

UPPER NEUSE RIVER BASIN ASSOCIATION

LICK CREEK WATERSHED RESTORATION PLAN

September
2009

EPA 319 Grant Final Report and Watershed Restoration Plan

Sponsored by the NC Division of Water Quality,
Department of Environmental and Natural Resources

Thank you to our partners who provided cost sharing on this project including the Center for Watershed Protection, NC State University Water Quality Group, City of Durham Stormwater Services, City and County of Durham Planning Department, Durham County Sediment and Erosion Control Division, Durham County Open Space and Real Estate Division, Triangle Greenways Council, and Triangle Land Conservancy.

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www.unrba.org/lick/downloads.shtml

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Finally, this project could not have been possible without the overwhelming interest and support of the local community, the Soil and Water Conservation District, local activists, local environmental groups, community members and, Lick Creek watershed residents. Their input, participation, and support demonstrates the value of water to this community, the desire of residents to serve as water quality stewards, and their call to the regulatory community to address the protection of water quality in the Lick Creek watershed.

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EXECUTIVE SUMMARY

Lick Creek was listed as “biologically impaired” by the NC Division of Water Quality on the 2006 NC 303(d) list (NCDWQ 2006). Lick Creek is also a tributary to Falls Lake, a state-designated nutrient-sensitive water (NSW) and a water-supply (WS) reservoir, providing drinking water to over 600,000 Wake County residents. In May of 2005, the Upper Neuse River Basin Association partnered with various organizations to create a Watershed Restoration Plan for Lick Creek that would identify sources of Lick Creek’s impairment and propose and prioritize management strategies to address those sources. The UNRBA aims to produce a demonstrable improvement in Lick Creek water quality through local implementation of the management strategies recommended in this watershed restoration plan.

During the summer of 2006, the UNRBA began identifying and contacting interested groups with a stake in the management of the Lick Creek watershed. This group eventually came to be known as the Local Watershed Planning Group and consisted of project partners, community stakeholders, and a technical team. Collectively, the local watershed planning group committed to initiate, facilitate, organize, guide, and provide input for the development of the watershed restoration plan. Furthermore, project partners committed to financially support the development and implementation of management strategies developed as part of the watershed restoration plan.

The Lick Creek Watershed Restoration Plan encompasses a suite of activities aimed at addressing the impairment of Lick Creek by improving water quality and habitat conditions. The Goals of this plan were to:

1. Develop a hypothesis about the causes of impairment in Lick Creek and recommend approaches to address impairment status;
2. Identify pollutants and their sources that may be impairing aquatic habitat and water quality in Lick Creek (water quality is not impaired currently). Suspected pollutants include dissolved oxygen and biochemical oxygen demand), fecal coliform bacteria, and turbidity;
3. Develop strategies for reducing, and maintaining at levels meeting water quality standards, the pollutants identified in Goal 2; and
4. Mitigate future changes to watershed hydrology and water quality.

In order to meet these goals, the Lick Creek planning group convened a large community of stakeholders made up of technical experts, residents, local agencies, and other community members who worked together over two years to assess the current conditions of the watershed, perform water quality monitoring, identify sources of pollution, predict land-use changes, perform critical lands analyses, identify and prioritize restoration opportunities, and develop comprehensive management strategies to address water quality impairment in the Lick Creek watershed. The culmination of this 3-year effort is thirteen detailed management strategies for implementation by local, regional, and state-level watershed stakeholders including:

1. Erosion and Sediment Control on New Development;
2. Managing Timber-Harvesting and Sites Classified as “Agricultural”;
3. Stormwater Management and Regulation;
4. Impacts from Infrastructure Crossing the Stream Corridor;
5. Riparian Buffer and Floodplain Encroachment;
6. Protection of High-Quality Streams and Wetlands;

7. Delineation of Stream and Wetland Boundaries;
8. Major Watershed Restoration Projects;
9. Restoration Projects to be Implemented by Volunteers;
10. Suspicious Discharges from Onsite Wastewater Systems;
11. Targeted Outreach and Education;
12. Long-Term Monitoring Recommendations; and
13. Low Impact Development.

With more than 18 groups represented, and almost 70 stakeholders constituting the Lick Creek Stakeholder Group, the efforts put forth in developing the Lick Creek Watershed Restoration Plan have been a great success. Furthermore, all four of the goals aspired to for this plan have been met.

Through water quality monitoring and stream corridor assessment, sources and causes of impairment to water quality in the Lick Creek watershed were identified. Subsequently, 13 comprehensive management strategies were put forth to improve and protect water quality and aquatic habitat in the watershed. These strategies were developed and embraced by all the stakeholders through a collaborative process and many of the recommendations put forth in this plan are already being implemented through strong ordinance changes, a true spirit of stewardship from both the local governments and the local community, and through new legislative requirements.

In addition, the Upper Neuse River Basin Association, the City of Durham, and the Durham County Soil and Water Conservation District are already engaging in implementing restoration projects identified through this planning process.

One of the greatest successes of this project has been the resulting atmosphere of understanding and cooperation between stakeholders, local governments, local programs, local community groups, developers, local business owners, and watershed residents. Bringing so many groups to the table provided an opportunity for each stakeholder to share and hear about the obstacles to implementation that each faced and find creative and mutually beneficial solutions to water quality management in the Lick Creek watershed.

BACKGROUND AND PROJECT GOALS

History and Watershed Planning

Lick Creek was listed as “impaired” by the NC Division of Water Quality (NCDWQ) on the 2006 NC 303(d) list (NCDWQ 2006). Lick Creek is also a tributary to Falls Lake, a state-designated nutrient-sensitive water (NSW) and a water-supply (WS) reservoir, providing drinking water to over 600,000 Wake County residents. In May of 2005, the Upper Neuse River Basin Association (UNRBA) partnered with various organizations to create a Watershed Restoration Plan (WRP) for Lick Creek that would identify sources of Lick Creek’s impairment and propose and develop management strategies to address those sources. The UNRBA aimed to produce a demonstrable improvement in Lick Creek water quality by implementing the management strategies recommended in the WRP.

The UNRBA has developed several tools for ongoing Upper Neuse watershed management efforts that were used to produce a high-quality WRP for Lick Creek. For example, the UNRBA and partners utilized the Upper Neuse Watershed Evaluation Tool (WET), an ArcView GIS tool that the US Geologic Survey (USGS) is in the process of testing and refining, to efficiently perform many of the basic watershed planning functions needed for a watershed restoration plan. The restoration project identification component of the Lick Creek WRP utilized the Site Evaluation Tool (SET), a NCDWQ Section 319 Non-Point Source (NPS) grant-funded product that the UNRBA developed in cooperation with NCDWQ, Tetra Tech, Inc., and NC State University (NCSSU). The WRP for Lick Creek has also benefited from an ongoing collaboration of project partners who have worked together on similar local watershed planning projects such as the WRP that was developed for neighboring Little Lick Creek (UNRBA 2006).

The UNRBA has a history of successful partnerships with stakeholders in this watershed from its participation and leadership on other projects in the Upper Neuse. The UNRBA is known to elected officials, local government staff, and the media as a credible source of information on how to best protect water quality in the Upper Neuse’s streams, lakes, and rivers.

To document improvements (and possible shortcomings that need to be corrected), the Lick Creek WRP has included a long-term monitoring component, which will be integrated with other monitoring activities that are taking place in Lick Creek. It is hoped that the long-term monitoring program will be implemented by City of Durham Stormwater Services (DSS), possibly with assistance from another organization with guidance from the UNRBA.

Watershed Restoration Plan Goals

The Lick Creek WRP encompasses a suite of activities aimed at addressing the impairment of Lick Creek by improving water quality and habitat conditions. The goals of the Lick Creek WRP are:

1. Develop a hypothesis about the causes of biological impairment in Lick Creek and recommend approaches to address impairment status;
2. Identify pollutants and their sources that may be impairing aquatic habitat and water quality in Lick Creek (water quality is not impaired currently). Suspected pollutants include dissolved oxygen (DO)(and biochemical oxygen demand [BOD]), fecal coliform bacteria (FC), and turbidity;
3. Develop strategies for reducing, and maintaining at levels meeting water quality standards, the pollutants identified in Goal 2; and
4. Mitigate future changes to watershed hydrology and water quality.

The planning and assessment phase of the process (funded by a NCDWQ Section 319 grant) has been a three-year effort and has included development and initial implementation of a WRP for Lick Creek. Implementation and post-intervention monitoring will take decades, and key partners are committed to assisting in the long-term effort.

EPA's 9 Key Elements for a Watershed Restoration Plan

1. An identification of the causes and sources.
2. A description of the NPS management measures that will need to be implemented to achieve load reductions.
3. An estimate of load reductions.
4. An estimate of the amount of technical and financial assistance needed.
5. An information/education component.
6. A schedule for implementing the NPS management measures.
7. Measurable milestones.
8. Criteria to determine whether loading reductions are being achieved.
9. A monitoring component to evaluate effectiveness.

Deliverables for 319 Grant

- Convene a comprehensive stakeholder group and hold eight meetings as described below:
 - To introduce the project and solicit participation;
 - To review stormwater hotspots analysis and stream corridor restoration;
 - To review potential future conditions analysis;
 - To review critical lands analysis;
 - To review prioritized projects;
 - To review other management strategies;
 - To discuss implementation approaches; and
 - To present the final Lick Creek Watershed Restoration Plan.

Status: Completed. A comprehensive stakeholder group representing more than eighteen agencies and groups was convened in 2006 and met 8 times over the course of the development of the watershed restoration plan as described above. Meeting details and summaries are available on the project website at <http://www.unrba.org/lick/downloads.shtml>. In addition, several meetings were conducted with local staff to review proposed management strategies; these meetings were used to better inform the final Lick Creek Watershed Restoration Plan recommendations.

- Develop a project webpage.

Status: Completed. A project website was developed and has been maintained by the Upper Neuse River Basin Association and the Triangle J Council of Governments throughout the life of the project. Lick Creek stakeholders provided input and feedback on the website during the course of the project. Please visit <http://www.unrba.org/lick/downloads.shtml>.

- Develop a baseline map of subwatersheds.

Status: Completed. A baseline map is available in the “Lick Creek Watershed—Initial watershed characterization, existing water quality data, and stakeholder process” technical memorandum and is available on the project website. The appendices for this document also provide a map of each subwatershed individually (B-1 through B-11 of Appendix B - Maps of Lick Creek Stream Conditions & Impacts).

- Provide technical memorandum detailing the results of work completed under Task 1 (Perform a Baseline Watershed Assessment) including a technical memo summarizing future impacts analysis; a technical memo summarizing major watershed problems and the stakeholders’ watershed goals; and a technical memorandum from the NC State University Water Quality Group summarizing data collection and evaluation, assumptions, methodologies, and monitoring recommendations.

Status: Completed. The Watershed Treatment Model was used by the Center for Watershed Protection to model future impacts. This model analysis is detailed in the “Lick Creek: Watershed Treatment Model Analysis” memorandum and is available on the project website. In addition, the Triangle J Council of Governments performed an accompanying land use analysis that is described in detail in the “Memorandum describing the process and results of the current and future land use analyses performed for the Lick Creek Watershed Restoration Plan.”

Major watershed problems are identified and referred to in both the “Lick Creek Watershed: Initial watershed characterization, existing water quality data, and stakeholder process” and “Lick Creek Fieldwork: Findings and Recommendations” memoranda available on the project website.

Data collection techniques, assumptions, methodologies, and monitoring recommendations are referred to in several technical memoranda, including the NC State University Water Quality Group’s “Analysis of Existing Data and Short-Term Monitoring Plan” memorandum and their “Lick Creek Long-Term Monitoring Recommendations” memorandum, as well as the “Summary of Water Quality Data for the Lick Creek Watershed” memorandum developed by the City of Durham Stormwater Services.

- Provide a technical memorandum summarizing the subwatershed restorability analysis including a retrofit inventory, descriptions of the sites visited and potential pollution reduction benefits of the high-priority projects, and summarizing the surveyed stormwater hotspots with suggested follow-up actions for each.

Status: Completed. Please refer to the Center for Watershed Protection’s memorandum “Lick Creek Fieldwork – Findings and Recommendations” on the project website for detailed discussions on hotspots and potential retrofits as well as suggested follow-up actions.

- Provide a technical memorandum summarizing stream corridor restoration and improvement opportunities.

Status: Completed. Both fieldwork and GIS analyses were used to identify restoration opportunities including stream, buffer, and retrofit restoration opportunities. The stakeholders worked together to prioritize these opportunities. This process is explained in detail late in this document and is also described in the “Lick Creek Watershed Restoration Priorities” memorandum available on the project website.

- Provide a technical memorandum summarizing all potential critical lands protection opportunities.

Status: Completed. The Upper Neuse River Basin Association worked together with stakeholders and local conservation groups including the Triangle Greenways Council and the Triangle Land Conservancy to perform a critical lands protection analysis. This process is described in detail in the “Lick Creek Watershed Critical Lands Protection Analysis” memorandum available on the website. This process is also explained in detail later in this document.

- Provide a technical memorandum summarizing analysis results and potential management strategies.

Status: Completed. In their 2007 “Lick Creek Fieldwork: Findings and Recommendations” memorandum, Hoyt and Kitchell of the CWP listed 12 management strategies for protecting water quality in the Lick Creek watershed. These management strategies were reviewed by the stakeholders and discussed in detail at a meeting. The culmination of this effort was the “Draft Lick Creek WRP Management Strategies” memorandum published in March 2009. Further refinement of the strategies recommended in this memo later became the final recommendations that have been produced as part the final Lick Creek WRP.

- Develop a map of priority projects. Also provide a technical memorandum summarizing priority restoration, BMP, and critical lands protection projects with justifications given and applicable parcel data included.

Status: Completed. Maps of priority areas were developed for both the critical lands analysis “Lick Creek Watershed Critical Lands Protection Analysis” and the “Lick Creek Watershed Restoration Priorities.” For the critical lands analysis, priority areas are depicted based on high-value Upper Neuse Clean Water Initiative parcels which rates a parcel’s conservation value based on criteria such as riparian areas, wetlands, hydrologic conductance, drinking water supply or well critical area, public water supply, erosive soils, land use, and headwaters. Please refer to the “Lick Creek Watershed Critical Lands Protection Analysis” memorandum for a detailed discussion of selection criteria. The critical lands analysis is also discussed in greater detail in this document.

In addition, maps and figures of restoration priorities and opportunity sites were developed as part of the “Lick Creek Watershed Restoration Priorities” memorandum.

- NC State Water Quality Group provides a technical memorandum identifying any additional water quality data collected, summarizing and interpreting any additional data, and describing any recommended changes to short-term project monitoring.

Status: Completed. Three technical memoranda were developed to specifically address water quality collection, monitoring, and results throughout the length of this project. At the onset of the planning process, the NC State Water Quality Group developed a short-term monitoring plan based on an analysis of existing data (Analysis of Existing Data and Short-Term Monitoring Plan). Once the short-term monitoring was completed, the NC State Water Quality Group provided all the data to the Upper Neuse River Basin Association and the City of Durham Stormwater Services who compiled all of the data and a produced a memorandum summarizing the findings (“Summary of Water Quality Data for the Lick Creek Watershed”). Based on these findings and suspected sources of pollution in the Lick Creek watershed, the NC State Water Quality Group also developed and published a set of long-term monitoring recommendations for the Lick Creek watershed (Draft Lick Creek Long-Term Monitoring Recommendations).

- NC State Water Quality Group provides a technical memorandum identifying long-term monitoring needs and recommendations for the Lick Creek watershed.

Status: Completed. Based on the short-term water quality monitoring conducted by the City of Durham’s Stormwater Services and the NC State Water Quality Group, a series of long-term monitoring recommendations was developed for the Lick Creek watershed. Please refer to the “Lick Creek Long-Term Monitoring Recommendations” memorandum for details.

- Development of a draft Lick Creek Watershed Restoration Plan.

Status: Completed. A draft Lick Creek Watershed Restoration Plan was completed and distributed to stakeholders for review in June 2009. Comments and feedback received from the stakeholder group was incorporated into the Final Lick Creek Watershed Restoration Plan (September 2009).

- Development of a Final Lick Creek Restoration Watershed Plan.

Status: Completed. After three years of assessment, monitoring, planning, and collaborating, the Lick Creek local watershed planning process has culminated in the development of this Lick Creek Watershed Restoration Plan. The Lick Creek Watershed Restoration Plan provides describes the watershed in detail and provides background for the need for water quality planning in the watershed. The plan describes the assessment and monitoring components of the planning process and summarizes current and future threats to water quality. Furthermore, the plan provides thirteen detailed strategies for managing, improving, and protecting water quality resources within the watershed. One of the most critical successes of the project is the fact that community members, local governments, and other stakeholders are committed to implementing the recommendations put forward in this plan.

- Use the Upper Neuse Site Evaluation Tool to evaluate the nutrient and sediment removal potential of several of the priority stormwater retrofit and critical lands protection projects.

Status: Completed. Four restoration opportunities were chosen to evaluate their nutrient and sediment removal potential using the Upper Neuse Site Evaluation Tool and other applicable tools. Two retrofits were analyzed for nutrient removal potential using the Site Evaluation Tool, one buffer restoration project was analyzed using the Tar-Pamlico Nutrient Model, and one stream restoration project was assessed using Dave Rosgen’s Bank Erosion Hazard Index. All four projects demonstrated nutrient removal potential, thereby supporting the usefulness of these projects in improving degraded water quality conditions. The demonstration projects are described in further detail in the “Lick Creek WRP Demonstration Projects” memorandum available on the project website. The stream restoration project analyzed is being implemented by the Durham County Soil and Water Conservation District. The Upper Neuse River Basin Association is currently engaged in a feasibility analysis for implementation of one of the retrofits, and the owners of the Brightleaf Subdivision where the potential buffer restoration project is located have expressed interest in improving their property for water quality.

- Conduct community information meetings when projects have been identified and provide appropriate follow-up.

Status: Completed. At least one stakeholder meeting was conducted specifically to present restoration opportunities that were identified during the planning process. Members of the community were welcomed to attend any stakeholder meetings and were actively engaged. Furthermore, members of the community including local business owners and residents served as a regular part of the stakeholder process. The Upper Neuse River Basin Association was also able to outreach to all the landowners identified as having volunteer buffer planting opportunities on their property through a grant from the Home Depot Foundation. All landowners were contacted and offered free riparian trees and free planting assistance. In addition, the Upper Neuse River Basin Association is currently developing an outreach strategy in partnership with the NC Ecosystem Enhancement Program to implement restoration opportunities identified in the Lick Creek Watershed Restoration Plan and has already held one meeting that included local governments, conservation groups, and community members.

THE LICK CREEK LOCAL WATERSHED PLANNING GROUP

During the summer of 2006, the UNRBA began identifying and contacting interested groups with a stake in the management of the Lick Creek watershed. Many groups participated in a kick-off informational meeting in November 2006

(<ftp://ftp.tjcoog.org/pub/unrba/lick/comagd111606.pdf>), and many of these participants

chose to become members of the group to guide the development of the Lick Creek WRP. The Local Watershed Planning Group consists of Project Partners, a Community Stakeholder group, and a Technical Team. Project partners are listed in the inset box.

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 WRP. Chris Dreps and Heather Saunders of the UNRBA coordinated, managed, and assisted with all aspects of the project including facilitating the stakeholder process, drafting the plan, and assisting with outreach and implementation efforts. John Hodges-Copple and Ben Bearden of Triangle J Council of Governments (TJCOG) conducted the future impacts analysis and the critical lands protection analysis and provided Geographic Information Systems (GIS) support. Sarah Bruce, Executive Director of the UNRBA, assisted in stakeholder and project management. September Barnes of TJCOG developed and managed the project website. Dan Line of the NC State Water Quality Group (WQG) assisted with the watershed assessment, the development of management strategies, performed short-term water quality monitoring, reviewed the watershed model, and provided long-term water quality monitoring recommendations. The staff of the Center for Watershed Protection (CWP) managed the Unified Stream Assessment and Unified Subwatershed and Site Reconnaissance central to this project, analyzed subwatersheds using the Watershed Treatment Model (WTM), assisted with project prioritization, and provided extensive peer review. DSS assisted with the watershed assessment, fieldwork, development of the management strategies, project prioritization, and short and long-term monitoring. Durham County Engineering assisted with the watershed assessment, fieldwork, developing the management strategies, and project prioritization. Durham City/Planning and GIS Services assisted with the watershed assessment, the critical lands protection analysis, developing the management strategies, and project identification and prioritization.

PROJECT PARTNERS

Upper Neuse River Basin Association

Chris Dreps, Project and Stakeholder Management
Heather Saunders, Project and Stakeholder Management

Triangle J Council of Governments

September Barnes & Ben Bearden, Information Management & GIS
Sarah Bruce, Water Resources Planning
John Hodges-Copple, Regional Planning Director

NC State Water Quality Group

Dan Line, Extension Specialist

Center for Watershed Protection (CWP)

Sally Hoyt, Water Resources Engineer, with Ted Brown,
Anne Kitchell, Julie Tasillo, and Paul Sturm

City of Durham Stormwater Services (DSS)

John Cox, with Bobby Louque, Chris Outlaw, Jacob Chandler,
Dave Brown, Laura Webb Smith, and Michelle Woolfolk

Durham County Engineering

Joe Pearce, with Joe Albiston and Chris Roberts

Durham City/County Planning and GIS Services

Cherri Smith and Helen Youngblood

The Community Stakeholder Group

The Community Stakeholder Group consists of members of the local community who can affect or are affected by the WRP. The Community Stakeholder Group included local landowners, businesspeople, elected officials, members of religious and 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. The group's 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

LICK CREEK WRP STAKEHOLDERS AND TECHNICAL TEAM

UNRBA

Heather Saunders
Chris Dreps

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
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Tom Hill, Wake County Environmental Serv.
Joel Sholtes, Durham Water Management Dept.
Nancy Newell, Durham Water Management Dept.
Helen Youngblood, Durham City/County Planning
Becky Heron, Durham County Commission
Rebecca Ferres, Durham County

Agency /Program Technical Advisors

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Nora Deamer, NCDWQ
Heather Boyette, NCDWQ
Kim Nimmer, NCDWQ
Steve Kroeger, NCDWQ
Dan Line, NC State Water Quality Group
Sally Hoyt, Center for Watershed Protection
Shari Bryant, NC Wildlife Resources Commission

Farming Interests

Eddie Culberson, Durham SWCD
Jennifer Brooks, Durham SWCD

LICK CREEK WRP STAKEHOLDERS AND TECHNICAL TEAM, CONTINUED

Landowners in Watershed

Allen McNally, The Crossings Golf Club
Amy Poole, Rollingview Marina
Mary Poole, Rollingview Marina
Lee Lambert, Resident
Nick Paliouros, Resident
Jim Paliouros, Resident
Dan DeForge, Grove Park Neighborhood Assoc.
Sandra Sebbas, Durham County Library
Bill Patrick, Resident
Lee Patrick Resident
Joe Mitchell, Century 21
Sue Harris, Resident
Judy Riggins, Resident
Jerry & Sylvia Detweiler, Residents
Jim Fyfe, Resident
Jeff Kirkpatrick, Resident
Donna Kirkpatrick, Resident
Mary Beth San Filippo, Resident
Tina Motley-Pearson, Resident

Local Water Quality and Habitat Interests

Jeff Masten, Triangle Land Conservancy
Richard Broadwell, Triangle Land Conservancy
Dean Naujoks, Neuse River Foundation
Alissa Bierma, Neuse River Foundation
Bev Norwood, Triangle Greenways Council
Frederick Lewis, Trust for Public Land

Development Interests

Jerry Radman, MacGregor Devt. Co.
Elizabeth Leaver, Rhein Brightleaf
Gary Parker, Rhein Brightleaf
Jack Adcock, Rhein Brightleaf
Frank Thomas, Home Builders Assoc. of DOC
Joe Grote, TWG, Inc.
Rick Grote, TWG, Inc.
Bill Peebles, TWG, Inc.
John Schrum, Horvath Associates

Stakeholder Group also has the critical role of helping the Local Watershed Planning Group understand and account for local watershed conditions and problems.

The Lick Creek Technical Team

The Technical Team is made up of project partners, the community stakeholder group, and other interested parties. Those that attended meetings and provided technical support and expertise to the Local Watershed Planning Group in assessing the watershed, conducting fieldwork, and developing the watershed management strategies are all considered to be critical members of the Technical Team. 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 originally convened on January 24, 2007 and has since guided the development of this plan. Technical team members have changed some over the duration of this three-year process; however, the spirit and commitments of the stakeholder group at large have remained consistent.

LICK CREEK WATERSHED CHARACTERIZATION

Information provided in this section has been adapted from the “Lick Creek Watershed—Initial watershed characterization, existing water quality data, and stakeholder process” document (UNRBA 2007a) and describes the geography, geology, soils, and other natural characteristics of the Lick Creek Watershed. Please refer to this document for a more detailed discussion of general watershed features.

The Lick Creek Hydrologic Unit is a 22.9 square-mile watershed located on the borders of Durham and Wake County (Figure 1). Lick Creek flows directly into Falls Lake, a drinking water supply for approximately 600,000 Wake County residents. NCDWQ has listed Lick Creek as “impaired” because it does not adequately support aquatic life, has excessive turbidity, and exhibits exceedingly low levels of dissolved oxygen (DO) (NCDWQ 2006). In addition, Lick Creek is classified as a water supply watershed with nutrient sensitive waters (WS-IV NSW) because it is in the Falls of the Neuse Reservoir Basin (hereafter referred to as Falls Lake watershed).

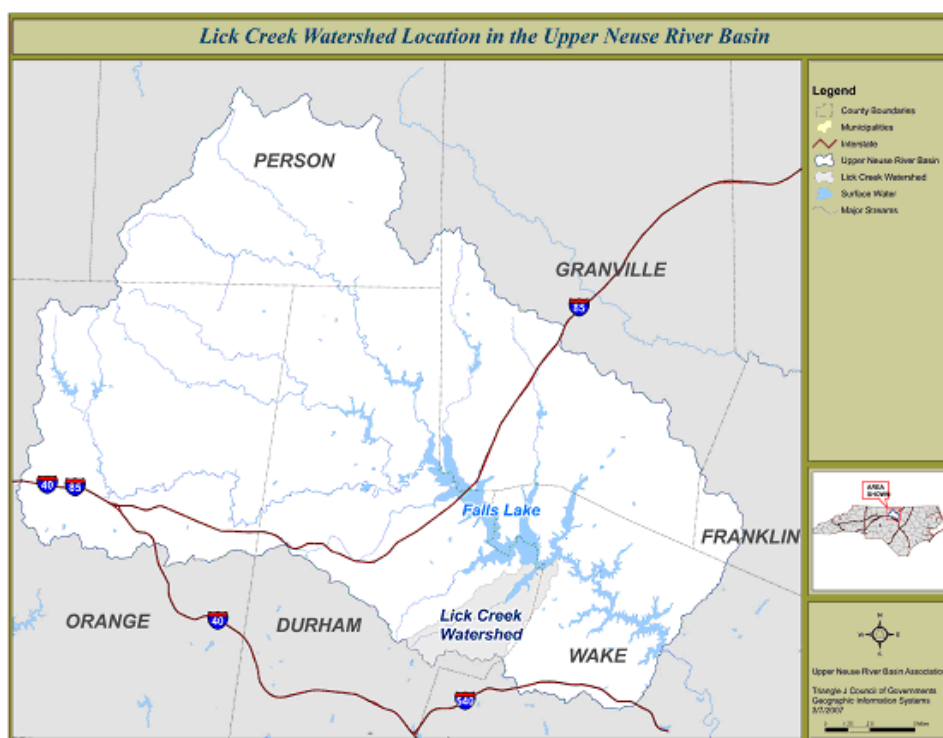


FIGURE 1. LOCATION OF THE LICK CREEK WATERSHED IN THE UPPER NEUSE RIVER BASIN

Geography

The Lick Creek watershed has an area of 22.9 square miles and is located the extreme eastern portion of Durham County (Figure 2). A short drive east from NC Highway 70 on Leesville Road and then north onto Carpenter Pond Road past NC Highway 98 and into Wake County is a tour of the southern and eastern divide of the watershed. From its headwaters, Lick Creek flows to the northeast under NC Highway 98, the main artery between Durham and Wake Forest. The creek flows several miles through newly

developing suburbs, forest, and a few farms before flowing into the federally protected land that forms the Falls Lake State Recreation Area. Just past this junction, Lick Creek slowly flows into Falls Lake near Rollingview Watershed State Recreational Area.

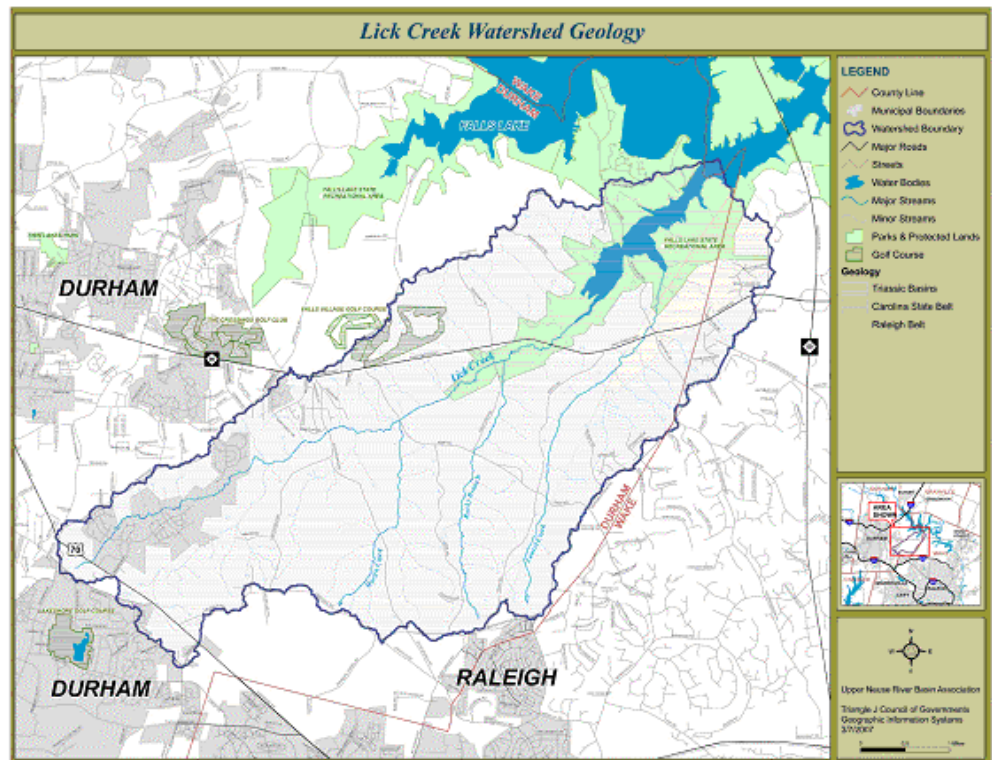


FIGURE 2. LICK CREEK WATERSHED GEOGRAPHY AND GEOLOGY

Geology

The Lick Creek watershed lies within the Durham Triassic Basin (Figure 2), a geologic formation within the larger Deep River Basin Triassic formation. It is believed that the Durham Triassic Basin formed from rifting of the super-continent Pangaea during the Mesozoic period 200 million years ago (NCGS 2008). The landmasses 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 huge Appalachian Mountains. These compacted sediments now form the parent material of the Triassic Basin (Clark et al. 2001).

The geology underlying Lick Creek is mainly unconsolidated Triassic Basin-formed sedimentary rock. The sedimentary parent material is a mix of various other parent materials, and thus its characteristics vary greatly within the basin. The alluvium underlying the stream valleys is made of eroded Triassic material. In general, the soils created by the weathering and eroding of this parent material are clay and are often considered poor quality soils with low nutrient levels (USDA 1971).

As has been previously noted, Triassic Basin geology covers most of the watershed; however, in the eastern portion of the watershed, Laurel Creek flows over less erosive metamorphic material of the Carolina Slate Belt (Figure 2). Because Laurel Creek and its tributaries flow through metamorphic formations with greater resistance to erosive forces such as increased stormwater discharges, the streambed is shallower and much rockier than other Lick Creek tributaries of similar size and land use. Although maps do not indicate it, there may be outcroppings of harder, less erosive metamorphic diabase material under Triassic Basin streams,

which were likely formed during the creation of the Triassic rift valleys, when magma escaped to the surface. In nearby Little Lick Creek, outcrops of diabase sills have resisted the erosion affecting the surrounding Triassic sandy-clay soils. These areas support relatively abundant and healthy aquatic life. In addition, diabase areas likely provide streams with a relatively rocky substrate compared with the surrounding Triassic material.

Soils

The Durham County Soil Survey (USDA 1971) identifies over 30 soils series in the Lick Creek watershed. The soil types are primarily determined by their parent geologies. White Store and other upland soils in the Triassic Basin portion of the watershed formed under forest cover in material weathered from Triassic Mudstone. These soils are highly erosive. Cecil and Wilkes are the predominant upland soils over metamorphic Raleigh Belt and Carolina Slate Belt in the eastern part of the watershed.

White Store is the primary upland soil series occurring in the Triassic Basin portion of the watershed, covering 54% of the total surface of the watershed. White Store is in hydrologic soils group D, meaning it has low permeability and the highest runoff potential of all the hydrologic soil groups (USDA 2009). Creedmoor and Pinkston soils are also prevalent in the Triassic Basin portion of the watershed. These soils are low in natural fertility and organic matter content; permeability is very slow; and the available water capacity is medium. According to the Durham Soil Survey (USDA 1971), “the major limitations are the erosion hazard resulting from runoff, the very slow permeability, the steep slopes, the high shrink-swell potential, and a perched water table.” Lick Creek’s large, broad flood zone is predominated by Chewacla Soils. These soils formed as upland soils weathered over time and washed to low-lying areas. These soils support lowland hardwood forests, and are used extensively for farming row crops.

Initial field observations of Lick Creek and its tributaries confirm that the stream substrate in the Triassic Basin portion of the watershed is primarily sand. These Triassic streams are greatly impacted by the increased flows accompanying urban development because the sand and clay substrate material erodes easily.

Topography

Light Detection and Ranging (LIDAR) data created for the NC Division of Emergency Management’s (NCDEM) Floodplain Mapping Program provide a very detailed representation of Lick Creek’s surface topography. LIDAR’s primary use is for use in NC Flood Insurance Rate Maps; however, USGS has developed a detailed digital elevation model for use in the Upper Neuse (Terziotti 2004). This digital elevation model has 20-foot precision, the best data currently available for watershed modeling in the Upper Neuse.

The digital elevation model data show that the watershed’s general change in relief from the headwaters to Falls Lake is low. The highest area of the watershed is at the headwaters along the southern divide separating Lick Creek from the Cape Fear Basin and along the eastern divide that separates it from Barton Creek Watershed. These ridges range from 480 to 509 feet above sea level in elevation. The divide between Lick and Little Lick Creek, along Sherron and Baptist Roads is relatively low (330 to 390 feet above sea level) and gently sloping. The lowest elevations are around Lick Creek where it meets the Falls Lake Reservoir. This area is about 250 feet above sea level. A straight-line measurement between the highest and lowest areas (about 32,000 feet) yields a watershed-wide gradient of less than 1%.

A map of areas of steep slopes tells a very different story. Figure 3 divides the Lick Creek watershed into slopes of less than 15%, 15%-25%, and greater than 25%. This figure shows that there are significant areas of slopes greater than 15%, particularly to the south and east of the main stem of Lick Creek. Subwatersheds 2, 4, 5, 6, 7, 8, 9, and 10 (Figure 4) exhibit slopes much steeper than those in subwatersheds 1, 3, and 6, which are similar to the slopes of neighboring Little Lick Creek. This area is a transition from Triassic Basin to Carolina Slate Belt and Raleigh Belt geology.

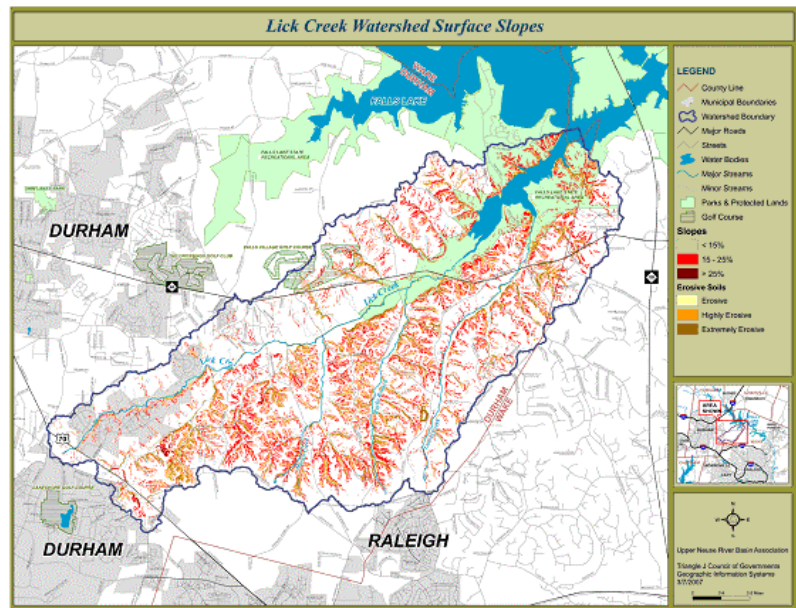


FIGURE 3. LICK CREEK WATERSHED SURFACE SLOPES

Surface Hydrology

Average annual rainfall at the National Weather Service’s Raleigh-Durham airport site is just over 43 inches per year. A study from nearby Duke Forest has shown that, under forested conditions, over 70% of this water would be evaporated or transpired (Schafer et al. 2002). Only about 5% of water in Duke Forest would become surface runoff, and over 20% would infiltrate to groundwater (Schafer et al. 2002). These results may vary somewhat based on soil type differences, but the findings of the Schafer study (2002) offer a general understanding of the forested

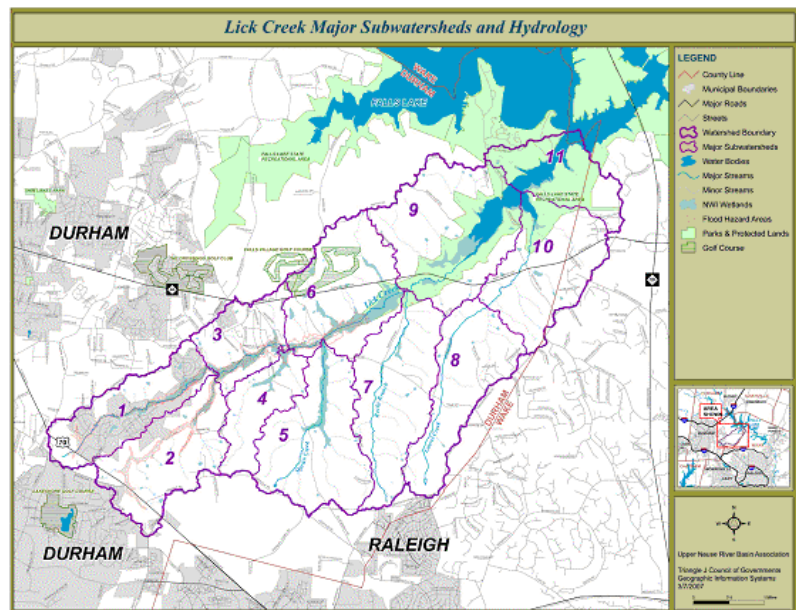


FIGURE 4. LICK CREEK HYDROLOGY AND SUBWATERSHEDS

hydrologic cycle in Durham County. Lick Creek is a fifth-order stream draining an area of 22 square miles in a watershed with approximately 120 miles of stream. Figure 4 provides a depiction of surface water hydrology features in the watershed. TJCOG used the LIDAR-derived Upper Neuse Digital Elevation Model (DEM) created by USGS to delineate the watershed and subwatersheds into 11 subwatersheds (Figure 4). Table 1 describes their total areas in acres and square miles.

The entire Lick Creek system is a tributary of the Falls Lake Reservoir and the watershed’s hydrology is strongly affected by the Falls Lake impoundment. The Lick Creek arm of the reservoir backs up into lower Lick Creek (Subwatersheds 9, 10, and 11) and the impoundment has changed the hydrology of this portion

TABLE 1. TOTAL AREA OF LICK CREEK SUBWATERSHEDS

Subwatershed	Total Area	
	(acres)	(square miles)
1	1,501	2.34
2	757	1.18
3	1,079	1.69
4	1,310	2.05
5	698	1.09
6	1,600	2.50
7	1,551	2.42
8	1,294	2.02
9	1,959	3.06
10	1,430	2.23
11	881	1.38

of the creek from what was a medium-sized, meandering Piedmont stream into a shallow, lentic system subject to eutrophication (enrichment by nutrients). The reservoir also hydrologically separates Laurel Creek (Subwatersheds 8 and 10) from the main stem of Lick Creek.

When Falls Lake was impounded, the new reservoir drowned 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 (USACE) constructed a series of “waterfowl impoundments” in tributaries to the reservoir. Lick Creek has such an impoundment, located immediately upstream of where the creek intersects NC Highway 98.

Floodplains and Wetlands

Lick Creek’s abundant wetlands are most likely due to a combination of the underlying Triassic Basin geology, low relief, sedimentary soils, and wide 100-year floodplains. According to Flood Hazard Areas GIS data from the NC Floodplain Mapping Program (NCFMP 2007), there are 1,510 acres of floodplains in Lick Creek. These floodplains are as wide as 3,000 feet near Falls Lake, and in most areas along the main stem of the creek measure over 1,000 feet wide. These floodplains harbor most of the watershed’s wetlands and likely contain the predominance of its biodiversity. The National Wetlands Inventory (NWI 2008) data estimate 979 acres of wetlands in Lick Creek.

Initial observations in Subwatersheds 1, 2, 4, and 7 confirm that many of these wetlands are, and may have historically been, closely related to impoundments created by beavers. The management of wetlands in the Lick Creek watershed may depend upon a thorough understanding and management of the beaver population. In Laurel Creek (Subwatersheds 8 and 10), there are relatively few wetlands and few observed beaver impoundments.

Habitat and Endangered Species

Lick Creek contains the Lick Creek Bottomlands Natural Heritage Areas, which encompass 1,652 acres of bottomland hardwoods forest recognized by the state for its high quality habitat (Hall 1995). The Lick Creek Bottomlands are given a high protection status by the NC Natural Heritage Program (NCNHP) because the Lick Creek stands of bottomland hardwood forest are “among the most mature and diverse in the entire area: and support fauna of forest interior and bottomland species among the “best remaining around the edge of Falls Lake” (Hall 1995).

Terrestrial Habitat

The Lower Lick Creek Bottomlands area is of regional significance for its fauna, which include over forty species of breeding birds indicative of high quality bottomland sites and four species that are permanent residents of large woodland tracts (Hall 1995). The area also supports two species of state Special Concern: four-toed salamanders (*Hemidactylium scutatum*) and Carolina darters (*Etheostoma collis*). Plant species of note in the Lower Lick Creek Bottomlands include Sweet Shrub (*Calycanthus floridus*, a NC “Watch List” plant) and three species of Ground Cedar (*Lycopodium [flabellum, obscurum and lucidulum]*).

The Middle Lick Creek Bottomlands contains young to middle-aged forest with lower diversity of tree species. Middle Lick Creek has colonies of Dissected Cress (*Cardamine dissecta*), significantly rare in NC, and the regionally rare plant species Doll's Eyes (*Actea pachypoda*).

On the east side of Laurel Creek, in Subwatersheds 8 and 10 is found a natural area referred to as Leatherwood Cove (Durham City-County Planning 2006). The cove gets its name from the Leatherwood plant (*Dirca palustris*), a woody, deciduous shrub found in very rich forests, on slopes or bottomlands (Weakley 2004). *D. palustris* has a ½-inch long, tube-like, greenish-yellow flower. *D. palustris* is on the NC Watch List. The plant's curiously flexible twigs and tan-brown bark are extraordinarily tough. Native Americans used the twigs for cordage, hence its common name. Leatherwood cove also contains several other plant species of note, including Douglass' Bittercress (*Cardamine douglassii*), Doll's Eyes, Yellow Lady's Slipper (*Cypripedium calceolus*), and five species of hickory (*Carya* spp.). This extensive undisturbed area of 140 acres is on private property. Both Leatherwood Cove and the Laurel Creek Wildlife Habitat Area downstream are high priority wildlife habitat areas in the East Durham Open Space Plan (Durham City-County Planning 2006).

Aquatic Habitat

Aquatic habitats were especially hard hit by impoundment. Species that once freely migrated up and down river and between tributaries are now isolated by the reservoir. Lake species such as perch (*Perca* sp.) and large-mouth bass (*Micropterus salmoides*) prey on both smaller native species in the streams and amphibians in formerly isolated vernal pools. The NCNHP Inventory lists one aquatic species of state concern, the Carolina darter (*Etheostoma collis*) and several water-quality sensitive aquatic species: mountain redbelly dace (*Phoxinus oreas*); white shiner (*Luxilus albeolus*); satinfin shiner (*Cyprinella analostana*); and swallowtail shiner (*Notropis procne*). Hall (1995) notes that the fish records in this inventory were probably made prior to the impoundment of Falls Lake.

Watershed Population

The population in Lick Creek is currently undergoing rapid growth. The City of Durham's Urban Growth Area (UGA) fully encompasses Subwatersheds 1–5 and much of Subwatersheds 6–8. However, Lick Creek remains the last rural area in eastern Durham County. A TJCOG study based on US Census data from 2000 showed the watershed population to be 2,276 people, or 996 households (TJCOG 2000). A GIS assessment of year 2002 traffic analysis zones data conducted for this project estimates that the watershed population at that time was just over 3,400 people (TJCOG 2000).

Watershed Land Use

Current Land Use

The land use analysis, as described in the "Lick Creek Watershed—Initial watershed characterization, existing water quality data, and stakeholder process" memorandum (UNRBA 2007a), shows that land use has not likely changed much since the 2000 Census data. The watershed is currently a relatively rural, undeveloped area surrounded by urban growth to the west (Durham), south (Raleigh), and east (Wake County). Figure 5 depicts current watershed land uses in Lick Creek based on available parcels data from Durham City and County Planning Department and Wake County Planning Department. Within the Lick Creek watershed, protected natural area, urban green space, forestry, agriculture, unmanaged rural lands, and undeveloped land make up over eighty percent (80%) of the watershed's land. At the same time, over half of the rural land (or 37% of the total watershed area) is not being actively managed (unmanaged rural lands and undeveloped lands). This indicates that the watershed is in a state of change from rural management to non-management to suburban.

Twenty-one percent (21%) of the lands in the watershed are under forestry use tax valuation, and over 6% of the lands are under agricultural use tax valuation. So, despite the changes, over 25% of the watershed is still managed for production of agricultural and forestry products.

Relative to surrounding watersheds, there is very little residential land use in the watershed. The majority of watershed residents live in single-family houses in very low-density to rural residential lots. Eleven percent (11%) of the watershed is divided into lots of 0.5 acre to 10 acres. Even in the most developed subwatersheds adjacent to Durham City, the total number of residential acres is low. In Subwatershed 1, for example, the total number of residential parcels on lots smaller than 10 acres is 65 acres. In Subwatershed 1, that is about the same amount of acreage devoted to row crops.

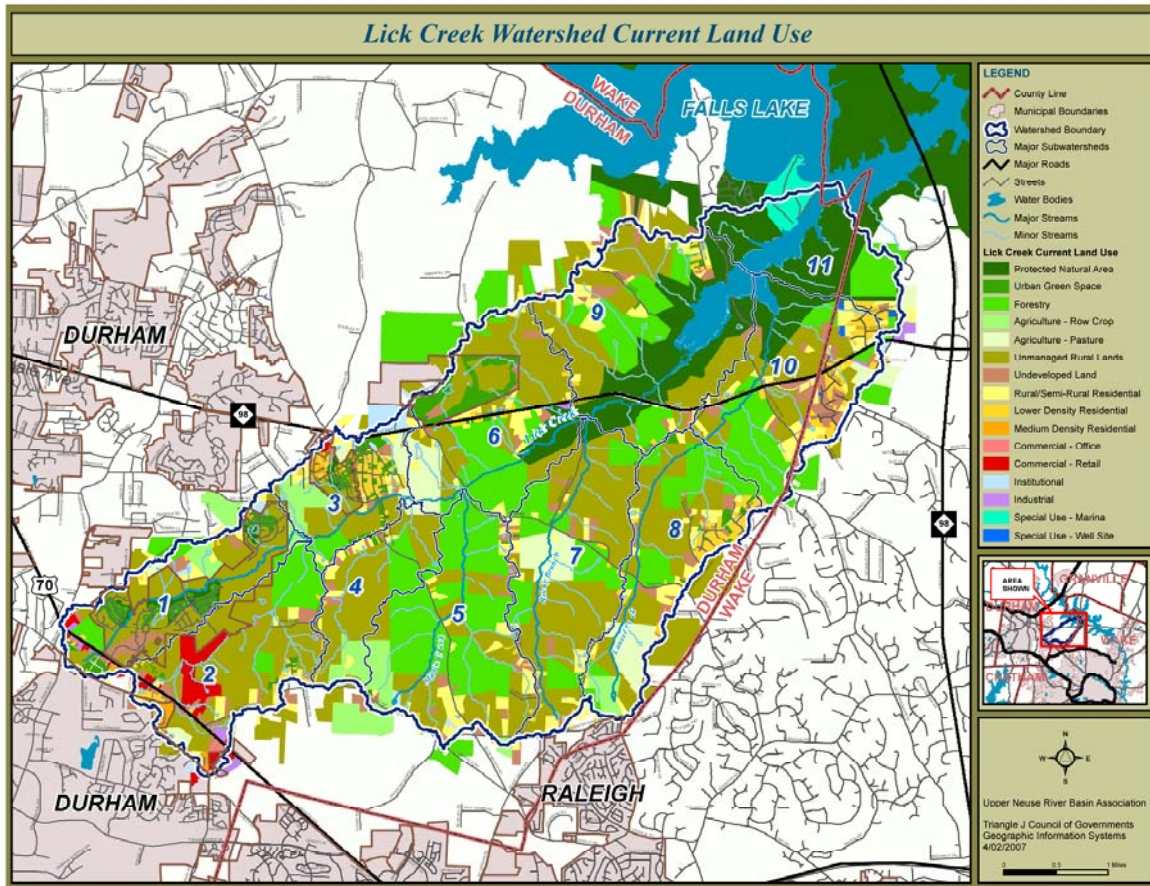


FIGURE 5. EXISTING LAND USE IN THE LICK CREEK WATERSHED

Future Land Use

There are major land use changes underway, however. Durham's UGA encompasses most of the southern portion of the watershed, covering all or large portions of Subwatersheds 1 through 8. These areas will be developed to suburban densities (Figure 6) similar to those of neighboring Little Lick Creek, with a majority of new housing on lots less than 0.5 acre.

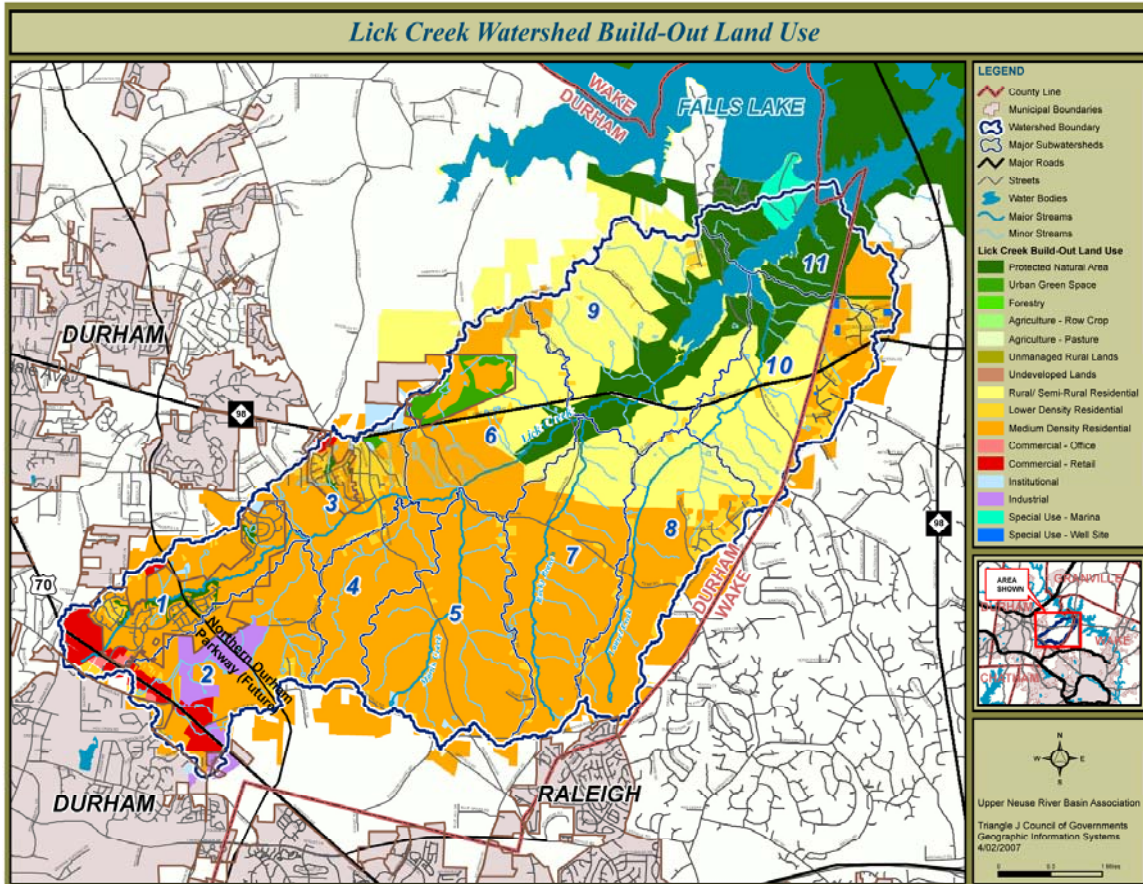


FIGURE 6. FUTURE LAND USE IN THE LICK CREEK WATERSHED

In March 2007, TJCOC produced a memorandum ("Memorandum describing the process and results of the current and future land use analyses performed for the Lick Creek Watershed Restoration Plan") (Hodges-Copple 2007) detailing land use attributes for both current and build-out conditions for each of Lick Creek's 11 subwatersheds. The resulting data was used to identify target areas for fieldwork and for prioritization of potential projects for implementation. Data collected for this effort was also used in the CWP's WTM. The full memorandum, including methodology and definitions, can be found at ftp://ftp.tjcog.org/pub/unrba/lick/appx062007_b.pdf. Table 2 lists the resultant land use acreages for the Lick Creek watershed under current and build-out conditions, and Figures 5 and 6 depict current and build-out uses, respectively.

TABLE 2. LICK CREEK WATERSHED CURRENT AND BUILD-OUT LAND-USE ANALYSIS

	Category	Current		Build-Out	
		Area (Acre)	% of Watershed	Area (Acre)	% of Watershed
1	Water Surface	362.56	2.58	362.56	2.58
2	Protected Natural Area	1,424.97	10.14	3,591.93	25.55
3	Urban Green Space	396.06	2.82	158.99	1.13
4	Institutional	42.90	0.31	60.78	0.43
5	Industrial	30.29	0.22	234.50	1.67
6	Commercial Retail	160.00	1.14	259.95	1.85
7	Commercial Office	9.15	0.07	22.33	0.16
8	Forest	2,993.56	21.29	0.00	0.00
9	Agricultural - Row Crop	382.13	2.72	0.00	0.00
10	Agricultural - Pasture	517.50	3.68	0.00	0.00
11	Medium Density Residential	35.86	0.26	33.29	0.24
12	Low-Medium Density Residential (0.125-0.25 Acre)	21.63	0.15	5,274.59	37.52
13	Low-Density Residential (0.25-0.5 Acre)	47.02	0.33	113.23	0.81
14	Very Low Density Residential (0.5-2 Acre)	454.09	3.23	623.88	4.44
15	Semi-Rural Residential (2-3 Acres)	193.25	1.37	55.46	0.39
16	Rural Residential (3-10 Acres)	673.25	4.79	1,531.74	10.90
17	Unmanaged Rural Lands (Vacant, Undeveloped, or Residential Parcels >10 Acres)	5,153.18	36.65	0.00	0.00
18	Undeveloped Land (Vacant Land < 10 Acres)	623.45	4.43	0.00	0.00
19	Special Use: Marina	70.94	0.50	70.94	0.50
20	Special Use: Well Sites	10.46	0.07	10.46	0.07
21	Major Roads (ROW) (US 70 & NC 98)	124.91	0.89	142.86	1.02
22	Local Roads (ROW)	329.46	2.43	1,511.62	10.75
Total Land Use Area Excluding Road Rights-of-Way (ROW)		13,587	97	13,587	97
Total Watershed Area		14,059		14,059	

Subwatershed Assessment

The March 2007 TJCOG “Memorandum describing the process and results of the current and future land use analyses performed for the Lick Creek Watershed Restoration Plan” (Hodges-Copple 2007) also included a subwatershed-level land-use analysis. Tables 3 and 4 summarize the current and predicted land-use coverage in acres for each subwatershed.

TABLE 3. LICK CREEK CURRENT LAND-USE ANALYSIS BY SUBWATERSHED (AREA SHOWN IN ACRES)

Category	Subwatershed #											
	1	2	3	4	5	6	7	8	9	10	11	All
1 Water Surface	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	169.21	32.47	160.88	362.56
2 Protected Natural Area	54.19	0.45	16.40	0.00	0.00	109.92	24.55	0.00	571.89	177.14	470.35	1,424.89
3 Urban Green Space	103.43	16.44	79.49	5.75	3.57	152.20	2.22	23.44	8.73	0.75	0.00	396.02
4 Institutional	7.96	0.82	18.96	0.00	14.31	0.58	0.00	0.00	0.17	0.10	0.00	42.90
5 Industrial	6.96	13.60	0.00	0.00	0.00	5.14	0.06	0.19	0.06	5.69	1.07	32.77
6 Commercial Retail	13.43	137.94	7.54	0.00	0.00	0.00	0.00	0.00	1.09	0.00	0.00	160.00
7 Commercial Office	2.13	7.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.15
8 Forest	61.98	174.14	48.21	107.64	781.85	340.90	332.93	297.49	360.28	361.60	126.53	2,993.55
9 Agricultural - Row Crop	62.96	2.80	91.77	71.63	96.58	0.00	0.00	56.39	0.00	0.00	0.00	382.13
10 Agricultural - Pasture	13.46	19.92	59.39	12.34	0.00	118.78	142.73	122.39	0.00	27.44	1.06	517.51
11 Medium Density Residential	2.86	32.69	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	35.86
12 Low-Medium Density Residential	2.35	0.00	18.97	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	21.60
13 Low-Density Residential (0.25-0.5 Acre)	8.39	2.20	31.83	0.68	0.77	0.00	1.00	0.32	0.96	0.86	0.00	47.01
14 Very Low Density Residential (0.5-2 Acre)	14.90	48.82	45.17	7.94	15.70	23.93	18.42	115.75	22.73	113.71	27.02	454.09
15 Semi-Rural Residential (2-3 Acres)	2.07	8.03	28.17	14.42	17.92	15.91	14.68	34.55	17.38	38.13	2.02	193.28
16 Rural Residential (3-10 Acres)	33.81	43.97	34.36	29.61	116.87	76.03	65.97	61.70	97.89	101.66	11.39	673.26
17 Unmanaged Rural Lands (Vacant, Undeveloped, or Residential Parcels >10 Acres)	531.66	678.56	195.08	410.05	464.41	579.67	857.61	487.46	580.87	367.79	0.00	5,153.16
18 Undeveloped Land (Vacant Land < 10 Acres)	75.96	73.02	32.59	25.49	56.49	40.48	51.69	56.93	61.00	145.86	3.91	623.42
19 Special Use: Marina	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.94	70.94
20 Special Use: Well Sites	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.58	2.88	10.46
21 Major Roads (ROW) (US 70 & NC 98)	17.29	25.63	6.53	0.00	0.00	18.15	0.00	0.00	31.59	25.72	0.00	124.91
22 Local Roads (ROW)	63.09	23.67	42.65	12.80	31.32	18.89	38.88	37.28	35.42	23.07	2.56	329.63
Total Land Use Area Excluding Road ROW	999	1,260	708	686	1,568	1,464	1,512	1,257	1,892	1,381	878	13,605
Total Watershed Area	1,079	1,310	757	698	1,600	1,501	1,551	1,294	1,959	1,430	881	14,059

TABLE 4. LICK CREEK BUILD-OUT LAND-USE ANALYSIS BY SUBWATERSHED (AREA SHOWN IN ACRES)

	Category	Subwatershed #											All
		1	2	3	4	5	6	7	8	9	10	11	
1	Water Surface	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	169.21	32.47	160.88	362.56
2	Protected Natural Area	154.26	121.96	86.52	100.68	227.95	365.71	311.96	259.06	985.19	486.39	492.25	3,591.93
3	Urban Green Space	0.00	0.20	12.25	0.00	0.00	145.71	0.23	0.04	0.38	0.18	0.00	158.99
4	Institutional	13.28	0.82	31.52	0.00	14.31	0.58	0.00	0.00	0.17	0.10	0.00	60.78
5	Industrial	0.02	232.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.46	0.00	234.50
6	Commercial Retail	130.91	114.98	14.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	259.95
7	Commercial Office	16.61	5.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.33
8	Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Agricultural - Row Crop	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Agricultural - Pasture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	Medium Density Residential	0.11	32.69	0.00	0.00	0.00	0.12	0.06	0.31	0.00	0.00	0.00	33.29
12	Low-Medium Density Residential	532.57	575.96	371.76	483.25	1,094.15	559.22	841.50	529.06	26.61	155.40	105.11	5,274.59
13	Low Density Residential	36.99	5.01	60.37	1.06	0.77	0.00	1.98	2.30	1.81	2.94	0.00	113.23
14	Very Low Density Residential	22.30	52.51	70.68	13.31	33.74	33.04	31.09	140.43	35.31	164.45	27.02	623.88
15	Semi-Rural Residential (2-3 Acres)	0.00	0.00	0.00	0.00	0.00	9.66	0.58	2.12	24.98	18.12	0.00	55.46
16	Rural Residential (3-10 Acres)	0.00	0.00	0.00	0.00	0.00	217.19	147.30	194.87	552.05	420.34	0.00	1,531.74
17	Unmanaged Rural Lands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	Undeveloped Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	Special Use: Marina	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.94	70.94
18	Special Use: Well Sites	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.58	2.88	10.46
19	Major Roads (ROW) (US 70 & NC 98)	22.00	38.87	6.53	0.00	0.00	18.15	0.00	0.00	31.59	25.72	0.00	142.86
20	Local Roads (ROW)	149.83	128.98	103.42	100.05	228.87	151.20	216.04	166.29	131.97	113.43	21.54	1,511.62
Total Land Use Area Excluding Road ROW		994	1,247	708	686	1,568	1,464	1,512	1,257	1,892	1,381	878	13,587
Total Watershed Area		1,079	1,310	757	698	1,600	1,501	1,551	1,294	1,959	1,430	881	14,059

WATERSHED ANALYSIS

The Lick Creek WRP is the result of several levels of analysis and assessment guided by the Lick Creek Project Partners, Community Stakeholder Group, Technical Team, and watershed management goals. This section describes the components of the analysis and the major findings.

Watershed Management Goals

The Lick Creek Planning Group developed goals to guide the Lick Creek WRP. 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 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 Assessment

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:

1. Develop a hypothesis about the causes of biological impairment in Lick Creek and recommend approaches to address impairment status;
2. Identify pollutants and their sources that may be impairing aquatic life and water quality in Lick Creek (water quality is not impaired currently). Suspected pollutants include dissolved oxygen (and biochemical oxygen demand), fecal coliform bacteria, and turbidity;
3. Develop strategies for reducing, and maintaining at levels meeting water quality standards, the pollutants identified in Goal 2; and
4. Mitigate future changes to watershed hydrology and water quality.

Water Quality Monitoring

NCDWQ classifies Lick Creek as “impaired” because it does not adequately support aquatic life (NCDWQ 2006). Two stream segments totaling 7.2 miles from the headwaters of the main stem to the Falls Lake Reservoir are listed as impaired. NCDWQ considers urban runoff and storm sewers as a potential source of impairment (NCDWQ 2006).

Lick Creek is classified as a WS-IV NSW because it is a tributary to Falls Lake. Extensive water quality monitoring conducted by NCDWQ over the last few years revealed that the Lake was consistently failing to meet the State standards for both turbidity and chlorophyll α , and has been listed as “impaired” on the NCDWQ Draft 2008 303(d) List (NCDWQ 2008). This listing and other factors have prompted the NCDWQ to begin the process of developing a Nutrient Management Strategy for the Lake in order to bring it into compliance.

Any assessment of water quality and aquatic habitat and any subsequent management strategies must consider Lick Creek’s impaired status and the Falls Lake Nutrient Management Strategy as driving factors. The Lick Creek WRP used these driving forces to guide the establishment of restoration goals and objectives.

Review of Existing Monitoring Data

The NC State WQG conducted watershed-wide water quality and aquatic biota monitoring as part of the development of this plan. This first step in assessing water quality and aquatic biota was a review of existing monitoring data, which resulted in the development of a short-term monitoring plan. The NC State WQG memorandum, “[Analysis of Existing Data and Short-Term Monitoring Plan for Lick Creek](#)” (Line and Penrose 2007), is available online and can be referred to for more details on existing water quality data.

Since 2004, DSS has conducted benthic macroinvertebrate and physical-chemical monitoring at a sampling site on the main stem of Lick Creek on Southview Road and physical-chemical monitoring at a site on Kemp Road in Rocky Branch. The Southview Road site is located at the outlet of Subwatershed 6 and therefore samples the stream at a point where its contributing watershed is 6,945 acres (10.85 square miles). The Kemp Road site is located in Rocky Branch, a 1,551-acre (4.42 square-miles) tributary of Lick Creek. Table 5 summarizes the data collected by DSS at these two sites. These sites were incorporated into the short-term monitoring plan (Line and Penrose 2007) in order to provide continuity and comparison.

Lick Creek Watershed Restoration Plan Documents (unrba.org/lick/downloads.shtml)

- UNRBA Technical Memorandum: [Initial watershed characterization, existing water quality data, and stakeholder process](#)
- Center for Watershed Protection Memorandum: [Lick Creek Fieldwork - Findings and Recommendations](#)
- Triangle J Council of Governments: [Process & results of current and future land use analysis](#)
- Center for Watershed Protection Memorandum: [Watershed Treatment Model Analysis](#)
- NCSU Water Quality Group: [Analysis Of Existing Data And Short-Term Monitoring Plan](#)
- UNRBA Technical Memorandum: [Lick Creek Watershed Restoration Priorities](#)
- UNRBA Technical Memorandum: [Lick Creek Watershed Critical Lands Protection Analysis](#)
- UNRBA Technical Memorandum: [Lick Creek - Preliminary Management Strategies](#)
- NC State Water Quality Group: [Lick Creek Long-Term Monitoring Recommendations](#)
- Durham Stormwater Services: [Summary of Water Quality Data for the Lick Creek Watershed](#)
- UNRBA Technical Memorandum: [Lick Creek WRP Management Strategies](#)
- Lick Creek Watershed Restoration Plan (this document)

TABLE 5. DATA COLLECTED BY DSS IN THE LICK CREEK WATERSHED (2004-2009)

Agency	Monitoring type	Sites	# of samples
DSS	Benthic macroinvertebrate	LC1.0LC Southview Rd. SR 1809	2
DSS	Physical and chemical	Lick Creek Southview Rd. SR 1809	16 samples (monthly)
DSS	Physical and chemical	Rocky Branch Kemp Rd. SR 1902	16 samples (monthly)

DSS Biological Data Summary

Collection and analysis of bottom-dwelling aquatic insects (benthic macroinvertebrates) provide important information about water quality and aquatic habitat conditions in a stream. A robust, diverse community of insects typically indicates good water quality and aquatic habitat conditions. The presence of a variety of insects that are intolerant of pollution, such as mayflies (*Ephemeroptera* spp.), stoneflies (*Plecoptera* spp.), and caddisflies (*Tricoptera* spp.), indicates a lack of pollution. DSS analyzes and rates these conditions and more, such as total number of Taxa, total number *Ephemeroptera*, *Plecoptera*, and *Tricoptera* (EPT), EPT diversity, biotic index, biotic rating, and bioclassification score. These indicators can be compared with those from other watersheds, including relatively undisturbed (reference) watersheds to provide a relative understanding of conditions. They can also be assessed over time or before and after an event (such as watershed disturbance) or intervention (for example, a stream restoration) to detect long-term changes.

In general, Triassic Basin aquatic macrobiology is poorly understood. DSS biological monitoring in Lick Creek and other Triassic Basin sites is providing important information for the NCDWQ and others as we attempt to better understand this unique habitat. Durham's aquatic insect monitoring at the Southview Rd. site resulted in Fair (borderline Poor) bioclassifications. In addition, total numbers of EPT were also very low. However, it is important to note that these samples were taken in summertime, when Triassic Basin streams have very low flow conditions. As part of the Lick Creek WRP, NCSU WQG conducted fall and winter monitoring of several sites in the watershed (see Summary of Water Quality Data for the Lick Creek Watershed later in this document).

DSS Physical and Chemical Data Summary

Physical and chemical data provide important information about the ambient conditions in the stream. Physical data such as pH (measure of acidity), turbidity, total suspended solids (TSS), and conductivity (indirect measure of elements in the water) are physical indicators of stream conditions. Chemical data include indicators such as nutrients (forms of nitrogen or phosphorous), total dissolved metals, DO, or FC (indicator of waste contamination).

Physical and chemical data can be compared across multiple subwatersheds to provide information about relative water quality conditions. They can also be assessed over time to indicate water quality changes. Most physical and chemical data are measured in concentrations (such as milligrams/Liter) and can be combined with water flow data to reveal the levels of a potential pollutant. The water quality scientist or

engineer can then determine if these levels are normal by comparing the information with data from relatively undisturbed watersheds.

Durham's physical and chemical sampling at the Lick Creek site on Southview Rd. site reveal relatively good water quality for most parameters; however, there are some concerns. Low DO during summer months are likely due to high water temperatures and low flow, the second of which is typical of the Triassic Basin. High turbidity and total suspended solids following rainfalls indicate that storm events may be moving heavy quantities of sediment. Sampling also reveals median concentrations of nitrogen forms sufficient to produce excessive algae growth. Finally, median FC levels at the Lick Creek site tend to meet the NC standards; however, these levels are occasionally high and can be very high during storms.

Durham's Rocky Branch Creek site generally exhibits better water quality than the Lick Creek main stem site with the exception of DO and biological oxygen demand (BOD), which are worse in Rocky Branch. This may indicate low flows (not measured by Durham) or algae growth. FC levels were generally low, but there were also several high concentrations exceeding the state standards, particularly on rainy days. Sampling indicates that metals such as copper and zinc may also be of concern. Sampling also indicates that turbidity values, which can indicate sediment and erosion in streams, are among the highest in the entire DSS monitoring network.

Point Sources Discharges

There are no major permitted point sources discharging facilities in the Lick Creek watershed. NC Department of Environment and Natural Resources Source Water Assessment Program's review of potential contamination sources in the Lick Creek watershed reveals only a handful of National Pollutant Discharge Elimination System (NPDES) sites, all of which are single-family wastewater treatment systems.

The Durham County Health Department has more detailed information about the overall number of on-site wastewater treatment systems in Lick Creek, shown in Table 6.

Table 6 estimates the number of buildings in the Lick Creek Watershed on public sewer and on-site wastewater systems. A GIS analysis of Durham parcels and public sewer system data indicate that, of the 976 total buildings currently in the watershed, about 159 are served by public sewer. The remaining 817 buildings are all being served by on-site wastewater treatment systems, the great majority of which are septic systems. The number of parcels without sewer is most likely an underestimate of the number of on-site wastewater treatment systems in the watershed. Durham City requires connection where a system owner has access, but according to City employees, this rule is not regularly enforced. The sewer system extends only into Subwatersheds 1–3, although it will be allowed throughout the City's UGA.

Of the total 817 on-site systems, an estimated 79 are discharging sand filter systems. The County allowed the installation of sand filter systems during the 1960's and 1970's in areas where soils would not permit standard septic systems. This treatment type was abandoned when it became clear that the systems were difficult to manage and often allowed untreated wastewater to pass into surface waters. The remaining filters are required to hold general NPDES discharge permits, and City, County and State officials hope to replace sand filters with cleaner methods over time. It is clear from experience in Little Lick Creek that these systems frequently fail, and even fully functioning systems are sources of nutrient pollution.

TABLE 6. SUMMARY OF WASTEWATER TREATMENT TYPE BY SUBWATERSHED AS OF 2007

Sub-watershed	Area (Acres)	Total Buildings*	With Sewer**	With On-Site WW**	Sand Filter Systems***
1	1501	74	24	50	4 (1)
2	757	88	13	75	2 (0)
3	1079	240	118	122	24 (0)
4	1310	23	0	23	2 (0)
5	698	61	0	61	11 (0)
6	1600	63	4	59	1 (0)
7	1551	51	0	51	6 (0)
8	1294	134	0	134	5 (0)
9	1959	57	0	57	12 (0)
10	1430	155	0	155	12 (12)
11	881	30	0	30	(0)
Total Area	14,059	976	159	817	79 (13)

*Parcels with building values were assumed to have buildings with wastewater disposal needs

**Parcels in City are assumed to have municipal sewer service; those outside city are assumed to treat wastewater with on-site wastewater systems

***Durham Environmental Health and Stormwater Services data. Number in parentheses indicates the number of systems for which City or County public sewer system is available.

Summary of Short-Term Water Quality Monitoring for the Lick Creek Watershed

Water quality monitoring data were obtained from the NC State WQG. Data included relevant information such as site number and description; date sampled; gage height; discharge (calculated); and results for turbidity, *Echerichia coli* (*E. coli*), nutrients, metals, DO, pH, turbidity, TSS and conductivity. Water temperature was also measured in-stream and rainfall was recorded as measured at the Falls Lake dam. Please refer to the "[Summary of Water Quality Data for the Lick Creek Watershed](#)" memorandum (Woolfolk 2009) for a more detailed water quality summary.

The short-term monitoring was conducted from August 2007 to March 2009, concurrently with the development of the Lick Creek WRP, and consisted of collecting monthly grab samples at six sites (Figure 7). Flow-proportional samples from at least two storm events per site were also collected during this period. Although monitoring sites were visited monthly over a period of 21 months, drought conditions persisted through most of 2007 and into early 2008. As indicated in the NCSU data, many streams were dry or not flowing when field teams visited monitoring sites. When streams were dry or not flowing, water quality samples were not collected. Even when water was present and flowing, samples may not be representative of typical conditions in Lick Creek because of the drought. Although DSS has monitored this watershed for several years, additional comparisons of NCSU data to DSS data were not performed for this interim summary.

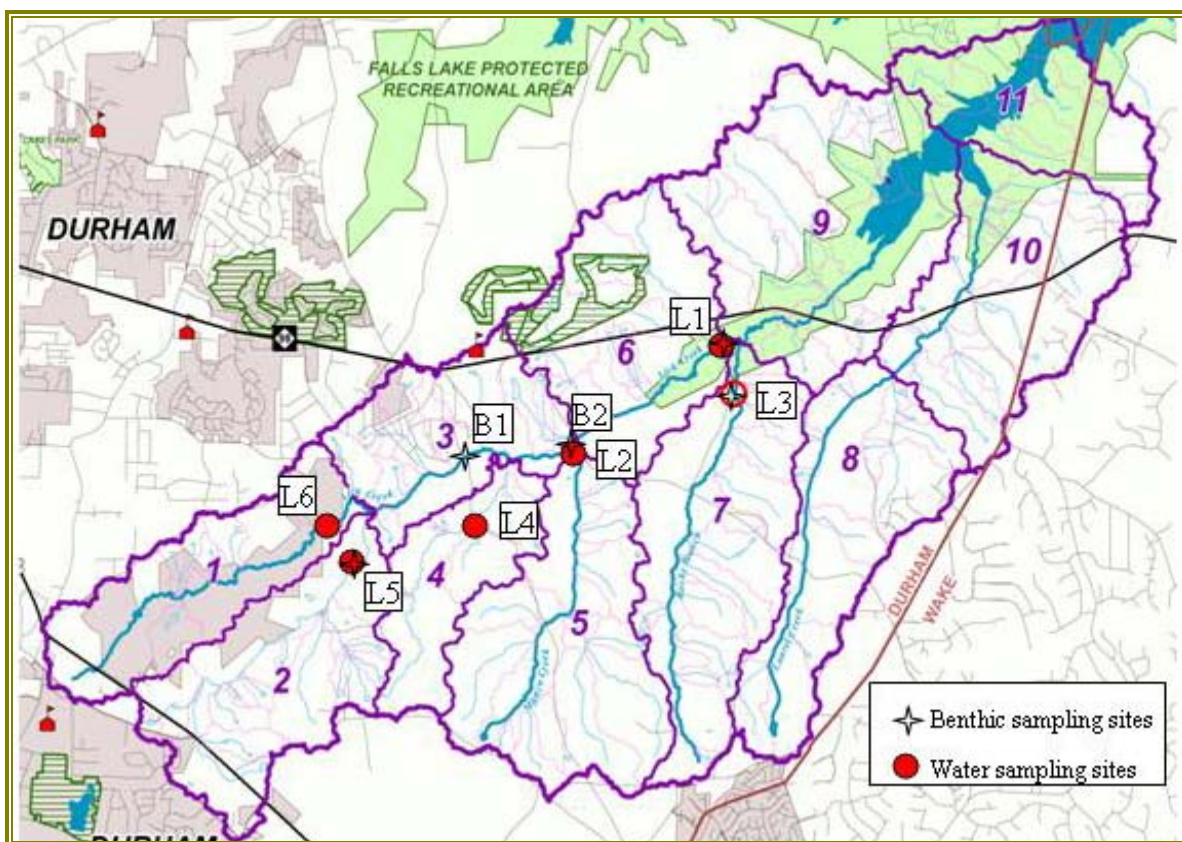


FIGURE 7. WATER QUALITY AND/OR MACROBENTHIC MONITORING SITES IN THE LICK CREEK WATERSHED

Methods

All data provided by NC State WQG were used. This includes data collected and analyzed by NC State WQG and DSS at L3 (Figure 7). Data at LC3 (LC3 and L3 are the same) did not extend beyond June 2007. All qualifying information was reviewed to determine if sufficient quality concerns existed to warrant discarding any individual observation. Quality assurance information provided describes samples outside of holding times, duplicate or split sample variation, laboratory blanks contaminated, and laboratory spikes out of range. Ultimately, all data were retained for the summaries. Values indicated as non-detected in the sample were included in statistics as the detection limit. All statistics were generated using JMP7®. NCDWQ water quality standards (15A NCAC 02B .0211) and US Environmental Protection Agency (EPA) Ambient Water Quality Criteria (AWQC) (EPA 2000) were used to provide benchmarks values to assist with interpretation of the numeric data. NCDWQ water quality standards were preferentially used over EPA AWQC values when both were available. NCDWQ standards were available for temperature, DO, pH, and turbidity. EPA AWQC values were available for ammonia, total phosphorus, total nitrogen, and *E. coli*. Where insufficient information for a criterion existed to provide practical comparisons, alternate or additional methods were used to highlight potential problem areas. This generally applied to nutrients and is noted where applicable.

Results

The interim results of water quality monitoring are provided in Table 7. Table 7 provides a detailed summary of water quality data including the number of samples, the arithmetic or geometric mean of the parameter, the range of the parameter, and two columns used to compare the results to accepted levels. The column labeled

TABLE 7. SUMMARY OF WATER QUALITY AND/OR MARCROBENTHIC MONITORING IN THE LICK CREEK WATERSHED

Site No.	Sub-watershed	Description	Pollutant Summary (b)														
			Temperature, C					Conductivity, uS/cm					DO, mg/L				
			n	Mean	Range	%>WQS (c)	Compliance status	n	Mean	Range	%>WQS (d)	Compliance status	n	Mean	Range	%<WQS (e)	Compliance status
LC6	1	Lick Creek at Sherr	7	16.3	3.41 - 25.61	0%	NA	7	143	68 - 204	NA	NA	7	5.21	2.01 - 13.5	43%	(e)
LC5	2	UT on Randsell Pro	8	15.7	3.83 - 30.19	0%	NA	8	218	67 - 800	NA	NA	8	5.46	2.39 - 12.93	50%	(e)
	3	None															
LC4	4	UT at Olive Branch	7	13.9	2.1 - 21.33	0%	NA	7	117	50 - 189	NA	NA	7	5.28	1.98 - 12.67	43%	(e)
LC2	5	Martin Creek at Ke	8	16.1	6.28 - 25.47	0%	NA	8	94	51 - 151	NA	NA	8	5.4	2.29 - 12.53	38%	(e)
LC1	6	Lick Creek at South	8	17.7	5.49 - 25.41	0%	NA	8	135	82 - 189	NA	NA	8	3.95	1.65 - 7.66	50%	(e)
LC3	7	Rocky Branch at Ke	2	11.5	5.7 - 17.34	0%	NA	2	121	73 - 169	NA	NA	2	7.41	2.37 - 12.46	50%	(e)

Site No.	Sub-watershed	Description	Pollutant Summary														
			Total Kjeldahl nitrogen, mg/L					Nitrate+Nitrite Nitrogen, mg/L					Ammonia, mg/L				
			n	Mean	Range	%>WQS (d)	Compliance status	n	Mean	Range	%>WQS (d)	Compliance status	n	Mean	Range	%> EPA criteria (g)	Compliance status
LC6	1	Lick Creek at Sherr	12	0.678	0.39 - 0.901	NA	NA	12	0.048	0.003 - 0.131	NA	NA	12	0.082	0.016 - 0.513		
LC5	2	UT on Randsell Pro	13	0.411	0.249 - 0.700	NA	NA	13	0.057	0.001 - 0.156	NA	NA	13	0.048	0.016 - 0.129		
	3	None															
LC4	4	UT at Olive Branch	11	0.548	0.298 - 1.167	NA	NA	11	0.041	0.007 - 0.214	NA	NA	11	0.057	0.022 - 0.22		
LC2	5	Martin Creek at Ke	12	0.0465	0.252 - 0.688	NA	NA	12	0.101	0.014 - 0.335	NA	NA	12	0.041	0.015 - 0.072		
LC1	6	Lick Creek at South	16	0.529	0.351 - 0.779	NA	NA	16	0.058	0.007 - 0.161	NA	NA	16	0.081	0.015 - 0.227		
LC3	7	Rocky Branch at Ke	6	1.59	0.07 - 2.8	NA	NA	6	0.127	0.05 - 0.20	NA	NA	6	0.39	0.025 - 1.42		

Site No.	Sub-watershed	Description	Pollutant Summary														
			Total phosphorus, mg/L					Total nitrogen, mg/L					Total suspended solids, mg/L				
			n	Mean	Range	%> EPA criteria (i)	Compliance status	n	Mean	Range	%> EPA criteria (h)	Compliance status	n	Mean	Range	%>WQS (d)	Compliance status
LC6	1	Lick Creek at Sherr	12	0.726	0.405 - 0.947	100%	(i #)	12	0.726	0.405 - 0.947	75%	(h #)	12	34.1	6.0 - 97.0	NA	NA
LC5	2	UT on Randsell Pro	13	0.08	0.051 - 0.159	100%	NA	13	0.467	0.250 - 0.816	23%	NA	13	7.21	1.0 - 22.0	NA	NA
	3	None															
LC4	4	UT at Olive Branch	11	0.057	0.038 - 0.096	100%	NA	11	0.588	0.322 - 1.202	36%	NA	11	7.55	4.8 - 12.0	NA	NA
LC2	5	Martin Creek at Ke	12	0.052	0.031 - 0.084	100%	NA	12	0.567	0.295 - 0.876	25%	NA	12	13.6	1.0 - 45.0	NA	NA
LC1	6	Lick Creek at South	16	0.089	0.047 - 0.168	100%	NA	16	0.587	0.374 - 0.866	25%	NA	16	12.6	1.5 - 45.0	NA	NA
LC3	7	Rocky Branch at Ke	6	0.11	0.05 - 0.334	100%	(i #)	6	1.72	0.27 - 2.9	66%	(h #)	6	30.6	14.0 - 68.0	NA	NA

Site No.	Sub-watershed	Description	Pollutant Summary														
			pH					Turbidity					E. coli, mpn/100mL				
			n	Mean	Range	%<WQS (k)	Compliance status	n	Mean	Range	%>WQS (f)	Compliance status	n	Geometric mean	Range	%> EPA criteria (j)	Compliance status
LC6	1	Lick Creek at Sherr	7	NA	4.84 - 7.53	43%	(k*)	13	74.7	30.0 - 119.0	76%	Non-compliant	13	215	9 - 2400	NA	Non-compliant
LC5	2	UT on Randsell Pro	8	NA	5.07 - 7.58	13%	(k*)	14	25.6	2.0 - 79.0	14%	Non-compliant	13	93	15 - 2400	NA	Compliant
	3	None															
LC4	4	UT at Olive Branch	7	NA	3.5 - 7.98	14%	(k*)	12	21.2	7.4 - 39.0	0%	Compliant	12	72	3 - 460	NA	Compliant
LC2	5	Martin Creek at Ke	8	NA	5.86 - 7.93	13%	(k*)	13	19.2	7.4 - 30.0	0%	Compliant	13	84	1.5 - 1100	NA	Compliant
LC1	6	Lick Creek at South	8	NA	5.18 - 7.15	13%	(k*)	15	36.7	4 - 97	27%	Non-compliant	18	178	15 - 2400	NA	Non-compliant
LC3	7	Rocky Branch at Ke	2	NA	6.02 - 7.68	0%	NA	2	33.7	29 - 38.5	0%	NA	6	777	71 - 25000	NA	Non-compliant

n = Number of samples analyzed

mean = arithmetic mean concentration except as noted.

Range = Minimum to maximum of reported levels. Where the minimum was not detected at a specified quantitation limit, the quantitation limit is shown.

Compliance state = evaluate of the concentrations and/or percent of criteria exceeded to determine compliance with criteria. For simplicity, a result of Compliant or Non-compliant is reported.

WQS = NC Water Quality Standard, 15A NCAC 02B .0211

* = Generally indicates minimum sample sizes are not met. See specific letter footnote.

= Generally associated with nutrients for which EPA has not provided sufficient guidance on applying recommended criteria. See specific letter footnote.

- (a) All data summarized in this table were provided by the NCSU Water Quality Group in November 2008 and includes data collected and analyzed by NCSU and the City of Durham Stormwater Services. The period represented is from January 2007 through September 2008.
- (b) All pollutants are included in this summary except metals (i.e., Copper, Lead and Zinc). Values reported as less than detected were used in calculations of means as the detection limit.
- (c) Temperature levels were compared to the North Carolina water quality standard for Class C lower piedmont streams which states that temperature is "not to exceed 2.8 degrees C (5.04 degrees F) above the natural water temperature, and in no case to exceed 29 degrees C (84.2 degrees F) for mountain and upper piedmont waters and **32 degrees C** (89.6 degrees F) for lower piedmont and coastal plain waters". 15A NCAC 02B .0211 (3)(j)
- (d) Conductivity, total Kjeldahl nitrogen, nitrate+nitrite nitrogen and total suspended solids do not have water quality standards or recommended criteria for Class C streams.
- (e) Dissolved oxygen levels were compared to the instantaneous North Carolina water quality standard for Class C streams which states that dissolved oxygen shall be "not less than a daily average of 5.0 mg/L with a minimum instantaneous value of not less than **4.0 mg/L**". 15A NCAC 02B .0211 (3)(b). When a minimum of 10 samples is available, the North Carolina Division of Water Quality methods for assessing stream use support allow a 10% exceedance of a standard before deeming the stream "Impaired". None of the monitored sites had a minimum of 10 samples, however all sites recorded non-compliant dissolved oxygen concentrations.
- (f) Turbidity levels were compared to the North Carolina water quality standard for Class C streams, which states "the turbidity in the receiving water shall not exceed **50 Nephelometric Turbidity Units (NTU)** in streams not designated as trout waters". 15A NCAC 02B .0211 (3)(k). When a minimum of 10 samples is available, the NCDWQ methods for assessing stream use support allow a 10% exceedance of the standard before deeming the stream non-compliant or "Impaired".
- (g) to be completed
- (h) Total nitrogen was determined as the sum of total Kjeldahl nitrogen and nitrate+nitrite nitrogen. North Carolina does not have water quality standards for total nitrogen, so the EPA AWQC recommendations for nutrients were used for comparison. For Region IX (which includes central North Carolina), Level III Ecoregion 45, the total nitrogen AWQC based on measured data is **0.615 mg/L** (EPA 2000). EPA has not provided guidance on the method for evaluating the AWQC, so the compliance status reflects those sites with an arithmetic mean concentration greater than 0.615 mg/L. These are noted with an (h #).
- (i) North Carolina does not have water quality standards for total phosphorus. The EPA AWQC recommends the following total phosphorus criteria for Region IX, Level III, Ecoregion 45: **0.03 mg/L**. (EPA 2000). However, all of the data for the Lick Creek watershed exceed this recommended criteria, possibly due to naturally elevated levels of phosphorus in soils. The Compliance status column highlights those sites with an arithmetic mean total phosphorus concentration greater than **0.10 mg/L** with an (i #).
- (j) North Carolina does not have water quality standards for E. coli, so the EPA AWQC recommendations for E. coli were used to judge instream levels. For freshwaters, a geometric mean concentration of **126 cfu/100mL** is recommended (EPA 1986). EPA recommends applying this geometric mean to a minimum of 5 samples collected within a 30-day period. Since samples were collected monthly over a 21 month period, this cannot be rigidly applied to the Lick Creek study. However, comparing the geometric mean of all the data collected to the 30-day criterion does provide an important indicator of sites that would most likely violate the criterion as written.
- (k) pH levels were compared to the North Carolina water quality standard for Class C streams, which states that pH "shall be normal for the waters in the area, which generally shall range between **6.0 and 9.0**". 15A NCAC 02B .0211(3)(g) When a minimum of 10 samples is available, the North Carolina Division of Water Quality methods for assessing stream use support allow a 10% exceedance of the standard before deeming the stream as noncompliant or "Impaired". None of the monitored sites had a minimum of 10 samples, however all sites recorded non-compliant pH at levels lower than 6.0. These sites are noted with a (k *).

“% > WQS” or “% > EPA criteria” indicates the percentage of samples that exceeded the applicable standard. Where a state water quality standard exists, the NCDWQ evaluates the percent of samples that violate the standard in order to deem a water “Impaired” and justify placement on the state impaired waters list. Generally, this decision is based upon 10% of the samples indicating a violation of the standard. There is no such evaluation of the EPA criteria to deem a water impaired, although samples may violate the criteria.

Problem parameters for Lick Creek monitoring sites were identified using the NCDWQ water quality standards and the EPA AWQCs. Total nitrogen and total phosphorus (nutrients) do not have water quality standards; therefore, they were compared to the recommended ambient water quality criteria published by EPA (EPA 2000). However, EPA did not provide guidelines for implementing the recommended criteria. For example, should the criteria never be exceeded, or the average concentration not exceed the criteria, or another method of evaluation be used? As such, the interpretation of total nitrogen and total phosphorous data should be considered best professional judgment until EPA or the State of North Carolina provides additional guidance. Overall, water quality appeared to be the best at monitoring sites describing Subwatersheds 4 and 5.

The poorest water quality was observed in Subwatersheds 1 and 7. Subwatersheds 1 and 7 had water quality data indicating high nutrient levels (phosphorus and nitrogen) and violations of either state water quality standards or EPA ecoregion thresholds for turbidity and *E. coli*.

Subwatershed 5 also had violations of standards or criteria for turbidity and *E. coli*, while Subwatershed 2 had violations of the water quality standard for turbidity. An overall summary of problem parameters is presented in Table 8. A check mark indicates a parameter that exceeded state or federal standards. In cases where a state or federal standard was not available, best professional judgment was used to indicate problem parameters. Data were not collected in Subwatershed 3.

TABLE 8. PROBLEM PARAMETERS FOR LICK CREEK SUBWATERSHEDS

Sub-watershed	Dissolved oxygen	<i>E. coli</i>	pH	Total nitrogen	Total phosphorus	Turbidity
1	√	√	√	√	√	√
2	√	-	√	-	-	√
3	N/A	N/A	N/A	N/A	N/A	N/A
4	√	-	√	-	-	-
5	√	-	√	-	-	-
6	√	√	√	-	-	√
7	√	√	-	√	√	-

DO levels were depressed below the NC instantaneous water quality standard (4.0 mg/L) at all monitoring locations during summer months. It is difficult to determine the cause of low DO during the period monitored due to drought conditions. DO may have worsened during the drought due to stagnant or pooled water. Other potential causes, for example continuous sources of ammonia and other oxygen-consuming wastes, may have become more pronounced during this period and may have contributed to the low DO values. Given the number of monitoring location visits where stagnant and/or dry conditions were recorded, drought

conditions most certainly contributed to low DO, but this could not be separated from other sources of pollution.

E. coli were evaluated using the EPA criteria for bacteria (EPA 1986). Using this criteria, Subwatersheds 1, 6 and 7 each had a geometric mean concentration of *E. coli* greater than the EPA criteria (126 cfu/100 mL). Subwatershed 7 had a geometric mean concentration more than five times worse than the EPA criteria, far worse than any other Lick Creek monitoring locations.

It appears that a one-time low pH event occurred in February and March 2007 throughout the Lick Creek watershed, causing this parameter to be highlighted as a problem. What event or condition may have caused these widespread low pH levels is unknown. In general, all other samples indicated a pH within the range specified by the NCDWQ water quality standards. (See Table 7, footnote (k)). Although pH is presented as a problem parameter in Table 8, it may not be of significance to current water quality management goals because it appears to be a one-time event.

Total nitrogen and total phosphorus were evaluated based on arithmetic mean concentrations. The arithmetic mean total nitrogen concentration was compared to the EPA AQWC to determine those sites that might be out of compliance. However, total phosphorus concentrations were worse than the EPA AWQC at all monitoring locations. In order to highlight those subwatersheds with significantly worse levels of total phosphorus, best professional judgment was used, as described in Table 7, footnote (i). Turbidity concentrations may be elevated whenever there is a significant amount of soil exposed on land or when stream flows are such that erosion of the stream banks occurs. Using the NC water quality standard as a benchmark, turbidity violations occurred at a high frequency in three subwatersheds, as noted in Table 7.

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 unique 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.

Watershed Restoration Fieldwork and Prioritization

Stream Corridor and Upland Assessment Methods

Teams consisting of individuals from CWP, UNRBA, DSS Water Quality and Plan Review, Durham County Stormwater and Erosion Control Division, and the NC Ecosystem Enhancement Program (NCEEP) conducted stream and upland assessments in the Lick Creek watershed the week of February 26, 2007. Pollution sources and threats to aquatic habitat in the Lick Creek watershed were identified using the Unified Stream Assessment (Kitchell and Schuler, 2004), the Unified Subwatershed and Site Reconnaissance (Wright et al. 2004), and a stormwater retrofit inventory. These methods focus on identifying potential restoration projects (i.e., stormwater retrofits, stream stabilization, buffer plantings, trash cleanup, and polluted discharge prevention). In total, 29 miles of stream corridor, all commercial areas, all suburban residential areas, all active construction sites, existing stormwater management practices, and the proposed stream restoration site at Olive Branch Rd. were assessed. Every subwatershed was visited.

Prior to fieldwork, CWP prioritized subwatersheds for the stream corridor assessment, beginning with those with the most urbanized areas and the most agriculture. In other reaches, a representative sample of reaches was assessed. In-stream reconnaissance used CWP's Unified Stream Assessment method to identify outfall locations (32 outfalls evaluated), severely eroded stream banks (8), utility crossings (7), impacted riparian buffers (27), trash dumping (9), stream crossings (16), channel modifications (1), and other miscellaneous impacts (31) within the stream corridor. The reach assessment was used to document conditions in impacted reaches, identify good quality reaches, and numerically rate 78 reaches based on the physical in-stream and riparian corridor conditions. Another 15 reaches were walked but not numerically scored.

Thirteen hotspots were identified using GIS methods prior to the fieldwork. Field reconnaissance at 16 potential stormwater hotspots (e.g., gas stations, commercial areas) included evaluation of vehicle operations, outdoor materials, waste management, physical plant, landscaped areas, and stormwater infrastructure. Each hotspot was rated on the likelihood that current site practices are causing contaminated stormwater runoff. Five sites are confirmed stormwater hotspots; five sites are potential stormwater hotspots.

Appropriate follow-up actions were suggested for each hotspot and can be read in further detail in CWP's "Lick Creek Fieldwork – Findings and Recommendations" memorandum (Hoyt and Kitchell 2007).

Twenty-eight potential retrofit sites were identified during desktop analysis. This included potential storage and on-site retrofits. After evaluation, only three sites were considered feasible. Two of these sites, with drainage areas of six and nine acres, are potential pocket wetlands downstream of highway outfalls. For a more detailed discussion about stream corridor and upland assessment methods used to identify these hotspots, please refer to CWP's "Lick Creek Fieldwork – Findings and Recommendations" memorandum (Hoyt and Kitchell 2007).

The results of the field assessment were reported in CWP's "Lick Creek Fieldwork – Findings and Recommendations" memorandum (Hoyt and Kitchell 2007) by the type of follow-up action recommended: enforcement, repair, protection, major and minor restoration project, and targeted education. Sites where impacts were observed, but were subsequently confirmed as permitted were grouped as "approved" impacts. The locations of in-stream diabase sills and riffle structures were also recorded.

Overall Stream Conditions

The following summary of overall stream conditions in the Lick Creek watershed is adapted from CWP's "Lick Creek Fieldwork – Findings and Recommendations" memorandum (Hoyt and Kitchell 2007) (please refer to this memorandum for a more detailed discussion on findings and recommendations). Lick Creek falls in the transition zone from Triassic Basin to Slate Belt geology. Subwatersheds 1, 3, 4, 5, 6, 9, and 11 reflect

Triassic conditions and are similar to those in the Little Lick watershed to the west. However, the Lick Creek streams have more frequent diabase sills which create riffles not found in the dominant clay-bottomed streams of Little Lick Creek. The bed material in Laurel Creek (Subwatersheds 8 and 10) and Rocky Branch (Subwatershed 7) is significantly different from Lick Creek's other subwatersheds. A considerable portion of the perennial stream channels in Lick Creek are entrenched (disconnected from floodplain), show evidence of historic widening, are severely eroded, and have little to no stable in-stream habitat structure (e.g., large woody debris, riffles, leaf packs). Many of these features are characteristic of the Triassic Basin and likely reflect stream adjustments to past clear cutting and agricultural land use. With the exception of a few areas in larger second or third order streams, most stream banks looked relatively stable (moss growing on them), rather than showing evidence of active erosion.

Triassic Basin streams are highly erosive and susceptible to minor increases in stormwater runoff volume. Experience in the Little Lick Creek watershed has shown that the easily erodible soils will experience bank erosion at a low threshold of hydrologic change. In fact, some of the most degraded reaches observed in Lick Creek were associated with uncontrolled runoff from existing and below active construction projects. Since most of the watershed falls within Durham's UGA, streams that are relatively stable now are at risk from impending development.

The physical in-stream and riparian corridor condition ratings were used to categorize the streams as Optimal, Sub-Optimal, Marginal, or Poor. The numerical ratings are listed Table A-99 of CWP's "Lick Creek Fieldwork – Findings and Recommendations" memorandum (Hoyt and Kitchell 2007). In summary, 5 optimal-condition reaches scored in the highest category for every measure of in-streams and riparian quality. All of these streams are located in the Laurel Creek (Subwatersheds 8 and 10). Due to the Slate Belt geology, these streams are likely less susceptible to historic bank erosion and downcutting as the Triassic streams. 49 suboptimal-condition reaches have primarily stable geomorphic conditions and forested buffers. 23 marginal-condition reaches are located adjacent to and downstream of development in the Route 70 corridor, recent timber harvesting sites, and the active construction sites of Brightleaf, Brightwood Trails, Ravenstone, and smaller sites in Wake County. Finally, one poor-condition reach is located at the Kingsmill Dairy Farm.

The current biological impairment status of Lick Creek is based on monitoring of one site in Lick Creek's Triassic Basin area. The aquatic biology at this site was compared to indices established from non-Triassic Basin streams, which tend to have more in-stream habitat structure that support a more diverse macro-invertebrate community. No biological reference sites have been identified in the Triassic Basin. This fieldwork further supports the recommendation of other project partners that an alternate index is needed to evaluate Triassic Basin streams.

Findings and Recommendations

The purpose of the field assessment efforts was to identify and document specific sources of pollutant loading and causes of biological impairment as well as to identify restoration activities to help address these issues. Based on field observations, however, it is likely that Lick Creek's biological impairment to date is more likely attributable to the highly erosive geological characteristic of the Triassic Basin and historic impacts from agricultural uses, rather than to extensive water quality and hydrologic changes commonly associated with urbanization. Very few restoration opportunities were found along the stream corridor (e.g., streambank stabilization, riparian buffer planting) or in the uplands (e.g., retrofits, pollution prevention). Conversely, extensive impacts to streams and wetlands from **active** construction activities were observed. Given the imminence of future development in the watershed, the susceptibility of Triassic soils and stream channels to erosion, and the downstream drinking water supply, we believe the focus of the Lick Creek WRP should be to minimize future impacts and to preserve high quality areas; however, restoration activities will complement

the overall “prevention” strategy. As a result, the most promising management strategies for the watershed will likely involve actions to minimize impacts from active construction, protect sensitive areas from future development, and implement both major and minor restoration projects in existing urban, agriculture, and silviculture areas.

In their memorandum, Hoyt and Kitchell (2007) also provide a set of preliminary watershed recommendations, as well as a list of follow-up actions. Please refer to this memorandum for a more detailed discussion of immediate action-items and preliminary watershed management strategies. These recommendations address:

- Erosion and sediment control;
- Sediment discharges from agricultural sites;
- Post-construction stormwater management;
- Impacts from infrastructure crossing the stream corridor;
- Buffer and floodplain encroachment;
- Protection of high-quality streams and wetlands;
- Delineation of streams and wetlands;
- Major restoration projects;
- Volunteer restoration projects;
- Suspicious discharges from septic systems;
- Outreach and education targets; and
- Municipal infrastructure repairs.

Lick Creek Watershed Restoration Priorities

After fieldwork identified potential restoration sites (“major” or “volunteer”), the sites were ranked according to a prioritization process, described in detail in the “Lick Creek Watershed Restoration Priorities” memorandum (UNRBA 2007b). In general, the prioritization process evaluates each project’s general need for restoration (by subwatershed), potential environmental benefits, potential benefits to the surrounding community or potential to garner community support, and overall feasibility for implementation.

Major Restoration Projects

“Major” restoration projects are projects for which implementation would require professional design and construction services such as stormwater retrofits, stream restoration, and large buffer planting projects. These projects are typically large, require design and site assessment by a professional engineer, would introduce heavy equipment into sensitive areas, and would require environmental permitting by the state and local governments. These projects typically require funding and long-term maintenance and monitoring by state or federal agencies.

The Technical Team identified 13 major restoration opportunities in the Lick Creek Watershed. Together, these projects could treat up to 25 acres of drainage and approximately 1 linear mile of stream. Details about each potential project including the type of restoration (retrofit, stream restoration, and/or buffer restoration), site location, prioritization, criteria, and feasibility constraints are discussed in greater detail in the “Lick Creek Watershed Restoration Priorities” memorandum (UNRBA 2007b).

Volunteer Restoration Projects

“Volunteer” projects are those that can utilize volunteer efforts and garner “quick wins” for on-the-ground implementation such as buffer plantings or small stormwater retrofits. Volunteer projects are relatively simple to design and relatively inexpensive compared to major restoration projects. These projects can often be constructed by volunteers with the technical assistance of local government staff or extension agents.

The Technical Team identified 14 Volunteer restoration opportunities. Together, these projects represent over 7,300 linear feet (almost 1.4 miles) of opportunities. Again, details about each potential project including the type of restoration, site location, prioritization, criteria, and feasibility constraints are discussed in greater detail in the “Lick Creek Watershed Restoration Priorities” memorandum (UNRBA 2007b).

These potential projects could capture at most 25 acres of surface runoff for water quality and reestablish buffers on or repair less than 2 linear miles of streams. The water quality and aquatic habitat benefits of these projects to Lick Creek at a watershed scale would be relatively minor. However, these projects can have significant local benefits at the small stream or subwatershed scale (1 square mile, for example). In addition, restoration projects could have educational value for Lick Creek watershed residents on the importance and benefits of watershed stewardship.

In order to protect water quality and habitat in Lick Creek and Falls Lake, strategies beyond traditional restoration efforts will likely be needed. Restoration practices within this watershed will achieve a very small percent of the pollutant reductions likely needed to restore water quality in Lick Creek. The Lick Creek Watershed Treatment Model (WTM) predicts that implementing these projects would achieve less than 4% overall reductions in total nitrogen, total phosphorous, TSS, or bacteria, with the greatest reductions resulting from riparian buffer reestablishment projects. The relatively low reduction rate predictions hold true even in subwatersheds with the highest current levels (Fralely-McNeal et al. 2007). Additional management strategies are clearly needed to restore water quality in Lick Creek.

The second major reason for a comprehensive management strategy in Lick Creek is that, although the watershed is a primarily rural now, it is developing rapidly. Currently, only 15% of the land is developed to the extent allowed under zoning laws, and only 6% of the watershed lies under impervious areas such as roads or rooftops (TJCOG 2007). In fact, Lick Creek is the least developed of the eight major watersheds on the south side of Falls Lake (UNRBA 2003). Despite this fact, the state already recognizes the creek as “impaired” under Section 303(d) of the Federal Clean Water Act because of poor biological integrity. What will happen to Lick Creek if the watershed is built to the full extent allowable under current regulations, when 70% of the land will be developed and impervious cover increases to almost 23%? The impervious cover would increase by 280% over current levels. That’s almost three times more surfaces that will not allow rainfall to infiltrate and that will contribute additional runoff and pollutants to the already impaired stream.

Watershed restoration projects of any type will not prevent additional degradation of Lick Creek. Over-dependence upon restoration practices at the expense of a comprehensive watershed management strategy would prevent us from addressing the root causes of Lick Creek’s water quality problems and would allow negative impacts to continue. And because Lick Creek is a direct tributary to the impaired Falls Lake Reservoir, these impacts extend beyond the creek. Clearly, a comprehensive watershed management approach is needed for Lick Creek to ensure that the land use changes that have already impacted water quality are not compounded by the continuing urbanization of the watershed.

Modeling

The Watershed Treatment Model (WTM) (Caraco 2002) was developed by the CWP and was applied in the Lick Creek watershed to help develop the Lick Creek WRP. Fundamentally, the WTM is a planning level model that can be used to

1. Estimate pollutant loading (nutrients, sediment, and bacteria) under current watershed conditions;
2. Determine the effects of existing management practices on minimizing these pollutant loads;
3. Evaluate effects of proposed structural and non-structural management practices identified during field assessments on current pollutant loads; and
4. Evaluate the effects of future development on pollutant loads.

There are many simplifying assumptions made by the WTM, and the model results are not calibrated against actual water quality data. Therefore, the results of the model simulations should be compared on a relative basis rather than used as absolute values. A more detailed summary about how the model works can be found in the “Lick Creek – Watershed Treatment Model Analysis” memorandum (Fralely-McNeal et al. 2007).

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 stormwater runoff loads from major land uses (e.g., commercial, residential, and agricultural). *Secondary sources* (e.g., sanitary sewer overflows, septic system failures, and channel erosion) are pollutant sources dispersed through the watershed whose magnitude cannot easily be estimated from available land use information.

The *existing management practices* and *future management practices* components of the WTM assess the ability of the treatment options in a watershed to reduce the uncontrolled pollutant loads from primary and secondary sources. The pollutant removal efficiencies associated with various structural and nonstructural stormwater management practices are based on existing research and studies in the National Pollutant Removal Performance Database for Stormwater Treatment Practices (Winer 2000) and research compiled in the WTM (Caraco 2002).

For the purposes of the plan, the WTM pollutants modeled for Lick Creek included total nitrogen (TN) and sediment (TSS). The following is a summary, adapted from the “Lick Creek – Watershed Treatment Model Analysis” memorandum (Fralely-McNeal et al. 2007), of the model findings and predictions based on an analysis for individual subwatersheds. Total Phosphorous (TP) and bacteria loads were also modeled, and generally follow the patterns seen in the TN and TSS loads.

Differences in Existing and Future Loads

The general trend in land use in the Lick Creek watershed is a shift from rural existing conditions to urban future conditions (Figures 8 and 9). The new development scenario considered full build-out in the watershed with future management practices. Under the future buildout conditions scenario, protected natural areas and roadways increase, forest and cropland do not exist, and the dominant land use becomes low- to medium-density residential.

The shift from rural to urban land uses is accompanied by TN and TSS load increases under the future conditions scenario. The main source of TN shifts from rural land to urban land (Figure 10). This shift can be attributed to the increase in urban land, specifically residential land uses. Nitrogen fertilizers are often applied to lawns at a higher rate than to cropland (Barth 1996). Load increases from urbanization of the watershed exceed the decrease from rural land to cropland (Barth 1996). Load increases from urbanization of the watershed exceed the decrease from rural land.

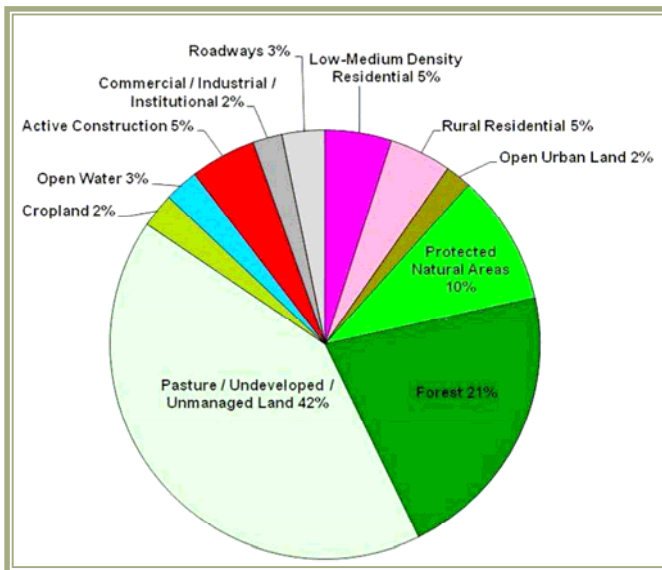


FIGURE 8. EXISTING LAND USES FOR THE LICK CREEK WATERSHED

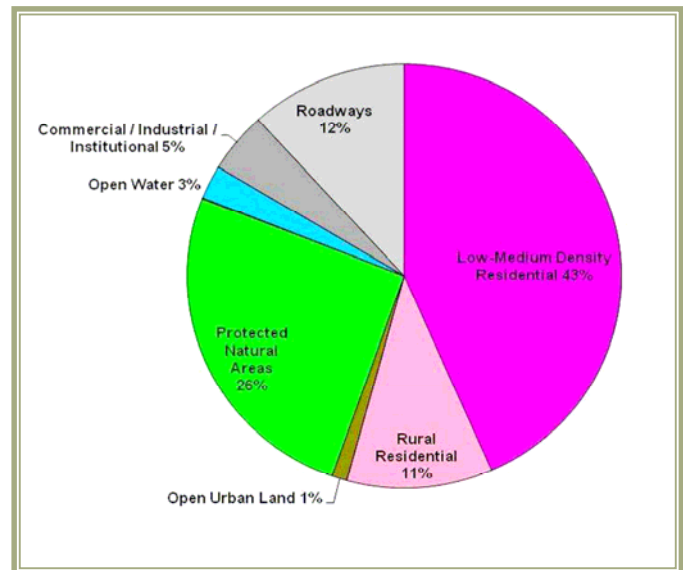


FIGURE 9. FUTURE LAND USES FOR THE LICK CREEK WATERSHED

Septic systems are also major contributors to the TN load in Subwatersheds 3, 8, and 10 for both existing and future conditions. This load does not substantially change between existing and future conditions. In Subwatershed 7, livestock is a significant TN source.

Channel erosion is the greatest existing TSS source for most subwatersheds and becomes an even greater source in the future (Figure 10). A sediment load attributed to channel erosion is part of a natural stream system; however, increased channel erosion is a predictable outcome of urbanization (Caraco, 2002). Active construction and rural land are large TSS sources under existing conditions, but are replaced as a major source by urban land in the build-out condition. In subwatersheds with a high percentage of existing active construction, such as subwatersheds 1 and 3, the TSS load decreases in the future conditions scenario.

Effects of Recommended Future Management Practices on Existing Loads

The modeled recommended future management practices, as recommended based on field assessment, were *improved erosion and sediment control, structural stormwater management retrofits, riparian buffer plantings, and septic system education.*

The improved erosion and sediment control as a future management practice can provide the greatest reduction in TSS (Fralely-McNeal et al. 2007). This effect is more pronounced in Subwatershed 1, where active construction comprises 20% of the existing land use. Here, TSS reductions are estimated at 18%, TP reductions at 12%, and TN reductions at 3%. These reductions correlate with the significant TSS loads the model shows under existing conditions. Additionally, two major findings from the February/March 2007 field assessments (Hoyt and Kitchell 2007) were “inadequate erosion and sediment control at construction sites” and “uncontrolled sediment discharges from ‘agricultural’ sites.” As stated in the input data assumptions (Hoyt and Kitchell 2007), the improvements include a shift from monthly to weekly inspection and increased training for inspectors and contractors. The increase inspection frequency is a major recommendation based on the field assessment. Also, a slight increase in the percentage of sites regulated (90% to 95%) was included to account for erosion and sediment controls at agriculture-exempt parcels. The results from the WTM support recommendations in the field assessment memorandum (Hoyt and Kitchell 2007) to increase inspection of sites with building permits and exercise regulatory authority over agricultural sites.



FIGURE 10. TSS AND TN LOADS FOR THE ENTIRE LICK CREEK WATERSHED

Riparian buffer plantings provide the greatest TN reduction (Fraley-McNeal et al. 2007). This assumes that existing 50-foot stream buffers will be left intact and the recommended buffer plantings from field assessments (Hoyt and Kitchell 2007) will be planted.

Structural stormwater management retrofits modeled were those found during field assessments. These retrofits would treat approximately 17 acres of impervious cover. This has a small impact on a watershed scale. The two largest retrofits are located in Subwatershed 1, and the model shows a 0.8% reduction in TN and 0.6% reduction in TSS for that subwatershed.

Septic system inspection, repair, and education were modeled as having an impact, particularly in Subwatersheds 3, 8, and 10 where the greater number of septic systems contributed significantly to the pollutant loads. In these subwatersheds, the septic system programs could reduce TN loads by 3%.

Overall Conclusions

The modest pollutant load reductions the model shows from future management practices will only be realized if the restoration practices are fully implemented.

This will require increased funding in the erosion and sediment control programs as well as the political will to hold land developers to a high standard for construction site controls. Additionally, a combination of grant funding for materials and staff time, a local government commitment to serve as project managers, and a sizable public education effort will be needed to realize the pollutant load reductions from retrofits, buffer plantings, and septic repairs.

Even with restoration practices, which are included in the future conditions scenario, the model shows that pollutant loads will be higher in the future. This is based on build-out conditions given Durham’s current UGA and zoning. The model also considered the existing post-construction stormwater management requirements

applied to the future development. Clearly, more rigorous efforts to prevent the increase of future nutrient, sediment, and bacteria loads are needed in order to achieve goals for Lick Creek and Falls Lake.

Techniques to mitigate this future increase in pollutant loads are available and could be instituted. The following recommendations based on the field assessment could be expected to mitigate future increases and could be modeled using the WTM:

- Post-construction stormwater management;
- Require post-construction water quality treatment for all new development;
- Encourage less than the maximum allowed impervious cover at development site by lowering the threshold at which post-construction stormwater management is required;
- Institute more rigorous design standards for post-construction stormwater practices;
- Institute more rigorous maintenance and inspection standards for post-construction stormwater management;
- Use a volume-based, rather than peak flow-based, water quantity control requirement;
- Increase offset fees to promote on-site treatment;
- Reduced impervious cover;
- Change zoning to cluster dense residential areas near transportation corridors while protecting other lands. This could result in less roadway construction and widening and therefore less imperviousness;
- Improve subdivision roadway design standards to reduce impervious cover in new residential areas through better site design;
- Buffer riparian corridors;
- Minimize impacts to 50-foot riparian buffers;
- Invest in land protection; and
- Protect existing forested and rural land to reduce the amount of land developed.

The WTM shows that with restoration practices alone cannot stem the increased pollutant loads exported from the Lick Creek watershed. The implementation of both restoration techniques and controls on future development will be needed to hold the line on future nutrient and sediment load increases to Lick Creek and Falls Lake.

Critical Land Analysis

The fourth and final goal of the Lick Creek WRP is to mitigate future changes to watershed hydrology and water quality within the 22 square-mile watershed. A key management strategy in preventing impacts to this largely undeveloped watershed is the protection of those lands that are most critical to water quality and aquatic habitat.

The Lick Creek Partners conducted a desktop analysis to identify and analyze all land parcels within the Lick Creek watershed for their potential water quality and selected conservation values. The analysis started with parcels defined as having high conservation value based on the Upper Neuse Clean Water Initiative (UNCWI) Conservation Plan (Trust for Public Land 2006), and further analyzed those parcels for other selected conservation criteria defined by staff from local land trusts and government land protection

agencies. A detailed discussion of the Critical Lands Analysis can be found in the “Lick Creek Watershed Critical Lands Protection Analysis” memorandum (UNRBA 2008). The following list highlights some of the findings of the critical lands analysis.

Area

- A total of 2,041 acres, or 14.5%, of the Lick Creek watershed is rated as having a high value for conservation by the UNCWI Conservation Plan.
- The 2,041 acres of high-value conservation lands are located on 539 land parcels that cover over 90% of the watershed. The average parcel is 25.9 acres and includes about 3.5 acres of UNCWI high-value land.
- About 1,735 acres, or 73%, of the total UNCWI high-value lands, are located on only 100 land parcels that total 9,710 acres.
- About ½ of the UNCWI high-value lands are located on 40 parcels that total 4,457 acres.

Flags

- Of the total 2,041 acres of UNCWI high-value lands, 1,374 acres (or 67%) are on land parcels that are developable under current zoning regulations. The total area of these land parcels is 11,406 acres.
- 59 of the 539 parcels with UNCWI high-value lands are adjacent to public lands, and 47 of these are over ten acres.
- 54 of the parcels with UNCWI high-value lands are designated as agriculture, forestry, or horticulture for tax and land use purposes.
- 156 of the parcels, totaling 6,315 acres, are prioritized in the East Durham Open Space Plan. Protection of these parcels would result in the preservation of 1,016 acres of UNCWI high-value lands.
- 122 of the parcels with UNCWI high-value lands are recognized by the State of North Carolina as Significant Natural Heritage Areas.
- Of the 539 parcels with UNCWI high-value lands, 24 have major restoration opportunities and 10 have volunteer restoration opportunities as identified by Lick Creek Fieldwork in February of 2007.

MANAGEMENT STRATEGIES

After 15 months of watershed analysis, fieldwork, planning, and prioritization by watershed stakeholders, the Lick Creek Technical Team recommends thirteen detailed management strategies for implementation by local, regional, and state-level watershed stakeholders, including:

1. Erosion and Sediment Control on New Development;
2. Managing Timber-Harvesting and Sites Classified as “Agricultural”;
3. Stormwater Management and Regulation;
4. Impacts from Infrastructure Crossing the Stream Corridor;
5. Riparian Buffer and Floodplain Encroachment;
6. Protection of High-Quality Streams and Wetlands;
7. Delineation of Stream and Wetland Boundaries;
8. Major Watershed Restoration Projects;
9. Restoration Projects to be Implemented by Volunteers;
10. Suspicious Discharges from Onsite Wastewater Systems;
11. Targeted Outreach and Education;
12. Long-Term Monitoring Recommendations; and
13. Low-Impact Development

This section generally describes each management category and summarizes its specific recommendations. The supporting documents to this plan (available at <http://www.unrba.org/lick/downloads.shtml>) offer a comprehensive and detailed summary of the analysis, fieldwork, monitoring, and modeling findings that led the Lick Creek Project Partners and Technical Team to recommend these particular management approaches. In addition, each recommendation section outlines the problem, current conditions, future threats, recommended strategies, general costs, and funding opportunities. This and other project memoranda, maps, and general information are also available on the project website, <http://www.unrba.org/lick/plan.shtml>.

Table 9 prioritizes each strategy as low, medium, or high and indicates its relative cost and potential for load reductions. Management strategies such as Erosion and Sediment Control on New Development, Managing Timber-Harvesting and Sites Classified as “Agricultural,” and Stormwater Management and Regulation are all immediate needs that will address excessive sedimentation, the high-volume discharge, and the high nutrient loading that are associated with typical storm events in our region. These strategies require regulatory supervision; however, the City of Durham already has well-structured programs to meet these needs and is currently working to strengthen their ordinances and programs. The potential for load reductions for these three strategies is high and the implementation costs relatively low for jurisdictions that already have local stormwater and sedimentation control programs. Many timber-harvesting and agricultural operations are exempt from erosion and sediment or stormwater controls and therefore would require legislative measures to address. Therefore, this strategy was given a priority of ‘medium.’

Most impacts from infrastructure are now reviewed for compliance during the plan review process and received a prioritization of ‘low.’ Historic impacts are hard to detect making implementation more costly.

Strategies such Riparian Buffer and Floodplain Encroachment, Protection of High-Quality Streams and Wetlands, and Delineation of Stream and Wetland Boundaries are all preventative measures, and while their potential for load reductions is considered ‘low,’ their value in preserving water quality is unmatched. Floodplains and wetlands remove nutrients, and provide water and sediment storage, thereby naturally

mitigating the damaging effects of stormwater runoff and pollution. Streams, wetlands, and riparian buffers are already protected under the Clean Water Act and the Neuse Rules. However, many impacts to all three systems are allowed through permits and variances. Efforts should be made to limit variances and enforce the proper delineation of jurisdictional areas for protection.

Because the Lick Creek watershed is still relatively undeveloped, opportunities for major restoration opportunities are relatively limited and therefore received a priority of ‘low.’ This is not meant to negate the value of these processes. In particular, voluntary riparian tree plantings should be given high priority. Riparian buffers provide excellent ecosystem services, are relatively inexpensive, and provide long-term educational and stewardship benefits to the community.

Detecting and fixing illicit discharges can be challenging because of overlapping jurisdictions and a lack of definitive data. Many times, even landowners who are able to connect to city sewer will not do so because of hook-up costs or a lack of awareness. Failing onsite wastewater systems are suspected to contribute high levels of nutrients and bacteria to receiving waters. Efforts to mitigate this problem should be given a high priority; however, implementation is expected to be difficult.

Targeted Outreach and Education is critical for improving and protecting water quality and aquatic habitat and should be given top priority.

Long-Term Monitoring will allow local governments to monitor their success and meet legislative requirements. The City of Durham is already conducting water quality monitoring as part of their stormwater management program; therefore, costs are expected to be relatively low.

Low-Impact Development is a progressive approach to protecting vital natural resources that involves matching post-development hydrologic characteristics of a site to its pre-development conditions. Many times, traditional ordinance language hinders techniques that would achieve low-impact development a misperception of higher costs persists. However, many efforts are underway to make low-impact development feasible in both from both a regulatory and cost perspective. This strategy should be given a high priority.

TABLE 9. PRIORITY FOR IMPLEMENTATION, COST, AND POTENTIAL FOR LOAD REDUCTIONS

Management Strategy	Priority (low, medium, high)	Potential for Load Reductions (low, medium, high)	Cost of Implementation (low, medium, high)
Erosion & Sediment Control on New Development	High	High	Low
Managing Timber-Harvesting/Sites Classified as “Ag”	Medium	High	Low
Stormwater Management & Regulation	High	High	Low
Impacts from Infrastructure Crossing Stream Corridor	Low	Low	Medium
Riparian Buffer & Floodplain Encroachment	Low	High	Low
Protection of High-Quality Streams & Wetlands	Medium	N/A	Low-Medium
Delineation of Stream & Wetland Boundaries	Medium	N/A	Low
Major Watershed Restoration Projects	Low	Medium	High
Restoration Projects Implemented by Volunteers	High	High	Low
Suspicious Discharges from Onsite WW Systems	High	High	Medium
Targeted Outreach & Education	High	Medium	Low
Long-Term Monitoring Recommendations	High	N/A	Low
Low-Impact Development	High	N/A	Medium

Implementation of any of these recommended strategies should be considered as measurable milestones and achievements in terms of the local watershed planning process. Most of the strategies rely on local governments for implementation and it should be noted that both the City of Durham and Durham County are in the process of strengthening their Unified Development Ordinance language well beyond state-required minimum standards. Other strategies rely on the enforcement of existing regulations from regulatory bodies like the NC Division of Water Quality or the US Army Corps of Engineers, among others.

Measurable milestones for implementation include, but are not limited to the following:

- Milestone achievement should be given to any local government or regulatory agency that refers to and studies the strategies recommended in this plan.
- Implementation of a portion of any strategy recommended in this plan should be considered a measurable achievement.
- Credit should be awarded to local governments who make ordinance and programmatic changes that support, enforce, or enhance recommendations made in this plan.
- NC House Bill 1099 of 2009 requires additional controls on land-disturbing activities, sizing of sediment basins, removal efficiencies, establishment of ground cover, and channel design that have partially resulted from the efforts conducted pursuant to the development of the Lick Creek Plan.

Many measurable achievements have already been accomplished. Durham County is currently working to increase erosion and sedimentation controls, impacts from infrastructure crossings have been incorporated into the plan review process, both major and volunteer restoration projects are underway in the watershed, targeted outreach and education is being conducted by the City of Durham Stormwater Education Program, and the watershed is currently being monitored for water quality.

Erosion and Sediment Control on New Development

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham*, and City of Raleigh* (*Subject to NPDES Phase I or II stormwater requirements)

Description

Excessive sediment in streams can degrade aquatic habitat by smothering insect life and fish spawning habitat, reducing the water's available oxygen, and increasing nutrient levels. When forested land is disturbed to accommodate new construction activities, the loss of vegetation and addition of impervious cover (pavement and rooftops) significantly alters hydrology, and increases surface water runoff. Under natural conditions, stream size and shape is naturally formed to accommodate base flows and storm flows; however, when the hydrologic regime is altered and discharge is increased, the size and shape of a stream changes to accommodate a new flow regime, often resulting in erosion of stream banks and incising. Sediment relocated from stream banks is deposited downstream where it may have negative impacts on water quality and aquatic life.

Indicators of the problem and current conditions

Stormwater flows and accelerated sediment levels in streams downstream of active construction or agricultural areas can be elevated, especially during storm events (when most sediment is moved). High stormwater flows can destroy habitat for aquatic invertebrates. The Lick Creek Partners monitored hydrology, sediments, and aquatic invertebrates in several key watershed locations.

The Durham County Engineering Department is responsible for ensuring that all new developments, within its jurisdiction, follow state and local sediment and erosion control (SEC) regulations to limit accelerated erosion. Durham has relatively strong SEC regulations, requiring a significant level of plan review, regular inspections, and potentially high penalties for noncompliance. There are also construction projects that are related to agricultural activities that are exempt from the Durham County Erosion Control Ordinance, and Durham County utilizes an affidavit that a landowner can sign stating that the activities are related to an exempt activity.

In addition to Durham County, there are other erosion control authorities that have jurisdiction of construction activities within Durham County. They include: NC Department of Transportation (DOT) (they monitor all activities with road Rights of Ways), NC Division of Environment and Natural Resources (DENR) (they monitor all projects that involve public interests such as utility installations, schools, parks, etc), Department of Forestry (they monitor all forestry activities), and Department of Mining. With many players involved in monitoring the construction activities within Durham County, it will take a combined effort with all responsible authorities to continue to reduce the amount of accelerated erosion from these construction sites.

Fieldwork carried out by the Lick Creek Partners concluded that extensive erosion and sediment control violations were occurring at active construction sites throughout the watershed (e.g. broken or bulging silt fences, poor inlet protection, and sediment-filled ponds), resulting in extensive sediment deposition in adjacent streams, wetlands, and lakes (Hoyt and Kitchell 2007), and potentially contributing to degraded water quality and aquatic habitat (Hoyt and Kitchell 2007). Hoyt and Kitchell (2007) suggest that many of these sediment-laden discharges can be attributed to lack of maintenance on structural sediment and erosion control practices.

Partially as a result of these findings, and a desire to improve sediment and erosion control within the County, Durham County has been working diligently to increase and enforce sediment and erosion control for construction activities. In response to the Center for Watershed's (CWP) recommendations for increased

inspections (Hoyt and Kitchell 2007), Durham County has increased their inspections by approximately 30%, and many additional improvements have been suggested in the proposed Environmental Enhancements to the Unified Durham Ordinance. Proposed changes include (but are not limited to):

- Redefine mass grading and remove infrastructure exemption;
- Change the minimum lot size that will require fingerprint grading for single family lots to 10,000 square feet;
- Require a Staged Grading Plan during the construction drawing period;
- Amend land disturbance buffer requirements; and
- Increase the width of required mass grading buffers.

Future threats

The majority of the southwestern portion of the Lick Creek watershed is expected to undergo a massive transformation in terms of development. In particular, Subwatersheds 1 through 8 are within the City of Durham’s UGA and are therefore expected to undergo the most development of all the subwatersheds. If the watershed is developed with current zoning densities, we can expect developed land areas to increase by up to 900% (Fraley-McNeal et al. 2007) (Figure 11). With such high levels of development expected in relatively undisturbed areas of the Lick Creek watershed with soils already prone to erosion (Triassic Basin), implementation of the recommended Ordinance changes presented by the Environmental Enhancements to the Unified Development Ordinance Stakeholder’s Group will be nothing short of critical for preserving the aquatic integrity of Lick Creek.

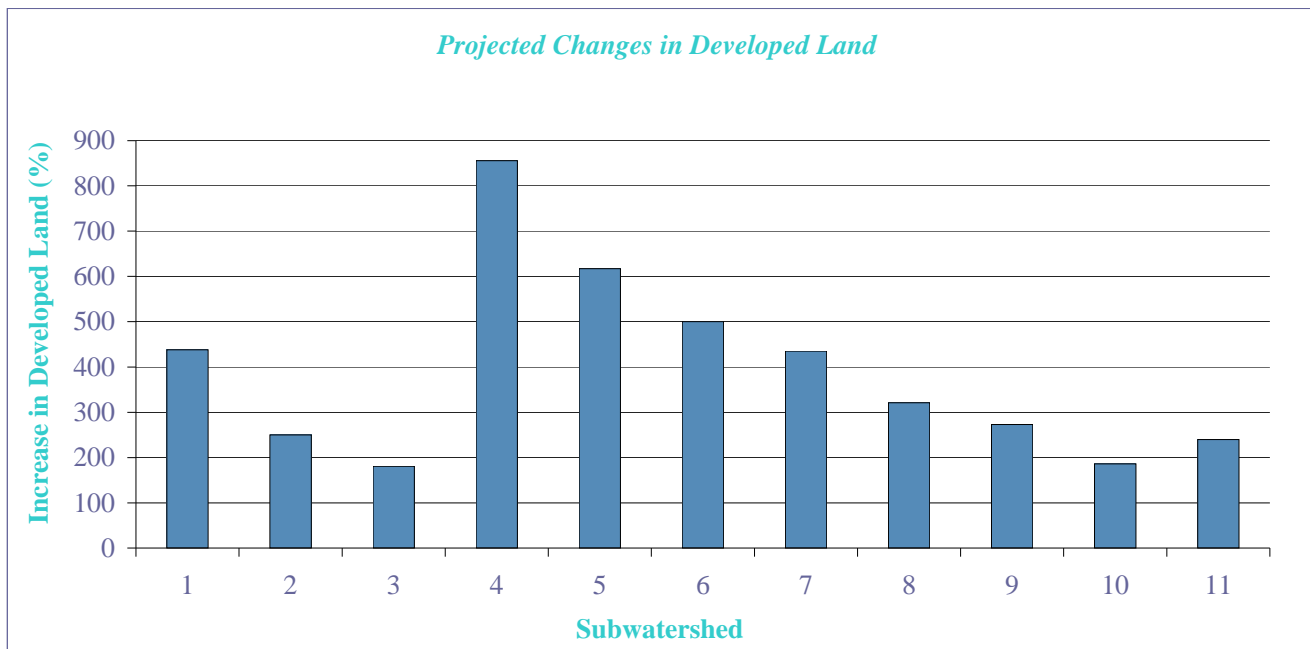


FIGURE 11. PROJECTED CHANGES IN DEVELOPED LAND COVERAGE AT BUILD-OUT (DATA FROM FRALEY-MCNEAL ET AL. 2007)

Recommended Strategies

- Increase the inspection frequency of active construction sites within Durham County's jurisdiction. Sites are currently visited approximately 1.3 times per month.
- Raise the fees for sediment and erosion control permits in Durham County to support increased inspection frequency.
- Support the recent Durham Ordinance changes presented by the Environmental Enhancements to the Unified Development Ordinance Stakeholder's Group.
- Increase the outreach associated with educating landowners about how to limit accelerated sediment discharges associated with pond-draining and emphasize the benefits of maintaining buffered ponds for water quality treatment and storage.
- The City of Durham provides contractor, engineering, and erosion control regulator training on a regular basis (approximately 4 times annually). Coordinate these educational opportunities with Durham County to maximize efficiency and increase the County's ability to improve sediment and erosion control.

Costs

- Jurisdiction: hiring new inspectors and support staff to monitor the construction activities within Durham County's jurisdiction, newer equipment (e.g., GPS unit, laptop), vehicle, legal assistance, and more staff time to review erosion control plans and perform sufficient follow-up.
- Builders: erosion control Best Management Practices (BMP) installation, maintenance, corrective measures, and repairs.

Funding Opportunities

- Increase plan review and permitting fees.
- State grants for program development.
- Operation permit issuance and re-issuance fees.
- Increase re-inspection fees.
- Financial performance bonds/guarantees/agreements (when necessary).

Managing Timber-Harvesting and Sites Classified as “Agricultural”

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

Removal of perennial trees and shrubs that obstruct, diffuse, and evapotranspire runoff more than other types of land cover increases the amount of runoff leaving the area. This additional runoff damages stream structure and helps carry sediment, pesticides, and fertilizers to waterways. Excessive sediment in streams can degrade aquatic habitat by smothering insect life and fish eggs, and destroying fish spawning habitat, clogging the gills of aquatic species (e.g. fish and mussels), reducing the water's available oxygen, and increasing nutrient levels. Because agricultural areas inherently provide less consistent vegetative cover than natural Piedmont forested conditions, the potential for deleterious stormwater runoff is higher. Pesticides and herbicides have been associated with agricultural runoff in several studies conducted by the USGS.

Indicators of the problem and current conditions

Indicators of uncontrolled sediment include excessive turbidity, low DO, excessive sedimentation on inside stream bends, the loss of porous substrate conditions, and the loss of visible pool and riffle sequences. Furthermore, sediment levels downstream of active construction or agricultural areas can be exacerbated during storm events (when most sediment is moved), further impairing conditions for aquatic life. The Lick Creek Partners have been monitoring rainfall, discharge, turbidity, TSS, TN, TP, and aquatic invertebrates in several key watershed locations.

The Lick Creek Partners observed turbid conditions in streams draining from properties with large areas of exposed soil that are zoned agriculture and are not required to have grading permits from the County (Hoyt and Kitchell 2007). Properties deemed agricultural are not subject to local erosion and sediment control regulations, even if their current use does not include row crops or pastures. Furthermore, many mining operations are also not subject to local sediment and erosion requirements, and “soil” farms (for the manufacturing of top soil) may possibly also qualify for mining exemptions if they are excavating soil to mix with soil amendments. A considerable area of denuded and compacted soil was observed near a power transfer station in the Rocky Branch subwatershed.

Durham County officials have no regulatory authority to require SEC at these sites regardless of sediment discharges from the site or downstream water quality complaints. Complaints on sites classified as agricultural must be directed to the NCDWQ Raleigh Regional Office at (919) 571-4718. (The local Soil and Water Conservation District [SWCD] office should also be notified.)

Future threats

According to NCDWQ's 2006 Integrated 305(b) and 303(d) Report (NCDWQ 2006), agriculture is a significant cause of stream use impacts in the state; however, in general, local governments cannot apply restrictions other than lot size to agriculturally zoned districts (UNRBA 2007c). Within agricultural zones, US Department of Agriculture (USDA) -Natural Resources Conservation Service (NRCS) standards and guidance may affect where facilities are sited and Voluntary Agricultural District (VAD) designations help ensure that rezoning decisions factor into existing agricultural operations (UNRBA 2007c).

Nontraditional agricultural operations (e.g., horse boarding, nurseries, stockpiling, community-supported agriculture, etc.) are on the rise and present management challenges because even though they are

considered agriculture (and therefore cannot be regulated by the local government other than to protect public health), they may have significant amounts of impervious cover, fertilizer or pesticide use, and land disturbance and also because local SWCDs may not have been made aware of them.

Recommended Strategies

The Upper Neuse Watershed Management Implementation Plan Recommendation Sheet 14 (UNRBA 2007d) provides an excellent discussion on Forestry Best Management Practices Education and Outreach and recommends the following implementation steps:

- Identify lands in the jurisdiction with forest cover and those that are classified as forestry for present-use value.
- Compile contact information for owners of those lands and make it available to agencies conducting outreach or training in your area.
- Meet with local NC Division of Forest Resources (NCDFR) County Rangers to learn more about forests, challenges forest landowners face, how forest harvesting differs from land-clearing work related to development, inspections for water quality, and other services NCDFR provides. In Orange County, NCDFR Foresters have led field trips to help local government staff recognize potentially noncompliant operations.
- Encourage forest owners who wish to manage and/or harvest their forestland to work closely with NCDFR and/or private consulting foresters on pre-harvest plans, forest regeneration programs, courtesy Forest Practices Guidelines (FPG) exams, and BMP implementation.
- Help disseminate existing information and educational materials to local landowners and citizens (e.g., pamphlets, websites, NCDFR contact information, etc.) and help landowners obtain technical assistance. Target education and outreach efforts based on Basic Steps 1 and 2. For example, staff can make sure forestry landowners are aware of the NCDFR's Forestry Stewardship Program.
- Develop a notification program that will notify a NCDFR County Ranger if forestry activities are suspected of contributing to an identifiable water quality concern.
- To avoid creating disincentives for landowners who continue to manage their land for forestry, promote the values of "working forests" when implementing land-use management policies or the Present Use-Value Taxation program for forestry. (Although present-use valuation may reduce property tax revenue, forestry costs less to support than other land uses.)
- Because ecological and economic conditions change for forestry activities over time, allow some flexibility in the development and execution of forest management plans as long as local water quality is being maintained.
- Pay special attention to tracts where the land use is to be converted from forestry to development. It is important that such sites have their riparian buffers maintained in accordance with the future, developed use. (Buffer requirements are often less restrictive for timber operations because tree harvesting does not permanently compact soil or add impervious surfaces, whereas development does.) The following measures would provide additional protection on sites that are slated for development:
 - Enforce required buffer widths during development, regardless of the amount of riparian vegetation left after timber harvesting.

- Impose and enforce a waiting period for new development (I think Durham County has this already) that would take place on sites where buffers were harvested. The waiting period should be sufficient to allow buffers to reestablish to more closely meet the standards in effect for new development generally (e.g., five years).
- Require developers to restore any buffers that were not maintained to local and/or state standards for new development before permitting clearing or grading of the site.
- Evaluate effects of bona fide forestry operations on local streams.

The Upper Neuse Watershed Management Implementation Plan Recommendation Sheet 15 (UNRBA 2007c) provides an excellent discussion on Agricultural Best Management Practices Education and Outreach and recommends the following implementation steps for encouraging voluntary water quality improvement projects and decreasing water quality impacts from silvicultural and agricultural operations:

- Encourage local farmers to seek assistance from NC Cooperative Extension (NCCE), SWCD, NCDWQ, NRCS, and other organizations to voluntarily reduce water quality impacts, for example, by installing and maintaining agricultural BMPs.
- Encourage VADs in the County. VAD status is an important step toward implementing other agricultural conservation agreements, and it provides an important mechanism for entities to work together.
- Create a memorandum of understanding for how the County will address animal and agricultural issues between local departments and agencies. (Orange County has this type of MOU between its Planning Department and Orange County SWCD.) Update the MOU on a regular basis or as conditions change. Ensure that nontraditional agricultural operations are included.
- Participate in county-level SWCD determinations of priority areas for agricultural BMP installation and annual work plan updates (which take place between April and June). (Districts can receive input at any time.)
- Participate in annual NRCS interested stakeholders meetings (generally in November or December) to help coordinate conservation and planning efforts.
- Obtain data on farmlands, pastures, lagoons, and spray fields from the local SWCD and the Farm Services Agency (FSA) on a regular basis. Consider this information when planning county land use (fragmented farmlands are less viable farmlands). (The FSA is currently undertaking a digital mapping initiative of agricultural areas nationwide that shows farm boundaries down to individual fields. The NRCS also includes agriculture in its National Resources Inventory effort, a statistical survey of land use and natural resource conditions and trends on non-Federal US lands.)
- Encourage farmers to participate in local and regional watershed and land use planning efforts.
- Support Soil & Water staff in inspecting receiving waters when they do site visits to see if there is offsite sedimentation occurring. This could be especially helpful at topsoil and dirt farms, where these operations are often exempt from regulation.
- If problems with an agricultural operation in the Upper Neuse Basin are suspected, report these problems to the NCDWQ Raleigh Regional Office at (919) 571-4718 and to the local SWCD office.
- NCDWQ should investigate how the regulations can be clarified to continue to exempt the target farming operations while disallowing these abuses of the exemption.

Costs

- NCDNR County Ranger offices and staff.
- Staff time to interface with NCDNR County Rangers and Water Quality Foresters.
- Staff time to conduct and participate in educational efforts on forest stewardship, forestry BMPs, FPGs, and Neuse Buffer Rules.
- Staff time to help landowners obtain basic information about forestry (e.g., directing requests to appropriate NCDNR staff and the NCDNR website).
- Staff time to coordinate with agricultural conservation agencies, attend meetings, etc.
- Staff time to work with the agricultural community.
- Funds for cost-share matching assistance.

Funding Opportunities

- EPA Nonpoint Source Section 319(h) grants.
- NCDNR Forest Stewardship Program and Southern Pine Beetle Prevention Program.
- NCSU Forest Education & Outreach Program (<http://www.ces.ncsu.edu/nreos/forest/feop/>).
- General funds.
- Bonds.
- Grants.
- Land conservancies and trusts.
- Landowners.
- Section 319 NPS grants.
- There are numerous programs to help farmers pay for BMP installation, such as Environmental Quality Incentives Programs (EQIP), Conservation Resource Programs (CRP), Conservation Reserve Enhancement Program (CREP), the NC Agriculture Cost Share Program, the Landowner Incentive Grant Program, and the Smithfield Agreement. Local SWCDs can provide guidance on the appropriateness of these funding sources for various projects.

Stormwater Management and Regulation

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

The use of structural stormwater BMPs is likely to become more and more important as the watershed continues to be developed and more rules are enacted governing their use. As development replaces natural drainage systems with human-made structures, BMPs must effectively remove pollutants over the long term if Upper Neuse water bodies are to meet water quality standards. However, according to the UNRBA (2007e), BMPs often deteriorate after construction if not properly maintained because of vegetative competition, orifice blocking, media clogging, structural failure, etc. Without regular maintenance, devices may not provide the environmental benefits for which they were designed and may cause public health risk or property damage. Annual inspections and follow-up measures help ensure that BMPs continue to perform at expected levels.

Indicators of the problem and current conditions/Future Threats

Many local and state regulations do not require new developments with less than 23% impervious cover to design post-construction stormwater controls to treat water quality. Many developments within the Lick Creek watershed have traditionally used 1-year detention dry ponds for post-construction stormwater treatment, and many of these ponds will be targeted for retrofitting based on new regulations being proposed in the Environmental Enhancements to Durham's Unified Ordinance (EEUDO). According to CWP (2003), water quality, hydrology, physical stream quality, and biological integrity all begin to show signs of degradation around 10% impervious cover. The new developments in Lick Creek are being designed to be just under the threshold for impervious cover at which Neuse rules require water quality treatment. In developments in the Lick Creek watershed, the 1-year detention requirements have been met with numerous small ponds.

Hoyt and Kitchell (2007) suggest that these ponds are unimaginative in their use of space within the site and are impacting streams and stream buffers and that innovative site designs that incorporate stormwater management into roadway right-of-ways or site designs that will minimize the total runoff will result in less buffer encroachment and stream impact from stormwater treatment facilities. In their 2007 memorandum, Hoyt and Kitchell point out that current stormwater requirements fail to give adequate incentives for the use of environmentally sensitive site and stormwater design (e.g. better site design [BSD] or low impact development [LID]) that minimize impervious cover and use trees and un-compacted pervious to maintain a predevelopment hydrologic regime.

The current rate-control-only stormwater practices are approved with the knowledge that the municipality will in the future return to retrofit the facilities to provide water quality treatment. The need to retrofit is driven by existing Neuse rules, the MS4 NPDES program, and the official impairment designations of streams and water bodies such as Lick Creek and Falls Lake. Water quality trends and modeling show that the current program will not prevent additional degradation of Falls Lake. The cost of the future water quality retrofits that may be required to meet a Falls Lake Total Maximum Daily Load (TMDL) will be borne by taxpayers as retrofits become part of local government budgets or as they are funded via state and federal grants. Cost-effective opportunities are missed when water quality concerns are not sufficiently addressed at the time of new development.

Recommendations

- The City of Durham recently modified their ordinance language to require water quality treatment for total suspended solids in some situations where impervious cover is less than 23%. Other jurisdictions should adopt this modification where appropriate.
- The City of Durham currently uses as-built plans to maintain a GIS database of BMPs. The GIS database should include latitude/longitude locations of each BMP; BMP type, location on the parcel, owner, date completed, photographs, and/or as-built drawings (if possible).
- Consider how inspections records can be integrated or referenced. Efforts should be made to either maintain a similar database for County projects or to integrate County projects into the framework of the City's existing database.
- An integration of County and City databases would require coordination between the two jurisdictions and compatible attribute fields. This information could be obtained from the developer during the permitting phase and then verified by the local government at a later date. The local government can collect this information during plan reviews, site inspections, and BMP maintenance.
- Require post-construction maintenance and monitoring of BMPs as codified in the EEUDO. The EEUDO recommends 12 storms be sampled over a four-season period.
- Continue working with academia and solicit funding to determine the nutrient removal efficiency of both traditional and non-traditional BMPs. BMP design selection should be site-specific and a combination of nutrient removal techniques be combined where appropriate. For example, a floating wetland pond that discharges through level spreaders into a riparian buffer.
- Analyze the effectiveness of BMPs and make adjustments to stormwater standards, preferably eventually to include revising development patterns and impervious cover requirements, to reduce impacts of development on water quality. Durham is currently pursuing this through the EEUDO.
- In addition to the 1-year detention requirement, which provides some channel protection storage, discharge volume criteria should be considered. A performance criterion, which limits the increase in volume, rather than peak discharge, could help spur the use of environmentally sensitive design (LID/BSD).
- The NCEEP should increase nutrient offset fee to push the economic incentive (lowest cost alternative) towards providing stormwater management on-site rather than paying a nitrogen offset fee. Currently the offset fee likely de-incentives onsite treatment.
- Current regulations require 'As-Built' drawings that certify the facility was built in accordance with the approved plans, but not all jurisdictions require that the design professional inspect construction or verify conformance. Add this requirement in planning departments if it is not already required (the City of Durham already does this).
- As an interim strategy, DSS should inspect 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 points of analysis; down peak flow rates
- The City of Durham currently conducts 4 contractor, engineering, and stormwater control regulator trainings per year, and requires a certification for people developing as-built designs and performing inspections. Durham County should mimic the City of Durham's certification program.

Furthermore, Durham County and the City of Durham should coordinate to make City trainings and training materials available to Durham County. Pooling resources is cost effective and will inherently improve coordination between the two jurisdictions.

- BMP inspections, both structural and nonstructural, should be performed by “certified professionals” to ensure they are maintained and functioning properly. (“Qualified professional” is many times interpreted to mean a landscape architect, land surveyor, engineer, or an employee of a city or county; the term is not officially defined.). Define “qualified professional” standards in Ordinance language (the City of Durham currently has a certification program and could be used as a model).
- Staff levels should be reviewed annually for adequacy and be increased as necessary.
- Enforce penalties for not complying with maintenance and inspections requirements, and require that any mitigating projects be done so that the water quality improvements benefit the same receiving waterbody to which impacts are being made. Currently, the location of mitigation projects is based on the Neuse estuary and opportunities to mitigate local effects may be lost.

Costs

- Jurisdiction: developing GIS database, hiring new inspectors and support staff, conducting inspections and follow-up actions, training, managing program, equipment (e.g., cameras, lights, tape measures, and handheld GPS unit), vehicles.
- Public: maintenance, repairs.
- Cost to developers.
- Evaluating the effectiveness of BMPs.

Funding Opportunities

- USGS Cooperative Water Program (<http://water.usgs.gov/coop>): assists local and state agencies with water-quality and hydrologic investigations, including monitoring and quantifying the effectiveness of BMPs and restoration efforts.
- Development plan review fees.
- BMP plan review fees.
- Inspections and maintenance fees.
- Local or user water, stormwater, or other utility fees.
- Financial performance bonds/guarantees/agreements.
- Operation permit issuance and re-issuance fees.
- Re-inspection fees.
- Accepted changes to the EEUDO are expected to result in changes in development, and consequently, a reduction in costs associated with stormwater management by providing financial incentives to provide on-site stormwater treatment, use the most efficient BMP, and incorporate low-impact design where appropriate.

Impacts from Infrastructure Crossing the Stream Corridor

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

The installation of utility crossings may remove riparian vegetation and alter stream hydrology, causing incision (the deepening of stream channels by down-cutting) that may inhibit streams from over-banking during high rainfall events, a key component to maintaining an active floodplain. An active floodplain can serve as a water storage facility during storm and flood events, and riparian vegetation along floodplains helps prevent erosion and provides aquatic habitat.

Indicators of the problem and current conditions

A build-up of debris at culvert mouths or evidence of erosion around headwalls and/or embankments may indicate poor flow alignment, and the build-up of sediment at the mouth of culverts may indicate hydrologic modification. Reduced velocity at the mouth of culverts and scouring at the base of culverts may also be indicators of hydrologic modification. These changes can impact macroinvertebrate communities and may inhibit the passage of fish and/or the suitability of spawning habitat.

During their 2007 fieldwork, the Lick Creek Partners observed that extensive riprap was present at most new infrastructure crossings, accompanied by steep side slopes (Hoyt and Kitchell 2007). The partners noted that some road crossing culverts in new developments were not flow-aligned, and that a surprising number showed evidence of erosion around headwalls and/or embankment failure. Many of the new developments in the watershed had gravity sewers that run parallel to the main stem of Lick Creek and cross it and its tributaries frequently in relatively short distances. Furthermore, it appears that the utility easements associated with the utility lines are encroaching into forested buffers. Design standards for sewer crossings and stream culverts could be modified to minimize the effect on the stream or wetland function.

Future threats

As development in the watershed continues (up to approximately 40% impervious cover in possible in some subwatersheds), and more land areas are incorporated into the city, it is inevitable that public utilities will be installed to service new communities. This means that the stream reaches in Lick Creek are likely to see many additional utility crossings in the coming decades.

Recommended Strategies

- Create a database of planned, active construction, and existing stream crossings for infrastructure. The City of Durham now includes new infrastructure crossings in a stormwater GIS layer via site plan processing. In addition, in the City of Durham, new crossings are reviewed for compliance. Other municipalities should implement a tracking mechanism and review for compliance. Efforts should also be made to identify, catalog, and visit existing crossings that may not have been originally reviewed.
- Follow-up with structural repairs identified in Hoyt and Kitchell's 2007 memorandum, "Lick Creek Fieldwork: Findings and Recommendations".
- Review criteria for stream crossings. Determine if design criteria for sewers needs revision or if more stringent oversight is needed.

- Review proposed infrastructure mapping during the planning and/or permit process to determine number and location of stream crossings; propose alternative layouts or designs (i.e. to reduce number of crossings).
- 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.
- Convene an interdepartmental task group to discuss the possibility of maintaining existing vegetation or at least encouraging re-vegetation with native grasses at a greater height in the mowed right-of-way.
- Reduce side slopes when possible and ensure that culverts are sized to account for increases in development possibly using a cumulative impacts analysis.
- Recommend inspections of utilities crossing streams to ensure that utility lines aren't getting exposed and/or damaged.

Costs

- Jurisdiction: database of crossings (planned, active construction, and existing crossings), inspectors and support staff time, equipment, and vehicles.

Funding Opportunities

- Plan review fees.
- Utility fees.
- General funds.
- Clean Water Management Trust Fund.
- Impact fees

Riparian Buffer and Floodplain Encroachment

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

The removal of riparian vegetation along stream corridors can have severe impacts on stream stability and flooding. Riparian vegetation helps slow water velocities during flood events when a stream overtops its banks and also helps keep soil in place through root structures. Removal of this vegetation may cause extensive and destructive flooding because there is no control on discharge, which contributes to in-stream erosion and bank-cutting. Protecting riparian vegetation, particularly trees can help minimize loss of a landowner's property due to stream bank collapse and erosion. Furthermore, riparian areas remove nutrients and evapotranspire runoff. Riparian buffers and floodplains also provide aquatic habitat in the form of backwater sloughs, intermittent water storage areas, root structures and masses, and shade. These habitat types provide spawning areas for fish and aquatic invertebrates and play a critical role in maintaining the stability of the aquatic food chain by providing a diversity of habitats.

Although many federal, state, and local regulations apply to these areas, some areas only require impacts to be subject to a permitting process, and they may not be implemented and enforced consistently. Insufficient or inaccurate information about riparian features in the development process may be partly responsible for the amount of impacted buffers observed in Lick Creek. Also, private landowners are often unaware that they have buffers on their property and that they should remain vegetated with native trees or woody shrubs, when possible.

Indicators of the problem and current conditions

The most obvious indicator of floodplain and buffer encroachment is the lack of riparian vegetation adjacent to streams and waterways. Other indicators include bank erosion, channelization, and sedimentation. The most egregious form of buffer and floodplain encroachment is placement of parking lots and other impervious surfaces close to streams. Such impervious cover can result in even greater discharge and sedimentation, further exacerbating the problems described above.

Fieldwork carried out by the Lick Creek Partners observed a multitude of impacts to stream and wetland buffers at recently constructed and active development sites, as well as in timber harvesting areas (Hoyt and Kitchell 2007). Observed impacts included the clearing of riparian vegetation, sedimentation, stream degradation, encroachment, and the deposition of fill materials adjacent to waterways. Furthermore, the Lick Creek Partners noted that many of these impacts were permitted by the NCDWQ as variances from the Neuse River Basin Buffer Rule (Hoyt and Kitchell 2007). Recommendations from Hoyt and Kitchell (2007) suggest "approval of buffer impacts should be linked with more stringent oversight of erosion and sediment control, stormwater management, and education efforts, as loss of buffer function leaves the respective stream or wetland more susceptible to degradation".

Future threats

A good portion of the Lick Creek watershed is expected to reach between 20 to 40% at buildout (Subwatersheds 1, 2, 3, 4, 5, 6, 7, and 8). If previous development patterns continue, more riparian vegetation and stream buffers will be encroached upon by new subdivisions and infrastructure. A continued policy of permitting riparian buffer impacts threatens riparian corridors that are supposed to be protected and compromises the integrity of previous modeling efforts that were used to develop the Neuse River Nutrient Management Strategy (NMS), which assumed that these buffers would be maintained as

development occurs. Increased erosion, flooding, sedimentation, and aquatic habitat degradation are all likely consequences of further buffer and floodplain encroachment.

Recommended Strategies

- Discourage applicants from applying for variances to buffer requirements. Explore alternative site configurations that reduce buffer impacts.
- Expand riparian buffer protections. Some suggested approaches):
- Utilize the wider buffer requirement suggested in the East Durham Open Space Plan (300 ft from top of bank on each side).
- Expand buffers to protect floodplains.
- Alternatively, create and enforce a system of riparian buffer requirements that restricts development in riparian areas based on environmental factors, such as floodplains, soils, and/or steep slopes. (Areas in the Upper Neuse critical to water quality were identified through UNCWI.) A system based on such factors would be more complicated to implement than prescribing buffer width, but it could be more protective and/or offer more flexibility. Additional enforcement would be needed to ensure that this system provides a level of protection comparable to the prescriptive approach.
- Visit and document any location where illicit buffer impacts are known or suspected.
- Utilize a citizen buffer watch group like Stream Watch or Muddy Water Watch.
- Choose a group to maintain this database and notify appropriate agencies of violations.
- Monitor riparian buffers during construction for compliance with development rules and conditions.
- Conduct post-development site visits to ensure that buffers have been managed as required by ordinance. Riparian buffers constitute the most effective stormwater management tool and buffers should receive the same level of oversight as other stormwater management controls. UNRBA (2003) describes an efficient and effective approach.
- Educate local officials, inspectors, NCDWQ and residents on the ecological services provided by mature vegetation, wetlands, streams, floodplains, and riparian buffers.
- Indirect impacts to wetlands through buffer removal need to be considered during impact review process. Additional wetland protections may be called for.
- Natural drainage design should be incorporated for new developments.
- The value of zero-order, ephemeral drainages has been documented and supports environmentally sensitive design and LID. The use of direct piped discharge to natural drainage channels (e.g., curb and gutter) should be discouraged.
- Change Durham UDO language governing the location of sewer lines [UDO 8.5.5(J)(3)] to make local practice consistent with statewide Neuse Buffer Rules.
- Create stronger protections for small (less than one acre) wetland areas adjacent to intermittent streams that currently escape protection (these are not shown on the USGS or NRCS maps).
- Do not allow manmade stormwater management features within the stream buffer.
- Do not plat single-family residential lots inside designated riparian buffers.

- Increase incentives to preserve existing trees and forested areas on sites slated for development.

Costs

- Database of planned, active, and illicit riparian buffer impacts.
- Improving ordinances for riparian protections.
- Plan reviewer trainings.
- Field inspectors and support staff time, equipment, and vehicles.
- Outreach materials and staff time.

Funding Opportunities

- Plan review fees.
- Utility fees.
- General funds.
- Impact fees.

Protection of High-Quality Streams and Wetlands

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

High quality streams and wetlands provide irreplaceable water quality and aquatic habitat benefits such as water storage, pollutant removal, aquatic and terrestrial habitat, erosion control, and recreation. In addition, the protection of these systems can be used to teach citizens about natural resource systems and can provide invaluable conservation benefits in terms of breeding and foraging areas for fish and birds.

Indicators of the problem and current conditions

An excess of degraded stream and wetland systems, a decline in macroinvertebrate community diversity, loss of riparian buffers and streamside vegetation, and a disappearance in fish species all suggest a loss of high-quality streams and wetlands. Furthermore, a lack of pristine stream and wetland areas is an obvious indicator that conservation measures within the watershed are lacking.

The Lick Creek watershed is already experiencing degraded water quality conditions (Line and Penrose 2007) and Lick Creek itself has been listed as impaired on the State's 303(d) list since 1998 (NCDWQ 2008). In addition, the watershed is also expected to experience significant development and increases in impervious cover (UNRBA 2008), especially in the subwatersheds that fall within Durham's UGA. Given the combination of declining water quality and expected increases in impervious cover, stream and wetlands are under threat from both pollutant loading and hydrologic changes from increased impervious cover and land clearing. According to the Lick Creek WTM Analysis (Fraley-McNeal et al. 2007), Subwatersheds 1 through 8 generally have lower levels of open green space and protected land areas than Subwatersheds 9, 10, and 11.

Future threats

A good portion of the land that is directly adjacent to Falls Lake (mostly in Subwatersheds 9, 10, and 11) is owned and protected by USACE and is preserved as open space in perpetuity. However, more than half of the Lick Creek watershed falls within the City of Durham's UGA, which suggests that high-quality streams or wetlands in this zone are at risk of being altered, removed, impaired, and/or degraded as a result of development. According to the WTM Analysis (Fraley-McNeal et al. 2007), most of the subwatersheds in the Lick Creek watershed are expected to see increases in the amount of open space and protected land area; however, percentage increases do not reflect the current levels of protected area in the watershed and cannot be used to evaluate whether sufficient green spaces and critical lands are protected to maintain water quality, especially since Lick Creek is already impaired. Every effort should be made to preserve as many existing high-quality aquatic and riparian systems as possible, starting with areas identified in the UNCWI Conservation Plan (Trust for Public Land 2006). Land preservation and conservation opportunities become scarcer and more expensive as development proceeds and urban services are extended. Long-term planning and a coordinated acquisition approach are critical for this strategy to be successful.

Recommended Strategies

- Protect the lands with highest conservation value identified Lick Creek Critical Lands technical memorandum (UNRBA 2008) in perpetuity using voluntary measures such as land acquisition and permanent conservation easements.

- Because unprotected headwaters significantly impact water quality and because they currently receive little to no protection, finding ways to protect headwater drainage networks should be a high priority.
- Preserve a large portion of Lick Creek Critical Lands (UNRBA 2008) by prohibiting development and disturbance within the 1% annual chance floodplain.
- Prioritize acquisition or conservation of tracts or tract segments with riparian features most likely to be developed or altered, or that are exempted from current ordinances.
- Identify which Lick Creek Critical Lands (UNRBA 2008) are most vulnerable to future development or impacts from adjacent development. For sites slated for development, ensure plan-review staff encourage open space protection. Also ensure that SEC and stormwater regulations are strictly enforced on Lick Creek Critical Lands and on adjacent developing tracts.
- Small (less than one 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, and seek conservation easements to protect riparian features.
- Create stronger protections for all riparian features that currently escape protection, including small (1/10 acre) wetlands.

Costs

- Fee-simple acquisitions and use rights/conservation easements (NCEEP estimates \$11,000 an acre for Durham).
- Outreach materials and staff time.
- Staff time to revise development ordinances, enhance plan review, and enforce codes.

Funding Opportunities

- Clean Water Management Trust Fund.
- 319 NPS Grant Program.
- Watershed management/protection “fee” paid by residents or businesses in the watershed.
- Existing and future state and local bonds.
- Citizen donations (cash, land, easements, etc.).
- Agricultural conservation programs (e.g., CRP, CREP, WRP, etc.)
- NCEEP (if land protection is tied to specific water quality benefits such as nitrogen reduction).
- Utility fees (water & sewer, stormwater).

Delineation of Stream and Wetland Boundaries

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

Accurate stream and wetland delineation is a crucial aspect to protection. Section 401 and 404 of the Clean Water Act implicitly protect intermittent and perennial streams and wetlands from development and encroachment. State and federal agencies rely on local consultants to delineate these areas based on criteria established and monitored by USACE. While all delineations are required to be visited and approved by a USACE representative, Hoyt and Kitchell (2007) expressed concern that delineations in the watershed under-represent the actual amount of streams and wetlands in the watershed. Moreover, delineation does not guarantee protection, as impacts are permitted to riparian areas and mistakes may be made during plan review and/or construction.

Indicators of the problem and current conditions

The Lick Creek Partners (Hoyt and Kitchell 2007) used stream and wetland layers from various sources during their fieldwork including USGS 1:24,000 quadrangle maps, DSS Hydro-I and Hydro-p mapping, DEM-generated streams, and NWI mapping. The Lick Creek Partners observed that many small, first-order DEM-generated streams were not captured by USGS or Durham mapping, but were verified as flowing streams by field teams. In addition, field teams noted significant differences between the NWI layer and wetland locations in the field. Furthermore, in many cases, wetland delineation flagging did not appear to fully cover the true wetland extent.

Future threats

Under current regulations, only streams that are depicted on an USGS 1:24,000 quadrangle maps or on NRCS Soil Survey maps are protected by the Neuse River Basin buffer rules. This means that any actual intermittent or perennial stream in the watershed that does not show up on these maps does not have protected buffers and is at risk of being impacted during development. Moreover, in practice, the Soil Survey maps may not be consulted because they are not always available in a digital format in Durham. This means that some streams, especially intermittent streams, might not be receiving adequate protection.

Recommended Strategies

- Create and enhance local protection of intermittent and ephemeral drainages and wetlands.
- Digitize the Soil County survey maps. Consolidate with USGS 1:24,000 quadrangle maps and Durham's riparian features GIS layer and use the consolidated GIS layer for plan review.
- Ground truth riparian maps (ground-truthing may be partly done by volunteers).
- Delineate and protect streams upstream of current points, to a designated catchment size. The Federal Emergency Management Act (FEMA) delineation begins at a 1 square-mile drainage area.
- Have staff verify stream and wetland locations when development proposals are first submitted.
- Ensure that all plan review stages utilize best available data based on steps listed above.
- A local wetland inventory should be conducted to revise NWI maps.
- Wetland delineations associated with recent developments could contribute to the inventory.

- Incorporate this revised inventory into the compiled riparian feature GIS layer

Costs

- Staff time to ground-truth maps and/or coordinate volunteer ground-truthing teams.
- Staff time to revise development ordinances, enhance plan review, visit development sites, and enforce codes.

Funding Opportunities

- Plan review fees
- Clean Water Management Trust Fund
- Impact fees

Major Watershed Restoration Projects

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

Lick Creek has been listed as “impaired” by the State due to its inability to support aquatic life and low levels of dissolved oxygen (NCDWQ 2006). In addition, fieldwork conducted as part of this planning process has revealed that sedimentation is another major problem in terms of aquatic habitat and water quality. Furthermore, a large majority of the watershed falls within the Triassic Basin, which is represented by highly erodible and relatively impermeable soils. While stream restoration alone is likely not enough to reverse the impairment in the watershed, it is an important component to restoring water quality conditions. In many circumstances, because of massive stream incision, a stream channel will not become stable and fully functioning without some sort of assistance through restoration efforts.

Major restoration projects include practices such as stormwater retrofits, stream restoration, floodplain reconnection, and large buffer plantings that require engineering design, construction by a contractor, long-term maintenance, and/or project management by a local government. Stabilizing the many sections of stream that are actively eroding will significantly reduce the amount of sediment in these streams. In addition, restoration may enable a stream to better transport sediment under varying flow conditions, reduce flow velocities along and/or near the banks, remove nutrients and sediment through flooding, stabilize stream banks, provide habitat for aquatic life, and prevent loss of soil.

Indicators of the problem and current conditions

Multiple major restoration opportunities that could help restore lost ecosystem functions have already been identified for the Lick Creek watershed (UNRBA 2007b). Almost 25 acres of drainage area could receive water quality treatment by stormwater retrofits and one linear mile of stream buffer could be reforested (Hoyt and Kitchell 2007). The NCEEP and UNRBA are currently developing a Project Atlas that will catalog potential major restoration projects, such as those listed in the “[Lick Creek Watershed Restoration Priorities](#)” memorandum (UNRBA 2007b), and are facilitating implementation of restoration projects among local stakeholders and NCEEP.

Future threats

As the watershed becomes more developed, major restoration projects will likely become more difficult, costly, and scarce due to encroaching urbanized land uses and because land costs rise as urban services are extended. It is therefore imperative to ensure that restoration opportunities already identified are factored into future planning efforts and implementation begins as soon as possible. Delaying implementation will result in higher costs.

Recommendations

- Ensure that new potential restoration projects are incorporated into the NCEEP Project Atlas for Lick Creek, including nutrient offset buffer restoration opportunities and projects that do not meet current NCEEP mitigation credit criteria.
- Partner with NCEEP and UNRBA to implement high-priority stream and buffer repair opportunities, focusing first on projects where development is likely to take place in the near future (Fraleigh-McNeal et al. 2007) and/or on publicly owned land that are visible, accessible, and/or provide opportunities for community outreach/involvement.

- Regulatory agencies should work with NCEEP to develop mitigation credit strategies that address urban and urbanizing watershed stressors, such as stormwater retrofits and land preservation, that traditional mitigation project do not.
- Conduct annual stream walks and/or review aerial photography in the watershed to identify new restoration opportunities. Some of this work may be able to be conducted by volunteers and/or in conjunction with efforts to enforce riparian buffer protection regulations.
- Coordinate with UNRBA, NCEEP, and other agencies implementing restoration projects to encourage owners of properties that have been identified as high-priority stream and buffer restoration opportunities to participate in restoration efforts.
- During reviews of development plans and building permit applications, check to see if any potential watershed restoration projects exist on the parcel. If so, ensure that the potential restoration project will not be compromised by encroachment or excessive sedimentation or runoff (during construction or afterward).
- Include the UNRBA Project Atlas in the plan review checklist.
- Note that if the developer sets aside open space as a local stipulation of the development, the NCEEP cannot get mitigation credit for working on the same piece of land. However, other funding sources, such as Clean Water Management Trust Fund (CWMTF), may be available.
- Update stormwater ordinance language to include requirements or consideration of LID designs as mitigation.
- Institutionalize a goal to further reduce stream or buffer restoration needs due to new development.

Costs

- Land acquisition and associated fees.
- Planning and construction costs.
- Landowner outreach.
- Staff time for plan review.

Funding Opportunities

- NCEEP (<http://www.nceep.net>): a statewide, non-regulatory program to restore, enhance, preserve and protect wetlands, streams, and riparian areas in the State. The program funds planning efforts and can fund “traditional” compensatory mitigation projects (stream repair, riparian buffer restoration) directly or as a part of a comprehensive watershed management approach.
- Local or user water, stormwater, or other utility fees.
- Private landowners may contribute cash (especially in jurisdictions where there is a stormwater fee and a credit for project implementation) or may donate or allow easements on the project land.
- CWMTF: Riparian land acquisition and restoration projects (www.cwmtf.net).
- EPA NPS Section 319 grants: Stream restoration planning, implementation and monitoring (www.epa.gov/owow/nps/cwact.html).
- Division of Soil & Water Conservation (DSWC), which administers cost share and grant programs such as CREP to establish and protect riparian buffers (www.enr.state.nc.us/DSWC/pages/crep.html).

- USDA- NRCS, which administers cost share and grant programs for water quality restoration and protection (www.nrcs.usda.gov/programs/programs_faq.html).
- Conservation on Private Lands (www.nfwf.org/programs/nrcsnacd.cfm), a partnership between the National Fish and Wildlife Foundation (NFWF) and NRCS to support conservation and stewardship of private lands.
- Five-Star Restoration Matching Grants Program (<http://www.nfwf.org/programs/5star-rfp.cfm>), which awards between \$5,000 and \$20,000 to restoration projects with a community component.
- USGS Cooperative Water Program (<http://water.usgs.gov/coop>), which assists local and state agencies with water-quality and hydrologic investigations, including monitoring and quantifying the effectiveness of BMPs and restoration efforts

Restoration Projects to be Implemented by Volunteers

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

Opportunities exist for small restoration projects that can serve as “quick wins” for on-the-ground implementation. These projects are fairly simple to design and relatively inexpensive compared to major restoration projects. Additionally, volunteers can often accomplish these projects with the technical assistance of local government staff and/or extension agents. Examples include trash cleanups, simple buffer plantings, and small stormwater retrofits such as rain gardens.

Current conditions

Multiple volunteer restoration opportunities have already been identified for the Lick Creek watershed (UNRBA 2007b) and efforts are underway to see implementation of some of these projects on the ground through a Home Depot Foundation Grant that was awarded to UNRBA via the CWP. Furthermore, NCEEP and UNRBA are currently working on a project atlas that will catalog volunteer projects such as those listed in the “Lick Creek Watershed Restoration Priorities” memorandum (UNRBA 2007b).

Future threats

As the watershed becomes more developed, volunteer restoration opportunities will likely multiply. However, a reliance on post-impact mitigation efforts should be avoided and every effort made to preserve existing aquatic systems as they provide a suite of environmental services such as water storage and pollutant removal that are difficult to replace. Volunteer restoration projects will have the most benefit in areas that are only slightly impacted; alone, they cannot bring an impaired watershed back to health. In addition, space for tree and buffer plantings will also likely become more limited as watershed residents add appurtenant structures to their properties. Repairing watershed impacts after the fact is difficult, time consuming, and expensive. Therefore volunteer restoration projects will possible address future impacts by providing an outreach educational opportunity to demonstrate the importance of protecting existing buffers.

Recommendations

- Continue outreach to landowners with lands intersecting buffer restoration opportunities to encourage them to implement volunteer restoration, retrofit, and land protection projects identified during this planning process. 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.
- Continue working with partner organizations to obtain grants and other resources to implement volunteer restoration projects on both public and private properties, such as buffer plantings, rain gardens, etc.
- Conduct annual stream walks and/or review aerial photography in the watershed. Stream walks will help identify new restoration opportunities and strengthen riparian buffer protection stewardship.
- Contact existing and local groups that have been established for the purpose of education and outreach.
- Database of needs and resources (clearinghouse).
- Address insurance/liability concerns

Costs

- Implementation of restoration and other management practices (designs, materials, staff time, installation, maintenance, monitoring, volunteer coordination, etc.)
- Voluntary conservation easements and fee-simple acquisitions.
- Planning and construction costs.
- Landowner outreach.

Funding Opportunities

- Local or user water, stormwater, or other utility fees
- Private landowners may contribute cash (especially in jurisdictions where there is a stormwater fee and a credit for project implementation), may donate land, or may allow easements on the project land.
- CWMTF: Riparian land acquisition and restoration projects (www.cwmtf.net).
- EPA NPS Section 319 grants: Stream restoration planning, implementation and monitoring (www.epa.gov/owow/nps/cwact.html).
- DSWC, which administers cost share and grant programs such as CREP to establish and protect riparian buffers (www.enr.state.nc.us/DSWC/pages/crep.html).
- USDA-NRCS, which administers cost share and grant programs for water quality restoration and protection (www.nrcs.usda.gov/programs/programs_faq.html).
- Conservation on Private Lands (www.nfwf.org/programs/nrcsnacd.cfm), a partnership between the NFWF and NRCS to support conservation and stewardship of private lands.
- Five-Star Restoration Matching Grants Program (<http://www.nfwf.org/programs/5star-rfp.cfm>), which awards between \$5,000 and \$20,000 to restoration projects with a community component.

Suspicious Discharges from Onsite Wastewater Systems

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

Onsite wastewater systems are prevalent throughout Lick Creek. Due to the geology, traditional septic onsite wastewater system designs are not possible in many locations, and there are a significant number of sand filter systems that discharge directly to streams. Because these are more complex than conventional onsite wastewater systems, they are more prone to failure and are supposed to be permitted by the state and inspected by the County Health Department annually (15A NCAC 18A .1961). Fieldwork from Little Lick Creek in 2005 and Lick Creek in 2007 confirm that many of these systems are failing (most are nearing 30 to 50 years old) and that they are frequently not sufficiently maintained or inspected.

Finding a solution to this problem is complex for many reasons:

- Many of these systems are aging systems owned by low-income households or on low-rent properties;
- Many of these systems could be connected to the City's sewer system, but the hook-up fees and plumbing costs can be prohibitive;
- Because these systems are permitted by the state, it is the state's responsibility to monitor and enforce regulations of their NPDES permits, not the responsibility of Durham County Environmental Health (DCEH); and
- The City has a program for detecting and stopping illicit discharges, but Durham County's program is ambiguous.

According to the UNRBA (2006), failing septic systems can contribute to elevated levels of nutrients, bacteria, and other contaminants in surface waters and ground waters within the watershed. Furthermore, UNRBA suggests that in many places, there is no systematic method of capturing and tracking information on locations of specific failing systems and assuring their improvements. Although the state requires that some systems (those with pumps or advanced technologies) installed after 1992 be inspected on a regular basis by the local health department, the majority of systems are not. Additionally, most counties lack the resources and funding to carry out this state-mandated inspection program.

Indicators of the problem and current conditions

Fecal coliform bacteria (FCs), or more specifically *E. coli* bacteria, in receiving waters is the major indicator of untreated discharges from onsite wastewater systems. A secondary indicator may be elevated levels of ammonia, which primarily originates from human and animal wastes. Non-functioning or malfunctioning onsite wastewater systems can cause high levels of FCs even during periods of low flow because these systems run all the time.

Although sand filter and other potentially problematic systems are not as numerous in the Lick Creek watershed as they are in Little Lick, pollution from these systems can be a serious problem in small, concentrated areas within these subwatersheds. In particular, fieldwork teams observed a concentrated number of onsite wastewater system discharges to streams in residential neighborhoods.

Future threats

It is not clear if the potential future threat from malfunctioning onsite wastewater systems is substantially increasing; however, it may be likely that most systems at high risk of failure are already near the age threshold when failures become most probable. New housing developments in the watershed are annexed into the city and are served by the city's sewer system. However, experience from Little Lick Creek shows that many existing dwellings with such systems have not been hooked up to City sewer, even when service is available nearby, because of the expense associated with new hookups. This creates islands of homes with aging, substandard onsite wastewater systems on poorly drained soils.

Recommended Strategies

- Begin conversations between appropriate agencies in Durham County (County Health Department), the City of Durham Stormwater Services, NC Division of Water Quality, and others to coordinate efforts for tracking and cataloging permitted onsite wastewater treatment systems.
- Provide a list of supposed systems to NCDWQ and field teams. The teams and/or NCDWQ can carry a GPS and verify the presence and/or absence of onsite wastewater treatment systems.
- Work to determine situations in which people have a connection fee but have not had their systems connected.
- Possibly field verify existing lists through the use of a graduate student and/or intern.
- The City of Durham currently has a program for detecting and stopping illicit discharges. The City of Durham and Durham County should coordinate to make sure that illicit discharges in both jurisdictions are being addressed and rectified.
- Create, implement, and maintain a GIS database of existing on-site septic systems and well locations. Maintain a database of mailing addresses for properties, current property owners, and inspections information (histories, system type, etc.) using GIS or another database that can be joined with the GIS database.
- Create a task force with other stakeholders such as NC Division of Environmental Health (NCDEH) to explore opportunities to prevent and address onsite wastewater treatment system failures and ensure that high-risk onsite systems (such as sand filter systems) are hooked up to available public sewer systems.
- Create and implement a mechanism to educate on-site wastewater system owners and users about their systems, maintenance, and the possible need for an NPDES permit (landowners may need assistance with this process). The GIS database could be used to help target these efforts. Choose one of the two alternative approaches described below to conduct outreach.
- Conduct outreach at regular intervals, e.g., on an annual basis. NCSU and NCCE have numerous educational publications on maintenance of onsite wastewater systems available in hard copy and on the web at: <http://www.soil.ncsu.edu/about/publications/index.php>.
- Provide information to new owners at time of property transfer. (For example, Wake County distributes NCCE fact sheets to new homeowners with a video or CD copy of the NCSU video "Septic Tanks" via realtors, local Wake County Extension Center, and the Wake County Department of Environmental Services.)
- Maintain a list of certified installers and inspectors in your area, similar to that of NCDEH, and update applicable ordinances to require that all inspections, installations, and repairs of systems be

performed by a certified installer/inspector. The NC On-Site Wastewater Contractors and Inspectors Certification Board (http://www.deh.enr.state.nc.us/oet/septic_tank_cert/septic_tank_cert_main.htm) provides a certification program for people who construct, install, and repair on-site wastewater systems.

- Help low-income onsite wastewater system owners obtain funding to cover costs associated with converting to City sewer service through cost sharing, capital improvements, or restoration and/or mitigation funding.
- If landowners with systems that should have NPDES permits are not complying with the law, pursue enforcement actions.

Costs

- Inspectors, vehicles, equipment, and legal support.
- GIS database of systems.
- Educational materials and programs.
- System maintenance, repairs, replacements, tap-ons to sewer, inspections, upgrades to more suitable treatment systems (including community systems).

Funding Opportunities

- CWMTF.
- Inspection fees.
- Onsite wastewater management utility/enterprise.
- Impact fees on new systems.
- Section 504 Loan & Grant Program (administered through USDA).
- NC Division of Community Assistance
- NC Rural Communities Assistance Project.
- NC Clean Water Revolving Funds (NCCWRF) (Recent changes to the EPA budget have reduced NCCWRF funding levels nationally but have also specified that a part of this national funding is directed for decentralized technologies. Hence, county management programs, system upgrades, etc. may be fundable to a greater extent than in the past from this funding source. However, changes may be needed to local NCCWRF authorization language to utilize funds this way.)

Targeted Outreach and Education

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham* (*Subject to NPDES Phase II stormwater requirements)

Description

The Lick Creek fieldwork teams identified several locations where targeted education to watershed residents, businesses, and the development community is needed regarding illicit discharges and best management practices. Practices such as uncovered fuel storage, poor waste storage, and poor stream buffer management reveals opportunities for education to help landowners and business owners better follow regulations and best management practices.

Fieldwork, subsequent site visits, and talks with local stakeholders all underscore the need to “educate local elected officials and the public on the impacts of impervious cover to aquatic systems, the susceptibility of the Lick Creek watershed to future impairment due to growth potential and Triassic Basin conditions, and potential management techniques to minimize future impacts (i.e. buffers, BSD, post-construction stormwater quality treatment)” (Hoyt and Kitchell 2007). The UNRBA and other stakeholders should work together in an effort to raise general awareness of these pressing issues and stimulate support for initiatives to address them.

Indicators of the problem and current conditions

Many poor practices can be observed throughout the Lick Creek watershed, including the following:

- Homes and businesses along stream buffers storing or disposing of waste, often hazardous materials, in the riparian buffer;
- Poor maintenance of on-site wastewater treatment systems, particularly of sand filter-type systems;
- Vehicle maintenance and repair operations discharging toxins such as solvents, waste oil, antifreeze, and other fluids to surface waters;
- Gas stations discharging fuel (primarily diesel), a significant source of copper, zinc, and petroleum hydrocarbons;
- Outdoor materials storage, including hazardous materials, lacking secondary containment areas and adequate labeling of storage containers; and
- Restaurant pollution source control, including improper grease storage, wash water disposal, and dumpster management.

Furthermore, in many cases, landowners and businesses were observed to have mowed their vegetation to the edge of water bodies, leaving no riparian buffer along waterways other than grasses. The Lick Creek watershed is one of the fastest-growing areas in Durham County, so educating local elected officials and the public is important and timely.

Future threats

As Lick Creek becomes more densely developed, the stormwater runoff, impacted buffers, stream erosion, erosion and sediment control violations, sewer leaks, and failing onsite wastewater systems that degrade water quality and aquatic life in Lick Creek are likely to become more prevalent. These stressors contribute to degraded water quality conditions, have negative impacts on aquatic life, and increase the costs of water treatment. In addition, the erosive nature of Triassic Basin soils makes the Lick Creek watershed even more

susceptible to water quality degradation. Regulatory programs alone cannot address all the stressors in the Lick Creek watershed; education and other voluntary measures are critical to restoring water quality, especially as the watershed continues to become more urbanized.

Recommendations

- Educate elected officials about the need for stronger ordinance language and adoption of watershed management practices.
- Provide educational materials (including applicable regulations) to all streamside landowners on a regular basis about the value and function of streams and riparian buffers and the impacts of littering, illicit discharges, poor lawn care, and improper septic system maintenance.
- Tie education for residents into the volunteer restoration projects.
- Educate area businesses about pollution prevention.
- Conduct outreach presentations and discussions with small auto repair and sales shops, gas stations, business storing materials outdoors, and restaurants with recurring pollution incidents.
- Educate all landowners in Lick Creek with on-site wastewater treatment systems about proper maintenance and inspections (especially sand filter-type systems).
- Conduct mailings and/or outreach to landowners to encourage them to implement the restoration, retrofit, and land protection projects recommended throughout 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.
- There are many citizens who understand the value of clean streams and water supplies. The City of Durham has an “Adopt-a-Stream” program that trains citizens to detect common water quality problems. Some criteria for targeting sites for volunteer programs include stream 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; and
 - Near schools, where science classes could establish long-term water quality monitoring sites.

Costs

- Staff time to plan, develop, coordinate, conduct, publicize, and evaluate outreach activities.
- Developing, printing, and/or distributing educational materials.
- Staff overhead (e.g., vehicles, office furniture and supplies, etc.).
- If participating in a partnership, cost shares or other dues.

Funding Opportunities

- Stormwater fees.
- Water supply utility funds.

- General funds.
- State, federal, and private grants.
- In-kind contributions from volunteers, nonprofits, and other organizations (e.g., the Eno River Association has its own Streamwatch program).
- Direct donations.
- Resources leveraged through cross-jurisdictional collaboration (e.g., the NC Clean Water Education Partnership).

Long-Term Monitoring Recommendations for the Lick Creek Watershed

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham*, and City of Raleigh*, NC Division of Water Quality (*Subject to NPDES Phase II stormwater requirements)

Description

The design of a long-term monitoring plan depends, to a large extent, on the goal of the monitoring. Monitoring locations, monitoring frequencies, monitoring parameters, and monitoring duration all depend on the goal. The goals of the long term monitoring program proposed for the Lick Creek watershed are to (1) document the effects of development on water quality in a subwatershed, (2) document changes in pollutant inputs from the overall watershed to Falls Lake, and (3) document the effects of restoration efforts in a given subwatershed. The long-term monitoring may also be used to help determine the cause of the biological impairment, which is thought to be, at least partially, a result of development in the watershed (NCDENR 2008). The monitoring plan as outlined below is aimed at meeting these goals and is adapted from Line (2009).

Indicators of the problem, current conditions, and future threats

NCSU's two-year monitoring effort for this planning effort and Durham Stormwater Services' (DSS) long-term monitoring have been gathering data on various water quality and aquatic habitat parameters.

This water quality monitoring has revealed water quality degradation in Subwatersheds 1, 4, and 7, in addition to water quality degradation on the main stem of Lick Creek just upstream of its confluence with Falls Lake. The parameters of concern include sediment (turbidity and TSS), FC, and nutrients.

While DSS's long-term monitoring can be used to depict general water quality and aquatic habitat trends in the watershed, their long-term monitoring efforts are not expected to explicitly gage improvements achieved or degradation to specific subwatersheds. Durham's current long-term monitoring program will not tell us whether specific sites such as new developments or large sites with agricultural exemptions are complying with regulations, which is needed in order to meet Goals 1 and 2 of the long-term monitoring plan. Furthermore, more monitoring is needed to determine exactly where the largest sources of pollution are. When specific sources of pollutants are identified, specific actions can be identified and taken to eliminate those sources.

In some cases, such as in Rocky Branch Creek, existing water quality problems may be due to one or two site-specific practices that are unlikely to be repeated in other areas throughout the watershed (e.g. a large agricultural operation). If this is the case, working with landowners to change practices may result in improvements, and monitoring might reveal those improvements, which is necessary for achieving Goal 3 of the long-term monitoring plan. Furthermore, in order to develop and assess an effective NMS for Falls Lake, it will be imperative that nutrient reductions can be monitored and accounted for.

Furthermore, as an example, water quality monitoring being conducted by DSS and the NCSU WQG revealed DO levels were depressed below the NC instantaneous water quality standard at all monitoring locations during summer months. However, short-term monitoring of this parameter occurred during a period of significant drought. DO may have worsened during the drought due to stagnant or pooled water. Other potential causes, for example continuous sources of ammonia and other oxygen consuming wastes, may have become more pronounced during this period and may have contributed to the low DO values. Long-term monitoring would provide a clearer picture of the true water quality trends over time and reduce uncertainty in water quality reporting.

The greatest threat to Lick Creek’s water quality is likely to be urban development of the watershed within Durham’s UGA. Current monitoring of Subwatersheds 1 and 2 has hinted that new development, especially active construction sites, is causing water quality degradation. If this is the case, some level of monitoring efforts should be continued in Lick Creek’s urbanizing subwatersheds (1-8) to assess the extent to which pollution is occurring. In addition, it will be important to monitor how a transition from agricultural lands to developed lands will affect water quality in the watershed. This assessment will allow local planners and governments to implement water quality improvement measures more effectively by focusing on the actual sources of pollution (runoff vs. pesticides, for example). This will also become increasingly important to water managers as the Falls Lake NMS is developed.

Recommended Strategies

- A detailed long-term monitoring plan, “Lick Creek Long-Term Monitoring Recommendations” has been developed by the NCSU WQG (Line 2009) and is available at <http://www.unrba.org/lick/downloads.shtml>. Long-term monitoring recommendations are summarized in Table 9.

TABLE 10. SUMMARY OF LONG-TERM MONITORING RECOMMENDATIONS

Site	Location	Measurements	Frequency/ number
L1	Lick Creek near Southview Road	Field & laboratory grab sample ¹	monthly
		Laboratory storm sample ¹ + discharge	2-4 storms/yr
		Benthic macroinvertebrates	2x/yr
		Discharge	monthly
L3	Rocky Branch at Kemp Road	Field & laboratory grab sample ¹	monthly
		Laboratory storm sample ¹ + discharge	2-4 storms/yr
		Discharge	monthly
L5	Unnamed tributary	Field & laboratory grab sample ¹	monthly
		Laboratory storm sample ¹ + discharge	2-4 storms/yr
		Discharge	monthly
L6	Lick Creek upstream of confluence with tributary of L5	Field & laboratory grab sample ¹	monthly
		Laboratory storm sample ¹ + discharge	2-4 storms/yr
		Discharge	monthly

- Seek additional partners and funding to implement the portions of the Lick Creek long-term monitoring program not implemented by DSS (e.g., additional monitoring sites, permanent/monumented cross-sections).
- Form volunteer stream monitoring groups, especially in areas where data are needed to help reach the goals of the long-term monitoring plan. Currently, the City of Durham is only funded to continue monitoring L1 and L3 (Table 9). The UNRBA and/or the Neuse River Foundation (NRF) could possibly pioneer this project or assist local governments in developing their own programs.
- A Quality Assurance Project Plan (QAPP) should be developed and approved by NCDWQ to help insure acceptance of the data by all parties involved. Along with this sample, analyses should be conducted by a state certified lab to help ensure acceptance of the results. To avoid the additional cost of lab work, volunteer collected data could be limited to physical parameters measurable in the field.
- Encourage consistency of data collectors and techniques by developing a volunteer guidebook that describes QAPP-approved sampling techniques and protocol. A partnership between the NRF and the UNRBA could be established to spearhead this cause.
- The UNRBA should investigate the feasibility of compiling and utilizing volunteer monitoring data for assessment purposes, and research options for maintaining the database of water quality information.
- Update the long-term monitoring plan at appropriate intervals.

Costs

- Additional staff time and other resources to conduct additional monitoring.
- Resources required for the purchase of equipment, the development of a handbook, the training of volunteer monitors, and the tracking of volunteer monitoring data.

Funding Opportunities

- Regional or cooperative programs such as the Triangle Area Water Supply Monitoring Project.
- Stormwater fees.
- Water utility fees.
- EPA NPS Section 319 Grant.

Low-Impact Development

Implementation Scale: Regional and local

Applicable Jurisdictions: Durham County, Wake County, City of Durham*, and City of Raleigh*

Description

Conversion of land to developed uses can create a host of environmental impacts. LID is a suite of practices and tools that can be utilized to minimize the impacts of development on water resources. When used holistically, LID practices can help ensure that the development has as few impacts on local and regional waterbodies as possible.

The goal of LID is to create an environmentally functional landscape that mimics natural watershed hydrologic functions (discharge, frequency, recharge and volume) to manage stormwater. This is accomplished in four ways (Coffman et. al. 1998):

1. Minimizing impacts to the maximum extent practicable, through conservation of natural resources/ecosystems, maintained natural drainage courses, minimized clearing and grading, reduced imperviousness, and reduced stormwater infrastructure;
2. Modifying detention and retention storage throughout a site with the use of open swales, reduced slopes, rain gardens (bioretention), and rain cisterns;
3. Maintaining pre-development runoff flows; and
4. Encouraging property owners to use effective pollution prevention measures and to maintain management measures.

Indicators of the problem and current conditions

Conventional development patterns coupled with conventional stormwater management have proven detrimental to Durham's waterways. Particularly in the highly erosive and easily compacted soils of the Triassic Basin, removal of vegetation, grading and soil compaction, and impervious cover associated with development cause changes to site hydrology that are difficult to mitigate. It is critical, therefore, to implement practices to reduce these stressors as much as possible, conserving natural areas that perform critical ecological functions. LID is essentially a "source-reduction" approach, whereby impacts are avoided first and foremost, then mitigated to the greatest practical extent through innovative and ecologically beneficial stormwater management practices.

Evidence of insufficient stormwater management is clear from the highly eroded stream banks found in Lick Creek, which result from high flows of stormwater leaving sites during and immediately following storm events. In undisturbed watersheds, runoff is released gradually through subsurface flow, which feeds waterways through dry spells and recharges groundwater. When the additional runoff (created when land is cleared, graded, and paved or built upon) is not sufficiently detained or infiltrated, high flows erode receiving drainage channels and creeks. Over time, this erosion prevents the watercourse from accessing its floodplain. Localized flooding of this type actually reduces downstream flooding and nourishes critical stream buffer areas so they can slow and remove nutrients from surface runoff before it reaches waterbodies with high sediment loads and excess nutrients.

Future threats

Lick Creek currently has a lot of potentially developable land; approximately 42% of the watershed is undeveloped pasture or unmanaged land and 24% is forest (Fraley-McNeal et al. 2007). Future developed lands in the Lick Creek watershed are expected to be predominantly low- to medium-density residential, a land use that under buildout conditions will be 364% of current levels (TJCOG 2007). According to the "Lick

Creek Watershed Treatment Model” technical memorandum (Fraley-McNeal et al. 2007), “Load increases from urbanization of the watershed exceed the decrease from rural land.” This is because fertilizers are often applied to lawns at a higher rate than cropland (Barth, 1996), and the additional impervious cover is expected to cause increases in channel erosion and suspended solids from channel erosion.

The WTM analysis did not model the effectiveness of an LID strategy explicitly, but LID would benefit many of the strategies that were modeled. For instance, increasing the amount of set-aside land on a development project would contain disturbance and likely reduce offsite export of construction sediment in addition to helping retain soil infiltration capacity. Riparian buffers would be less likely to be impacted under LID scenarios. Matching post-development hydrologic conditions of developed areas to predevelopment conditions would help protect stream channel integrity in developing watersheds.

The Triangle region is growing rapidly, and the Lick Creek watershed is an area of the Triangle that is relatively desirable, accessible, and affordable. Unfortunately, Lick Creek is already impaired, and the watershed’s Triassic Basin geology is very susceptible to impacts of land use changes. Durham and Durham County are considering stricter requirements on new development, but it has not yet been demonstrated that the measures under consideration would be sufficient to “hold the line” on degrading water quality in Lick Creek even as development continues. An LID approach that minimizes impacts of development and redevelopment projects to the fullest practical extent is justifiable given the impaired status of Lick Creek.

Recommended Strategies

- On a regular basis, educate planning staff, elected officials, citizens, and developers on relationships between the development sites (development pattern, stormwater management) and the aquatic system (water quality, hydrology, and stream morphology).
- Engage a committee of all stakeholders (developers, utility department staff, planners, stormwater managers, elected officials, citizens, etc.) to conduct a review of local ordinances and codes to identify barriers to LID and other protective strategies.
- Support the stakeholder group to recommend specific changes to the Joint City-County Planning Commission based on the review of barriers to LID and other protective strategies.
- Identify additional measures that could be taken to ensure that new developments do not further degrade waterways. For example, rezoning requests could be granted contingent on implementation of additional open space or higher levels of volume and quality treatment in the proposal’s committed elements.
- Ensure that planning and stormwater management staff review all development proposals for existence of watershed restoration opportunities as cataloged in the EEP Lick Creek Watershed Restoration Project Atlas. If a potential project is on the site, ensure that the development and stormwater system configurations do not jeopardize the viability of the project. Encourage the developer to implement the project, particularly if a rezoning or other concession is being sought.
- Based on the findings of the LID code and ordinance review, enact ordinance revisions. Require a comprehensive suite of LID practices on large developments (those adding substantial amounts of impervious cover).
- Create incentives, such as reduced site plan review and permit fees or expedited approvals (in suitable situations), to encourage developers to implement additional voluntary LID practices.

- Publicize the fact that developments with lower levels of impervious cover will have lower stormwater utility fees in perpetuity.

Costs

- Additional staff time and other resources to work with developers, review and evaluate site plans, and visit parcels slated for development.

Funding Opportunities

- Interlocal, regional, or cooperative programs.
- Stormwater fees.
- Water utility fees.
- EPA NPS Section 319 Grant

MEETING EPA'S 9 ELEMENTS FOR A WATERSHED RESTORATION PLAN

➤ **An identification of the causes and sources.**

Status: Completed. Discovering the causes and sources of impairment to Lick Creek was the first goal of the Lick Creek WRP. Water quality monitoring in the Lick Creek watershed suggests that low levels of dissolved oxygen, high nutrient levels (total nitrogen and total phosphorous), excessive turbidity, low pH, and exceedences of E. coli state standards may all contribute to degraded water quality conditions in the Lick Creek watershed (see the [Detailed Watershed Assessment](#) section of this document). Many of these problem parameters are the result of poor stormwater management or the lack thereof. Other activities that contribute to water quality degradation are the removing of riparian vegetation, earth-moving for construction and agriculture, fertilizer and pesticide applications for both agriculture and homeowners, and a poor understanding of the effects of oils, grease, and pet waste on water quality by landowners. All of the activities suspected of contributing to degraded water quality conditions are discussed in greater detail in the [Management Strategies](#) section of this document.

➤ **A description of the NPS management measures that will need to be implemented to achieve load reductions.**

Status: Completed. Thirteen detailed management strategies have been presented as a comprehensive management strategy for reducing sediment and nutrient loading in the Lick Creek watershed. These strategies are discussed in greater detail in the [Management Strategies](#) section of this document.

➤ **An estimate of load reductions.**

Status: Completed. Table 9 of the [Management Strategies](#) section of this document lists the relative potential of management strategies to reduce nutrient and sediment loading based on a scale of low, medium, and high. In addition, the Upper Neuse River Basin Association, in cooperation with the NC State Department of Biological and Agricultural Engineering, the NC State Stream Restoration Program, Baker Engineering, Durham County Soil and Water Conservation District, and the NC State Cooperative Extension Service modeled the pollution removal potential that could be achieved by implementing several of the restoration opportunities identified during this planning process including two stormwater retrofits, one buffer reforestation, and one stream restoration project. Pollution removal potential was modeled using the Upper Neuse Site Evaluation Tool, the Tar-Pamlico Nutrient Model, and the Bank Erosion Hazard Index. A further discussion on these projects can be found by referring to the UNRBA's "Lick Creek Local Watershed Plan Demonstration Projects" memo (UNRBA 2009).

➤ **An estimate of the amount of technical and financial assistance needed.**

Status: Completed. Each management strategy detailed in this plan ([Management Strategies](#)) provided a description of the strategy and provides a discussion of problem indicators, current threats, future threats, costs, and funding sources. In addition, Table 9 of the [Management Strategies](#)

section of the plan lists the cost of implementation based on a scale of low, medium, or high. In many cases, costs may vary among jurisdictions.

➤ **An information/education component.**

Status: Completed. One full management strategy in this plan is devoted to education and outreach. Please refer to the “Targeted Outreach and Education” management strategy located in the Management Strategies section of this plan.

➤ **A schedule for implementing the NPS management measures.**

Status: Completed. Table 9 of the Management Strategies section of this document prioritizes the schedule for implementation of each of the strategies based on a scale of low, medium, and high. This section also provides a discussion of each strategy and provides justification for the prioritization scheme.

➤ **Measurable milestones.**

Status: Completed. The Management Strategies section of this document lists several measurable milestones that can be used to assess adoption of this plan and its recommended management strategies. In short, use of the plan to assess and implement water quality protection or improvement measures should be seen as a measurable milestone. Furthermore, many measurable milestones have already been achieved.

➤ **Criteria to determine whether loading reductions are being achieved.**

Status: Completed. A detailed monitoring plan has been recommended in conjunction with this plan. Implementing a long-term monitoring plan will allow local planners and other groups to assess the effectiveness of implemented management strategies. Please refer to the “Long-term Monitoring Recommendations” management strategy located in the Management Strategies section of this document. The Upper Neuse Site Evaluation Tool, the Tar-Pamlico Nutrient Model, and the Bank Erosion Hazard Index are also tools that can be used to evaluate the effectiveness of specific restoration activities. A further discussion on these tools can be found by referring to the UNRBA’s “Lick Creek Local Watershed Plan Demonstration Projects” memo (UNRBA 2009).

➤ **A monitoring component to evaluate effectiveness.**

Status: Completed. A detailed monitoring plan has been recommended in conjunction with this plan. Implementing a long-term monitoring plan will allow local planners and other groups to assess the effectiveness of implemented management strategies. Please refer to the “Long-term Monitoring Recommendations” management strategy located in the Management Strategies section of this document.

OUTCOMES AND CONCLUSIONS

Lick Creek, a tributary to Falls Lake, was listed as “biologically impaired” by the NC Division of Water Quality on the 2006 NC 303(d) list (NCDWQ 2006). In May of 2005, the Upper Neuse River Basin Association partnered with various organizations to create a Watershed Restoration Plan for Lick Creek that would identify sources of Lick Creek’s impairment and propose and prioritize management strategies to address those sources. To this end, the UNRBA began identifying and contacting interested groups with a stake in the management of the Lick Creek watershed during the summer of 2006. This group eventually came to be known as the Local Watershed Planning Group (Stakeholder Group) and consisted of project partners, community stakeholders, and a technical team. Collectively, the local watershed planning group committed to initiate, facilitate, organize, guide, and provide input for the development of the watershed restoration plan. Furthermore, project partners committed to financially support the development and implementation of management strategies developed as part of the watershed restoration plan.

The stakeholder group met 8 times to collaborate on characterizing the watershed, performing water quality monitoring and assessment, evaluating land-use changes and critical lands, prioritizing restoration opportunities, and developing comprehensive management strategies to steer water quality planning and management in the watershed. Often times, smaller groups convened to discuss particular or technical aspects such as outreach and education, implementation, or regulatory processes. Project partners provided the staff resources to monitor water quality in the watershed for 2 years and conduct fieldwork, and more than twelve documents were produced to report and synthesize the project partners and stakeholders efforts. These documents are housed on the project website at <http://www.unrba.org/lick/downloads.shtml>.

Aquatic Habitat and Water Quality

In general, Triassic Basin aquatic macrobiology is poorly understood. Biological monitoring in Lick Creek and other Triassic Basin sites is providing important information for the NCDWQ and others as we attempt to better understand this unique habitat. Durham’s aquatic insect monitoring at the Southview Rd. site resulted in Fair (borderline Poor) bioclassifications (note: NC DWQ no longer rates Triassic Basin streams).

Water quality degradation for Lick Creek was characterized using NC DWQ and EPA standards, where applicable. Total nitrogen and total phosphorus do not have water quality standards; therefore they were compared to recommended ambient water quality criteria published by EPA (EPA 2000). However, EPA did not provide guidelines for implementing the recommended criteria. For example, should the criteria never be exceeded, or the average concentration not exceed the criteria, or another method of evaluation be used? As such, the interpretation of total nitrogen and total phosphorous data should be considered best professional judgment until EPA or the State of North Carolina provide additional guidance.

Overall, water quality monitoring in the Lick Creek watershed suggests that low levels of dissolved oxygen, high nutrient levels (total nitrogen and total phosphorous), excessive turbidity, low pH, and exceedences of E. coli state standards may all contribute to degraded water quality and aquatic habitat conditions in the Lick Creek watershed (see the [Detailed Watershed Assessment](#) section of this document). Many of these problem parameters are the result of poor stormwater management or the lack thereof. Other activities that contribute to water quality degradation are the removing of riparian vegetation, earth-moving for construction and agriculture, fertilizer and pesticide applications for both agriculture and homeowners, and a poor understanding of the effects of oils, grease, and pet waste on water quality by landowners. All of the activities suspected of contributing to degraded water quality conditions are discussed in greater detail in the [Management Strategies](#) section of this document.

Effects of Changes in Land Use

The general trend in land use in the Lick Creek watershed is a shift from rural existing conditions to urban future conditions. While the watershed is a primarily rural now, it is developing rapidly. Currently, only 15%

of the land is developed to the extent allowed under zoning laws, and only 6% of the watershed lies under impervious areas such as roads or rooftops. In fact, Lick Creek is the least developed of the eight major watersheds on the south side of Falls Lake. Despite this, the state already recognizes the creek as “impaired” under Section 303(d) of the federal Clean Water Act because of poor biological integrity. If the watershed is built to the full extent allowable under current regulations, 70% of the land will be developed and impervious cover will increase to approximately 23%, an increase of 280% over current levels. This is almost three times more impervious surface that will prevent rainfall infiltration and that will contribute excess runoff and pollutants to the already impaired stream.

Based on the land-use analysis (Hodges-Copple 2007), under future conditions, protected natural areas and roadways increase, forest and cropland do not exist, and the dominant land use becomes low- to medium-density residential. Furthermore, the land-use analyses revealed that this shift from rural to urban land uses will be accompanied by high nutrient and sediment load increases, attributable to the increase in urban land, specifically residential land uses. However, when modeled, recommended future management practices showed that the most significant improvements to sediment and nutrient loading could be achieved through **improved erosion and sediment control, structural stormwater management retrofits, riparian buffer plantings, and septic system education.**

Critical Lands Analysis

One of the primary goals of the Lick Creek Watershed Restoration Plan is to mitigate future changes to watershed hydrology and water quality within the 22 square-mile watershed. A key management strategy in preventing impacts to this largely undeveloped watershed is the protection of those lands that are most critical to water quality and aquatic habitat. The Lick Creek Partners conducted a desktop analysis to identify and analyze all land parcels within the Lick Creek Watershed for their potential water quality and selected conservation values. The analysis started with parcels defined as having high conservation value based on the Upper Neuse Clean Water Initiative Conservation Plan (Trust for Public Land 2006), and further analyzed those parcels for other selected conservation criteria defined by staff from local land trusts and government land protection agencies. A detailed discussion and significant results of the Critical Lands Analysis can be found in the “Lick Creek Watershed Critical Lands Protection Analysis” memorandum (UNRBA 2008). The following list highlights several significant findings:

- A total of 2,041 acres, or 14.5%, of the Lick Creek Watershed is rated as having a high value for conservation by the Conservation Plan.
- The 2,041 acres of high-value conservation lands are located on 539 land parcels that cover over 90% of the watershed. The average parcel is 25.9 acres and includes about 3.5 acres of UNCWI high-value land.
- About 1,735 acres, or 73%, of the total UNCWI high-value lands, are located on only 100 land parcels that total 9,710 acres.
- About ½ of the UNCWI high-value lands are located on 40 parcels that total 4,457 acres.

Watershed Restoration Opportunities

Fieldwork identified “major” and “volunteer” potential restoration sites, which were subsequently ranked based on a prioritization scheme developed by the stakeholders. In general, the prioritization process evaluates each project’s general need for restoration (by subwatershed), potential environmental benefits, potential benefits to the surrounding community or potential to garner community support, and overall feasibility for implementation.

The Technical Team identified 13 major restoration opportunities in the Lick Creek Watershed, which together could treat up to 25 acres of drainage and approximately 1 linear mile of stream. Fourteen volunteer restoration opportunities were also identified, representing over 7,300 linear feet (almost 1.4 miles) of opportunities. These potential projects could capture at most 25 acres of surface runoff for water quality and reestablish buffers on or repair less than 2 linear miles of streams. The water quality and aquatic habitat benefits of these projects to Lick Creek at a watershed scale would be relatively minor. However, these projects can have significant local benefits at the small stream or subwatershed scale. In addition, restoration projects could have educational value for Lick Creek Watershed residents, teaching them the importance and benefits of watershed stewardship.

Watershed restoration projects of any type will not prevent additional degradation of Lick Creek. Over-dependence upon restoration practices at the expense of a comprehensive watershed management strategy would prevent us from addressing the causes of Lick Creek's water quality problems and would allow negative impacts to continue. And because Lick Creek is a direct tributary to the impaired Falls Lake Reservoir, these impacts extend beyond the creek. Clearly, a comprehensive watershed management approach is needed for Lick Creek to ensure that the land use changes that have already impacted water quality are not compounded by the continuing urbanization of the watershed.

Management Strategies

After 15 months of watershed analysis, fieldwork, planning, and prioritization by more than 70 watershed stakeholders representing more than 18 groups, the Lick Creek Watershed Restoration Plan recommends thirteen detailed management strategies for implementation by local, regional, and state-level watershed stakeholders including. Together, these strategies represent a comprehensive approach to restoring water quality and aquatic habitat in its 23 square-mile 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. These thirteen strategies include:

1. Erosion and Sediment Control on New Development;
2. Managing Timber-Harvesting and Sites Classified as "Agricultural";
3. Stormwater Management and Regulation;
4. Impacts from Infrastructure Crossing the Stream Corridor;
5. Riparian Buffer and Floodplain Encroachment;
6. Protection of High-Quality Streams and Wetlands;
7. Delineation of Stream and Wetland Boundaries;
8. Major Watershed Restoration Projects;
9. Restoration Projects to be Implemented by Volunteers;
10. Suspicious Discharges from Onsite Wastewater Systems;
11. Targeted Outreach and Education;
12. Long-Term Monitoring Recommendations; and
13. Low Impact Development.

The supporting documents to this plan (available at <http://www.unrba.org/lick/downloads.shtml>) offer a comprehensive and detailed summary of the analysis, fieldwork, monitoring, and modeling findings that led the Lick Creek Project Partners and Technical Team to recommend these particular management approaches. In addition, each recommendation presented in this plan outlines the problem, current conditions, future threats, recommended strategies, general costs, and funding opportunities. This and other project memoranda, maps, and general information are also available on the project website,

<http://www.unrba.org/lick/plan.shtml>. The following table prioritizes each strategy as low, medium, or high, and indicates its relative cost and potential for load reductions.

TABLE 11. COPY OF TABLE 9 (PRIORITY FOR IMPLEMENTATION, COST, AND POTENTIAL LOAD REDCUTIONS)

Management Strategy	Priority (low, medium, high)	Potential for Load Reductions (low, medium, high)	Cost of Implementation (low, medium, high)
Erosion & Sediment Control on New Development	High	High	Low
Managing Timber-Harvesting/Sites Classified as “Ag”	Medium	High	Low
Stormwater Management & Regulation	High	High	Low
Impacts from Infrastructure Crossing Stream Corridor	Low	Low	Medium
Riparian Buffer & Floodplain Encroachment	Low	High	Low
Protection of High-Quality Streams & Wetlands	Medium	N/A	Low-Medium
Delineation of Stream & Wetland Boundaries	Medium	N/A	Low
Major Watershed Restoration Projects	Low	Medium	High
Restoration Projects Implemented by Volunteers	High	High	Low
Suspicious Discharges from Onsite WW Systems	High	High	Medium
Targeted Outreach & Education	High	Medium	Low
Long-Term Monitoring Recommendations	High	N/A	Low
Low Impact Development	High	N/A	Medium

Management strategies such as Erosion and Sediment Control on New Development, Managing Timber-Harvesting and Sites Classified as “Agricultural,” and Stormwater Management and Regulation are all immediate needs that will address excessive sedimentation, high-volume discharges, and the high nutrient loading that are associated with typical storm events in our region. These strategies require regulatory supervision; however, the City of Durham already has well-structured programs to meet these needs and is currently working to strengthen their ordinance language. The potential for load reductions for these three strategies is high and the implementation costs relatively low for jurisdictions that already have local stormwater and sedimentation control programs. Many timber-harvesting and agricultural operations are exempt from local erosion and sediment or stormwater controls and therefore legislative measures would be necessary to address them all at once. Therefore, this strategy was given a priority of ‘medium.’

Most impacts from infrastructure are now reviewed for compliance during the plan review process and received a prioritization of ‘low.’ Historic impacts are hard to detect making implementation more costly.

Strategies such Riparian Buffer and Floodplain Encroachment, Protection of High-Quality Streams and Wetlands, and Delineation of Stream and Wetland Boundaries are all preventative measures, and while their potential for load reductions is considered ‘low’, their value in preserving water quality is unmatched. Floodplains and wetlands remove nutrients, and provide water and sediment storage, thereby naturally mitigating the damaging effects of stormwater runoff and pollution. Streams, wetlands, and riparian buffers are already protected under the Clean Water Act and the Neuse Rules. However, many impacts to all three systems are allowed through permits and variances. Efforts should be made to limit variances and enforce the proper delineation of jurisdictional areas for protection.

Because the Lick Creek is still relatively undeveloped, opportunities for major restoration opportunities are relatively limited and therefore received a priority of ‘low’. This is not meant to negate the value of these processes. Voluntary riparian tree plantings should be given high priority however. Riparian buffers provide excellent ecosystem services, are relatively inexpensive, and provide an educational component.

Detecting and fixing illicit discharges is an onerous task because of overlapping jurisdictions, and a lack of data. Many times, even landowners who are able to connect to city sewer will not because of prohibitive

hook-up costs or a lack of awareness; however, these systems are suspected to contribute high levels of nutrients and bacteria to receiving waters. Efforts to mitigate this problem should be given a high priority; however, implementation is expected to be difficult.

Targeted Outreach and Education is a critical path for improving and protecting water quality and aquatic habitat and should be given top priority.

Long-term monitoring will allow local governments to monitor their success and meet legislative requirements. The City of Durham is already conducting water quality monitoring as part of their stormwater management program; therefore, costs are expected to be relatively low.

Low-impact development takes a holistic approach to managing environmental resources in a community. It incorporates water, energy, and social aspects and is a progressive approach to protecting vital natural resources. Because it is a relatively new concept in the Lick Creek watershed, it may be challenging to implement. Many times, traditional ordinance language is prohibitive and a misperception of high costs persists. However, many efforts are underway to make low-impact development feasible in both from both a regulatory and cost perspective. This strategy should be given a high priority.

Implementation of any of these recommended strategies should be considered as measurable milestones and achievements in terms of the local watershed planning process. Most of the strategies rely on local governments for implementation and it should be noted that both the City of Durham and Durham County are in the process of strengthening their Unified Durham Ordinance language well beyond State standards. Other strategies rely on the enforcement of existing regulations from regulatory bodies like the NC Division of Water Quality or the US Army Corps of Engineers, among others. Measurable milestones for implementation include, but are not limited to the following:

- Milestone achievement should be given to any local government or regulatory agency that refers to and studies the strategies recommended in this plan.
- Implementation of a portion of any strategy recommended in this plan should be considered a measurable achievement.
- Credit should be awarded to local governments who make ordinance language changes that support, enforce, or enhance recommendations made in this plan.
- House Bill 1099 of 2009 requires additional controls on land-disturbing activities, sizing of sediment basins, removal efficiencies, establishment of ground cover, and channel design that have partially resulted from the efforts conducted pursuant to the development of the Lick Creek Plan.

Project Successes

With more than 18 groups represented, and almost 70 stakeholders constituting the Lick Creek Stakeholder Group, the efforts put forth in developing the Lick Creek Watershed Restoration Plan have been a great success. Furthermore, all four of the goals aspired to for this plan have been met.

Through water quality monitoring and stream corridor assessment, sources and causes of impairment to water quality in the Lick Creek watershed were identified. Subsequently, 13 comprehensive management strategies were put forth to improve and protect water quality and aquatic habitat in the watershed. These strategies were developed and embraced by all the stakeholders through a collaborative process and many of the recommendations put forth in this plan are already being implemented through strong ordinance changes, a true spirit of stewardship from both the local governments and the local community, and through new state legislative requirements.

Many measurable achievements have already been accomplished. Durham County is currently working to increase erosion and sediment controls, impacts from infrastructure crossings have be incorporated into the plan review process, both major and volunteer restoration projects are underway in the watershed, targeted outreach and education is being conducted by the City of Durham Stormwater Education Program, and the watershed is currently being monitored for water quality.

However, the greatest success of this project has been the resulting atmosphere of understanding and cooperation between stakeholders, local governments, local programs, local community groups, developers, local business owners, and watershed residents. Bringing so many groups to the table provided an opportunity for each stakeholder to share and hear about the obstacles to implementation that each faced and find creative and mutually beneficial solutions to water quality management in the Lick Creek watershed.

BUDGET SUMMARY

Budget Summary				
Budget Categories	Section 319	Non-Federal Match *	Total	Justification
Personnel/Salary	\$31,531	\$50,286	\$81,817	<i>labor on fieldwork, analysis, and other major tasks</i>
Fringe Benefits	\$9,459	\$2,587	\$12,145	<i>UNRBA and TJCOG fringe</i>
Supplies	-	-	-	
Equipment	-	\$3,000	\$3,000	<i>NCSU monitoring</i>
Travel	\$366	-	\$366	<i>Travel to fieldwork, meetings, and local government offices</i>
Contractual	\$92,195	-	\$92,195	<i>NCSU and CWP monitoring, fieldwork, modeling, and tech. reports</i>
Other	-	\$25,940	\$25,940	<i>3 years of benthic and ambient data collection and lab analysis on two sites</i>
Total Direct	\$133,551	\$81,813	\$215,463	
Total Indirect	\$14,589	\$24,709	\$39,199	<i>Funds requested are for TJCOG/ UNRBA overhead.</i>
Total Budget	\$148,140	\$106,522	\$254,662	
Percent	58.2%	41.8%	100%	

Budget Summary (Combined federal and match funds)							
	BMP Impl.	Project Management	Education Training Outreach	Monitoring	Technical Assistance	Other	Total
Personnel	-	\$4,922	\$1,395	\$248	\$75,252	-	\$81,817
Fringe Benefits	-	\$1,477	\$419	\$74	\$10,175	-	\$12,145
Supplies	-	-	-	-	-	-	-
Equipment	-	-	-	\$3,000	-	-	\$3,000
Travel	-	-	\$366	-	-	-	\$366
Contractual	-	-	-	\$48,000	\$44,195	-	\$92,195
Operating Costs	-	\$3,839	\$1,088	\$20,896	\$13,376	-	\$39,199
Other	-	-	-	\$25,940	-	-	\$25,940
Total	-	\$10,238	\$3,268	\$98,158	\$142,998	-	\$254,662

Non-Federal Local and State Match Summary	
Total Match amount	\$106,522
Cash Match (UNRBA, TJCOG hours)	\$ 10,482
In-kind Match (Partner hours: field work, lab work, critical lands protection analysis)	\$ 96,040
Source(s) of Cash Match	UNRBA, TJCOG
Source(s) of In-kind Match	Durham City Stormwater Services, Durham County Engineering, Durham City/County Planning, Durham GIS, NC State University Water Quality Group

REFERENCES

- Barth, C. 1996. Nutrient Movement from the Lawn to the Stream; The Practice of Watershed Protection. eds. T. Schueler and H. Holland. Center for Watershed Protection. Ellicott City, MD.
- Caraco, D. 2002. The Watershed Treatment Model. Version 3.1 Center for Watershed Protection. Ellicott City, MD.
- Carle, M.V., Halpin, P.N., and Stow, C.A. 2005. "Patterns of Watershed Urbanization and Impacts on Water Quality." *Journal of the American Water Resources Association* 41:3: 693-708.
- Schafer, Karina, Ram Oren, Chun-Ta Lai, and Gabriel G. Katul. 2002. "Hydrologic balance in an intact temperate forest ecosystem under ambient and elevated atmospheric CO₂ concentration." *Global Change Biology* 8: 895-911.
- Center for Watershed Protection (CWP). 2003. Impacts of Impervious Cover on Impervious Streams. Center for Watershed Protection. Ellicott City, MD. Available at <http://www.cwp.org/>, T.W., Gore, P.J.W., and Watson, M.E. 2001.
- 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.
- Coffman, L.S., Clar, M.L., Weinstein, N. 1998. *New Low Impact Design: Site Planning and Design Techniques for Stormwater Management. Revolutionary Ideas in Planning*: AICP Press. 1998. <http://design.asu.edu/apa/proceedings98/Coffmn/coffmn.html>.
- Durham City-County Planning. 2006. East Durham Open Space Plan. Durham, NC. Available at http://www.durhamnc.gov/departments/planning/pdf/ED_OS_Plan_Adopted.pdf.
- Hall, Stephen P. 1995. Inventory of the Wildlife Habitats, Movement Corridors, and Rare Animal Populations of Durham County, NC NC Natural Heritage Program, Division of Parks and Recreation, NC Department of Environment and Natural Resources.
- Hodges-Copple, J. 2007. Memorandum describing the process and results of the current and future land use analyses performed for the Lick Creek Watershed Restoration Plan. [Online]. Available at: ftp://ftp.tjcoq.org/pub/unrba/lick/appx062007_b.pdf.
- Hoyt, S. and Kitchell, A. 2007. Lick Creek Fieldwork: Findings and Recommendations. [Online]. Available at: <ftp://ftp.tjcoq.org/pub/unrba/lick/techmemo060707.pdf> [accessed May 15, 2008].
- Fraley-McNeal, L., Hoyt, S., and Kitchell, A. 2007. Lick Creek—Watershed Treatment Model Analysis. [Online]. Available at: <ftp://ftp.tjcoq.org/pub/unrba/lick/techmemo062007.pdf> [accessed May 15, 2008].
- Kitchell, A. and Schueler T. 2004. Unified Stream Assessment: A User's Manual. Manual 10 in the Urban Subwatershed Restoration Manual Series. Center for Watershed Protection. Ellicott City, MD.
- Line, D., 2009. Draft Recommendations for Long Term Monitoring Of Lick Creek. [Online]. Available at: <ftp://ftp.tjcoq.org/pub/unrba/lick/techmemo20090213.pdf>

- Line, D. and Penrose, D., 2007, Analysis of Existing Data and Short-term Monitoring Plan for Lick Creek. [Online]. Available at: <ftp://ftp.tjocog.org/pub/unrba/lick/stermmonplan.pdf> [accessed May 15, 2008].
- National Wetlands Inventory (NWI). 2008. National Wetlands Inventory; Wetlands Mapper. [Online]. Available at <http://www.fws.gov/wetlands/Data/Mapper.html>
- NC Geologic Survey (NCGS). 2008. Triassic Basin. [Online]. Available at http://gis.enr.state.nc.us/sid/zGeologic_maps/Geology.htm
- NC Department of Environment and Natural Resources (NCDENR). 2008. Neuse River Basinwide Water Quality Plan. NC Department of Environment and Natural Resources, NC Division of Water Quality. Raleigh, NC.
- NC Division of Water Quality (NCDWQ). 2006. Final North Carolina Water Quality Assessment and Impaired Waters List (2006 Integrated 305(b) and 303(d) Report). May. Available at http://h2o.enr.state.nc.us/tmdl/documents/303d_Report.pdf.
- NC Division of Water Quality (NCDWQ). 2008. North Carolina 303(d) List; Draft for Public Review. [Online]. Available at: <http://h2o.enr.state.nc.us/tmdl/documents/B.Draft2008303dList.pdf> [accessed May 15, 2008].
- NC Floodplain Mapping Program (NCFMP). 2007. [Online]. Available at <http://www.ncfloodmaps.com/>
- Schafer, Karina, Ram Oren, Chun-Ta Lai, and Gabriel G. Katul. 2002. "Hydrologic balance in an intact temperate forest ecosystem under ambient and elevated atmospheric CO₂ concentration." *Global Change Biology* 8: 895-911.
- Terziotti, S. 2004. A geographic information systems file created by Silvia Terziotti (of the USGS) 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 (NCDEM) 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.
- Upper Neuse River Basin Association (UNRBA). 2003. Upper Neuse Watershed Management Plan. [Online]. Available at: <ftp://ftp.tjocog.org/pub/unrba/finlplan.pdf>[accessed May 15, 2008].
- Upper Neuse River Basin Association (UNRBA). 2006. Little Lick Creek Local Watershed Plan. [Online]. Available at <ftp://ftp.tjocog.org/pub/unrba/llc/llclwplan.pdf>.
- Upper Neuse River Basin Association (UNRBA). 2007a. Lick Creek Watershed—Initial watershed characterization, existing water quality data, and stakeholder process. Technical memorandum to Kimberly Nimmer, NC Division of Water Quality. March. Available at <ftp://ftp.tjocog.org/pub/unrba/lick/techmemo031907.pdf>.
- Upper Neuse River Basin Association (UNRBA). 2007b. Lick Creek Watershed Restoration Priorities. [Online]. Available at: <ftp://ftp.tjocog.org/pub/unrba/lick/techmemo101507.pdf>[accessed May 15, 2008].

- Upper Neuse River Basin Association (UNRBA). 2007c. Upper Neuse Watershed Management Implementation Recommendation #15. [Online]. Available at: <http://www.unrba.org/downloads.htm>[accessed May 15, 2008].
- Upper Neuse River Basin Association (UNRBA). 2007d. Upper Neuse Watershed Management Implementation Recommendation #14. [Online]. Available at: <http://www.unrba.org/downloads.htm>[accessed May 15, 2008].
- Upper Neuse River Basin Association (UNRBA). 2008. Lick Creek Watershed Critical Lands Protection Analysis. Available at <ftp://ftp.tjco.org/pub/unrba/lick/techmemo012408.pdf> [accessed May 15, 2008].
- Upper Neuse River Basin Association (UNRBA). 2009. Lick Creek Local Watershed Plan Demonstration Projects. Available at <ftp://ftp.tjco.org/pub/unrba/lick/licklwpdemoproj.pdf> [accessed July 23, 2009].
- US Department of Agriculture (USDA). 1971. Soil Survey of Durham County, North Carolina. US Department of Agriculture, Soil Conservation Service.
- US Department of Agriculture (USDA). 2009. White Store Data: http://www2.ftw.nrcs.usda.gov/osd/dat/W/WHITE_STORE.html
- US Environmental Protection Agency (USEPA). 1986. Ambient Water Quality Criteria for Bacteria – 1986. Office of Water Regulations and Standards and Standards Division. Washington, DC. [Online]. Available at <http://www.epa.gov/waterscience/beaches/files/1986crit.pdf>
- US Environmental Protection Agency (USEPA). 2000. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000). Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency, Washington, DC.
- Trust for Public Land. 2006. Upper Neuse Clean Water Initiative Conservation Plan.
- Weakley, A. 2004. "Natural Heritage Program List of Rare Plant Species of North Carolina." North Carolina Natural Heritage Program; Office of Conservation and Community Affairs; N.C. Department of Environment and Natural Resource.
- Winer, R. 2000. "National Pollutant Removal Performance Database for Stormwater Treatment Practices." Center for Watershed Protection. Ellicott City, MD. [Online]. Available at <http://www.stormwatercenter.net/Library/STP-Pollutant-Removal-Database.pdf>
- Woolfolk, M. 2009. Interim summary of water quality data for the Lick Creek watershed. [Online]. Available at <ftp://ftp.tjco.org/pub/unrba/lick/techmemo20090224.pdf>.
- Wright, T., Swann C., Cappiella K., and Schueler T. 2004. Unified Subwatershed and Site Reconnaissance: A User's Manual. Manual 11 in the Urban Subwatershed Restoration Manual Series. Center for Watershed Protection. Ellicott City, MD.