 2, 4, and 5.
- Riparian buffer enhancements would account for an estimated 4% reduction in TSS across the Watershed. The TSS would be reduced by 5-14% in subwatersheds 3 and 7 through 13 and reduced by >1% in the most urbanized subwatersheds (1, 2, 4, 5, 6).

Relating the Results to Key Findings from Fieldwork

Several management practices to reduce nitrogen, phosphorus and sediment loads are recommended in the 2005 stream and upland assessment fieldwork (Hoyt 2005 and Hoyt and Tomlinson 2005). These are described in Recommendations 1-3 of Section 4, Management Strategies. Some other key findings include the following, which are addressed in Recommendation 6, Improved Enforcement of Existing Rules:

- Poorly implemented and maintained erosion and sediment control devices. The recommendations from the key findings would provide the additional benefits demonstrated in the WTM. These recommendations included increased inspection and enforcement, a citizen-watch hotline, training for erosion control professionals, and updating erosion and sediment control criteria with more specific maintenance obligations.
- Failing on-site septic systems and improperly designed sanitary sewer laterals (house connections) were prevalent in the Watershed. The WTM demonstrates the nutrient benefits that could be achieved with upgrade and repair of septic systems (Hoyt 2005b). To achieve the level of adoption modeled in the WTM, mandatory inspection of septic systems

and fines or cost-share incentives are needed to motivate system owners to repair and upgrade.

- Impacted buffers were observed and it was not clear that the existing 50’ Neuse Riparian Buffer Protection Rules were being observed at all construction sites. As indicated by the WTM, enforcement and education regarding these rules can reduce the pollutant loads significantly.
- Preservation of buffer areas was another finding of the USSR (Hoyt and Tomlinson 2005). As indicated by the WTM, buffers wider than 50’ have additional benefits. Therefore, there are benefits to preserving existing high quality buffers.
- Historic and active channel erosion was observed during the Winter 2005 fieldwork. Though this sediment load was not modeled in the WTM, the effects of channel erosion would account for more than half of the total suspended solids load (Hoyt 2005b). This emphasizes the need for better site design techniques to be applied to future development so the increase in runoff volume associated with development will be less than that of traditional development. This also makes a case for stormwater retrofits in developed catchments with active channel erosion.

Critical Land Analysis

The Little Lick Creek Project Partners conducted an analysis of lands critical for meeting the Watershed management goals set out in Technical Memorandum #1 (UNRBA 2005a). The analysis uses scientifically-based criteria to identify over 143 acres of land on 320 tracts that are critical to water quality and aquatic habitat. For an explanation of the criteria and analytical process behind the analysis, see “Little Lick Creek Local Watershed Plan Technical Memorandum #2: Suggested Approach for Critical Lands Protection Analysis” (UNRBA 2005b).

The following list highlights some of the findings of the critical lands analysis, and Recommendation #4 of this plan reflects these findings.

- The landscape analysis identifies a total of 143 acres of “critical” high resource value lands located on 320 tracts that total 3,492 acres (26% of the Watershed)
- Well over ½ of the highest-value critical land (82 acres) is located on 13 tracts, each of which has over 3 acres of critical land
- Almost ½ of the tracts (154 of 320) are less than 1 acre in size. This highlights the need for multiple management strategies to protect critical lands.
- Most of the highest-scoring lands identified as high priority lie within the Little Lick Creek’s 1% chance flood zone (the area where the annual statistical chance of a flood is 1%, often called the “100-year floodplain”)
- 78 of the critical tracts are over 10 acres, 64 are over 15 acres, and 18 are over 50 acres
- 63 of the critical parcels are within ¼-mile of public land
- 14 of the parcels are on prime farmland
- 41 parcels have over ¼-mile of stream frontage
- 57 parcels contain a planned trail
- 133 parcels are “developable”
- 31 parcels are grandfathered out of current floodplain and buffer regulations
- 3 parcels contain historic or cultural features
- 51% and 44% of the area of subwatershed 9 and 10, respectively, is covered by parcels with the highest-value critical lands

Section 4: Management Strategies

This section summarizes the comprehensive watershed management strategies recommended in *Little Lick Creek Local Watershed Plan Memorandum #5—Watershed Management Strategies recommended for Little Lick Creek for improving and maintaining water quality and aquatic habitat conditions in the Little Lick Creek Watershed* (UNRBA 2006).

After 14 months of watershed analysis, fieldwork, planning, and prioritization by watershed stakeholders (*described in Section 3 of this plan*), the Little Lick Creek Technical Team recommends nine detailed management strategies for implementation by local, regional, and state-level watershed stakeholders.

This section generally describes each management category and summarizes the specific recommendations. UNRBA (2006) offers a more detailed summary of the analysis, fieldwork, monitoring, and modeling findings that led the Little Lick Creek Project Partners and Technical Team to recommend the particular management approach and a specific set of steps that the Little Lick Creek Project Partners and Technical Team members suggest for addressing the management needs. In addition, each recommendation section outlines specific steps, general costs, and lists potential pitfalls that may be encountered when implementing the recommendations. This and other project memoranda, maps, and general information are available on the project website, http://www.nceep.net/services/lwps/little_lick/.

Little Lick Creek
Watershed Management Strategies

Watershed Restoration Projects

1. Stream Repair Projects
2. Riparian Buffer Restoration
3. Stormwater Retrofits

Strategies to Prevent Future Degradation

4. Critical Lands Protection
5. Better Site Design
6. Improved Enforcement of Existing Rules

Strategies to Increase Watershed Stewardship

7. Watershed Outreach and Education
8. Adopt-a-Stream Programs
9. Stream and Watershed Monitoring

Watershed Restoration Strategies

Little Lick Creek's impairment is due its inability to support sufficient levels of aquatic life and its low levels of dissolved oxygen. Three of the nine management strategies are meant to restore degraded watershed functions. The Little Lick Creek partners and technical team refer cumulatively to these three approaches, stream repair, buffer restoration, and stormwater retrofit projects, as "watershed restoration."

Project partners prioritized the most urban areas in Little Lick Creek (subwatersheds 1-8) for field assessments and conducted two stages of fieldwork in January and March, 2005. During field assessment, project partners walked and assessed over 30 stream miles (41%) of Little Lick Creek and tributaries and conducted one week of windshield tours of the Watershed to identify potential stormwater retrofits and pollution "hot spots" (Hoyt & Tomlinson 2005). Table 4 summarizes the number of potential watershed restoration opportunities in each subwatershed.

Sub-shed	Stream Repair sites	Buffer Restoration sites (length, in ft)	Stormwater Retrofits
1	1	5 (4,700)	12
2	1	6 (3,900)	9
3	2	2 (1,070)	6
4	6	1 (270)	6
5	8	4 (2,650)	15
6	2	0	7
7	0	1 (200)	6
8	0	0	3
9	0	0	3
10	3	2 (500)	1
11	0	1 (750)	0
12	0	0	0
13	1	2 (650)	3
Total	24	24 (14,690)	71

Table 3. Little Lick Creek Watershed restoration opportunities

The Technical Team guiding the Little Lick Creek Local Watershed Plan prioritized watershed restoration strategies for restoring water quality and aquatic habitat functions to many of the degraded reaches of Little Lick Creek. The general conclusions of the restoration prioritization include:

- Among the priority projects are 16 high or highest priority buffer restoration, 7 high or highest priority stream repair, and 51 high or highest priority stormwater retrofit opportunities.

Watershed Restoration Priorities in Little Lick Creek			
Project Importance	Buffer Restoration	Stream Repair	Stormwater Retrofit
Priority	8	17	19
High Priority	15	7	43
Highest Priority	1	0	8

- Many of these projects exist in clusters, and implementing these clusters together is expected to have the greatest benefit to hydrology, water quality, and aquatic habitat.
- There are many opportunities to implement highly-visible restoration, repair, and retrofit projects that will have strong educational benefits.
- Overall, buffer restoration, stream repair, and stormwater retrofit projects can improve the Watershed's water quality, particularly the hydrology and sediment loading. However, this protection is limited and illustrates the need for comprehensive watershed management.
- Assessing the environmental benefits of individual buffer, stream, or retrofit project is a necessary step toward implementing and designing these projects. Nutrient removal and detailed cost analyses were not a part of this prioritization, although the priority scores do consider the relative nutrient or sediment removal benefits and relative cost of the various projects. These important analyses should be completed, potentially as a part of the implementation phase of this plan.

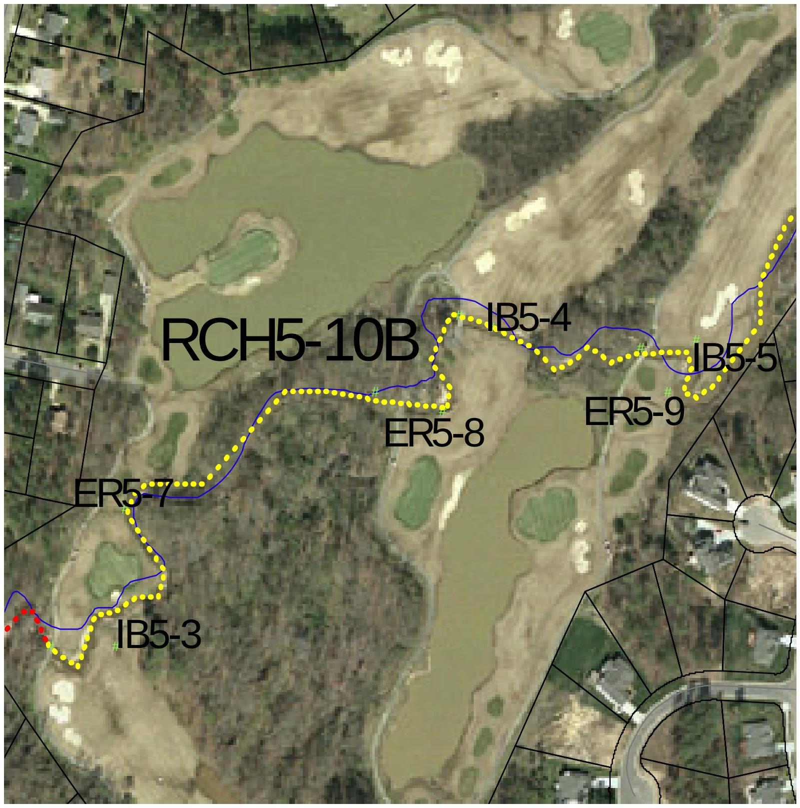

Figure 9. Little Lick Creek Sub-Watershed 5 Restoration Opportunities

There are several opportunities to restore clusters of projects like these buffer restoration and stream repair projects on a golf course in subwatershed 5. Blue line represents USGS GIS coverage of stream location, red and yellow dotted lines represent the stream based on the Little Lick Creek Team's global position system coverage of the line.

Subwatershed	Stream Repair	Buffer Restoration		Stormwater Retrofits		
	# Stream Repair	# Buffer Restoration	Restoration Length (feet)	# Retrofits	Min. Drainage Area (Acres)	Clusters of Projects
1	1	5	4,700	12	57.5	1) Near Angier Ave., 3 retrofit projects could treat >20 acres upstream of RCH 1-7. 2) SR 1-11 is upstream of RCH 1-1, a high-scoring buffer project. 3) 3 buffer restoration needs and 4 retrofits near the outflow of subshed 1.
2	1	6	3,900	9	51	1) Combine several buffer restoration and one stream repair project where Pleasant Rd. crosses LLC. 2) At confluence of subsheds 1 and 2, there are 3 large buffer restoration opportunities and 4 retrofit opportunities.
3	2	2	1070	6	4	1) 5 potential retrofits and 5 hotspots are within a strech of stream reach 3-4 near Miami Blvd., so retrofits could be combined with education and enforcement. 2) 2 buffer restoration and 1 severe stream repair need lie upstream of Holder Rd. Downstream are stream repair and retrofit needs. (Note: monitoring at this site found high levels of calcium, magnesium, and fecal coliforms, and many potentially failing septic systems are nearby).
4	6	1	270	6		1) 3 stream repair, 1 buffer restoration, and 4 stormwater retrofit needs in area around Ross St. north of NC 98.
5	8	4	2,650	15	30.5	1) Immediately downstream of the confluence of subsheds 1 & 2 are 3 large buffer restoration opportunities and 4 retrofit opportunities. 2) Reach 5-10B, Crossings Golf Club, has 5 potential stream repair, 1 buffer restoration, and 2 stormwater retrofit opportunities. Downstream on city-owned land is another large-scale repair opportunity.
6	2	0	0	7	247	1) Reach 6-1 contains a second stream repair need and retrofit opportunity. 2 buffer restoration and 1 severe stream repair need lie upstream in Subshed 2 across Holder Rd. (Note: see subwatershed 3 note).
7	0	1	200	6	10	1) Reach 7-1 has a buffer restoration need and two opportunities to retrofit stormwater outfalls. 2) Just downstream of Reach 7-1 are several large-scale retrofit opportunities on county land, at Southern High School.
8	0	0	0	3		Two retrofits at outflow of subshed 8 involve protecting lands that are currently treating stormwater runoff.
9	0	0	0	3	5.5	SR 9-1 a, b, and c: retrofit opportunities at Neal Middle School, upstream of the LLC monitoring reference site.
10	3	2	500	1		1) Within a 1/2 mile stretch to the east of Fletcher's Chapel and Redwood Roads, Reaches 10-2, 10-3, and 10-4 have several stream repair and buffer restoration opportunities, as well as a stormwater retrofit need.
11	0	1	750	0	0	
12	0	0	0	0	0	
13	1	2	650	3		Reaches 13-1 and 13-2 have buffer restoration needs and 2 potential stormwater retrofit sites.
Total	**24**	**24**	**14,690-15,520**	**71**	**405.5**	

Table 4. Potential watershed restoration opportunities, by subwatershed

Recommendation 1: Stream Repair Projects

The Problem

The State of North Carolina recognizes Little Lick Creek as “impaired” because of its inability to support aquatic life and its low dissolved oxygen levels. Both monitoring and fieldwork confirm that the greatest threat facing habitat in Little Lick Creek is severe sedimentation.   As much as two-thirds of the overall sediment load in Little Lick Creek may come from erosion of the stream channel itself (Hoyt 2005b). Some reaches of the stream, such as the one shown in the Figure 7, are severely eroded.

Many streams in the Watershed are incised and unable to access floodplains. Many stream banks are unstable. Although repairing these areas is not sufficient, on its own, to bring recovery to water quality and aquatic habitat, it is an important element of watershed restoration in Little Lick Creek. Repairing the many sections of stream that are actively eroding will significantly reduce the amount of sediment in these streams.

Repairing a stream reach provides various water quality and aquatic life benefits. There are numerous stream repair techniques that allow the stream to carry sediment under varying flow conditions, reduce stream flow velocities, remove nutrients and sediment through flooding, stabilize stream banks, and prevent loss of soil.

Findings

- Stream assessment identified at least 2,000 feet of potentially repairable channel (Hoyt 2005)
- Twenty of the 24 stream repair opportunities lie in subwatersheds 1 through 6.
- Most potential projects (17 of 24) do not meet NC Ecosystem Enhancement Program’s (NC EEP) minimum project length criterion of 1500 linear feet. However, the impacts are significant and should be addressed as soon as possible to prevent them from enlarging.
- Eight projects are either on public land or on land owned by a willing land owner.
- Subwatersheds 4 and 5 contain over half of the stream repair opportunities (14 of 24).
- The greatest reductions in sediment will come from protection of riparian buffers and improved stormwater management. (Hoyt 2005b).
- Little Lick Creek streams will be unstable until site designs and stormwater management practices improve.

Figure 10. Little Lick Stream Erosion

Recommended management strategy:

City and County of Durham

- Contact landowners on lands intersecting high priority stream repair.
- Conduct annual stream walks or review of aerial photography in the Watershed.
- Strongly enforce the existing buffer and erosion control requirements (Recommendation #6)

City and County with NC Ecosystem Enhancement Program

- Partner together to address the restoration needs of select high priority stream repair opportunities, focusing first on projects on public land or with willing landowners. Durham City and County should insure that the remaining projects are completed.
- NC EEP should explore avenues that broaden activities and criteria that it uses to credit restoring urban aquatic environments.

Recommendation 2: Riparian Buffer Restoration

The Problem

Little Lick Creek is recognized by the State of North Carolina as “impaired” because of its inability to support aquatic life and because of low dissolved oxygen levels. There is broad, scientifically based consensus that intact riparian areas are essential for the healthy functioning of streams (McNaught et al 2003). In Little Lick Creek, the streambank root systems provided by riparian buffers may be the only line of defense for preventing massive stream channel erosion and sedimentation. As much as two-thirds of the overall sediment load in Little Lick Creek may come from erosion of the stream channel itself (Hoyt 2005b).

The City and County of Durham require buffer protection on newly developed lands around perennial and intermittent streams, flood zones, and near water supplies. However, the rules apply to new development only. Areas built upon prior to the 1999 Natural Resources Protection Standards Ordinance received no protection, and individual lots platted before that time are exempt from the current rules. The result is that many riparian areas in the Little Lick Creek Watershed are impacted, thus further reducing the benefits buffers provide.

Figure 11. Little Lick Creek Buffers improve water quality

Findings

- 15,000 linear feet (almost 3 miles) of riparian buffers are prioritized for restoration.
- Most of the opportunities, over 11,000 feet (or 2 miles), lie in subwatersheds 1, 2, and 5. These subwatersheds also contain the greatest number of stormwater retrofit opportunities (Recommendation 3) and stream repair opportunities (Recommendation 1).
- Six opportunities meet current NC EEP minimum criteria for buffer restoration.
- Six projects are either on public land or on land owned by a reportedly willing landowner.
- Many buffer restoration opportunities are contiguous within the same stream corridor.
- Many impacted riparian buffers are the result of sewer right-of-ways, where vegetation is controlled to prevent tree growth and maintain access
- The Watershed Treatment Model (Hoyt 2005b) shows that riparian buffer enhancements can reduce the total suspended solids (TSS) load by 4% watershed-wide, with 5-14% improvements in subwatersheds 3, 7, and 13.

Recommended management strategy:

<u>City and County of Durham</u>

- Partner with NC EEP to restore the high priority buffer sites in Little Lick Creek. Prioritize projects on public lands (in some cases, changing management practices or simple plantings may suffice).
- Contact landowners on lands intersecting high priority buffer restoration opportunities.
- Conduct annual stream walks and/or review aerial photography in the Watershed. Stream walks will help identify new restoration opportunities and strengthen enforcement of the riparian buffer protection regulations (see Recommendations 6 and 9). The long-term goal should be to have no buffer restoration needs in the Watershed.

Recommendation 3: Stormwater Retrofit Projects

The Problem

As Little Lick Creek's watershed has become urbanized, both the volume and the rate of stormwater runoff have increased dramatically, resulting in stream instability, in-stream erosion, and increased pollution that contribute to the impairment of Little Lick Creek.

Stormwater best management practices (BMPs) such as wetlands, rain gardens (bioretention areas), or grass swales installed within the stream corridor or upland areas can capture and treat stormwater runoff before it reaches the stream (Hunt 2005). Although Durham City and County currently require BMPs for most new development, most of the development in Little Lick Creek's watershed predates the regulations. Retrofitting existing sites is an expensive, but often necessary way to correct existing impacts.

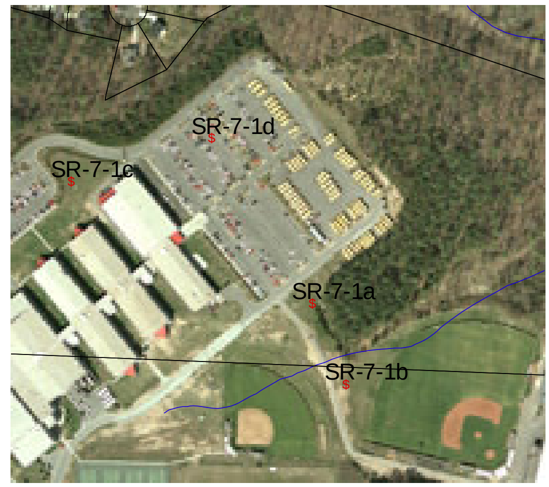

Figure 12. Little Lick Creek Stormwater Retrofit at Southern High

Findings

- Fieldwork identified seventy sites with a high potential for retrofit in the Watershed
- Forty-eight of the retrofit opportunities are in urban subwatersheds 1-5.
- At least 5, and possibly more, retrofit opportunities could treat areas over 10 acres.
- Many of the projects exist in clusters and could be combined with stream repair, buffer restoration, or critical land protection projects.
- Nineteen projects are either on public land or on the land of a reportedly willing landowner.

Recommended management strategy

<u>Durham City and County</u>

Construct the identified stormwater retrofits, beginning with those ranked "highest priority." Overall, the seventy-one identified retrofits can be described as follows:

- Use on-lot stream buffers and rain gardens in older neighborhoods
- Preserve existing forests and wetlands as filter areas.
- Encourage planting of trees and shrubs.
- Convert existing dry ponds to wet ponds or stormwater wetlands
- Construct stormwater controls for apartment complexes and mobile home communities
- Address commercial areas on-site controls and pollution source control measures
- Retrofit public sites as demonstration projects
- Outreach to churches to maintain and enhance sheet flow off parking lots
- Treat larger drainage areas in County and City-owned lands

Strategies to Prevent Future Degradation

Although Little Lick Creek is biologically impaired, the greatest long-term threat to water quality and aquatic habitat lies in the future. Currently, greater than one-half of Little Lick Creek's 21 square-mile watershed is covered by rural, forested, or agricultural land. In the future, the Northern Durham Parkway will run through the center of the Watershed and 57% of the Watershed will be under residential development, while 24% is expected to be open space (UNRBA 2005a). Will the current land use, stormwater and buffer regulations protect basic watershed functions if the level of development in the Watershed triples?

As the Watershed is urbanized, it will become more impervious to stormwater infiltration. The current level of impervious cover (rooftops, roads, parking lots, and driveways) is 11%. If that level increases to 23% and several subwatersheds (1-4) exceed 30% impervious cover, as this plan predicts, in stream runoff will increase and cause further stress on the already stressed stream channels.

At the same time as property owners in the City and County continue to develop the Watershed, the State of North Carolina is legally required to enforce the restoration of Little Lick Creek. In addition, the Creek flows into Falls Lake, a nutrient sensitive reservoir under active study for development of a nutrient management strategy. The reservoir may also be declared impaired.

The following recommendations are crucial to protecting the water quality and habitat functions of the Little Lick Creek Watershed from future degradation. It is recommended that partners in Little Lick Creek utilize three strategies to prevent future degradation of the Little Lick Creek Watershed:

Recommendation 4. Critical Lands Protection

Recommendation 5. Better Site Design

Recommendation 6. Improved Enforcement of Existing Rules

As Durham City, County, and other watershed partners implement the recommended approaches, both the number and severity of impacts on the Watershed from new development will decrease, and the result will be better water quality and a cleaner living environment for future watershed residents. Ultimately, a cleaner environment will mean more desirable neighborhoods and better quality of life.

Recommendation 4: Protection of Lands Critical to Water Quality and Aquatic Habitat

The Problem

Currently, about 10% of the Little Lick Creek Watershed is protected natural area and over 52% are forested or agricultural lands (UNRBA 2005a). Even with Durham's new and more protective buffer and floodplain regulations, the projected percent of protected natural area and greenspace will be 24% and the Watershed will lose all of its agricultural lands to low-density residential development.

The conversion of farmlands and forest to suburban development will have negative consequences for water quality in Little Lick Creek and Falls Lake. When fully built-out, the Watershed will export 24% more nitrogen than it currently does, according to the Center for Watershed Protection's Watershed Treatment Model (Hoyt 2005b). This increase occurs despite accounting for Durham's urban growth boundary, the use of structural stormwater management practices, and increased levels of homeowner education.

Findings

An analysis of lands critical to water quality and aquatic habitat identifies over 143 acres of critical land on 320 tracts that total 3,492 acres (26% of the Watershed). UNRBA 2005b explains the analysis. The following list highlights some of the findings.

- Well over ½ of the highest-value critical land (82 acres) is located on 13 tracts.
- 78 of the tracts containing critical lands are over 10 acres, and 18 are over 50 acres.
- 63 of the critical tracts lie within ¼-mile of public land, 14 are on prime farmland, 41 have over ¼-mile of stream frontage, 57 contain a planned trail, and 3 have historic/cultural sites.
- Almost all tracts with critical lands (133 of 143) are "developable", and 31 are grandfathered out of current floodplain and buffer regulations.
- Almost half of subwatersheds 9 and 10 are covered by tracts with high-value critical lands.

Recommended Management Strategy

Durham City and County, the Triangle Land Conservancy, and the Conservation Trust for NC

- Protect the highest conservation value using voluntary measures such as land acquisition and conservation easements, targeting these areas in the Eastern Durham Open Space Plan.
- The vast majority of the 143 acres of critical lands would be protected by Durham's ordinance prohibiting development in the 100-year floodplain. Durham can protect these lands by strictly enforcing the existing rules (see Recommendation 6).
- Prioritize developable tracts, especially those that are exempted from current ordinances.
- Small (less than 1-acre), developed tracts make up 48% of the total tracts with high value lands. Educate landowners about the ecological and water quality value of maintaining these lands in an undisturbed state (see Recommendation 7).
- The City and County of Durham's urban growth boundary was recently moved into subwatersheds 9 and 10. Durham should consider returning the boundary to its previous location based on the following logic:
    - Falls Lake's ½-mile critical area, which is meant to protect water quality, is not hydrologically-based, and sites outside the critical area but within subwatersheds 9, 10, and 13 will effectively bypass this "buffer" and send pollutants to the Lake.
    - The NC Division of Water Quality found an aquatic macroinvertebrate community in subwatershed 9 that may reflect reference conditions in the Triassic Basin. NC DWQ and Durham Stormwater Services want to use the site in subwatershed 9 as a reference site.

Recommendation 5: Better Site Design

The Problem

Little Lick Creek's soils are highly erosive and therefore vulnerable to increases in stormwater runoff. In fact, hydrologic impacts pose the single greatest management challenge in the Watershed. The only way to restore a degraded stream while allowing new development is by preventing that development from further impacting the system. To achieve this, we must manage stormwater on development sites so that post-development stormwater peak flow and total volume are attenuated to the greatest extent possible.

Findings

Depending upon its location in Durham City or County, new development in the Little Lick Creek Watershed must meet the City of Durham Natural Resource Protection Standards (1999), Falls Lake Water Supply Watershed Overlay Zoning Districts (1994), the Neuse River Stormwater Management for Nitrogen Controls (2001) rules, and federal NPDES stormwater regulations. These ordinances require limiting the nitrogen export from development sites, controlling the channel forming discharge from development sites, matching post-development stormwater peak flow rates to pre-development rates, avoiding development in floodplains, protecting slopes over 25%, treating runoff on sites with 24% or greater impervious cover, and protecting buffers around streams, ponds, wetlands, and the reservoir. These requirements were created to maintain an acceptable level of water quality in *currently healthy* surface waters. Particularly since the great majority of development will be under 24% impervious cover, these requirements will not prevent future degradation in the already impaired Little Lick Creek Watershed.

Recommended Management Strategy

The "Low-Impact Development (LID)" approach to stormwater management attempts to mimic a site's natural, or pre-development, drainage functions to the greatest extent possible through runoff minimization, rainwater capture, landscaping, infiltration, and conveyance. LID is a challenging standard to meet, particularly on Little Lick Creek's soils. However, the LID approach is most easily implemented and most successful on low-density residential sites like those sites that are likely to predominate in Little Lick Creek Watershed in the future. In many cases, the LID approach will allow developers to save money.

<u>Durham City and County</u>

Revise existing stormwater management for new development to meet a hydrologic performance standard such as "Low-Impact Development". Where LID is not practical, consider other rule changes to closely mimic the LID standard:

- Change Durham Unified Development Ordinance (UDO) language governing the location of sewer lines [UDO 8.5.5(J)(3)] to make local practice consistent with statewide Neuse Buffer Rules. Study the possibility of encouraging native grasses or, at the least, maintaining existing vegetation in the mowed right-of-way at a greater height.
- Create stronger protections for small (less than one acre) wetland areas adjacent to intermittent streams that currently escape protection (these are not on the USGS or SCS maps). Do not allow stormwater management facilities within the wetland or its buffer.
- Allow grass channels in lieu of curb and gutter in low-density residential areas. Where this is not practical, require that all discharges from curb-and-gutter systems, even those in low-density developments, receive treatment to reduce nitrogen at least 30% in accordance with the Neuse Buffer Rules.
- Meet Upper Neuse Watershed Management Plan phosphorous reduction goals for new development.
- Encourage the use of bioretention with underdrain systems in landscaped areas of parking lots for stormwater treatment.
- Encourage, or require, the use of conservation subdivisions allowed in Durham's UDO (see Recommendation 4). Require that open space be maintained in natural condition.
- Within the Triassic Basin, adapt the steep slopes ordinance to reduce the required slope from 25% to 15% (see Recommendation 4).

- Consider requiring development on previously-platted lots grandfathered from the Neuse Requirements to meet LID. These sites would only have to treat runoff at the lot level.
- Increase incentives to preserve existing trees/forested areas on developing sites.

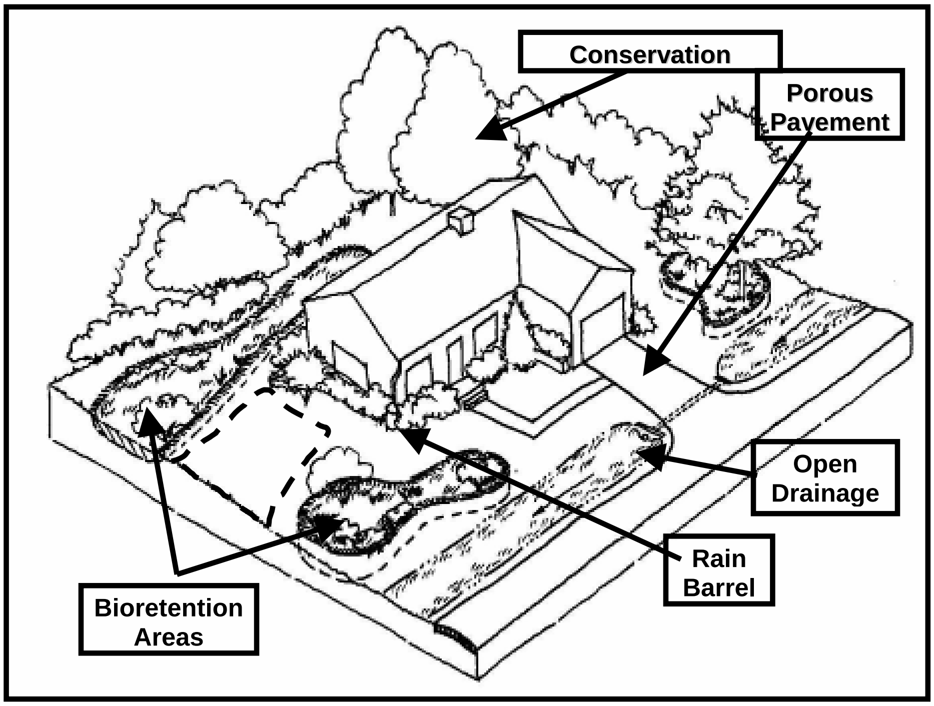

Figure 13. Low-impact development site (Prince George's County, MD 1999)

Recommendation 6: Improved Enforcement of Existing Rules

The Problem

Currently, Durham City and County have rules governing erosion control, stormwater management, floodplain protection and riparian buffer protection. Although there are opportunities for improvement (see Recommendations 4 and 5), proper enforcement of these ordinances could protect watershed function. However, fieldwork revealed examples in which failure to enforce ordinances led to impacts that degrade the Watershed.

Findings

Fieldwork identified instances of poorly functioning erosion and sediment controls, illicit discharges from septic systems and failing sanitary sewer lines, trash dumping, impacted buffers on new and existing development, and poorly designed stormwater management controls (Hoyt 2005 & Hoyt and Tomlinson 2005, summarized in UNRBA 2006). Durham ordinances and state regulations prohibit illegal discharges, surfacing wastewater from septic systems, sewer overflows, and dumping of trash. The following two examples of findings illustrate the need for strong enforcement.

Sediment and erosion control—The Little Lick Creek Watershed treatment model predicts that a program of weekly inspections, the implementation and maintenance of controls at a rate of 90% or greater, and additional education of contractors regarding effective practices could result in an 8% reduction of annual sediment (total suspended solids, or TSS) loading (Hoyt 2005b).

Wastewater—a high percentage of sand filter onsite wastewater treatment systems are failing, and only 15% of these are permitted by the state. NC rules require hook up of permitted systems where public wastewater is available.

Figure 14. Failing sand filters (left) and failure to protect buffers (right) pose health risks and harm water quality.

Recommended Management Strategies

Specific recommendations are listed, by program area, below.

Erosion and Sediment Control (Durham County and NC Division of Water Quality)

- Durham County falls under NPDES Phase II Stormwater regulations, which requires construction site runoff control. NC DWQ's Stormwater Program administers these regulations, but, due to the amount of construction activity in the State and its limited number of staff, the Program is unable to inspect all construction sites over 1 acre. The Stormwater Program should either complete inspections to ensure

the NPDES permit reports are being implemented as required or provide incentives to Durham County to complete these inspections.
- Sediment and erosion control should be required for all construction projects.
- NC DWQ should inspect pond draining projects prior to the onset of draining.
- Contractor, engineering, and erosion control regulator training should be provided.

Impacted Buffers (Durham City Stormwater Services and County Stormwater Mgmt.)
- Conduct post-development inspections to ensure that buffers have been managed as required by Durham ordinance. UNRBA (2006) describes an efficient and effective approach.
- Conduct regular stream assessments like the assessment undertaken in Little Lick Creek in 2005. This will require additional staff. Since riparian buffers constitute the most effective stormwater management tool, it makes sense that buffers should receive the same level of oversight as do other stormwater management controls.

Stormwater Management (Durham Stormwater Services. and County Stormwater Mgmt.)
Durham Stormwater Services regularly encounters stormwater facilities that are not built in accordance with the design. Current regulations require 'As-Built' drawings that certify the facility was built in accordance with the approved plans, but there is no requirement for the design professional to inspect construction or verify conformance. As an interim strategy, Stormwater Services inspects new construction so that improper construction can be corrected while the contractor is still at the work site. This has been successful, but currently requires additional staff time.
- Increase the number of City Stormwater Services staff to inspect new construction and to conduct annual inspections of the existing BMPs. Alternatively, consider strengthening As-Built certification requirements to place more responsibility on the design professional.
- The number of projects requiring BMP's has increased dramatically and the number will continue to increase in the future. Review staff levels annually for adequacy.

Trash Dumping (Durham City Solid Waste Management and Stormwater Services)
Enforcing littering regulations is challenging in low-visibility areas like stream corridors.
- Include citizens in efforts to clean up Little Lick Creek.
- Advertise a citizen hotline to facilitate enforcement. Homeowner education is a vital part of this approach (see Recommendations 7 and 8)
- Site household waste collection sites in apartment complexes or use a mobile oil recycling program that covers the Watershed on a regular basis. The City may be able to reduce problems with dumping of white-goods and yard waste by similar measures. The City should review the fees it charges for white goods pick-up and for participating in the yard waste pick-up/recycling program.

Sewer and Wastewater Discharges (Durham County, City, and NC DWQ)
Create a task force with other stakeholders such as NC Division of Environmental Health to explore opportunities to improve the enforcement mechanisms to prevent:
  - Failures of wastewater lines within the stream corridor;
  - Failures of onsite wastewater treatment systems; and
  - Instances where high-risk onsite systems (such as sand filter systems) are not being hooked up to available public sewer systems.

Watershed Stewardship

This plan recommends several strategies for restoring basic watershed functions and preventing future degradation. However, it is clear that restoration and protection will not be possible without increased stewardship of the Watershed. Little Lick Creek needs stewards at various levels. At the most basic level, the general level of awareness of the Creek must be raised. How can we expect people to protect the Creek if they do not know they live in the Watershed? Additionally, a high level of awareness will not, on its own, improve water quality and aquatic habitat. Only stewardship through action can lead people to change habits or actively protect Little Lick Creek.

The following section recommends three approaches for improving stewardship in the Little Lick Creek Watershed. *Recommendation #7: Watershed Outreach and Education* recommends that the City of Durham's stormwater education program provide targeted education for landowners with the goals of protecting more backyard riparian buffers, maintaining on-site wastewater treatment systems, preventing commercially-related water pollution, and implementing restoration and stormwater retrofit projects.

Recommendation #8: Adopt-a-Stream Programs suggests that citizens throughout the Watershed can work together through the City's Adopt-a-Stream program to take active responsibility for the well-being of the Creek. The responsibilities range from walking the stream to measuring water quality and reporting findings.

Recommendation #9: Water Quality Monitoring suggests several short and long-term monitoring strategies to better understand baseline conditions, the Creek's hydrologic response to development, and the pollutants entering the Creek. This level of understanding can only be accomplished through increased monitoring, and both government and watershed citizens have a role.

The stewardship strategies recommended herein will require additional resources of time and effort. Little Lick Creek occupies less than 7% of the entire City of Durham, and the needs are great. Durham Stormwater Services' environmental educator and water quality staff already operate very efficiently in providing a loose network of water quality monitoring and education throughout the city. Increasing such efforts may seem a challenge; however, there are compelling reasons why the City and County should implement these strategies. First, Little Lick Creek is already impaired. As the Watershed grows increasingly more urban, hydrologic impacts, erosion, and pollution potential will worsen. We must change our current way of thinking and depend upon a diffuse source of actors to ensure that the strategies are implemented, rules are enforced, and that water quality and habitat goals are being met.

Another compelling reason for increasing the level of monitoring and stewardship in Little Lick Creek is to protect Falls Lake. The state is developing a nutrient management strategy for the Lake, which is nutrient sensitive and may be impaired. The strategy will require polluters to reduce the amount of nutrients (nitrogen and phosphorous) entering the Lake. New development will face increasing pressures to reduce impacts (see Recommendation 5), and communities in the Falls Lake Basin will be forced to find ways to reduce existing pollutant loads (see Recommendations 1-3). Communities will also need to show the effectiveness of management strategies, and monitoring and stewardship practices like those recommended

Recommendation 7: Watershed Outreach and Education

The Problem

Fieldwork in January and March of 2005 revealed many instances of potential pollution "hot spots" in the Little Lick Creek Watershed (Hoyt 2005, and Hoyt and Tomlinson 2005).

Findings

- *Trash Dumping*—Many homes and businesses located along stream buffers store or dispose of waste, often hazardous materials, in the riparian buffer; and
- *Poor maintenance of on-site wastewater treatment systems*—Poor maintenance, particularly of sand filter-type systems, resulted in raw sewage entering surface waters (Hoyt 2005).
- *Vehicle maintenance and repair operations*—Many operations are discharging toxins such as solvents, waste oil, antifreezes, and other fluids to surface waters.
- *Gas stations*—Stations discharging fuel (primarily diesel), can be a significant source of copper, zinc, and petroleum hydrocarbons.
- *Outdoor materials storage*—Findings include lack of secondary containment areas, improper labeling of storage containers, and uncovered outdoor storage of hazardous materials.
- *Restaurant pollution source control*—Recurring pollution at restaurants in Little Lick Creek included grease storage, wash water disposal, and dumpster management.

Figure 15. Improper storage of waste and fuels pollute the Creek and Falls Lake.

In addition, field work identified many opportunities for stream repair, buffer restoration, stormwater retrofit projects and critical lands protection (Recommendations 1-4).

Recommended Management Strategy

Figure 16. Stream clean-ups teach stewardship

- Contact all streamside landowners, about proper maintenance of riparian buffers and the regulations governing (and penalties for noncompliance with) littering.
- Educate all landowners in Little Lick Creek with on-site wastewater treatment systems about proper maintenance and inspection (especially sand filter-type systems)
- Conduct outreach presentations and discussions with small auto repair and sales shops, existing gas stations, business identified as having significant storage of outdoor materials, and restaurants with recurring pollution incidents (Hoyt and Tomlinson 2005)
- Conduct mailings and/or outreach to landowners to encourage them to implement the restoration, retrofit, and land protection projects recommended in Recommendations 1-4 of this plan. Most people will not know of the opportunities without outreach. Start with opportunities at public schools. Involve teachers and other staff who may be able to champion these projects

Recommendation 8: Adopt-a-Stream Program

The Problem

Stormwater runoff, impacted buffers, stream erosion, erosion and sediment control violations, sewer leaks, and failing septic systems degrade water quality and aquatic life in Little Lick Creek. It is impossible for local or state governments to detect all of these.

Findings

Despite having excellent water quality monitoring and enforcement programs, Durham City and County cannot monitor regularly enough to detect the great majority of problems in the Watershed.

There are many citizens who understand the value of clean streams and water supplies. The City of Durham recently formed an “Adopt-a-Stream” program that recognizes these community strengths and draws on them to protect waterways from pollution.

Recommended Management Strategy:

Trained citizens can detect many common problems that affect water quality and strengthen existing water quality programs in the City and County. Implementing the City’s Adopt-a-Stream program will raise the level of stewardship and increase oversight in Little Lick Creek. The program should focus on the most impacted subwatersheds in Little Lick Creek, subwatersheds 1-8. Some criteria for targeting sites include reaches:

- With easy access to the stream;
- Where at least one, but preferably a group of, interested citizens live;
- Downstream of areas with high densities of septic systems;
- Downstream of active construction sites;
- Where known impacts exist (identified in this plan); and
- Near schools, where science classes could establish long-term water quality monitoring sites.

Figure 17. Adopt-a-Stream can enhance oversight of Durham’s water quality regulations

Volunteers commit to at least two years of monitoring at one of three levels, the highest of which places volunteers on a stream at least twice a month to conduct visual monitoring and measure designated water quality parameters. Volunteers are provided training and monitoring kits and have direct contact with Durham Stormwater Services to report findings. In addition, volunteers are expected to conduct two stream clean-ups per year and have the option of conducting biological monitoring.

Recommendation 9: Stream and Watershed Monitoring

The Problem

Little Lick Creek is "impaired" because of its inability to support aquatic life and because of low dissolved oxygen levels, and the amount of urban development is expected to double in when the Watershed is built to the extent allowable under current regulations. What is the cause of Little Lick Creek's impairment?

We know relatively little about water quality and aquatic habitat conditions in Triassic Basin streams, particularly regarding aquatic life, dissolved oxygen, hydrology, and sediment transport. NC Division of Water Quality does not rate Triassic Basin streams based on aquatic life and other key water quality indicators. However, the Draft 2006 303(d) List of Impaired Streams lists Little Lick Creek based on aquatic life and low dissolved oxygen. Do Triassic Basin geology and soils support distinct levels of aquatic life? What will be the results, in terms of important water quality and habitat indicators, of new development? Can management strategies stabilize the stream's condition or reduce pollutants entering the stream and Falls Lake?

The City of Durham Stormwater Services (DSS) monitors two sites in the Little Lick Creek Watershed, at sites 3 and 5 in the map below. In addition, NC DWQ has conducted chemical, biological, and toxics sampling across 11 sites shown in Figure 5 of this plan.

Findings

- Poor stormwater management and buffer impacts likely create severe sediment impacts in Little Lick Creek
- Good aquatic life exists in relatively undeveloped tributary streams with rocky substrates (subwatershed 9), and this areas may help us understand Triassic Basin "reference" conditions.
- Little Lick Creek's dissolved oxygen and aquatic life vary greatly with seasonal flow.
- There are an estimated 6,000 septic systems in the Watershed, and hundreds of problem septic systems exist. Monitoring in subwatersheds 5 and 3 indicate failing septic systems and sewer spills may be a risk to public health and to Falls Lake.
- Stream reaches with riparian buffers are more resistant to channel erosion than are streams with no buffers, and roots may be the only protection for stream banks in most areas;
- Many stormwater management and sediment and erosion control devices were not working as planned, and DSS followed up with enforcement (see Rec. 7).
- Subwatershed 8 had very high levels of residues, turbidity, aluminum and iron, likely caused by a large-scale violation of sediment and erosion control practices.
- Some areas of steep slopes are experiencing massive stream erosion.
- Watershed stewardship is poor; there are high amounts of litter, dump sites, and unkempt outdoor storage areas (see Recommendation 8).

Recommended short-term monitoring objectives

- *Establish a better understanding of baseline conditions in the Triassic Basin*
- *NC DWQ and DSS investigate the extent of wastewater pollution*
- *Assess the use of new toxicity assays in Little Lick Creek*
- *Study important management questions*

Recommended long-term monitoring programs

- *Establish annual stream walks to gage the progression of in-stream erosion*
- *Establish a long term flow gage in Little Lick Creek*
- An effective program must involve citizens
- Monitor flow and nutrient loading to Falls Lake

Figure 18. Stream flow gages are crucial for monitoring water quality and flow (USGS Gage Site on the Flat River).

Conclusions

Little Lick Creek partners developed the Little Lick Creek Local Watershed Plan with funding from the NC Ecosystem Enhancement Program. The plan recommends a comprehensive approach to restoring water quality and aquatic habitat in the 21 square-mile Little Lick Creek Watershed. Although any single set of recommendations will have positive effects on its own, only a comprehensive strategy is expected to improve water quality and aquatic habitat in the Watershed.

The plan is the culmination of 14 months of watershed analysis, fieldwork, planning, and prioritization by watershed stakeholders. A technical team of project stakeholders met 10 times over this period to guide the NC EEP, Upper Neuse River Basin Association, the Center for Watershed Protection, the Triangle J Council of Governments, and other project partners in completing project tasks. Technical memoranda developed during the planning process, referenced herein and available on http://www.nceep.net/services/lwps/little_lick/, describe the analyses and recommendations in greater detail.

The Little Lick Creek Planning Team presents these watershed management conclusions.

- Little Lick Creek is currently impaired due to its inability to support sufficient levels of aquatic life and its low levels of dissolved oxygen.
- Restoring water quality and aquatic habitat conditions within the Watershed is complicated by several factors such as lack of understanding of baseline stream conditions, sewer and septic impacts, utilities, and rapid urban development.
- The great majority of restoration and retrofit opportunities lie in subwatersheds 1-5. 18 (of 24) stream repair opportunities, 18 (of 24) buffer restoration opportunities, and 48 (of 71) retrofit opportunities are in this upper 1/3 of the Watershed. Watershed-wide, restoration projects must be part of a comprehensive approach toward restoring water quality and aquatic habitat.
- We must better understand the baseline watershed conditions in Triassic Basin streams, particularly aquatic life, dissolved oxygen, hydrology, and sediment transport. NC Division of Water Quality does not rate Triassic Basin streams based on aquatic life and other key water quality indicators, yet the Draft 2006 303(d) List of Impaired Streams lists Little Lick Creek based on aquatic life and low dissolved oxygen. Clearly, the NC DWQ and local governments should partner to conduct further monitoring that will allow NC DWQ to consistently rate Triassic Basin streams.
- The Triassic Basin soils that comprise the Little Lick Creek Watershed are almost devoid of rocky material, with the exception of a few metamorphic Diabase intrusions. In-stream erosion caused by hydrologic changes from urban development is, by far, the greatest source of sediment in the stream.
- The State is developing a nutrient management strategy for Falls Lake, which is nutrient sensitive and may be impaired. A nutrient management strategy (NMS) will require polluters to reduce the amount of nutrients (nitrogen and phosphorous) entering the Lake. New development will face increasing pressures to reduce impacts, and communities in the Falls Lake Basin will be forced to find ways to reduce pollutant loads. The strategies recommended in this plan, although not developed specifically for Falls Lake, are likely to mirror Falls Lake NMS requirements.
- One of the greatest potential water quality threats in the Watershed is failing septic systems and sewer spills. It will be necessary to remove this threat to water quality from Little Lick Creek before we can hope to restore aquatic life and water quality to the Watershed. In particular, the Creek has the greatest density of sand-filter type systems in the entire Upper Neuse Basin. Sand filter-type systems exhibit high rates of failure. Unlike other septic systems, the failures are going unnoticed for long periods of time because they discharge the raw, untreated sewage directly into streams. Even properly functioning sand filter systems export high concentrations of nutrients to streams, contributing to algae growth and low levels of dissolved oxygen.
- The level of urban development is projected to more than double in the long run. Restoring Little Lick Creek will be impossible without stronger approaches for preventing impacts from future land use changes like those recommended in this plan.

- Watershed citizens are a much underutilized resource. There is little hope of effectively managing water quality in Little Lick Creek without better stewardship. Education programs and citizen participation in monitoring and enforcement are key components.
- There is a need for significant additional management and enforcement in Little Lick Creek. Since the Watershed occupies only a small portion of Durham City and County, staff members are not able to spend the time sufficient for the necessary management and oversight. Durham's excellent stormwater staff is stretched to the limit and the City's stormwater fees are among the lowest in the region.

References

Center for Watershed Protection (2004). "An Integrated Framework to Restore Small Urban Watersheds." Version 1.0. Volume 1 of the *Urban Subwatershed Restoration Manual Series*. March. Available at www.cwp.org.

Center for Watershed Protection (2003). "Impacts of Impervious Cover on Aquatic Systems." March. Available at www.cwp.org .

Carle, M.V., P.N. Halpin and C.A. Stow (2005). "Patterns of Watershed Urbanization and Impacts on Water Quality". *Journal of the American Water Resources Association* 41(3):693-708.

Clark, T.W., Gore, P.J.W., and Watson, M.E. (2001). "Depositional and structural framework of the Deep River Triassic Basin, North Carolina" *in* Hoffman, C.W. editor, *Field trip guidebook*, 50th Annual Meeting, Southeastern Section, Geological Society of America, Raleigh, North Carolina, April.

Eaton, Larry (2006). "UT Little Lick Creek Resample-Neuse Subbasin 01; EEP Special Study". Memo to NC Ecosystem Enhancement Program by NC Division of Water Quality. (March 31).

Hall, Stephen P. (1995). "Inventory of the Wildlife Habitats, Movement Corridors, and Rare Animal Populations of Durham County, N.C." NC Natural Heritage Program, Division of Parks and Recreation, NC Department of Environment and Natural Resources.

Hoyt, Sally (2005). Memorandum: Summary of Field Work Activities in Little Lick Creek-January 2005. Memorandum from Sally Hoyt, of Center for Watershed Protection, to the UNRBA. March 10.

Hoyt, Sally (2005b). Memorandum: Little Lick Creek-Watershed Treatment Model. Memorandum from Sally Hoyt of the Center for Watershed Protection. June 15.

Hoyt, Sally and Jennifer Tomlinson (2005). Memorandum: Summary of Field Work Activities in Little Lick Creek-March 2005. Memorandum from Sally Hoyt and Jennifer Tomlinson, of the Center for Watershed Protection, to the UNRBA. April 29.

Hunt, William F. III (2005). "Urban Waterways: Urban Stormwater Structural Best Management Practices." Available at http://www.bae.ncsu.edu./people/faculty/hunt/ag588-15.pdf

Kroeger, Steve (2005). "Summary of Water Quality Monitoring in the Little Lick Creek Watershed and Tributaries, Durham County, North Carolina, March—June 2005". Prepared for the NC Ecosystem Enhancement Program by NC Department of Environment and Natural Resources, Division of Water Quality. (November, revised February 2006).

McNaught, David, Joseph Rudek and Elizabeth Spalt (2003). *Riparian Buffers: Common Sense Protection of North Carolina's Water*. A report produced by Environmental Defense that reviews the literature on riparian buffers and recommends basic protection strategies.

Piatt, W.M. and Co. (1985). "Water and Wastewater Facilities, Durham, N.C.: Preliminary Plan for 2005." W.M. Piatt and Company, Consulting Engineers. July.

Prince Georges County, Maryland Department of Environmental Resource Programs and Planning Division (1999). *Low-Impact Development: An Integrated Design Approach*. June.

Terziotti, Silvia 2004. A geographic information systems file created by S. Terziotti (US Geological Survey) based on a 20-foot resolution digital elevation (DEM) model that the USGS created for the Upper Neuse River Basin. The DEM is based on high-resolution light detection and radar (LIDAR) data created for the entire Neuse River Basin for the NC Division of Emergency Management's Floodplain Mapping Program.

TJCOG (2000). "Census 2000 Data for the Neuse River Basin: An Analysis of Population and Households by County and Hydrologic Unit." Triangle J Council of Governments Report. January.

USDA (1971). “Soil Survey of Durham County, North Carolina.” U.S. Department of Agriculture, Soil Conservation Service.

Upper Neuse River Basin Association (2005a). “Revised Little Lick Creek Local Watershed Plan Technical Memorandum #1—Initial watershed characterization, existing water quality data, stakeholder process and project goals.” Technical memorandum to NC Ecosystem Enhancement Program. February. Available on http://www.nceep.net/services/lwps/little_lick/

Upper Neuse River Basin Association (2005b). “Little Lick Creek Technical Memorandum #2—Suggested approach for critical lands protection analysis” Technical memorandum to NC Ecosystem Enhancement Program. June. Available on http://www.nceep.net/services/lwps/little_lick/

Upper Neuse River Basin Association (2005c). “Little Lick Creek Technical Memorandum #4—Priorities for watershed restoration in Little Lick Creek” Technical memorandum to NC Ecosystem Enhancement Program. December. Available at http://www.nceep.net/services/lwps/little_lick/

Upper Neuse River Basin Association (2006). “Little Lick Creek Technical Memorandum #5—Watershed Management Strategies recommended for Little Lick Creek. February. Available at http://www.nceep.net/services/lwps/little_lick/